5. Materials Technology

The Vehicle Technologies Office (VTO) supports research, development, deployment, and demonstration (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the national laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well as innovations in connected infrastructure for significant systems-level energy efficiency improvement); combustion engines to reduce greenhouse gas (GHG) emissions; and technology deployment and integration at the local and state level. In coordination with the other offices across the Office of Energy Efficiency and Renewable Energy (EERE) and the U.S. Department of Energy (DOE), the Vehicle Technologies Office advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources.

The Materials Technology subprogram supports the Vehicle Technologies Office goals of achieving 100 percent decarbonization of the transportation sector by 2050. This ambitious goal will be realized through the increased deployment of electric and hydrogen fuel cell vehicles. Materials play an important role in increasing the efficiency of electric vehicles through weight reduction as well as enabling additional functionality such as faster charging and new sensing technologies. Lighter weight vehicle structures and electric drivetrains will require fewer batteries to achieve the same range, which in turn reduces battery cost, material needs, and reduces the GHG emissions from battery production. Functional materials with improved properties such as electrical conductivity, thermal conductivity, and unique sensing capabilities will enable innovations in charging and autonomous vehicles. The materials and manufacturing methods used to make vehicles also contribute to greenhouse gases and the Materials Technology subprogram supports research, development, and deployment to increase recyclability and reduce the overall embodied energy of vehicles. The Materials Technology subprogram accomplishes its technical objectives through research programs with academia, national laboratories, and industry.

Lightweight Materials supports national laboratory, academia, and industry-led research in advanced high-strength steels, aluminum (Al) alloys, magnesium (Mg) alloys, carbon fiber composites, and multi-material systems with potential performance and manufacturability characteristics that greatly exceed today's technologies. This includes projects addressing materials and manufacturing challenges spanning from atomic structure to assembly, with an emphasis on establishing and validating predictive modeling tools for materials applicable to light- and heavy-duty vehicles.

Powertrain Materials supports research at national laboratories, academia, and industry to develop higher performance materials to address the future properties needs of electric and hydrogen fuel cell vehicles to increase efficiency and decrease manufacturing cost, supporting the transition to all electric light duty vehicles by 2035. Research funded through this activity applies advanced characterization and multi-scale computational materials methods, including HPC, to accelerate discovery and early-stage development of cutting-edge structural and high temperature materials for lighter and more efficient powertrains.

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses (*on a scale of 1.0 to 4.0).* In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A table presenting the average numeric score for each question for each project is presented below.

Table 5-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
mat132	High Strength Steel-Aluminum Components by Vaporizing Foil Actuator Welding	Glenn Daehn (The Ohio State University)	5-11	3.00	3.38	3.25	3.50	3.28
mat146	Ultra-Lightweight, Ductile Carbon-Fiber Reinforced Composites	Seokpum Kim (Oak Ridge National Laboratory)	5-14	3.00	3.17	3.17	2.67	3.06
mat149	Shear Assisted Processing and Extrusion (ShAPE) of Lightweight Alloys for Automotive Components	Scott Whalen (PNNL)	5-18	3.50	3.38	3.50	3.33	3.42
mat151	Phase-Field Modeling of Corrosion for Design of Next-Generation Magnesium-Aluminum Vehicle Joints	Adam Powell (Worcester Polytechnic Institute)	5-21	3.17	3.00	3.17	2.83	3.04
mat152	A Hybrid Physics-Based, Data-Driven Approach to Model Damage Accumulation in Corrosion of Polymeric Adhesives	Roozbeh Dargazany (Michigan State University)	5-24	3.63	3.75	3.63	3.25	3.64

mat159	Cost Effective Lightweight Alloys for Electric Vehicle Propulsion: Fundamental Fatigue and Creep in Advanced Lightweight Alloys	Amit Shyam (Oak Ridge National Laboratory)	5-28	3.08	3.42	3.17	2.92	3.24
mat160	Cost Effective Lightweight Alloys for Electric Vehicle Propulsion: Hybrid Dispersion Strengthened Al Matrix Composites for Higher Efficiency Electric Vehicle (EV) Powertrains	Mert Efe (Pacific Northwest National Laboratory)	5-33	3.10	3.20	2.70	3.10	3.10
mat164	Multiscale Development and Validation of the Stainless Steel Alloy Corrosion (SStAC) Tool for High-Temperature Engine Materials	Michael Tonks (University of Florida)	5-37	2.50	2.63	3.00	2.33	2.60
mat174	Carbon-Fiber Technology Facility (CFTF)	Merlin Theodore (Oak Ridge National Laboratory)	5-42	3.50	3.50	3.50	3.50	3.50
mat195	Industrialization of Carbon Fiber Composite Wheels for Automobiles and Trucks	Brian Knouff (Oak Ridge National Laboratory)	5-44	3.25	3.25	3.25	3.00	3.22
mat196	High Temperature Carbon Fiber Carbonization via Electromagnetic Power	Felix Paulauskas (Oak Ridge National Laboratory)	5-48	3.13	3.25	3.13	3.00	3.17
mat197	Multi-Functional Smart Structures for Smart Vehicles	Patrick Blanchard (Ford Motor Company)	5-52	3.75	3.50	3.75	3.50	3.59

mat198	Development of Tailored Fiber Placement, Multi-Functional, High-Performance Composite Material Systems for High Volume Manufacture of Structural Battery Enclosure	Venkat Aitharaju (General Motors Company)	5-55	3.00	3.17	3.50	3.33	3.19
mat199	Ultra-Lightweight Thermoplastic Polymer/Polymer Fiber Composites for Vehicles (Inter-Lab Project)	Kevin Simmons (Pacific Northwest National Laboratory)	5-58	3.00	3.17	3.50	3.33	3.19
mat200	Additive Manufacturing for Property Optimization for Automotive Applications	Seokpum Kim (Oak Ridge National Laboratory)	5-61	3.38	3.50	3.25	3.00	3.38
mat201	Additively Manufactured, Lightweight, Low-Cost Composite Vessels for Compressed Natural Gas Fuel Storage	James Lewicki (Lawrence Livermore National Laboratory)	5-65	2.75	3.00	3.00	3.13	2.95
mat202	3D Printed Hybrid Composite Materials with Sensing Capability for Advanced Vehicles	Rigoberto Advincula (Oak Ridge National Laboratory)	5-69	2.60	2.70	2.90	2.70	2.70
mat203	Low-Cost, High-Throughput Carbon Fiber with Large Diameter	Felix Paulauskas (Oak Ridge National Laboratory)	5-74	3.00	3.17	3.17	3.25	3.14
mat204	New Frontier in Polymer Matrix Composites via Tailored Vitrimer Chemistry	Tomonori Saito (Oak Ridge National Laboratory)	5-79	3.20	3.30	3.20	3.40	3.28

mat205	Adopting Heavy-Tow Carbon Fiber for Repairable, Stamp-Formed Composites	Amit Naskar (Oak Ridge National Laboratory)	5-83	2.88	3.13	2.88	2.63	2.97
mat206	Soft Smart Tools Using Additive Manufacturing	Jay Gaillard (Savannah River National Laboratory)	5-87	3.20	3.20	3.30	3.30	3.23
mat207	Multi-Material, Functional Composites with Hierarchical Structures	Christopher Bowland (Oak Ridge National Laboratory)	5-92	3.50	3.50	2.67	3.33	3.38
mat208	Efficient Synthesis of Kevlar and Other Fibers from Polyethylene Terephthalate (PET) Waste	Lelia Cosimbescu (Pacific Northwest National Laboratory)	5-95	3.25	3.38	2.88	3.00	3.23
mat209	Bio-based, Inherently Recyclable Epoxy Resins to Enable Facile Carbon-Fiber Reinforced Composites Recycling	Nicholas Rorrer (National Renewable Energy Laboratory)	5-99	3.33	3.50	3.17	3.17	3.38
mat210	A Novel Manufacturing Process of Lightweight Automotive Seats - Integration of Additive Manufacturing and Reinforced Polymer Composite	Patrick Blanchard (Ford Motor Company)	5-102	3.25	3.00	3.25	3.25	3.13
mat211	Sustainable Lightweight Intelligent Composites (SLIC) for Next-Generation Vehicles †	Masato Mizuta (Newport Sensors, Inc.)	5-104	3.08	3.00	3.17	2.92	3.03

mat212	Integrated Self sufficient Structurally Integrated Multifunctional Sensors for Autonomous Vehicles †	Amrita Kumar (Accelent Technologies, Sunnyvale)	5-110	3.13	3.25	3.25	2.88	3.17
mat215	Short Fiber Preform Technology for Automotive Part Production †	Dirk Heider (Composites Automation, LLC)	5-114	3.50	2.90	3.20	3.38	3.15
mat216	Low Cost Resin Technology for the Rapid Manufacture of High-Performance Fiber Reinforced Composites †	Henry Sodano (LLC)	5-119	3.50	3.50	3.25	3.38	3.45
mat221	Lightweight and Highly-Efficient Engines Through Al and Si Alloying of Martensitic Materials	Dean Pierce (Oak Ridge National Laboratory)	5-123	3.50	3.33	3.83	3.58	3.47
mat222	Extending Ultrasonic Welding Techniques to New Material Pairs	Jian Chen (Oak Ridge National Laboratory)	5-129	3.25	3.42	3.08	3.00	3.28
mat223	Extending High Rate Riveting to New Material Pairs	Kevin Simmons (Pacific Northwest National Laboratory)	5-135	3.30	3.50	3.20	3.20	3.38
mat224	Solid State Joining of Multi-Material Autobody Parts Toward Industry Readiness	Yong Chae Lim & Piyush Upadhyay (Oak Ridge National Laboratory/Pacific Northwest National Laboratory)	5-140	3.63	3.50	3.63	3.13	3.50

mat225	Surface Modifications for Improved Joining and Corrosion Resistance	Yong Chae Lim & Vineet Joshi (ORNL/PNNL)	5-144	2.88	3.13	2.88	3.00	3.02
mat226	Machine Learning for Joint Quality and Control	Zhili Feng & Keerti Kappagantula (ORNL/PNNL)	5-148	3.25	3.63	3.88	3.25	3.52
mat229	Development of a Novel Magnesium Alloy for Thixomolding of Automotive Components	Govindarajan Muralidharan & Bryan Macek (ORNL/FCA LLC)	5-152	3.17	3.50	3.33	3.00	3.33
mat235	Light Metals Core Program - Thrust 4 - Residual Stress Effects	Ayoub Soulami (Pacific Northwest National Laboratory)	5-155	3.25	3.38	3.38	3.25	3.33
mat236	Advanced Characterization and Computational Methods	Thomas Watkins (Oak Ridge National Laboratory)	5-159	3.25	3.38	3.75	3.13	3.36
mat237	Materials, Lubricants, and Cooling for Heavy Duty Electric Vehicles	Jun Qu (Oak Ridge National Laboratory)	5-163	3.80	3.70	3.60	3.60	3.70
mat238	Advanced Processing and Additive Manufacturing for Electric Vehicle (EV) Propulsion, Ultra Conductor Development for Enhanced EV performance	Keerti Kappagantula (Pacific Northwest National Laboratory)	5-168	3.60	3.60	3.70	3.50	3.60

mat241	Advanced Processing and Additive Manufacturing for Electric Vehicle (EV) Propulsion, Advanced Ceramics and Processing for Wireless Charging Systems	Beth Armstrong (Oak Ridge National Laboratory)	5-173	3.20	3.30	3.20	3.30	3.26
mat242	Advanced Processing and Additive Manufacturing for Electric Vehicle (EV) Propulsion, Novel Ultra High Conductivity Composites for EVs	Tolga Aytug (Oak Ridge National Laboratory)	5-178	3.25	3.42	3.33	3.58	3.39
mat243	Manufacturing Demonstration of a Large-scale, Multi-material Passenger Vehicle Sub-system	Srikanth Pilla (Clemson University)	5-183	2.88	3.00	3.13	3.38	3.03
mat244	LMCP P1A - Sheet Materials with Local Property Variation	Scott Whalen (PNNL)	5-187	3.50	3.67	3.50	3.17	3.54
mat245	LMCP P1B - Form-and-Print - AM for Localized Property Enhancement of High-strength Al sheet	Alex Plotkowski (ORNL)	5-190	3.50	3.25	3.50	3.25	3.34
mat246	LMCP P1C - Local Thermomechanical Processing to Address Challenges to Implementing High Strength Al Sheet	Mert Efe & Govindarajan Muralidharan (PNNL/ORNL)	5-192	3.38	3.25	3.25	3.38	3.30
mat247	LMCP P2A - Solid Phase Processing of Aluminum Castings	Saumyadeep Jana & Zhili Feng (PNNL/ORNL)	5-196	3.13	3.25	3.13	3.00	3.17

mat248	LMCP P2B - High Intensity Thermal Treatment	Aashish Rohatgi (PNNL)	5-200	3.25	3.38	3.38	3.25	3.33
mat249	LMCP P2C - Cast-and-Print - AM for Localized Property Enhancement of Al castings	Alex Plotkowski (ORNL)	5-204	3.13	2.75	3.13	3.00	2.92
mat250	LMCP P3A - Cast Magnesium Local Corrosion Mitigation	Vineet Joshi & Jiheon Jun (PNNL/ORNL)	5-208	3.50	3.38	3.50	3.38	3.42
mat251	LMCP P3B - Thermomechanical Property Modification of Mg Castings	Mageshwari Komarasamy (PNNL)	5-212	3.38	3.25	3.25	3.13	3.27
mat252	LMCP - Thrust 4 - Materials Lifecycle	Jeff Spangenberg-er (Argonne National Laboratory)	5-217	2.00	2.38	2.75	2.50	2.34
mat253	Flexible, Lightweight Nanocomposites for EMI Shielding Suppression in Automotive Applications †	Carla Lake (Applied Sciences)	5-221	3.17	3.00	3.67	3.25	3.16
mat255	Graphene-enriched Hierarchical Polymer Additives Derived from Natural Gas †	George Skoptsov (H. Quest Vanguard, Inc.)	5-224	3.30	3.10	3.00	3.10	3.14
mat256	Game Changing Resin/Coating/Adhesive Technology for Lightweight Affordable Composites †	Scott Lewit (Structural Composites, Inc.)	5-230	3.00	2.70	3.20	2.80	2.85
mat257	Changing the Design Rules of Rubber to Create Lighter Weight, More Fuel Efficient Tires †	Kurt Swogger (Molecular Rebar Design, LLC)	5-235	3.50	3.42	2.50	3.30	3.31

mat258	Hierarchical Micro/Nano Reinforced Multiscale Hybrid Composites for Vehicle Applications †	Shawn Beard (Advent Innovations, LTD)	5-240	3.20	3.20	3.40	3.13	3.22
Overall Average				**3.21**	**3.25**	**3.24**	**3.15**	**3.23**

Presentation Number: mat132
Presentation Title: High Strength Steel-Aluminum Components by Vaporizing Foil Actuator Welding
Principal Investigator: Glenn Daehn, The Ohio State University

Presenter

Glenn Daehn, The Ohio State University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

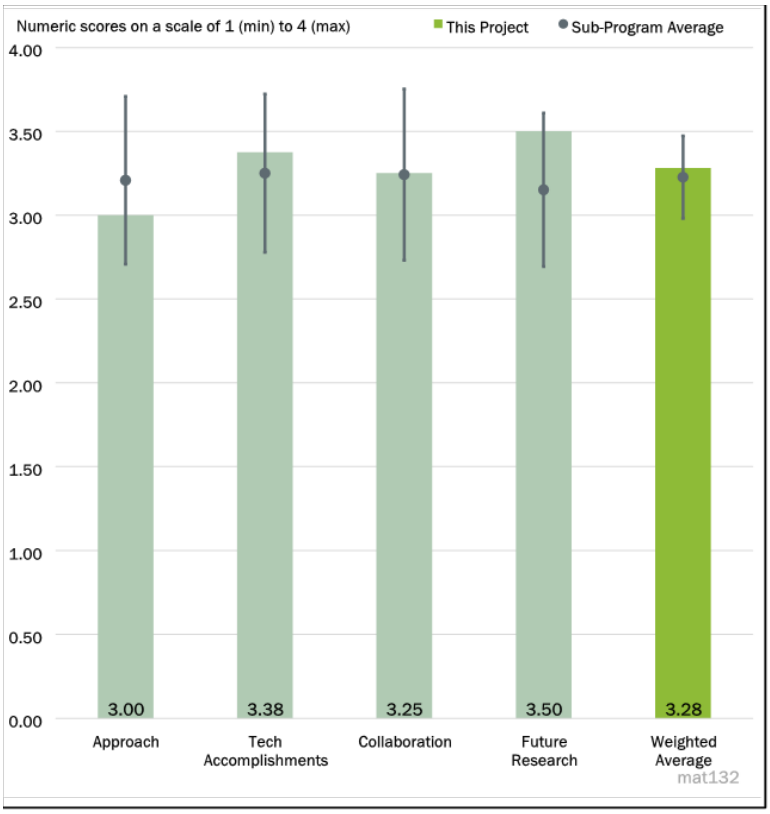

Figure 5-1 - Presentation Number: mat132 Presentation Title: High Strength Steel-Aluminum Components by Vaporizing Foil Actuator Welding Principal Investigator: Glenn Daehn, The Ohio State University

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 2

The project approach of including lab coupon evaluation, component/assembly finite element analysis (FEA), prototype build, and test to validate a new joining process is an outstanding approach. Corrosion evaluation of the completed assembly (especially since galvanic corrosion can be far more complex on assemblies than on simple coupons) would be good to consider.

Reviewer 2

The approaches are appropriate in terms of process and part design, fabrication, and validation. The in-depth analysis was not given in this presentation probably due to limited time.

Reviewer 3

Considering its infancy as a demonstrated technology, there is room for further growth before eventually being in the commercial manufacturing process.

Reviewer 4

Project barriers were highlighted as cost and mass savings, but these are the motivation and should not be construed as the technical barriers. This project is really a process development project, and as such the technical barrier is to increase the Manufacturing Readiness Levels (MRL).

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This project demonstrated that variable frequency arc welding (VFAW) can successfully weld stamping grade Al and steel pair in Al thickness relevant to sub-frame structures.

Reviewer 2

The reviewer said technical accomplishments are substantial and support the overall project approach very well.

Reviewer 3

The project has met the goal and achieved all the milestones.

Reviewer 4

The project worked to achieve quality welds for a given stack-up with no investigation of process robustness, i.e., process variables such as off-angle, variable sheet metal, or coating thickness, etc. However, the intended MRL was not indicated. It is unclear about the quality of welds on the subframe to meet the product performance requirements.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

It appears that the collaboration was well coordinated between partners. The reviewer was pleased to see a machine builder and targeted end user included as partners.

Reviewer 2

The collaboration and coordination across the team are good.

Reviewer 3

The project team consists of Ohio State University (OSU), Pacific Northwest National Lab (PNNL), Magna, Cold Water Machine Company, Ashland, and Arconic. However, the role of each team member was not clear.

Reviewer 4

The project benefits from great collaboration and cooperation among a group of participants with complementary areas of expertise. It was unclear about Ashland/Bostik team role in the project since there was no mention of their work in the presentation.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked the challenges and barriers are well identified. OSU is the expert in the research of VFAW.

Reviewer 2

The reviewer said remaining challenges and barriers have been clearly identified.

Reviewer 3

The project has ended.

Reviewer 4

The project has ended and so there is no future work plan.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

DOE is interested in GHG emission reductions. Application of lightweight materials supports this goal. In order to actualize application of the right material in the right form in the right application, it is imperative to achieve dissimilar material joints which this project supports.

Reviewer 2

Joining of dissimilar materials is a critical area in advanced manufacturing for DOE to reduce the structural weight and improve component performance and energy efficiency.

Reviewer 3

The project is focused on developing joining technology to enable increased use of Al in vehicles currently produced primarily of steel. The estimated cost ($14/kg saved) reported for Design 2 exceeds VTO objectives. It is likely that with fewer VFAW welds and greater weight reduction, the cost for Design 1 would be considerably lower and likely well below the VTO objectives.

Reviewer 4

The project is very well-aligned with the VTO objectives.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The project team did not achieve their intended milestone of Design and Build of a robotic welding system due to delays related to trouble shooting and coronavirus disease of 2019 (COVID). The milestone could have been accomplished if additional qualified were available under the COVID situation.

Reviewer 2

The team has sufficient recourses including hardware and software to deliver the milestones on time.

Reviewer 3

Resources are well planned and utilized throughout the project, with the possible exception of Ashland/Bostwick whose work was not presented.

Reviewer 4

The project has the appropriate resources to execute the project.

Presentation Number: mat146
Presentation Title: Ultra-Lightweight, Ductile Carbon-Fiber Reinforced Composites
Principal Investigator: Seokpum Kim, Oak Ridge National Laboratory

Presenter

Seokpum Kim, ORNL

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

67% of reviewers felt that the project was relevant to current DOE objectives, 33% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

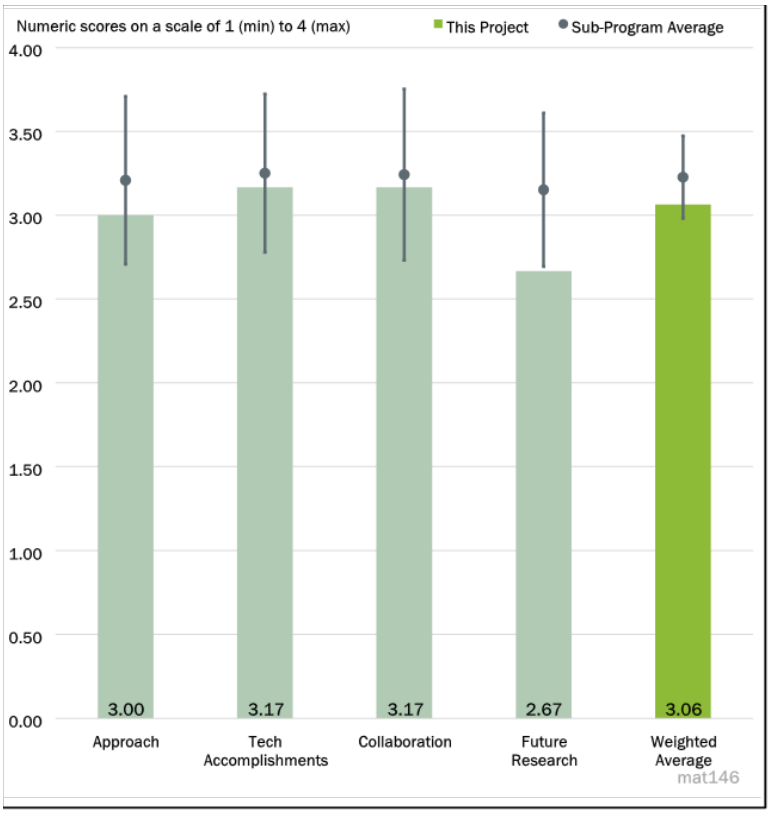

Figure 5-2 - Presentation Number: mat146 Presentation Title: Ultra-Lightweight, Ductile Carbon-Fiber Reinforced Composites Principal Investigator: Seokpum Kim, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project has addressed the need for lightweight, high mechanical performance materials through development of serially photo-printed engineered structures. The barriers of production speed and resolution versus part size, defined within the project, have been addressed through optimized scanning, development of new fixtures, etc. The industry and DOE barriers of material cost and part production time are not meaningfully addressed in this project. An extremely lightweight part that takes hours to print and is made of expensive photo-curing resin demonstrates scientific proof of principle but does not contribute to near- or medium-term reduction in fuel use or carbon dioxide emissions in the U.S. transportation sector. The technology is too expensive to be implemented at a scale that will reduce emission goals.

Reviewer 2

The team is addressing the challenge by considering a variety of aspects including materials, design, and equipment. Consideration of specific project goals with measurable metrics (e.g., percentage improvement of mechanical properties) has been encouraged.

Reviewer 3

The team has made good progress on a complex system for both the additive manufacturing (AM) system development and slicing, and the materials development into an extrudable ultraviolet (UV) curing system. The technical barriers have continued to advance as the team works to improve fiber alignment and feature

resolution. It was difficult to determine whether the project was an AM technology development project or a materials development project as the overall objective states "Create hybrid hierarchical materials that are ultralight, strong and tough for 3-D printing." However, the summary slide does mention AM in "Target: Develop an AM technology for hybrid hierarchical carbon fiber (CF)-reinforced materials that are ultralight, strong and tough for 3D printing." This statement was more in line with what was presented, and progress was made on both the AM system and the materials. An understanding of the fiber length effect in relation to feature size to determine the limitations of fiber lengths and expected orientations would be useful. Continuation of processing parameter development for fiber orientation is planned. Fiber aspect ratios relative to feature size being printed need to be also considered.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

There has been great technical progress in both the development of a larger AM system and in materials processing. The move to extrusion based cured system to improve fiber alignment showed significant progress. New plate like features added new dimension to the properties of the structure. The multi material plate structure was a significant new advancement providing excellent dampening features to the improved absorbed energy.

Reviewer 2

The team demonstrated good mechanical property and printing rate improvements. The project seems to be on track.

Reviewer 3

Print speed and resolution vs. part size have been improved through technical progress. Attempts were made to consider fiber loading and alignment, but degree of alignment was not quantified and only considered qualitatively. A key past reviewer had commented on the need for a comparison of this part technology performance with performance of alternative technologies. Performance comparisons including print area, resolution, stiffness, and strain of this work seem to be made relative to other photo-based AM technologies. A meaningful comparison of production time, cost, and performance of the project technology would be versus materials and production methods currently used in U.S. vehicle production such as injection molding, compression molding, vacuum assisted resin transfer molding (VARTM), sheet molding compound, and bulk molding compound. Comparison of a laboratory technique to a laboratory technique does not inform how it compares to the state of the auto industry.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer praised the good collaboration and coordination between Oak Ridge National Laboratory (ORNL) and University of California at Los Angeles (UCLA). An inquiry was made about the collaboration with Tier1 suppliers or original equipment manufacturer (OEMs) including any OEM interest in implementing the outcome of this project.

Reviewer 2

The team collaboration is clearer this year as the presentation clearly identified the responsibilities of each team. The team was working together to develop the AM system and the materials structure research. The

integration of the two team roles is important to make the system work and the requirements of the material performance in the new system design.

Reviewer 3

The team has the right technical expertise. The reviewer suggested including a user of the technology at least as a consultant in the team.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer suggested achieving localized fiber alignment for optimizing part design. Product demonstration of a full-size auto part (bumper) is interesting to connect the technology to the real need, but it may be infeasible for the bumper that may take 200 hours to print. The designed part demonstrates scientific proof of concept with the incorporation of sensing, but it is unclear how it will reduce material costs and decrease required production time for an adequate mechanical performance lightweight vehicle material.

Reviewer 2

The reviewer suggested a better understanding of the cost structure to determine the right applications.

Reviewer 3

The first two bullets on the future research slide are well aligned and are appropriate for further developing the research. However, the last bullet seems to be out of scope from the stated target of creating a hybrid hierarchical material that are ultralight, strong and tough for 3-D printing. The printing and testing of self-sensing structure do not appear to be part of the project scope based on the slides and the presentation discussion. The project should focus on the first two bullets in their future research slides and not dilute the project with out-of-scope elements.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said the project is related to vehicle light-weighting and sustainability.

Reviewer 2

The project is working on the development of lightweight and energy absorbing structures. The structures are complex and would be difficult to mold in traditional systems. The project has demonstrated both energy absorbing and sound dampening. This is inline the Materials program in lightweighting vehicles.

Reviewer 3

This project addresses neither of two major polymer composites goals, i.e., low-cost materials and high throughput manufacturing.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The team has done excellent work and have significant progress in meeting and exceeding their milestones. The work completed was also during more challenging times with COVID.

Reviewer 2

The throughput (printing speed) of the project has doubled in the last year. This is impressive, but it means that perhaps the part that took 50 hours to print can now be printed in 25 hours. There are not sufficient Available timeframe and funding in the project is insufficient to achieve industry and DOE-targeted part production rate of within a few minutes per part.

Reviewer 3

Project has sufficient support.

Presentation Number: mat149
Presentation Title: Shear Assisted Processing and Extrusion (ShAPE) of Lightweight Alloys for Automotive Components
Principal Investigator: Scott Whalen, Pacific Northwest National Laboratory

Presenter

Scott Whalen, PNNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

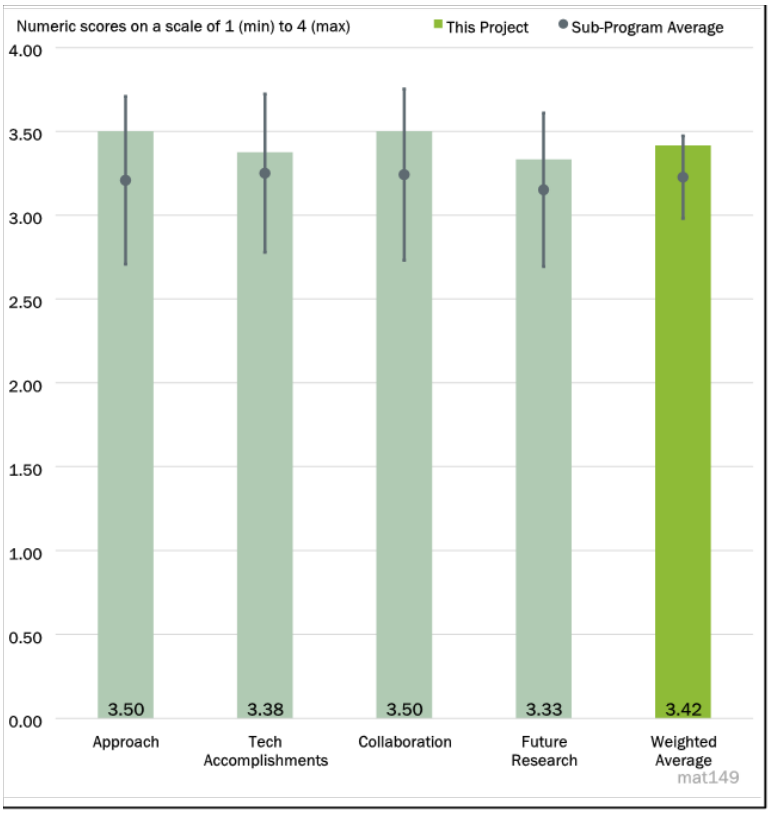

Figure 5-3 - Presentation Number: mat149 Presentation Title: Shear Assisted Processing and Extrusion (ShAPE) of Lightweight Alloys for Automotive Components Principal Investigator: Scott Whalen, Pacific Northwest National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project appears to have established strong parameters and settings to achieve good results for the 100% Al scrap aspect of the project. Porthole dies were demonstrated with no discernable seams that met production speeds as well as ASTM standard material properties in industrial heat treatments. The study on Mg (ZK60) did indicate the process could improve effects of texture but not at the required production speeds, thereby contributed to only good empirical data. This project has successfully demonstrated the goals and appears to be able to complete on time.

Reviewer 2

The reviewer noted this is the last year of this project. The project has achieved its objectives.

Reviewer 3

The work on using Al chips to make extrusions has both technical and environmental benefits. However, the technical barrier to Mg alloy ZK60 has not been addressed.

Reviewer 4

The reviewer said the four-year project is well executed as all aspects of Al extrusion were evaluated. The project evaluated simple and complex shapes, and virgin and recycled material. However, more efforts to evaluate the process for Mg could have been useful.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The project demonstrated the initial capability of using the Shear Assisted Processing and Extrusion (ShAPE™) process for 100% Al scrap. These results demonstrated sufficient promise that their commercial partner is pursuing the ability to take to production, and thereby the success of the project technical goals was achieved. The question of the application of this process for improvements of mechanical characteristics of ZK60 was also answered, but not at industrial speeds. The project also delivered a set of extrusion limits for ZK60 under this process, the data that can be used in a future study, if needed.

Reviewer 2

The progress on Al extrusions is impressive, but the same cannot be commented on Mg work.

Reviewer 3

The ability of the Shear Extrusion process to extrude Al and Mg tubes was evaluated. The project showed that Al alloy can be extruded well, even though at lower speeds than direct extrusion process. One advantage is that the ability to extrude solid briquettes consists of Al scarp rather than virgin material. This is beneficial to reduce energy footprint as well recyclability. The problem of texture as the major reason for not continuing the research on that material is also there in conventional extrusion process. The direct or hydrostatic extrusion process could have been tested to reduce the texture issue. More research on Mg in future may reveal usefulness of this process.

Reviewer 4

The milestones were met, and potential for commercial application with environmental gain was demonstrated for the Al alloy. No significant improvements for Mg-alloy were demonstrated.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The technical team clearly utilized industry input in determination of feasibility of this process for industrialization in their metrics.

Reviewer 3

The excellent collaboration between the partners was demonstrated as Magna had obtained license to commercially operate this process for automotive applications.

Reviewer 3

The support from industry is strong. The reviewer suggested some support from universities, especially in Mg alloys.

Reviewer 4

The contributions from the lab and industry were clear with effective synergy.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The effects of other alloys and contaminants in the recycling stream is recommended as a necessary next step towards the expansion of work. The focus on optimization of the briquettes is also important. It is a good decision in winding down any further project focus on Mg.

Reviewer 2

The proposed work for the remainder of the fiscal year is clear and very likely to achieve it within the time left.

Reviewer 3

The project is almost completed. I personally believe there is more work can be done on Mg alloys, perhaps with support from universities with strong expertise in Mg alloys.

Reviewer 4

No new work is proposed as it the last project year. A new project could be initiated to further explore the process for Mg.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This technology can serve as an enabler for utilizing secondary Al scrap in wrought applications.

Reviewer 2

The project is supporting the vehicle lightweighting goal.

Reviewer 3

The major impact of this project is the reduction in the energy and carbon footprints of manufacturing process by using the recycled material. Using low-cost lightweight material will enhance the use of Al in automobiles which can result in reduced weight and improved energy efficiency, thereby will contribute to the objectives of DOE.

Reviewer 4

The project goals support the VTO program goals. It demonstrated sustainability in extrusion technology.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The project only has a few more months to go and there appears to be sufficient resources to complete.

Reviewer 2

No request for additional resources was made at the end of project.

Reviewer 3

Resources are sufficient for completion.

Reviewer 4

The reviewer had no comments.

Presentation Number: mat151
Presentation Title: Phase-Field Modeling of Corrosion for Design of Next-Generation Magnesium-Aluminum Vehicle Joints
Principal Investigator: Adam Powell, Worcester Polytechnic Institute

Presenter

Adam Powell, Worcester Polytechnic Institute

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

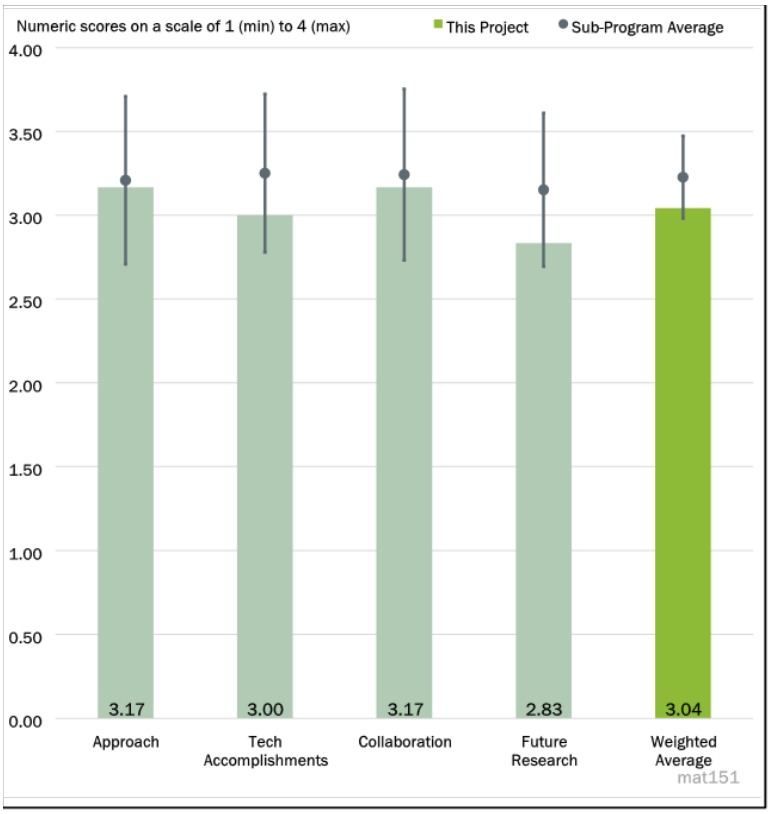

Figure 5-4 - Presentation Number: mat151 Presentation Title: Phase-Field Modeling of Corrosion for Design of Next-Generation Magnesium-Aluminum Vehicle Joints Principal Investigator: Adam Powell, Worcester Polytechnic Institute

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project team has accomplished a lot to further understanding of this joint type in spite the ambitious project scope. The project is well focused on the critical barriers. The combination of modeling and experimental work is providing a holistic approach.

Reviewer 2

It may be advantageous to extend the corrosion cycle out beyond the normal 8 weeks duration in order to introduce significant corrosion which can then be used for correlation. A plan to include charge transfer resistance is in place to address this issue of the higher simulated oxidation rates than the experimental values. The Mg corrodes by pitting and the modeling is based on this though the location of pit initiation sites is done manually. It was recommended to be able to predict the sites of pitting as part of the corrosion model.

Reviewer 3

The work was very clear and executed carefully. The research area is somewhat unconventional as it seems noncommittal between fundamental and applied work. The work could have more overall impact if a side were chosen.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

Excellent progress has been made. Potentially some further work could be done on understanding the role of microstructure in joint failure.

Reviewer 2

The team has made good progress in the technical challenges given the limitations of COVID. The team is cognizant of the remaining key challenges and have a plan in place to reach their goals.

Reviewer 3

This project shows that considerable and very good work is being done.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The project leverages the strength of each partner: PNNL for the friction stir welding (FSW), ORNL for the microscopy, and Worcester Polytechnic Institute for the Phase Field modeling.

Reviewer 2

Collaborators appear to be well coordinated in this project.

Reviewer 3

There is clearly good teaming. It is unclear about the auto industry engagement at this point with one of the team members moved to PNNL More connections for the industry applications would be valuable.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The team recognizes the remaining technical challenge (i.e., integrating the charge transfer resistance to the electrochemistry model) and thereby is focused on developing this in the remaining time in the project. In addition, coupling the mechanical performance to the electrochemistry model is planned.

Reviewer 2

The project plan forward seems appropriate as it is nearing end.

Reviewer 3

In the final months of the project, the team will be completing their modeling of corrosion/fracture in the FSW joints. It would be good to see a future work plan that indicates a more explicit path forward to fully integrate the various characterization tests and findings—for example, the work involved in understanding fracture in the context of grain size and micro- and nano-hardness maps. In the case of the micro- and nano-hardness data, it appears that some promising and interesting experimental work was done, but this is not yet being fully leveraged in models and it is not clear how this will be leveraged. Future work plans also do not explicitly include study of grain size effects despite this being a suggestion from reviewers in the last 2 years of reviews. The reviewer suggested that the project team will continue to consider these important aspects as they complete their project and final report.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

Application of lightweight materials supports the goal of DOE interest in GHG emission reductions. It is imperative to achieve dissimilar material joints to materialize application of the right material in the right form in the right applications. The impact of corrosion on mechanical performance is necessary for the implementation of dissimilar material joints.

Reviewer 2

Corrosion of ultra-light materials is clearly important for future vehicles and in scope for DOE.

Reviewer 3

The project is well aligned with DOE objectives in multi-material joining and corrosion mitigation.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The project was well resourced for the friction stir welding portion although the bulk of the challenging work remains in the modeling portion. Additional resources could be used here to achieve the final metric in the allotted time.

Reviewer 2

This project is sufficiently supported for the objectives.

Reviewer 3

Resources are sufficient.

Presentation Number: mat152
Presentation Title: A Hybrid Physics-Based, Data-Driven Approach to Model Damage Accumulation in Corrosion of Polymeric Adhesives
Principal Investigator: Roozbeh Dargazany, Michigan State University

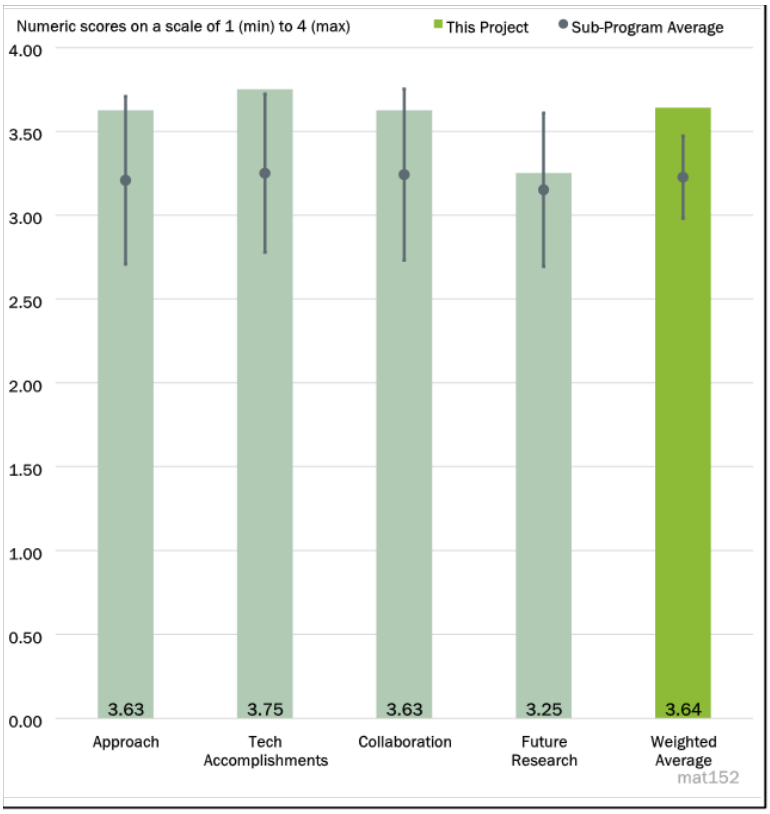

Figure 5-5 - Presentation Number: mat152 Presentation Title: A Hybrid Physics-Based, Data-Driven Approach to Model Damage Accumulation in Corrosion of Polymeric Adhesives Principal Investigator: Roozbeh Dargazany, Michigan State University

Presenter

Roozbeh Dargazany, Michigan State University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The approach for addressing primary technical barriers is well designed because it includes the individual damage mechanisms of deformation, vibration, and oxidation due to thermal, UV, hydrolysis, and combinations of these mechanisms. The approach follows a logical path for derivation of individual models, validation of those models, and training/fitting of a neural network engine. The timeline for accomplishing the work is timely and appropriately designed to accomplish the stated goals of the project. The approach also involves the project partners (Bosch and Endurica, LLC) at the appropriate levels within the project schedule to be effective in achieving the desired outcome of the research. There has been the lack of constitutive models to predict the effects of corrosion and accurate predictive modeling tools for addressing barriers. A significant challenge to the approach is obtaining the necessary test data for validating the test protocols to obtain data that will provide the desired prediction error of less than 10%. This will probably be improved using the data to be obtained in the last year of the project.

Reviewer 2

This program has a clear focus on the important problem of the aging of polymers. It is physically based and developed useful neural net approaches and reduced-order models. The publication history shows that this program is productive and aligned with contemporary science.

Reviewer 3

The project approach appears to be a logical approach to meet the stated goals of developing a theoretical model to describe damage accumulation with respect to deformation, vibration, hydrolysis, thermo-oxidation, and photo-oxidation as well as developing software to predict failure of cross-linked polymeric adhesives with respect to damage caused by environmental and mechanical loads.

Reviewer 4

The current project approach appears to be working, but it is hard for the reviewer to understand and follow. It is difficult to identify the 'physics' component of machine learning (ML) as it appears rather conventional analytical modeling to the reviewer. It is also unclear how the properties of unknown compounds will be predicted from the artificial intelligence (AI) surrogate model, which is outside of the boundary condition.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The technical accomplishments for the modeling have been outstanding. A sound, fundamental scientific approach was used for individual models and the achievement reported for the thermo-mechanical model for failure prediction to be the first ever validated model that covers permanent set and relaxation. The theoretical equations used for the models to predict a combination of effects (thermal, UV, and mechanical) were very effective for prediction this type of failure mode as observed by the data used to validate the models. The model for the effects of hydrolysis on joining materials such as silicone and polyurethane compared very well with the experimental data presented. Aging effects for these materials were well predicted by the models developed. The results for the ML training were very good at lower temperatures (60°) but seem to deviate significantly at the higher temperature (95°). More iterations may be necessary to get better results at the higher temperatures. For the three 3 that work has been performed, the progress has been very good, and the modeling appears successful to date.

Reviewer 2

Collaborations and publications highlight strongly to the impressive accomplishments of this program.

Reviewer 3

All of the work reported in the presentation appears to have been successful in meeting the stated project goals. The project is 90% complete and all of the milestones but one has been completed.

Reviewer 4

The project has made a good progress of the original proposed schedule/milestones.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The mix of performers is excellent for this type of research (materials modeling). Project partners included academia, a Tier 1 producer, a lightweighting consultant, a testing company, a research center, and a separate material modeling group. The project collaboration could only be improved if the project team included an

automotive OEM who would be exposed to the benefits of the models being developed. The organizational diagram on Slide 20 illustrates an effective, coordinated effort, and details of the coordination and collaboration are evident in the slides on the technical accomplishments.

Reviewer 2

There is a clear collaboration of many partners, and their contributions are clear.

Reviewer 3

The project includes a good selection of partners with complementary areas of expertise to conduct research, produce software modules, and to implement the models in adhesive joint design.

Reviewer 4

The project team consists of university and industry partners, which shows a good collaboration.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

Program is nearing end, but on good path.

Reviewer 2

The proposed future work appears to be a logical and complementary continuation of the completed work.

Reviewer 3

The proposed future research is good and appropriate.

Reviewer 4

The proposed future research only addressed what would be done in the remainder of the project; primarily studying degradation mechanisms of the bulk adhesive to other material substrates. It should also include any proposed research beyond the current project efforts. This was also stated on the response to previous year review comments slide. Follow-on future research could also include expanding to other adhesives used by automotive manufacturers.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project is relevant to supporting overall VTO subprogram objectives as stated on Slide 2 and referenced with the Light Duty Workshop Final Report and U.S. DRIVE Materials Technical Team (MTT) Roadmap, Section 5.1 which addresses the use of mixed material systems for lightweighting solutions, and Section 6 for high-priority research needs for modeling and response prediction of composite materials and accurate predictive tools for multi-material systems.

Reviewer 2

The project addresses clear topic of central interest.

Reviewer 3

The project addresses lack of reliable joining technology for dissimilar materials as well as cost-effective tests for adhesive corrosion by creating a constitutive model for predicting corrosion and damage accumulation of adhesive joints. It facilitates use of lightweight materials for vehicle mass reduction by helping to accelerate design of composite joints in vehicle structures and reducing time/cost for testing corrosion failure.

Reviewer 4

The research project supports the overall VTO objectives.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The project funding is around $1.5 million with a 33% cost share by the non-government companies. This is sufficient funding for the three primary performers, i.e., Mississippi State University (MSU), Bosch, and Endurica LLC with minimum support and consulting from the other collaborators.

Reviewer 2

Good level of support has been provided to the project.

Reviewer 3

The project is 90% complete and appears to be on budget and meeting all of its previously defined goals.

Reviewer 4

The overall DOE funding level is a bit excessive for a university to perform only theoretical tasks.

Presentation Number: mat159
Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion: Fundamental Fatigue and Creep in Advanced Lightweight Alloys
Principal Investigator: Amit Shyam, Oak Ridge National Laboratory

Presenter

Amit Shyam, Oak Ridge National Laboratory

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

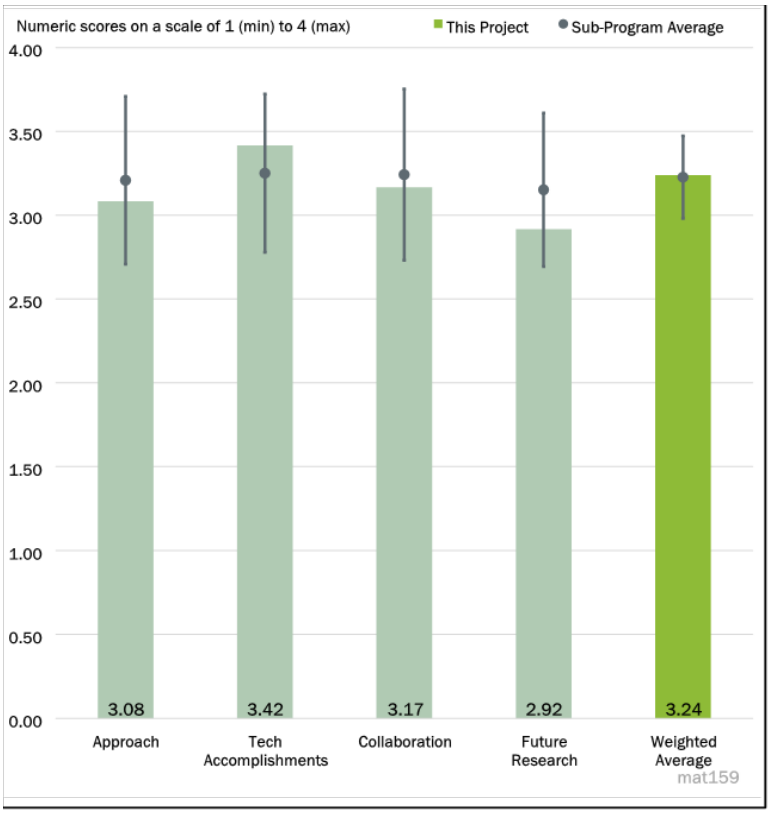

Figure 5-6 - Presentation Number: mat159 Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion: Fundamental Fatigue and Creep in Advanced Lightweight Alloys Principal Investigator: Amit Shyam, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project tasks are well designed to obtain fatigue and creep performance of selected alloys. The collaboration with Northwestern University team to bring in expert on creep behavior benefit the project significantly.

Reviewer 2

The project appears to be well designed. One of the central themes in the project title is "cost effective," which is consistent with VTO's goals. As no cost analyses components are called out in the task list, it needs to be called out instead of it may be buried in the task list as a subtask. A better understanding by the PIs of the likely operating conditions/temperature range of the component(s) being fabricated based on engineers in auto companies would be useful. This will prove invaluable in helping the PIs gauge whether their alloys will operate effectively as brake rotors or other components of interest after deployment in the field.

Reviewer 3

A literature search by the investigators on the past research and implementation in this space to understand past challenges to widespread adoption of Al brake materials would be useful. An understand of differences

between internal combustion engine (ICE) and BEV vehicles will enable the use of Al brakes in electric vehicles (EVs) that previously did not meet all necessary attributes.

Reviewer 4

It appears that there has not been much of a change in the work, even though the application has completely changed. Brake rotors and conductors have very different conditions than the previous work. As modern materials design approaches tailor the material to the application, which cannot be applied without spending time on the understanding of its applications. Starting with alloys from the past work makes sense, but more time needs to be spent right from the start to understand the new performance requirements.

Reviewer 5

The project timeline appears appropriate unless brake validation is required. The exact requirements for the brake application are not mentioned. The author should get specific requirements from the automotive OEMs to confirm that the limiting requirements are indeed fatigue and creep. This should then be related to the maximum sample testing temperature and duration. The function of thermal conductivity and yield strength is important and needs to be captured since changing alloy can have an influence on them. Good physical metallurgy research is being undertaken but connection to product requirements could be strengthened.

Reviewer 6

The microstructural evaluations are very supportive of the results being presented. More specific project definitions (with specific regard to application-based needs and constraints) would be extremely valuable in providing a more suitable vantage point for critical review.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

Great progress has been made so far. Additional results on particle stability, as the intermetallic population is resistant to elevated temperature evolution including theta particles would be desirable. These kinetic responses may become a concern depending on the expected operating temperatures.

Reviewer 2

The project team carried out detail microstructure characterization and correlate the observation with the performance (creep and fatigue). The quality of the work is high.

Reviewer 3

The technical progress of work has been good and appears to be in line with the planned work. Major schedule delays are not apparent.

Reviewer 4

The results reported were limited as compared to the amount of work which was cited to have been completed.

Reviewer 5

The authors demonstrate excellent microscopy and understanding of the mechanisms.

Reviewer 6

The technical work on fatigue and creep is valuable and interesting. However, it does not clearly address the new applications. This project has struggled to pivot to the new applications.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that some outside involvement was identified, such as mechanical testing done elsewhere. Leveraging Advanced Manufacturing Office (AMO) funding is also a reflection on the project management efforts and involving highly regarded manufacturing demonstration facility (MDF) research & development (R&D) capabilities.

Reviewer 2

The reviewer said the project team consists of multiple national laboratories and top-notch universities which brings in external experts to the project.

Reviewer 3

Northwestern is an excellent partner. It is imperative that the project needs to include a brake OEM, even at this stage of the project as a "no-cost" partner. Brakes are a highly engineered system, and the applications is not trivial.

Reviewer 4

Listed partners listed include PNNL and Northwestern University Prof. David Dunard. PNNL is the only organization listed in the Task table on Slide 3 and the role of Argonne National Laboratory (ANL) as an external partner is unclear without any mention of it on this slide or in the chart on Slide 18, in spite of its logo appears on Slide 2. Similarly, the role of Prof. Dunard is unclear. ORNL seems to be doing the bulk of the work, from the budget table presented on Slide 3. It would be helpful to have a better understanding of the collaboration synergies in the future.

Reviewer 5

Collaborations were clearly discussed and seem reasonable.

Reviewer 6

More industrial collaboration/benchmarking is needed to help target this research.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The work plan will likely achieve targets.

Reviewer 2

The reviewer said the future research addresses the appropriate areas but needs to be clearly defined in terms of ultimate targets. The research is appropriate from a fundamental materials science standpoint, but would benefit from specific ties application-based targets.

Reviewer 3

The proposed work is fine.

Reviewer 4

The tasks proposed seem to be all related to property characterization and mechanism study. It is not clear how the project team is going to address the barrier "property requirements for specific EV applications" which remains to be clearly defined.

Reviewer 5

The future research plan indicated its contribution towards achieving the overall project goals. The plan may consider the following issues: cost analyses of the material(s)/component(s); increased effort on the understanding of the operating ranges of the target components for the alloys being developed (this information might precipitate an adjustment of the temperature at which creep testing is conducted); corrosion testing mentioned in the task list, but not highlighted in the future work; and no mention of measurements or improvements in electric property data for the materials being developed.

Reviewer 6

The reviewer suggested the authors consider other requirements after understanding the brake system. Information on brakes from the literature could be used if unavailable from OEMs. Al brakes have been studied in the past.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said this project is a good program. The line between lightweighting and EV range seems reasonably obvious, but a quantification of targets based on specific criteria for brake rotor systems is not clear. Creep and fatigue resistance are certainly a starting point.

Reviewer 2

The project clearly supports the DOE goal for materials.

Reviewer 3

This work contributes to advances in EV component development.

Reviewer 4

The project is targeted at lightweight for EVs.

Reviewer 5

The project supports the lightweighting goal as brakes are a very heavy vehicle sub-system.

Reviewer 6

The new application for EVs is highly relevant to the subprogram objectives.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

Team is well suited to performing the work proposed at an advanced level. The funding is moderate but well positioned within the propulsion materials thrust area.

Reviewer 2

The resources are sufficient to carry out the tasks proposed.

Reviewer 3

The resources appear sufficient.

Reviewer 4

Resources were sufficient for the tasks outlined.

Reviewer 4

Resources available to the project were not discussed.

Reviewer 4

Resources were sufficient but more focus is needed to align with and understand the needs of brakes for the EV drive cycle.

Presentation Number: mat160
Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion: Hybrid Dispersion Strengthened AL Matrix Composites for Higher Efficiency Electric Vehicle (EV) Powertrains
Principal Investigator: Mert Efe, Pacific Northwest National Laboratory

Presenter

Mert Efe, PNNL

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

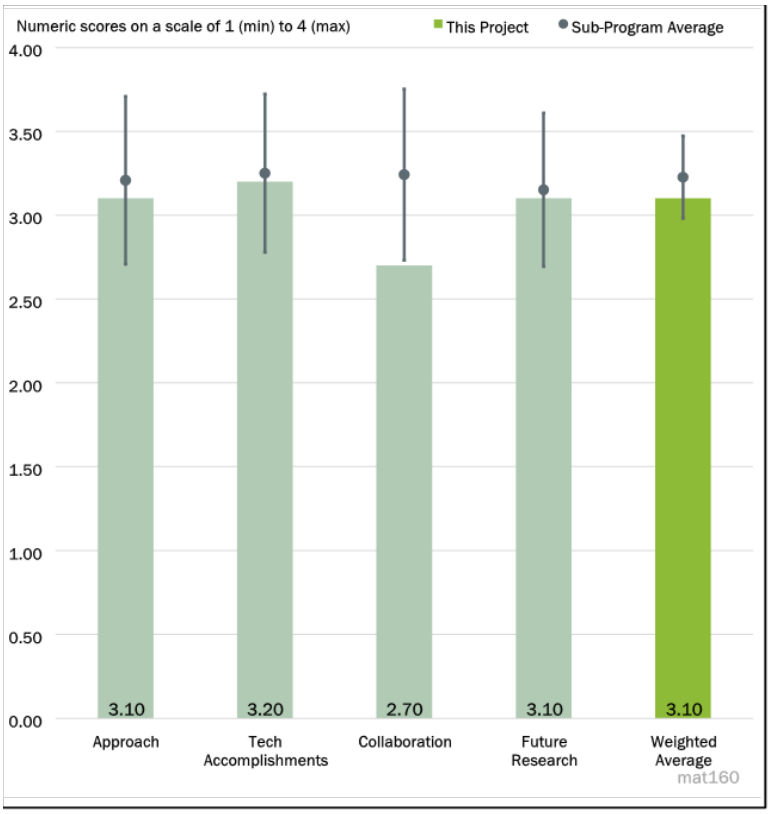

Figure 5-7 - Presentation Number: mat160 Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion: Hybrid Dispersion Strengthened AL Matrix Composites for Higher Efficiency Electric Vehicle (EV) Powertrains Principal Investigator: Mert Efe, Pacific Northwest National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

Overall, the in-situ reaction interesting approach looks good and has a lot of potential. A lot of time was spent on the understanding of demand applications, but this may have been excessive.

Reviewer 2

The use of Al metal matrix composites (MMCs) for gears is very exciting and has direct relevance in EV development. A lot of focus is on technologies already deployed such as Al rotors. Additional funding would offer many options to designers as they look to decrease spinning mass, which has an increased effect on range over normal vehicle loads.

Reviewer 3

Brake rotor application typical operating targets is benchmarked and the Al MMCs appear to show a reasonable match for the application. Strength targets for Al gears are 2-3x below current carburized steel levels and a breakthrough in strength appears necessary to make Al gears viable.

Reviewer 4

The reviewer encouraged the authors to list all the key requirements for brakes and gears and state why their material potentially addresses these requirements. Collaboration with component suppliers should be considered important (addressed later under collaboration).

Reviewer 5

The project is in early stages and the technical barriers are yet to be overcome. Some of the barriers include formation of titanium diboride (TiB_2) particles by in-situ reactions, distribution of particles of specific size ranges at various location of the parts, absence or close to no porosity, matrix softening, and mechanical performance, etc. The challenges are quite daunting for a two-year project.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The novel work in gears is stellar, and the opportunity to create TiB_2 in-situ is very interesting. Development of an isotherm associated with the TiB_2 formation that could be monitored during solidification as a quality control was suggested. Stir casting is interesting, but this process has never been successfully commercialized after a lot of research over many years. It would be great if this project could overcome that barrier that would spin-off a lot of recent opportunities for the technology.

Reviewer 2

Matrix alloy, processing method, mold designed to minimize porosity, A356 solidification, and wear rate experiments completed demonstrate test method viability. 7075 test samples made show various levels of mixing and some opportunity areas.

Reviewer 3

In the first three months after the project start in October 2021, the stir caster was shown to perform adequately with a 356 alloy. Although the scope of the work is to use in situ reactions to introduce TiB_2 in the composites, the reported results appear to be on the composite where TiB_2 particles were incorporated in the alloy 356 using a friction stir process.

Reviewer 4

Progress seems reasonable and processing approaches are innovative. The reviewer suggested characterization of any residual fluoride content as it may have an impact on the behavior. Fatigue property is likely to be a potential problem and yet to be tested, and so need to be prioritized in the near future for this new project.

Reviewer 5

Only the casting and tribology progress is shown in the presentation. Elevated temperature and bending fatigue testing approach is not shown, even if not done.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

Collaborations expected to be established with ORNL for brake testing and also with industry for stir casting.

Reviewer 2

Good research and having team be in a single location at PNNL makes this easier, and they clearly have capitalized on that.

Reviewer 3

No listed partners outside PNNL are working on this project, but the principal investigator (PI) is reaching out to gear and brake experts in industry. It would be useful for experts be a little more aligned to brake validation requirements and standards currently in place. Benchmarking and designing for typical operating temperature conditions may not suffice for abusive conditions mandated in OEM validation testing.

Reviewer 4

Only ongoing collaboration appears to be with ORNL. There is no collaboration with component manufacturers who have the requirements for the parts as well as testing capability. This is sorely needed to make progress in a component that has evolved and matured over time, particularly for very demanding applications of gears and brakes. Stiffness, for example, is a key requirement for gears and cannot be solved with larger gears as there is no space. The reviewer suggested discussion with the project MAT159.

Reviewer 5

There does not seem to be much ongoing project collaboration. Nothing seems to be currently going on as only a company discussion and development of a collaboration with ORNL is underway.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

Proposed future work seems reasonable.

Reviewer 2

Squeeze casting proposal is nice, should be a logical next step to increase density. The tensile testing of the friction consolidation samples will also help define next steps as it shows the direct influence of that process.

Reviewer 3

While gear applications appear to be a ‘stretch goal’ for the 7075 composite, it is worthwhile to see what else can be done in this space by evaluating other matrix alloys and coating options.

Reviewer 4

The project needs to address the key considerations as it appears too casting focused.

Reviewer 5

Issues related to key items such as controlling the particle distributions, porosity, and matrix softening in braking applications need to be given more thoughts and a detailed technical plan needs to be worked on.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said it is a great work. Lower mass in any rotating components increases acceleration at constant power and decreases losses during deceleration including regeneration. This is a very important space to mine in the work to increase EV range and increase the number of consumers that would be willing to purchase an EV by overcoming range anxiety.

Reviewer 2

Reducing rotating mass of vehicles by using Al brake rotors has good merits for fuel economy/range extension. Similarly reducing mass of gears will provide benefits, but probably less so than the brake rotors due to lower rotating inertia.

Reviewer 3

Lightweighting is a key imperative in this project.

Reviewer 4

Use of MMCs can contribute towards lightweighting of EVs by obviating the use of steel and cast iron parts. This will be beneficial in extending the range for the EVs. Furthermore, lighweighting can also lead to smaller size batteries for the EVs. The project is well aligned with the goals of VTO's Materials Program.

Reviewer 5

The proposed work is very relevant to the program goals for EVs.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

Resources seem to be in line with accomplishments and opportunities.

Reviewer 2

Resources appear to be sufficient.

Reviewer 3

Sufficient resources from PNNL as listed but unclear about the other resources.

Reviewer 4

During the project duration, the team will be looking for external collaboration with industry in the area of squeeze casting.

Reviewer 5

The resources were not evaluated as they were not addressed in the presentation.

Presentation Number: mat164
Presentation Title: Multiscale Development and Validation of the Stainless Steel Alloy Corrosion (SStAC) Tool for High-Temperature Engine Materials
Principal Investigator: Michael Tonks, University of Florida

Presenter

Michael Tonks, University of Florida

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

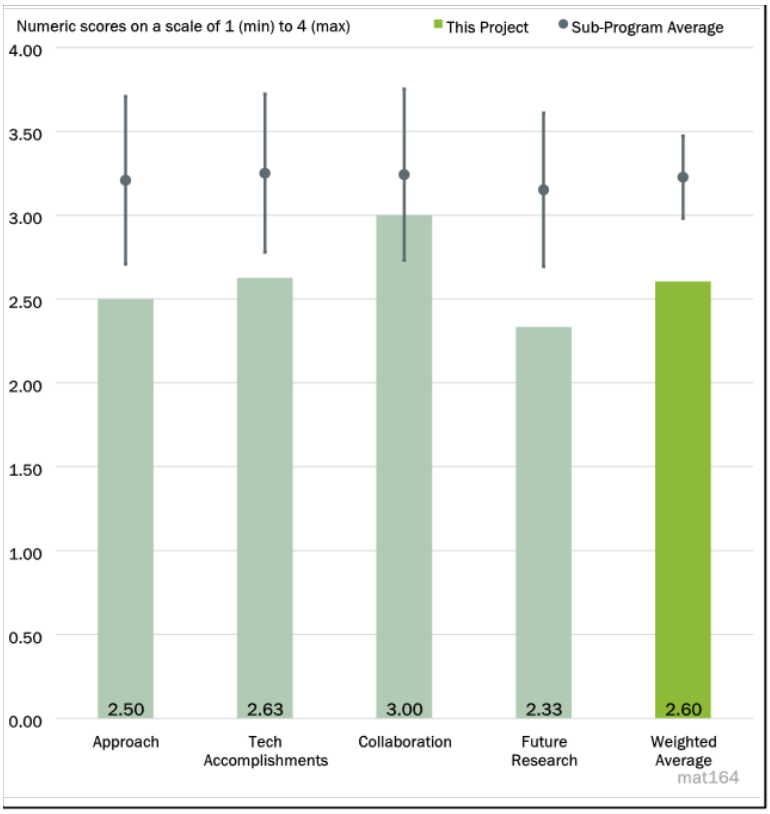

Figure 5-8 - Presentation Number: mat164 Presentation Title: Multiscale Development and Validation of the Stainless Steel Alloy Corrosion (SStAC) Tool for High-Temperature Engine Materials Principal Investigator: Michael Tonks, University of Florida

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The original multi-scale modeling approach was promising. Incorporating phase field modeling with atomic scale simulations with lab experiments is logical. The evaluation of oxygen mobility in varying oxide phases is of value, as is the study of the growth order of the oxides with varying alloy composition and chromium (Cr) and manganese (Mn) depletion in stainless steels.

One of the main objectives of the project to quantify the impact of microstructure and alloy composition on valve steel corrosion, which were valuable and relevant goals. However, at 95% of project completion (4- year effort), the impact of the following key factors is still not incorporated in the presented results: alloy microstructure; water vapor effects (since the combustion environment is being modeled); and engine validation (which has begun). It seems very unlikely that if the first two have not yet been investigated and incorporated at 95% completion of the project, they will not be achieved in the final 5% stage of the effort as those two factors are among the most complex endeavors described. It seems the approach to the proposed work did not adequately prioritize the importance of simulating microstructure and water vapor in prior years. The approach does not account for one of the most essential elements of oxidation behavior of time prediction to oxide spallation at the targeted temperature and atmosphere (water vapor and dry environment). It is oxide spallation that often defines the initiation of accelerated oxidation attack and component degradation in most alloys although the Cr depletion is being modeled.

Reviewer 2

The model appears to be focused on understanding and quantifying the migration barrier for vacancy-based diffusion but unclear what will the tool allow the industry to accomplish. The role of Ni is not captured and how the microstructure of a single austenite phase will be modeled is not clear. It was unclear whether the oxidation layer growth is the key to engine valve performance which has been around for a while else the audience assumes that other factors are not considered. A lot of supplier data on engine valve materials and their behavior should also be available in the open literature. The model should be applied to those materials to demonstrate the robustness of the model. The project does not identify what it is looking for in terms of engine operation: lighter valves, smaller valves, higher temperature valves, or lower cost valves.

Reviewer 3

The project aims to develop Stainless Steel Alloy Corrosion (SStAC) tool to predict corrosion performance of stainless steel at high temperature. The second objective is to "Quantify the impact of microstructure and alloy composition on valve steel corrosion using laboratory and engine experiments and mesoscale modeling and simulation." The project team has developed a tool, but the impact of microstructure and composition are not well addressed. The tasks designed are not enough to address them. The characterization of oxide film shows only scanning electron microscopy (SEM) energy dispersive X-Ray analysis (EDAX) map but lack of phase and thickness information.

Reviewer 4

The current project approach requires too many parameters that are not readily available and thus experimental calibration is needed to perform any simulations. It is understandable that the first-principal type of prediction is not yet available due to the complexity of the field. It appears that the boundary condition of this approach is very narrow, i.e., the specific type of alloy, temperature, and operating conditions.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The project team developed the tool that shows the same trend as the experiment, but it does not match the experimental result quantitatively with the goal of within 10% error. It is probably understandable since the tool has not considered microstructure.

Reviewer 2

The project appears to have successfully predicted oxidation rate and Cr/Mn depletion at one temperature including the model prediction of its depletion for specific alloy compositions. It would be good to see a new model capability that delivered more than prediction of oxide mass gain and Cr/Mn depletion in dry carbon dioxide (CO_2) after 4 years of effort and almost $1.5 million invested.

At 95% of the project completion ($1.5 million over 4 years), the impact of the following key factors remain to be incorporated in the results under review: a) alloy microstructure, b) alloy composition, c) the quantification of the impact of microstructure and alloy composition on valve steel corrosion (main project objective) d) water vapor effects (since the combustion environment is being modeled), and e) engine validation (which seems to have begun). As (a), (b), and (d) factors have not yet been investigated and incorporated at 95% completion of this project, it is unlikely they will be at the final 5% of the effort—as at least two of those factors are among the most complex endeavors described. It is surprising to note that after 4 years of effort, the new oxidation tool predicts only oxidation mass gain and is unable to predict essential outcomes such as: a) time to spallation of the protective oxide layer, preferably at various temperatures, b) time to spallation of the

protective oxide layer at specific temperatures for comparative alloy compositions, and c) the effect(s) of water vapor on oxidation kinetics and time to oxide spallation on various alloy compositions at various temperatures. These are the essential questions necessary to guide alloy design and/or selection for specific applications. The modeling of the valve shown in Slide 12 would require simulation of varying temperatures over the length of the valve, since even peak temperature varies with location and combustion conditions over such exhaust components. On the positive side the model does predict Cr and Mn depletion for specific alloy compositions.

Reviewer 3

The comparison of model data for oxidation in dry CO_2 has been done at the project end, where the effect is minor. The model calculates weight gain, while all the preceding data is thickness. It is difficult to do the translation including curve shape even at the bottom of Figure 6 and compare the two curves.) should use Similar colored symbols for the right and left plots showing oxide character should be in used in Figure 7 (bottom right). Also, the alloy and oxide are reversed between the two figures; alloy and oxide should be in similar Left/Right placement to allow easy comparison. Finally, Figure 13 shows comparison of model and data. It is unclear about the benefits of a 10% error prediction shown in comparison of model and data in Figure 13, especially when the correlation is for dry CO_2 where not much is happening.

Reviewer 4

The amount of work performed within the project is good. However, the direction and the actual work done, particularly for model/simulation tasks, are rather questionable. For example, the discrete Fourier transform (DFT) calculations of activation energy for metal cations in the oxides can be regarded as a very nice fundamental and low-level study, but it is not explained how such information has been used/connected to the different simulations.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

There seems to be good collaboration with University of Wisconsin, Tenneco, and Idaho National Laboratory (INL), although at 95% of project completion stage the macroscale tool development and validation against Tenneco engine testing data are yet to be completed. As the engine testing is in progress has been mentioned during the presentation, so those outcomes can be anticipated. The monthly project meetings are a good strategy. A substantial quantity of essential effort is occurring in the last 5% of the project, so it is very difficult to assess the probability of successful completion of these key activities.

Reviewer 2

The project team consists of national lab, universities, and industry partners. The effort on material characterization has some room for improvements.

Reviewer 3

The reviewer recommended the industrial collaborator to provide a sense check based on years of experience with valve materials. The reviewer questioned whether the observed literature results on the replacement of nickel (Ni) with Mn is similar in actual engine tests.

Reviewer 4

The collaboration and coordination among the project team members look good.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

If there is a follow up project, the reviewer said consider the impact of microstructure, as indicated in the previous review.

Reviewer 2

The amount and relevance of remaining effort reported is remarkable at this 95% project completion stage. The key objectives of the effort such as water vapor as well as microstructure and alloy composition remain to be considered. Tool validation for various alloys and engine conditions remain. The remaining effort described on Slide 16 seems to far exceed the remaining time and budget for the project, but it is possible that significant progress has been made. It is encouraging to note that engine validation has begun.

Reviewer 3

The project shows 95% complete yet the key items of introducing water vapor, alloy composition, and microstructure are yet to be addressed. It is unclear whether all the data has been collected as they were not presented.

Reviewer 4

The effect of microstructural evolution is important; however, it is not clear how it will be incorporated in the future research.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project supports the VTO objectives on Materials.

Reviewer 2

The project is relevant and supports overall VTO objectives.

Reviewer 3

The product benefit of this work relative to the DOE goals such as cleaner engine, etc. need to be stated.

Reviewer 4

The research topic is very well-aligned with the VTO program objectives.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The resources provided were sufficient.

Reviewer 2

The team is well resourced.

Reviewer 3

The resource allocated may neither be able to consider the impact of microstructure and composition nor validate the tool with other alloys.

Reviewer 4

$1.5 million for a 3-year project for an academic institute is a very large award, and the project outcome is only valid for a specific class of alloy at a specific temperature/environment.

Presentation Number: mat174
Presentation Title: Carbon-Fiber Technology Facility (CFTF)
Principal Investigator: Merlin Theodore, Oak Ridge National Laboratory

Presenter

Merlin Theodore, ORNL

Reviewer Sample Size

A total of one reviewer evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

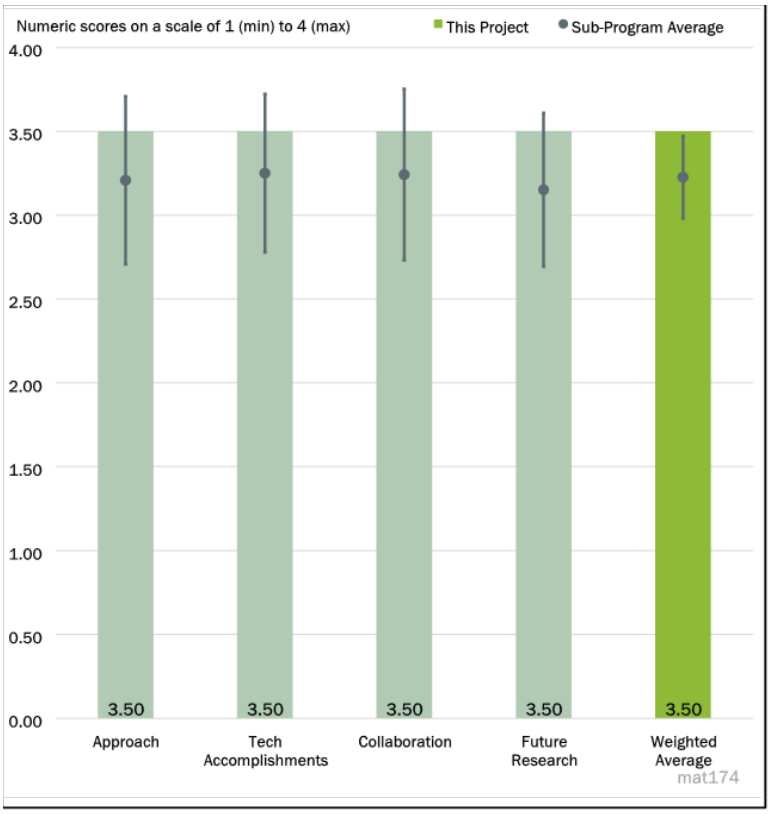

Figure 5-9 - Presentation Number: mat174 Presentation Title: Carbon-Fiber Technology Facility (CFTF) Principal Investigator: Merlin Theodore, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The Carbon Fiber Technology Facility (CFTF) is the only CF R&D facility which is important for critical material scaling. The project is well positioned to address the technical barriers for the material scaling. The project timeline is reasonable, and the project is on track.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The CFTF extends polyacrylonitrile (PAN) precursor to textile PAN, melt blown pitch, and nylon precursors. The project is on track and has met the milestones as planned. The technical challenges have been well identified. The accomplishments on scaling textile PAN, melt blown pitch, and nylon precursors have been demonstrated.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The CFTF is the central facility for the scaling of CFs. It provides a platform for collaboration with academy and industry, and they have been going well.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The future research plan has been well proposed containing reasonable targets with the thoughtful risk mitigation plan. The project is anticipated to achieve its targets.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

Carbon fiber is the critical material to reduce vehicle weight and carbon emissions. Low-cost lightweight CF is anticipated to reduce batteries and extend vehicle range for EVs. The CFTF serves as a bridge for scaling up and technology transfer.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The CFTF is well equipped with state-of-the-art resources and an easier access to the characterization facilities and expertise in ORNL.

Presentation Number: mat195
Presentation Title: Industrialization of Carbon Fiber Composite Wheels for Automobiles and Trucks
Principal Investigator: Brian Knouff, Oak Ridge National Laboratory

Presenter

Brian Knouff, ORNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

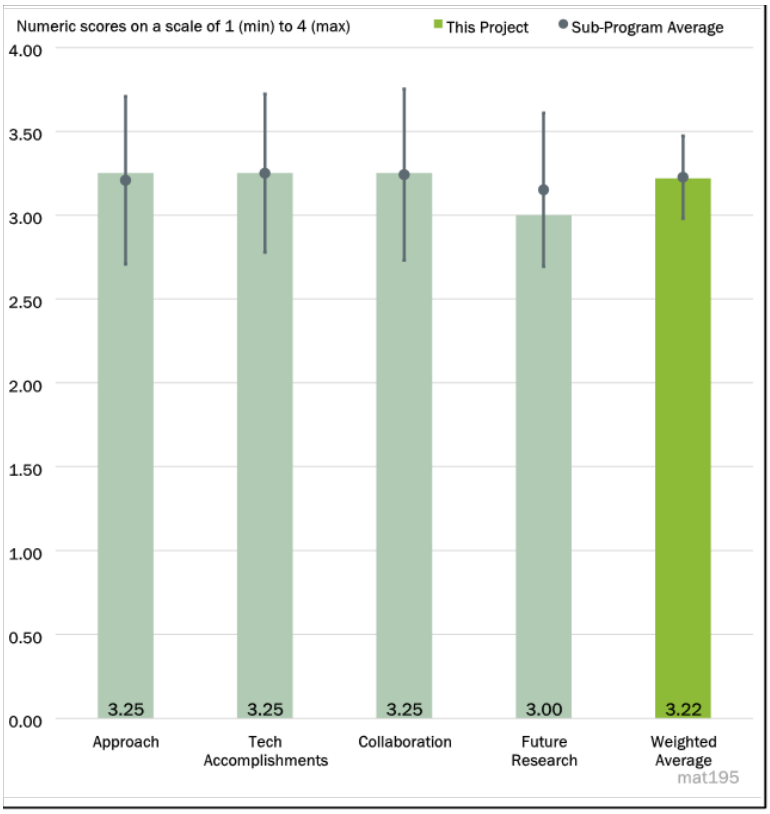

Figure 5-10 - Presentation Number: mat195 Presentation Title: Industrialization of Carbon Fiber Composite Wheels for Automobiles and Trucks Principal Investigator: Brian Knouff, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The effort on the project has been commendable with a focus on the basic material testing and design of wheels. The effort would be complete with the consideration more basic material selection as well as the molding processes.

Reviewer 2

The tailored fiber placement (TFP) and AM technologies are being used to maximize the value of composites. Physical testing of the wheels for the validation of the virtual tools and demonstration on the value of this new development over baseline is yet to be planned.

Reviewer 3

A methodological project approach was used. The team faced many barriers during COVID-19 that impacted their schedule on fabrications that needed to be completed to meet milestones. The team modified their approach and focused more on the modeling aspect that was to be completed in year 2. The team benefited from the change learned from the design approach. Wheels and plaques for testing were then fabricated using the design change. The final goal of weight reduction in wheels using composites with out of autoclave processing has been met by the project.

Reviewer 4

The project goals are clear, and the manufacture of functional prototypes shows strong progress. A cost/performance comparison of other technologies being commercialized would be helpful.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The participants have done commendable work in making progress according to plan despite of the slowdown caused by the pandemic.

Reviewer 2

The main progress has been on coupon testing and how this would facilitate in the baseline wheel design improvements was not discussed. The discussion on details of the completion of the fabrication and testing of new wheels shown on Slide 4 has been unavailable.

Reviewer 3

The team is on the 80% project completion target. The team was able to get back on track of the plan with all the challenges and be a successful project end. The test data presented indicated lots of progress. It is difficult to assess whether the material property tests were exceeded or are 90% of target without any metrics. The remaining environmental tests are yet to be completed.

Reviewer 4

The manufacturing approach is good with functional prototypes being manufactured. There is limited information of the materials being utilized from a fiber and resin perspective.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The two collaborators worked great together with each other relying on their strengths. The success and progress in the project through difficult times were evident by the excellent results presented and the completion of the project to date.

Reviewer 2

There is significant cost share between the partners.

Reviewer 3

The reviewer was pleased with evaluation of the AM tooling. The reviewer encouraged more interactions with the ORNL expertise to lead to the design improvement over baseline wheels by ESE Carbon Company.

Reviewer 4

The work would have been more complete and have more relevance if it included and stated the types of fiber that was (were) used and factors affecting the molding cycle time. A third or a fourth project participant such as a fiber manufacturer or an OEM may have been useful as these factors will affect the cost viability of the product.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

Project has a reasonable plan.

Reviewer 2

This is an extremely relevant work. The understanding of cost versus performance consideration in future work may be important. A deeper dive into the manufacturing process (e.g., TFP and molding) with the use of AI – ML techniques, and use of blended or hybrid fibers driven by an understanding of the stress distributions may be useful to further optimize the product. One of the questions raised on paramount appearance factor for automotive needs to be included into the objectives.

Reviewer 3

The project is nearly complete with environmental and fatigue studies remaining. The last major item to complete is the AM tooling study that would improve the tooling cost by 50%. This would be a significant impact on the wheel costs and achieve the weight savings into vehicles. Designs were also shown on how to improve the thermal management in the tooling.

Reviewer 4

Future research plans could be better stated. It is not clear whether the current materials meet all target mechanical properties and the thermal performance with all testing is being performed at room temperature.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

Development of a lightweight automotive structures is very relevant today to achieve an overall reduction of carbon emissions. The project team should consider the challenges of a difficult composite wheel task. A promising path has been considered but more work will be necessary to take this effort into the mainstream.

Reviewer 2

The reviewer noted that CF wheels provide vehicle lightweighting potential.

Reviewer 3

The project supports the materials program by demonstrating a 40% weight reduction over Al wheels. It also has elements on how to reduce manufacturing cost by demonstrating out of autoclave process over traditional high performance aerospace autoclave processes. Lastly, using AM to further reduce tooling cost by 50% due to complex thermal management channels that are difficult and expensive in machining.

Reviewer 4

The important component of lightweight reduces unsprang mass, rotational inertia, and total wheel weight.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said resources are sufficient.

Reviewer 2

The reviewer remarked the project team has done a wonderful job for this tough task, based on the program on a process, i.e., TFP that came from the textile industry. An excellent demonstration on how one can learn from adjacent technologies in the effort to use continuous fibers effectively for weight reduction. More effort and resources should be directed into this and similar projects. The reviewer suggested additional resources for a

complete understanding and molding process improvements, and then taking the molded wheels through the rigors of OEM evaluations for increasing the worth of this effort.

Reviewer 3

The team achieved all milestones in the project plan. All milestones have been except for one for TFP parametric study, which was removed due to COVID-19 and the inability to get it done are the legitimate reasons for the one milestone exception.

Reviewer 4

There is significant cost share between the partners.

Presentation Number: mat196
Presentation Title: High Temperature Carbon Fiber Carbonization via Electromagnetic Power
Principal Investigator: Felix Paulauskas, Oak Ridge National Laboratory

Presenter

Felix Paulauskas, ORNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

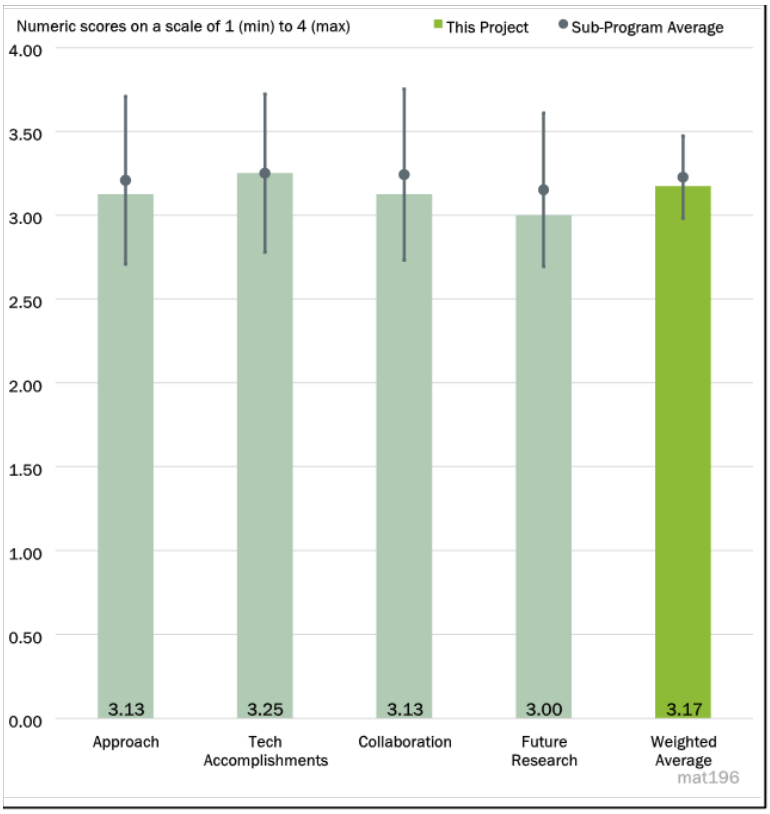

Figure 5-11 - Presentation Number: mat196 Presentation Title: High Temperature Carbon Fiber Carbonization via Electromagnetic Power Principal Investigator: Felix Paulauskas, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the project has a reasonable approach on using dielectric heating to reduce the carbonization cost. The reviewer suggested a cost modeling result directly comparing the proposed and conventional high temperature carbonization (HTC) processes.

Reviewer 2

The reviewer said parametric tests need to be well calibrated in order to achieve the desired result of obtaining optimum conditions to fabricate the carbon composite. Enough time to reach the end of the tests should be ensured to correct or understand the desired test time. It is presumed that a cost analysis will be part of this work, as nothing is mentioned in the future work section about it.

Reviewer 3

While the approach is innovative, perhaps the focus of the efforts could be narrowed to improve the overall opportunity for success and being able to fine-tune the resulting fiber performance in terms of both properties and consistency. For example, the cited "positioning challenges" could be the only source of manufacturing variability. Data reporting with statistics is generally a good approach and the project could consider stepping back and focus on 1 x 100k first the evaluate the fiber performance variability.

Reviewer 4

The project team is working toward developing a CF based on high temperature carbonization in which the heating is enabled through dielectric heating. The goal is to achieve faster and more efficient conversion than conventional process and scale to capacity up to one annual metric ton by end of the project. The tensile strength ranges from 260-380 ksi and tensile modulus of 27.7-29.5 msi based on location within the furnace presented on Slide 9 seem to be consistent with the milestones presented on Slide 4. It was somewhat unclear where the current work began to evaluate significant 'current' contribution(s) as several of the frontend slides were repeats from prior years. Some timeline gaps perhaps due to COVID-19 or other circumstances were not clear to the reviewer.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The reviewer remarked good progress in general.

Reviewer 2

A bit of data remains to be collected as part of the parametric studies as alluded by PI alluded for a better understanding of the impact of input parameters on the physical properties and morphology of the CF.

Reviewer 3

The project appears to be progressing satisfactorily thus far by meeting the milestones. Significant challenges remain to be addressed in order to meet the stated goals and objectives. It is not clear if these challenges can be successfully resolved within the remaining performance period.

Reviewer 4

The work is technically strong and interesting. The science behind the project is excellent and the reviewer suggested the team consider the value proposition for it to make a big market impact after the project is completed. This was not very clear at this time. It is unclear about the project status on the metrics for tensile strength and tensile modulus of their fiber under development in comparison to: (a) the ORNL CFTF textile grade fiber which has exceeded 400 ksi and 35 ksi, (b) the Deakan fiber, which is also based on the low-cost premise, or (c) Zoltek PANEX which is now marketed at more than $5/lb. It is unknow what specific space does this project attempt to fill amongst its competition. The reviewer suggested a fair side by side comparison of this fiber to various ones identified here at the next review. This could also include comparison of the energy metrics to determine whether the current fiber is lower in energy consumption and reasons for it.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The collaboration between ORNL and 4X Technologies is logical and the developmental work done at ORNL has a pathway to scale up at 4X.

Reviewer 2

Roles of the partners are clearly defined, and work is well coordinated.

Reviewer 3

Collaboration between geographically close in proximity ORNL and 4X Technologies seems has facilitated a good and close working relationship. It is unclear about specific contributions 4X has made and planned in the future.

Reviewer 4

The PI adequately addresses the role of collaborator 4XTechnologies. However, one of the project partners, i.e., Pol Grappe, is mentioned on the title slide but not on the overview slide. If they are indeed partners, their role and contributions are not immediately evident. Further, it may be beneficial to the PI/team to have the CF products developed also tested by a suitable independent partner.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer inquired whether the team has considered a comparison of the properties of the fibers processed via the proposed and conventional HTC processes.

Reviewer 2

Cost analyses is suggested as the future research area.

Reviewer 3

The PI has articulated the remaining work and challenges for the remaining duration of the performance period. Perhaps, as a part of the remaining future work, the quantification of the expected cost savings, estimated with a reasonable fidelity may help showcase the success of the technical approach.

Reviewer 4

The reviewer cited prior comments, which are also applicable in this case. The in-depth project plan is unclear as the remaining challenges and barriers and future work were barely bulletized in the presentation. For it was not clear how the impressive 700 ksi would be attained. Although it was not a programmatic milestone, but the rationale behind it was not clear. Slides 17 and 18 could have used additional elaborations as it was not easy to assess based on limited information.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project is relevant to DOE/VTO as low-cost CF for future of the U.S. economy is a DOE and Presidential initiative.

Reviewer 2

Reducing CF cost is critical to expand the application of CF composites.

Reviewer 3

This project will help to reduce the cost of CF and hence CF composites, which will affect energy efficiency of mobility systems.

Reviewer 4

If the goals of this project are realized as articulated, the technology developed could have the potential for reduced energy consumption (hence, embodied energy), and afford a modest cost reduction in the manufacture of CFs. It would thereby serve to support the VTO program objectives for Materials.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

Sufficient resources are available to this project.

Reviewer 2

The resources seem adequate.

Reviewer 3

The project is well resourced, and sufficient to achieve the stated but some narrowly focused milestones in a timely fashion. Any supply chain disruptions at this stage may challenge the project.

Reviewer 4

The resources between ORNL and 4X are sufficient. ORNL line upgrade plan was mentioned but it was not clear how uniform heating of the fiber to obtain narrow properties bound would be ensured. The existing properties are highly dependent on the location.

Presentation Number: mat197
Presentation Title: Multi-Functional Smart Structures for Smart Vehicles
Principal Investigator: Patrick Blanchard, Ford Motor Company

Presenter

Patrick Blanchard, Ford Motor Company

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

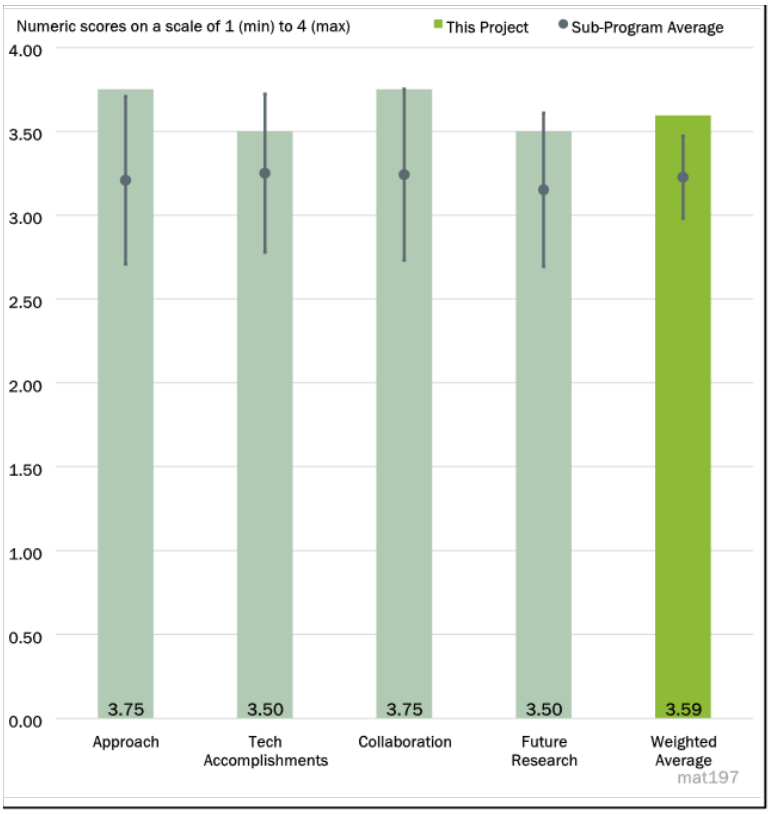

Figure 5-12 - Presentation Number: mat197 Presentation Title: Multi-Functional Smart Structures for Smart Vehicles Principal Investigator: Patrick Blanchard, Ford Motor Company

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project is well designed and executed very well. The ongoing work integrates several technologies that were generally isolated in prior applications. Using a cross-arm as the member of interest, the team is exploring all-in-one recycled materials, embedded electronics, process innovations for hollow sections, thermally and electrically conductive polymers, hybrid continuous-discontinuous, and AI. The vision and efforts of the project team is well aligned with the direction of the mobility feature. The timeline is managed well and despite COVID-19 constraint the team seems to have advanced and is on track.

Reviewer 2

The project is well designed. Some technical barriers such as water-assisted injection molding, composite recycling, and sensor development, etc. have been addressed. It is not clear whether it will be easier to integrate the sensing devices at a later (separate) stage rather than in-situ during the electronics integration stage, which might overcome the fabrication incompatibility issue.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

It is a well-managed project, and the technical accomplishments are on track with no outstanding tasks. The team has completed the cross-beam concept development with extensive ribbed structure. A cost metric is also

included to illustrate that the cost metric is achievable. Mass savings of greater than 40% has been demonstrated at cost of $1.93/lb which is impressive given the proposal target is $3/lb. The team has considered a range of material streams and the property (performance)-process-cost relationships are currently ongoing. Water injection molding and associated tooling for hollow shapes has been an excellent innovation with potential to save energy. Concepts of tape placement and sensor integration have been advanced including AM attachments and hard points are being integrated. AM tooling and recycled materials are also being considered in the study.

Reviewer 2

The research team utilizes a convergent approach. Many sub-components have been developed and their properties/performance have been demonstrated. The following project period would focus on integrating them together to demonstrate a working prototype.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The team has complementary expertise. The specific contribution from each team member is very clear.

Reviewer 2

The project has demonstrated a case of collaboration. The task distribution is clear, and the project management ensures that all partners deliver in a timely fashion. There is no duplication or bias of the work, and the team is well organized.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The PI has laid out clear goals for future research. Given the current progress, the future work will very likely achieve its targets based on the current progress made.

Reviewer 2

The proposed future directions on Slide 20 are appropriate. It is not clear about the build prototype tooling to manufacture cross car beams for testing and validation stage although materials and processing optimization will continue. Full scale injection molding including the ability to fixture inserts and continuous fiber into the injection mold and retain them through the injection process will be demonstrated. It was not clear about the material for the prototype tool, i.e., Al, AM, or other and for injection molding. The overmolding tool feature is a good plan and some more details on this would be helpful. It would be good to follow up in the coming periods.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

As stated in Question 1, the proposal integrates numerous emerging trends in future of mobility. The work aligns well with the VTO objectives.

Reviewer 2

The goal of this project is to develop a new class of multifunctional composite materials and processing technologies for producing lightweight recyclable structures with fully integrated sensing devices, which is highly desired for future vehicle manufacturing.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said Ford, ORNL, Purdue, MSU, and Yanfeng have more than adequate capabilities to address the proposed work.

Reviewer 2

The research team has all the necessary resources for this project.

Presentation Number: mat198
Presentation Title: Development of Tailored Fiber Placement, Multi-Functional, High-Performance Composite Material Systems for High Volume Manufacture of Structural Battery Enclosure
Principal Investigator: Venkat Aitharaju, General Motors Company

Presenter

Venkat Aitharaju, General Motors Company

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

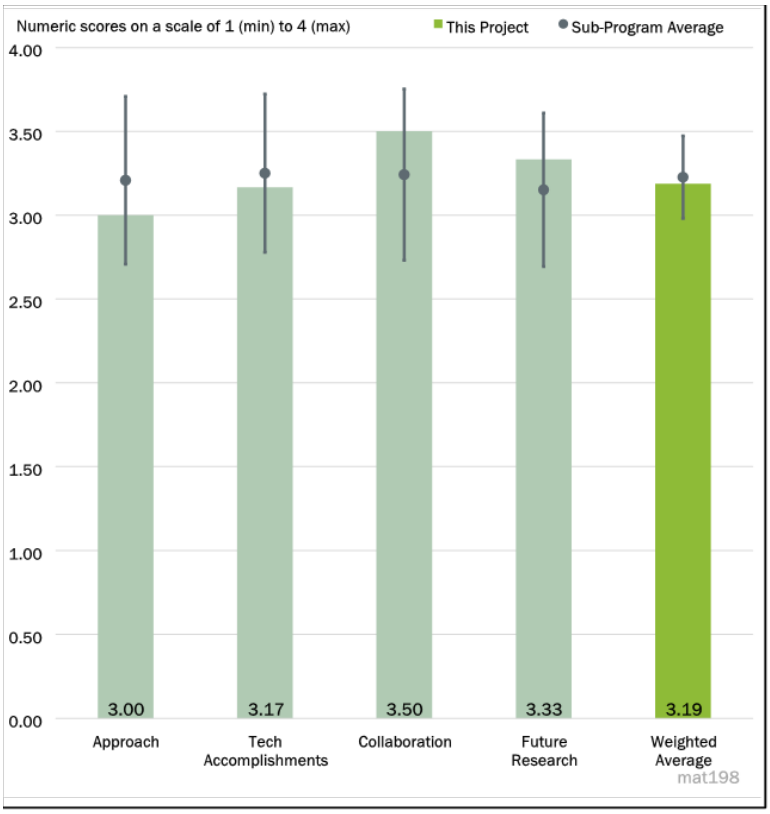

Figure 5-13 - Presentation Number: mat198 Presentation Title: Development of Tailored Fiber Placement, Multi-Functional, High-Performance Composite Material Systems for High Volume Manufacture of Structural Battery Enclosure Principal Investigator: Venkat Aitharaju, General Motors Company

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The technical barriers have been identified and addressed. The project is well- designed and -planned. The novel approach of creating a hybrid composite with glass and CFs was not clear. A more novel approach to meeting the technical barriers should have been proposed based on the large available DOE project budget.

Reviewer 2

The project timeline is reasonable, and it has addressed many critical barriers to meeting the minimum requirements. The focus on hybrid fibers (carbon/glass) has been excellent and detailed work has been carried out. There was no detailed work on fire retardance, and electromagnetic compatibility (EMC) performance mentioned in various slides, but it may be planned for the next fiscal year. Some areas such as crashworthiness and thermal management requirements for multi-functional battery enclosures still could have been included in the approach.

Reviewer 3

There has been delay in the project due to pandemic, and so some technical challenges remain to be addressed. For example, the CF tow was designed to functionalize as the strain sensor, but its integration effect on the final composite mechanical properties and the final product cost remains unknown.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The reviewer remarked the work done is excellent and in line with the proposed work within over a year of the project start. The technical progress is targeting most of the critical barriers with a few exceptions such as incorporating EMC and fire-retardance properties at the design phase itself as these functionalities are hard to incorporate later.

Reviewer 2

The research team completed some tasks, such as composite preparation, characterization, sensor design, and predictive model development in spite of the project progress slowdown caused by the pandemic.

Reviewer 3

The team made good progress on achieving the milestones this past year. The milestones consisted of a variety of sensor development and additional functional properties that were integrated into the composite. The reviewer suggested showing in future AMR presentations how the progress was measured against the listed criteria towards meeting the milestones. The results should accompany the criteria on the slide for that research task to measure success of the task quantitatively. It would be good to include the data used to quantify the fire-retardant capabilities which was mentioned as the most important functional properties for the automotive industry. However, no data was presented that quantified the fire-retardant capabilities. It was not clear how good of a flame-retardant is the matrix as the fibers are inherently flame-retardant.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The research team has complementary expertise.

Reviewer 2

The project team consists of an excellent team of partners and collaborators. It would be good to note which partner/collaborator is working on which part of the project in in future AMR presentations. The project role of the partner Coats was described, but not for the rest of the partners/collaborators.

Reviewer 3

The number of participants and their expertise were mentioned, but a clear and specific contribution from each partner for this project was not covered. Therefore, it was difficult to understand the specific contributions requirement from the other partners in the future.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The remaining challenges and barriers have been identified and there is a clear plan to effectively overcome those barriers within the future proposed research. The future research directions seem reasonable and attainable in the remaining time of the project based on the prior accomplishments. It would be good to show

what electrical system would need to be added to the battery enclosure to utilize the self-sensing attribute of the enclosure for the last bulleted future milestone of the battery enclosure design.

Reviewer 2

The future milestones are well aligned with the goal of the project. The future work focus is more toward computational and analytical work so it would be good to consider a detailed scale-up experiment plan for achieving a 3-minute cycle time.

Reviewer 3

The proposed future research seems reasonable. It is not clear whether 3-minute process cycle time is for sensing device integration.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project is well-aligned with the VTO objectives as the battery boxes will be one of the critical components for battery electric vehicles (BEVs) in the future. In addition, a multi-functional light composite battery box will help to reduce the overall weight of the vehicles significantly and thereby the project is vital to achieving the VTO objectives.

Reviewer 2

This project is relevant to the overall DOE objectives. The project clearly identifies the end application of a structural battery enclosure with a lower material cost and added functional properties that can make the enclosure safer and self-sensing.

Reviewer 3

The goal of this project is to develop high-performance multi-functional composite materials, which are highly desired for vehicle manufacturing.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The funding amount is sufficient to develop the technologies.

Reviewer 2

The team has the necessary resources for carrying out the project.

Reviewer 3

The resources are excessive to achieve the remaining milestones for the project and more novel research output would justify such a large budget.

Presentation Number: mat199
Presentation Title: Ultra-Lightweight Thermoplastic Polymer/Polymer Fiber Composites for Vehicles (Inter-Lab Project)
Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

Presenter

Kevin Simmons, PNNL

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

67% of reviewers felt that the project was relevant to current DOE objectives, 33% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

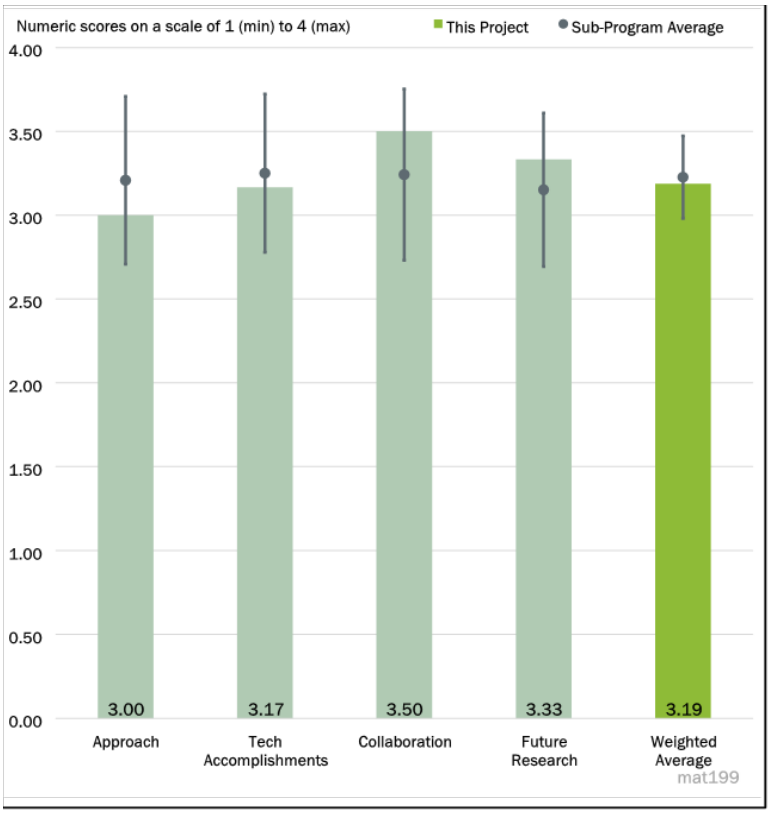

Figure 5-14 - Presentation Number: mat199 Presentation Title: Ultra-Lightweight Thermoplastic Polymer/Polymer Fiber Composites for Vehicles (Inter-Lab Project) Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This project is well designed and targeting an important research direction by fabricating all thermoplastics-based composites. Some technical barriers such as polymer fiber preparation (showing 500 mega Pascals [MPa] tensile strength) and composite synthesis etc. have been addressed. The preparation of longer polymer fibers still needs further improvement.

Reviewer 2

Overall, the project is well designed, and the researchers either addressed or acknowledged major challenges. The progress in the presentation is showing that the project is on track. The project addressed some of the major issues of fiber-reinforced polymer composites. The replacement of commonly used fibers (glass fibers or CFs) with thermoplastic fibers has two major advantages: enhances the adhesion strength between fibers and matrix and more sustainable approach because of higher recyclability and lower embodied energy thereby lower carbon footprint. The key challenges of this approach will be: developing high performance thermoplastic fibers, maintaining the high performance of the fibers during composite manufacturing processes (e.g., injection molding, compression molding), and ensuring the adhesion between the fibers and matrix.

The milestone deadline for the first challenge (i.e., high performance fibers) is the end of this fiscal year, and the preliminary results show promising performances in terms of strength, stiffness, and failure strain of fibers.

The researchers plan to identify an optimal processing window for addressing the second challenge (i.e., performance loss during processing). The processing temperature window has been determined by examination of the thermal shrinkage behavior of ultra-high-molecular-weight polyethylene (UHMWPE) fibers and a small shrinkage of polypropylene (PP) fibers after the exposure to a high temperature (150°Celsius [C]) was shown. The mechanical performance decreases due to the shrinkage or the effect of exposure time on the shrinkage which is yet to be presented. The shrinkage of the material might be affected by the duration of heating, or the shrinkage might affect the mechanical performance.

The third challenge (i.e., ensuring the bonding between the fibers and matrix) was met by fiber coating on PP fibers and verified by component testing images of PP fiber/low-density polyethylene matrix. The effect of fiber coating on the improved performance remains to be demonstrated by the comparison of the mechanical performance between coated fiber/matrix composites and un-coated fiber/matrix composites. It is encouraging to note reasonably high-performance results presented for thermoplastic fiber/matrix composites with different matrix materials.

Reviewer 3

The project is not well designed to address the technical barriers based on a study published in 2013. The study needs to consider the trends seen in the automotive industry's acceptance for use of composite material for high-volume manufacturing.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

All the milestones have been met as per the progress details commented in quarter 2.

Reviewer 2

The research team has made good progress in spite of some unexpected issues such as thermoplastics matrix-polymer fiber interfacial interaction were addressed. The new proposed approach by the team of using aqueous based maleated polypropylene dispersion for fiber treatment could improve the filler-matrix bonding.

Reviewer 3

The remaining listed challenges and barriers listed are yet to be appropriately incorporated into the project plan. A concise story on how the project objectives were accomplished in a timely fashion remains also to be discussed.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented expertise from the PNNL and ORNL teams is highly complementary, and both teams are carrying out their research simultaneously and synergistically. The specific contribution from each team is very clear.

Reviewer 2

The reviewer noted that the work is divided into two parts, i.e., fiber manufacturing and processing with matrix. The fiber manufacturing is done by ORNL whereas the composite manufacturing with matrix and other processes by PNNL. The synergy provided by the collaboration of the two organizations seem to result in a good progress.

Reviewer 3

The reviewer said different tasks conducted at PNNL and ORNL were presented. A project plan consistent with the stated objectives and an appropriate timing needs to be developed jointly by two teams.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The future milestones are well aligned with the goal of the project. The fiber preforms for composite manufacturing undertaken by ORNL show high mechanical performance of fibers with a small shrinkage, unlike the more effect between them was anticipated. The PNNL team plan for composite manufacturing is to demonstrate a compression molding process with uniform heating and an injection molding process with chopped fibers and fabric fibers.

Reviewer 2

The reviewer said an understanding of the manufacturing cost remains to be addressed.

Reviewer 3

It would be good to discuss detailed research tasks for each team (i.e., PNNL and ORNL). It is likely that the future teamwork could achieve its targets.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The goal of the project is to develop materials and processing techniques for high performance polymer composites, which is directly relevant to the VTO objectives.

Reviewer 2

The project goal of development of a low-cost high-performance thermoplastic polymer matrix/polymer fiber composite system with good mechanical property and recyclability, is highly desirable for composites use in vehicle manufacturing.

Reviewer 3

The reviewer said the project goal may not support the VTO objectives as it is not clear how the outcomes of the project can be effective in acceptance and use of lightweight composites being proposed by the project for low-cost, high-volume production application.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The funding amount is sufficient to develop the technologies.

Reviewer 2

Resources appear to be fully utilized.

Reviewer 3

The team has all the necessary resources to perform the project.

Presentation Number: mat200
Presentation Title: Additive Manufacturing for Property Optimization for Automotive Applications
Principal Investigator: Seokpum Kim, Oak Ridge National Laboratory

Presenter

Seokpum Kim, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

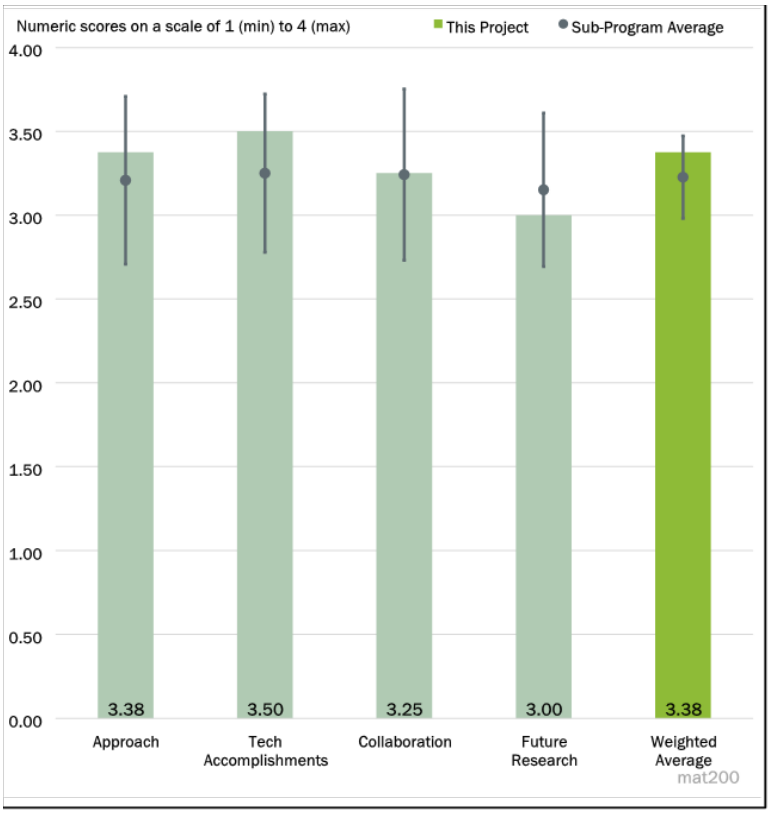

Figure 5-15 - Presentation Number: mat200 Presentation Title: Additive Manufacturing for Property Optimization for Automotive Applications Principal Investigator: Seokpum Kim, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This entire effort and the depth to which the researchers have taken is commendable and relevant. 3-D printing when it is brought into the mainstream of automotive composites manufacturing will be a game changer.

Reviewer 2

The printing of cellular structures with hybrid materials is of great interest to automotive industry for reducing weight and carbon footprint. The project is well designed to address the technical barriers. The project timeline is reasonable and the decision points for go/no-go are clear.

Reviewer 3

Project has a reasonable approach of developing ML and out-of-plane techniques. It would be good to see discussions/strategies on the cost reduction and mass savings project objectives.

Reviewer 4

The project is addressing the technical barriers in material options, bumper, and arm rest designs using geometric structures and ML to assist in optimal structure designs. The project approach of the consideration of two different products may instead focus on one product, i.e., either a bumper or an arm rest. It was not

clear if the intent for the arm rest was for demonstrating the out of plane AM technique. The project is on schedule and some interesting work has been done. The development of the continuous path printing was a significant change in time for the part completion. It would be helpful to more discussion about the compounding of the ABS/CF blends with thermoplastic polyurethane, and how the blending could be damaging the CF or the ABS/CF dispersion within the mixture to determine the either homogenous or phase segregated type of dispersion. The test data is intriguing but evaluation of the strength properties beyond the modulus of the material would be useful.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The participants have done a wonderful job of breaking down the project to its essential subsets and then addressed each segment in a proper scientific manner.

Reviewer 2

The project has a good progress on part fabrication and design optimization.

Reviewer 3

The project plan is moving along as scheduled. The team is progressing on all their milestones. Technical progress has been made on each of the main tasks for the material, bumper, arm rest, and the machine learning. Testing has been commencing with impact property measurements with model predictions that have mostly good correlation.

Reviewer 4

The project is on track and has met the milestones as planned. The cellular architecture with design and printing flexibility has demonstrated advantages over traditional automotive manufacturing. The reviewer suggested that the project print different or hybrid cellular structures at different necessary locations.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The entire thought process and progress is extremely well organized in the presentation. The presenter was knowledgeable and addressed all the questions professionally and so reflected extremely well and coordinated team effort.

Reviewer 2

Partners have well defined roles in the project.

Reviewer 3

The project PI has been collaborating with Ford and UCLA. The project team members have knowledge and rich experience in 3-D printing and resources for scaling.

Reviewer 4

The project has been well coordinated with team members and so demonstrated a good collaboration between the partners. It is clear where UCLA and Ford are working to support the ORNL project with each providing data and part design details that feed into models for structure optimization through ML. Each partner is clearly identified on their project responsibility and accordingly contributing to the project.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The future research is well planned and anticipated to meet the milestones.

Reviewer 2

The presentation clearly defined a path forward for future work. It would be useful to incorporate aspects of total cost viability; sustainability; a better understanding of material engineering boundary conditions for the 3-D process; and a way to bring in the use of continuous directed fibers in the 3-D process.

Reviewer 3

The reviewer said the team may consider a comparison with baseline commercial products.

Reviewer 4

The proposed future work plan is clearly laid out. The material testing needs to include a little more detail on the contributing factors to the material changes. It is not clear whether the material changes are based on rule of mixtures of a stiff material with a soft material or an effect of blending the melt mix together. An understanding on where the properties are being contributed from, the CF, or the resin itself would be useful. Similarly, it is not clear whether the same effect of ABS alone can be obtained without the CF.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This is an extremely relevant project. It is a great work by the project team and the support of DOE VTO for pursuing this effort is appreciated.

Reviewer 2

Findings on AM potentially would facilitate the lower cost implementation of advanced materials for specific applications.

Reviewer 3

The 3-D printed cellular structure enables lightweighting and flexible manufacturing. The project supports the overall VTO objectives.

Reviewer 4

The project demonstrated that the design optimizations with structures that would only be available through AM for weight reductions with novel structure design. The team should compare their bumper or arm rest weight reduction targets that are trying to achieve to demonstrate the benefit of their approach.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

Project has the sufficient resources, and the project team is encouraged to find a way to fold in sustainability and a method to use continuous fibers into future projects.

Reviewer 2

Project is receiving sufficient support.

Reviewer 3

The resources at ORNL, Ford, and UCLA are sufficient for the project to achieve the milestones in a timely manner.

Reviewer 4

The team has done an excellent job in meeting milestones and achieving the results. They are adequately funded and have met all their milestones.

Presentation Number: mat201
Presentation Title: Additively Manufactured, Lightweight, Low-Cost Composite Vessels for Compressed Natural Gas Fuel Storage
Principal Investigator: James Lewicki, Lawrence Livermore National Laboratory

Presenter

James Lewicki, LLNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

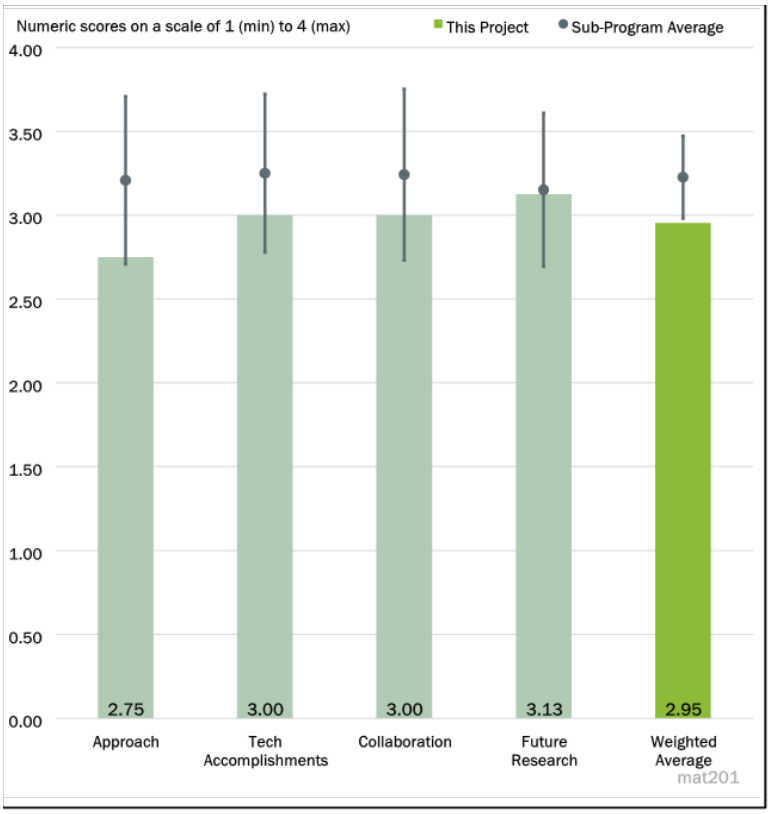

Figure 5-16 - Presentation Number: mat201 Presentation Title: Additively Manufactured, Lightweight, Low-Cost Composite Vessels for Compressed Natural Gas Fuel Storage Principal Investigator: James Lewicki, Lawrence Livermore National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project includes an interesting approach to using different resin grades throughout the thickness of the tank. In principle this should potentially eliminate the cost for a separate gas barrier. However, there are general concerns on the scalability of the technology for high volume production. The time required to produce each tank needs to be adequately addressed and could be a significant impediment to future implementation.

Reviewer 2

The project has identified and addressed the key technical batteries for Type IV compressed natural gas (CNG) tanks. The CNG tank design is novel and the timeline is reasonable. Adding multiple nanofillers in resin is of great interest to tank liner and matrix.

Reviewer 3

The project aims to fabricate lightweight CNG tanks at reduced cost using an interesting AM technique. The team incorporates a hybrid approach using a nanomaterials enhanced resin composite. The project seems well-designed but major conclusions need to be based on sufficient data and experiments. The project technical barriers such as the lack of low-cost and high-volume manufacturing options for fabricating CNG tanks remain to be addressed.

Reviewer 4

It is expected the technology may find use in other composite manufacturing applications. The program needs to specify the resin matrix used and compare its pressure vessel performance to SOA resins used including to SOA towpreg laminate data need to be considered. It is rather easy to add fillers to unformulated epoxies to improve performance. While tensile strength and modulus is important but composite fracture toughness and shear strength are more critical measures. Permeability data is difficult to develop that is yet to be presented for the inner barrier. It is unlikely the approach can match the very high-speed winding accomplished with towpreg which yields superior performance over wet winding. The model study is necessary to support the benefit of its ability to better tailor fiber orientation. It is unclear whether fiber tension possible with the AM approach which is also critical factor for thick-walled larger tanks.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The project team appears to have made significant progress in the development of the multi-axis print head, which will be required to achieve further improvements in the manufacturability of storage tank designs. Several nano fillers have also been investigated to improve resin performance.

Reviewer 2

The project is on track and making progress toward the milestones as planned and the decision points for go/no-go are clear. Printing nanofillers of different materials is very challenging. The project team needs to address voids and filler agglomeration, which often leads to low mechanical properties and gas leaking. Cross-sectional characterization on the printed CNG tank is needed to show the defect distribution and find the solution how to print defect free CNG tanks.

Reviewer 3

The team made good progress on developing resin and structural development. Milestone progress appears to be on track, but printing and testing CNG tanks would be interesting. The gas barrier property and mechanical property of resin were unavailable including the print of CNG tank prototypes and its performance under similar conditions.

Reviewer 4

Material formulation work has progressed but key material properties tied to functional layer improvements remain to be measured. Laminate data is the best to consider for functional layer improvements because fiber will cause local orientation of the nanoparticles. In addition, fracture toughness under Mode I and II, shear strength, and hoop strength are critical properties. More progress has been made on the manufacturing side to enable tank geometry fabrication. It would be good to see results of the planned deposition rates as compared to high speed towpreg winding.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The project seemed to have a good coordination between MSC materials science LLC and the University of Illinois.

Reviewer 2

There is good collaboration across the current team. The reviewer recommended that existing tank producers are contacted to determine if all downstream production concerns have been addressed.

Reviewer 3

The collaboration with materials science has been going well. The relationship between printing parameters, microstructural defects, and mechanical properties needs to be established. ML may be helpful in this regard.

Reviewer 4

It is unclear whether MSC as an active participant in Slide 22 list of collaborators and responsibilities will fabricate a baseline tank for comparative testing.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The development of a comprehensive cost analysis will be essential in order to fully evaluate the viability of the proposed technology.

Reviewer 2

The proposed future research makes sense. The project team may focus on defects and how to print defect free (or less defect) CNG tanks/samples. Burst testing is also essential for validating the additively printed CNG tanks.

Reviewer 3

The proposed research seems to align with the project aims very well. The team may consider the sensitivity analysis of a wide range of parameters. The reviewer suggested that an optimized resin design and composite will play a critical role in designing CNG tanks.

Reviewer 4

More information on the graded structure approach is necessary. It is unclear whether discrete layers are shown in Figure 6 or the composition changed/graded was without any basis. Optimized tool path will be of interest to help justify the manufacturing approach. As the static strength alone is not sufficient to predict fatigue and damage tolerance effects, hybrid printing would be of interest, potentially for other part geometries.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project scope supports current VTO mission objectives.

Reviewer 2

The project supports the VTO overall objectives. CNG tanks help decarbonization and weight savings for vehicles. The proposed multi nanofillers help strengthen CNG tank matrix and liner.

Reviewer 3

The project goals align with the DOE objectives. Developing of lightweight CNG storage tanks with reduced cost has significant benefits for commercial natural gas fueled transportation.

Reviewer 4

The project does advance composite materials formulations and new manufacturing methods. It is unclear whether the approach will exceed SOA composite tank manufacture both in performance, cost, and

manufacturing rate. The materials and manufacturing method developed may find use in other DOE focus areas.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

There are sufficient resources deployed on the project although further validation of the commercialization pathway is recommended through additional external review.

Reviewer 2

Lawrence Livermore National Laboratory and Materials Sciences have the required printing, characterization, and testing resources for the project to achieve the stated milestones in a timely fashion.

Reviewer 3

The resources of the project seem sufficient to achieve milestones in a timely fashion.

Reviewer 4

It is not clear what comprises of the continuous fiber additive manufacturing resin including its supplier. It was recommended to include a resin formulator or at least benchmark SOA resins used in this application. The use of ceramic nanofibers may provide some benefit if it can act as nano Z-pins in the laminate. This approach may be useful for making towpreg to be used in various composite applications.

Presentation Number: mat202
Presentation Title: 3D Printed Hybrid Composite Materials with Sensing Capability for Advanced Vehicles
Principal Investigator: Rigoberto Advincula, Oak Ridge National Laboratory

Presenter

Rigoberto Advincula, PNNL

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

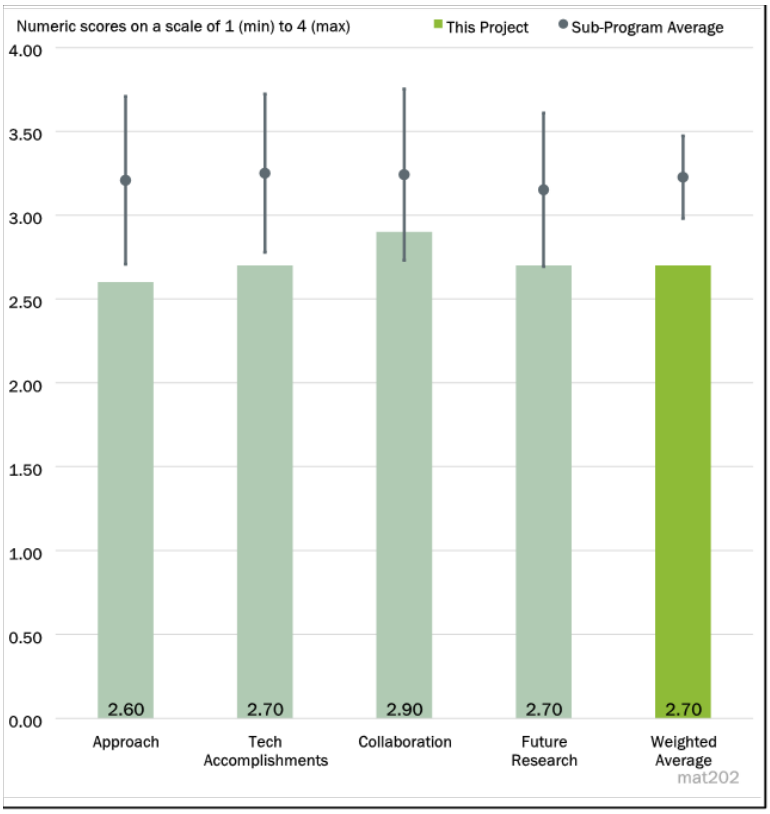

Figure 5-17 - Presentation Number: mat202 Presentation Title: 3D Printed Hybrid Composite Materials with Sensing Capability for Advanced Vehicles Principal Investigator: Rigoberto Advincula, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The CF polymer interphase is a complex region that is not only dependent on chemical interactions but also the properties and structure of the 1-50 nm interphase region. The important factors of the failure mode generated on the cured interphase relating to the CF polymer adhesion to the composite properties. remain to be considered in this research. The methodology for measuring CF polymer adhesion, interphase characterization, and failure mode needs to be identified and discussed.

Reviewer 2

The project has a reasonable approach. Three-dimensional (3-D) printing of continuous fibers and sensor embedding can potentially expand the application of the composite 3-D printing technology. It would be good to consider the scale up challenges of the CF surface treatment and comparison with commercial products.

Reviewer 3

The reviewer remarked the approach appears to be reasonable.

Reviewer 4

The approach to printing continuous fiber with an epoxy matrix is interesting in spite of the printing of discontinuous fiber is not very novel. The results show poor strength gains with the included fibers and at 10%

loading the strength drops significantly. This volume fraction would be very low to begin with and shows the approach may not be appropriate. It is not clear about the purpose of printing on a woven fabric. The cathode printing may be out of place and in what way does this relate to the rest of the program.

Reviewer 5

This project focuses on AM for developing prototype parts and digital manufacturing with a goal of high-performance parts from continuous fiber composites. As part of this effort, new materials development and simulation simultaneous with 3-D printing and provision for integrated sensor for health monitoring are being examined. The science of the work is good but the connectivity to the intended application is somewhat ill-defined.

Slide 13 provides a somewhat unclear schematic of where and how the sensors are embedded in an automotive part. It appears from the figure on this slide that these are in the frame structure. It was not clear what the premise of the component in terms of whether it is: (a) 3-D printed; (b) a stamped sheet metal frame incorporating a 3-D printed sensor or (c) a 3-D polymer/CF composite with integrated sensors. Despite any of these cases, it may be too optimistic to make assumptions that the 3-D printed part will meet the stringent structural requirements without providing any evidence. Critical materials development aspects such as crashworthiness, sensor integrity under different loading conditions etc. need to be considered.

The role of the fiber-polymer interface has been emphasized on Slide 9 with only experimental tensile data results while the interface data is presented as modeling results only. The term interfacial strength needs to be properly used by appropriately defining fiber-matrix interface or the composition of composites. The experimental data like ILSS or fiber-matrix pull-out etc. needs to be included to represent the intent of capturing interfacial properties.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The technical progress on the tasks identified has been satisfactory.

Reviewer 2

The progress on the four tasks has been good.

Reviewer 3

Key outputs and accomplishments were made for development of the 3-D printed inks with embedded sensors.

Reviewer 4

There has been some progress with an exception in the discontinuous fiber work shows poor performance. This may be an issue with defects rather than interfacial strength but the results are no promising given that many vinyl esters can reach the tensile strength of the highest values without any carbon. It may not be appropriate to use epoxy as the performance is low to begin with and therefore the improvements are not substantial. The cathode printing does not fit with the project scope limited to composites. It is not clear how the team used epoxy and chopped CF to demonstrate up scalability of the process and show that continuous CF can be printed and scaled. It is not applicable for continuous CF and the demonstration on a woven and preimpregnated fabric does not contribute to the project goals.

Reviewer 5

The science of AM, careful printing experiments, and amine chemistry is well developed. The science of the work is good, but the connectivity to the intended application is rather weak.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

It is not clear whether the team is planning to consider to partner with a product customer for technology demonstration.

Reviewer 2

Reasonable contribution and collaboration between project partners were observed.

Reviewer 3

The distribution of resources is not clear.

Reviewer 4

The collaboration appears to be good based on statement made at the presentation "The coordination between ORNL and UNT [University of North Texas] is seamless and beyond the regular meeting, a lot of discussions and joint experiments are done in-between group members- email and calls (zoom)." Additional quantitative data would have been useful for the evaluation.

Reviewer 5

The collaboration between ORNL (different units) and UNT seems to be based on UNT expertise in interface and embedded sensors. The collaboration seems to stem from prior work done by the researchers in this area, although the compelling reason for this collaboration was not clear from the briefing.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The leap to a demonstration with larger structures and optimized formulations appears to be too large a step considering what has been accomplished to date on the materials side.

Reviewer 2

Good plan in general.

Reviewer 3

Well-outlined proposed future research.

Reviewer 4

The future work is not clearly articulated since the current material performance is poor and the printing of continuous CF remains to be technically accomplished.

Reviewer 5

The future work is built upon current work and here are some of some things to consider of which some may be applicable for the overall project goals with no substantive quantification or basis for the metrics:

- Demonstrate optimized continuous CF-epoxy 3-D printing into larger structures with optimized formulations: appropriate optimization metrics to be developed based on the rationale for the selection of target size and shape large structures;
- Investigate long-term thermo-mechanical properties of CF/polymer composites tandem with simulations using FEA and genetic algorithms for optimized 3-D printing methods: the vehicle crashworthiness needs to be considered for vehicle applications for the relevance of the study to the intended application. Thermo-mechanical properties with target metrics need to be included as well.
- Investigate other modes of surface modification of CF including use of other sizing and surface modifiers (silanes, phosphonates, crown ethers, etc.) with various weight % CF/epoxy composites in a continuous CF/epoxy 3-D printing system: the rationale behind surface modification for improved interface and weak interface (for energy dissipation) need to be clear.
- Sandwiching of 3-D printed sensor (zinc [Zn], vanadium, molybdenum, etc.) and develop a high-resolution sensor with the epoxy/CF composite.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The ability to utilize in-situ sensing to evaluate CF-polymer composite properties and their changes with exposure to various environments is an important goal for increased use of polymer composites in various structural applications.

Reviewer 2

Project addresses challenges in vehicle lightweighting.

Reviewer 3

The work is relevant. Performance results of printed vehicle structures with continuous fiber reinforced composites compared to poor performance obtained for vehicle structures with discontinuous fiber reinforced composites is necessary to determine the overall project impacts.

Reviewer 4

Addressing earlier comments is necessary to make this relevant to the program objectives. Presently it is a nice science study, with a big gap to reality.

Reviewer 5

The reviewer had no additional comments.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The team seems to have adequate resources in chemical aspects, 3-D printing, modeling, and simulation, and the needed tools to address the objectives.

Reviewer 2

The qualifications of the four investigators (Prof, Ph.D, grad, undergrad and what science or engineering background) are not identified nor is the percent time devoted to this project identified making the evaluation of the resources very difficult.

Reviewer 3

Resources are sufficient.

Reviewer 4

Resources are sufficiently utilized.

Reviewer 5

The reviewer stated progress is not promising and the program seems to be in too many directions, i.e., discontinuous fibers, continuous fibers, interfaces, sensors, and batteries. Minor impacts across a range of topics can be avoided by selecting some and do it well rather than trying to make all.

Presentation Number: mat203
Presentation Title: Low-Cost, High-Throughput Carbon Fiber with Large Diameter
Principal Investigator: Felix Paulauskas, Oak Ridge National Laboratory

Presenter

Felix Paulauskas, ORNL

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

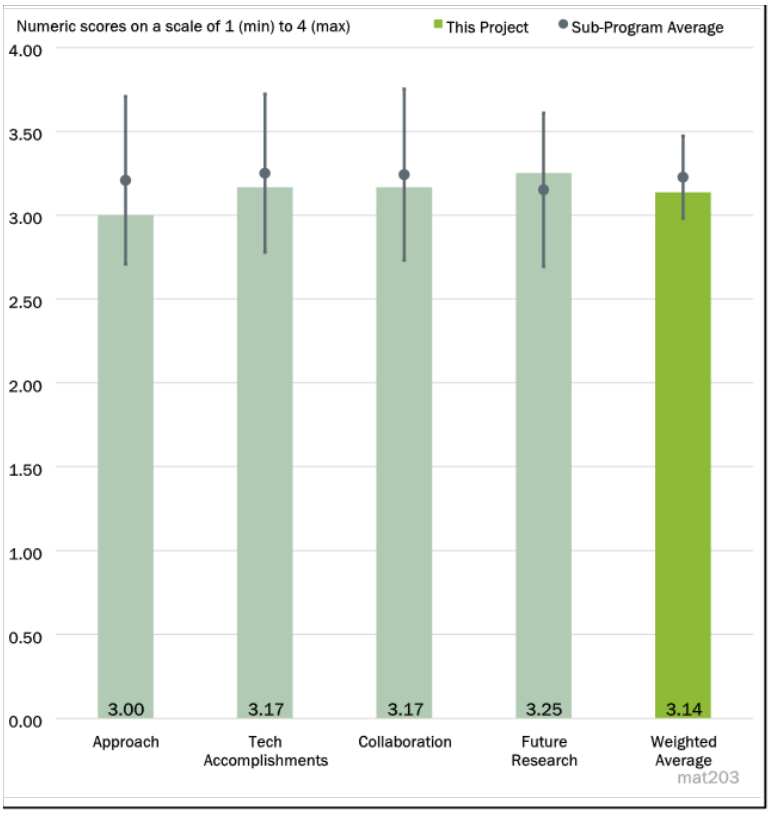

Figure 5-18 - Presentation Number: mat203 Presentation Title: Low-Cost, High-Throughput Carbon Fiber with Large Diameter Principal Investigator: Felix Paulauskas, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project aims at lowering the cost of CF feedstock production. The approach is to increase fiber diameter and use atmospheric plasma oxidization to convert PAN fibers to CF. Plasma will accelerate the oxidization process and help oxygen penetrate deeper, particularly for more difficult to fully oxidize thicker fibers.

Reviewer 2

This project is difficult to evaluate because of the external factors such as changing collaborators, economic factors etc., beyond the control faced by the project team.

Reviewer 3

The project has identified and addressed the technical barriers. The timeline is reasonable and the targets are achievable as planned. The bigger diameter PAN precursors with plasma oxidation are expected to reduce the cost and find the applications in vehicle lightweighting.

Reviewer 4

It is useful to pursue alternate precursor fibers to produce low-cost CF given the much lower performance targets of interest for vehicles. Due to constraints regarding fiber availability from supply chain partners, it may we useful to explore more deeply effect of carbonization processing on properties. Large fiber diameter

should not be an area of focus for this project, instead compression strength in composites should be measured if it is a goal.

Reviewer 5

The project Mat203 target is good as it aims to produce CFs from large diameter textile PAN. The approach utilizes their unique capability of plasma oxidation. Technoeconomic analysis needs to be completed after large diameter fibers become available. It will be helpful how cost benefits can be achieved by using larger diameter textile PAN fibers to demonstrate the benefit of using larger diameter textile PAN that is still conceptual today.

Reviewer 6

The use of a larger diameter CF is important and would be particularly useful in pultrusion where small cross section of current fibers requires too many tows to fill even a small tool. The approach has changed due to significant impacts on the project caused by COVID. It is not clear whether the team has considered pitch fibers which have the larger diameter and exceed the specified properties. In addition, consideration of any alternative approaches that could be investigated to reduce the generally higher cost of these fibers was not clear.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The team made good progress. The team produced 50% larger diameter CF. The year 2 cost target was not reached but shown to be achievable. The project could have achieved the if Dralon's Acrylic used as precursors supplied by Dralon were operational and not shut down due to Covid-19. ORNL team is working on alternative providers.

Reviewer 2

The progress has been satisfactory taking into account the external factors.

Reviewer 3

The project has identified a new supplier for bigger diameter PAN precursors. The preliminary results on plasma oxidation of the large diameter PAN are encouraging.

Reviewer 4

The project could have met the goals if the available of Dralon fibers were viable. It was suggested for ORNL to spin their own demo fiber by using their in-house capability.

Reviewer 5

Carbon fiber production from large diameter textile fibers has been conducted despite an issue of acquiring large diameter textile PAN. The CF properties are great for this new type of large diameter fibers, and it requires several adjustments for optimizing the oxidation condition. It meets VTO low-cost CF target. Some of the milestones are delayed mostly due to unexpected issues of acquiring fibers. It was not clear about its cost advantages as well as volume to utilize large diameter textile PAN. Larger diameter vs. smaller diameter textile PAN fibers difference may not be much if comparisons were mass based. The achieved CF diameters in this project are 6-8 μm range, which indicates high stretching is happening during the process. The benefits will be clarified if simple cost comparison as well as comparison in some other factors (environmental impact, availability etc.) are made between conventional textile PAN vs. large diameter textile PAN.

Reviewer 6

Given the availability of the original precursor the team has made good progress by securing other materials. The Sudamericana de Fibras fibers do not appear to be viable and the cross section is expected to be bad for packing and obtaining high fiber volume fraction.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked the ORNL team is working hard to reach out and find the alternate feedstock providers. This awkward situation reflect this country's supply chain issues.

Reviewer 2

Alternate collaborators and precursor materials have been identified and brought into the project.

Reviewer 3

The collaboration between ORNL and 4XT/4M has been going well. The project is also seeking U.S. suppliers for bigger PAN precursors.

Reviewer 4

The original team had potential for strong collaboration. It is not clear about the potential interest from traditional CF suppliers, Hexcel, Toray, Taiji, etc. Also if there is a market for low strength/modulus CF and why they do not make it.

Reviewer 5

The collaboration among ORNL, 4X technologies, and textile PAN providers are necessary for this project. They will eventually need to secure a provider of large diameter textile PAN fibers to avoid the current unforeseen situation in the future.

Reviewer 6

The team is working to integrate new suppliers.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The proposed work appears to be reasonable.

Reviewer 2

It is assumed that adequate material and process models have been developed and are being used to guide this project. The evaluation of resin infusion and interfacial properties should be done through modeling and simulation.

Reviewer 3

The proposed future research makes sense and the targets are achievable. The project has clearly defined the decision points for go/no-go.

Reviewer 4

More development on true market and cost projections for this grade of fiber would be good to have to determine if market forces can meet the demand.

Reviewer 5

The future research plan is well mapped out after a stable provider of large diameter dry spun PAN fibers has been identified.

Reviewer 6

There is considerable risk in the future work given a lack of fiber suppliers. The Asian company that is supplying precursors is most likely not able to manufacture larger diameter fibers.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

Carbon fiber has wide applications in energy efficiency and renewable energies. The proposed efforts of using plasma method to improve process efficiency and lower the cost support overall VTO subprogram objectives.

Reviewer 2

The ability to develop lower cost CFs is critical to achieving national light weighting and energy efficiency advances,

Reviewer 3

The project supports the overall objectives. Low-cost CFs are critical to fuel efficiency and EV drive range.

Reviewer 4

It is likely that low performance CFs has little market pull unless it is $2-3/pound to compete with glass where modulus is needed over strength.

Reviewer 5

The project is relevant to VTO if low-cost CFs from low-cost large diameter textile PANs can be made. It could then open some possibility of using these CFs for vehicles in the future.

Reviewer 6

The use of a larger diameter CF is important and would be particularly useful in pultrusion where small cross section of current fibers requires too many tows to fill even a small tool.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The project lacks the resource needed to accomplish the planned technical milestones.

Reviewer 2

It is difficult to judge the adequacy of the resources in the absence of detailed effort distribution of the project team members.

Reviewer 3

ORNL and 4XT/4M have the sufficient resources for the project to achieve the milestones in a timely manner.

Reviewer 4

The resources may not meet the needs given the drop-off in precursor availability from partners. It was suggested for a better program ORNL to buy the polymer and spin their own controlled fiber for processing.

Reviewer 5

The resource is adequate.

Reviewer 6

The resources are sufficient.

Presentation Number: mat204
Presentation Title: New Frontier in Polymer Matrix Composites via Tailored Vitrimer Chemistry
Principal Investigator: Tomonori Saito, Oak Ridge National Laboratory

Presenter

Tomonori Saito, ORNL

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

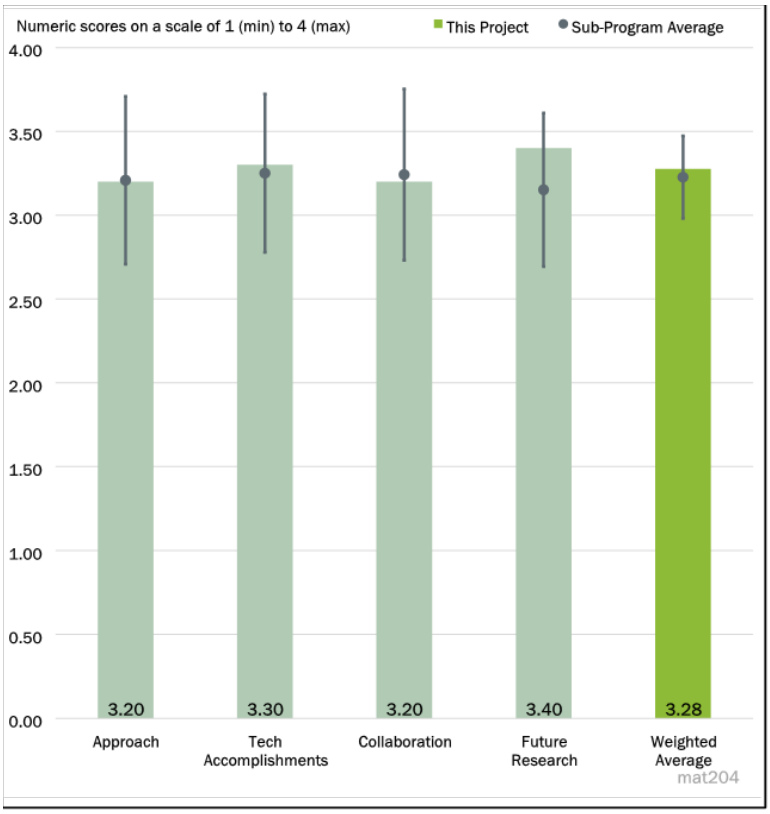

Figure 5-19 - Presentation Number: mat204 Presentation Title: New Frontier in Polymer Matrix Composites via Tailored Vitrimer Chemistry Principal Investigator: Tomonori Saito, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The technical approach is well defined and able to demonstrate a pathway to creating a recyclable polymer system. Milestones are reported to be on track and performance targets are being met.

Reviewer 2

The vitrimer formulation developed in the project has shown equivalency with standard epoxy and vitrimer epoxy for the neat polymer case. The reprocessing benchmarks set out as a goal has been achieved. Several performance and property measurements for the next vitrimer work started remain to be completed. They are: moisture absorption, effect of moisture absorption on mechanical properties; fatigue resistance; creep resistance; freeze-thaw exposure; and surface energy. The surface treatment and/or sizing that would be used with carbon or glass fibers need to be identified. These required additional measurements would indicate that this vitrimer could perform equal or better than conventional epoxy.

Reviewer 3

It is one of the best presentations in this year AMR meeting. Project objectives along with supporting work have been well stated.

Reviewer 4

Project has had success with key objectives such as vitrimer synthesis, forming and testing samples, reprocessing, and repair. A thermoplastic matrix resin such as nylon would most likely provide superior performance at lower cost. The greatest distinction for this effort seems to be the ability to dissolve the matrix in several solvents to recover the fiber. It is not clear whether the polymer is recoverable from the solvent or is it now hazardous waste.

Reviewer 5

The project is well designed and the proposed timeline is very reasonable. A working polymer resin has been developed, which will be further integrated with CFs to fabricate target carbon fiber reinforced composites (CFRC)s via prepregs and compression molding.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The results presented show that the new materials can perform well against target with some flexibility to tune performance based upon the working temperature range. It is however recommended that an assessment of the business case commence earlier than the planned start date of FY23.

Reviewer 2

The base polyurea/epoxy vitrimer formulation shows high potential and has achieved some of the project goals.

Reviewer 3

Wonderful progress has been made on technical accomplishments.

Reviewer 4

Technical progress appears to be on track with the plan.

Reviewer 5

The research team has made good technical progress, including CF surface functionalization, polymer resin synthesis and exploration of processing conditions, and reprocessibility demonstration, etc. Better understanding of the contribution of urea vs. disulfide groups to the malleability/reprocessbility of the polymer resin is recommended.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The team breakdown was presented with detailed roles and responsibilities.

Reviewer 2

It is recommended to provide contributions of each member of the collaborating members and the time they devote to the project.

Reviewer 3

The team has accomplished an excellent summary of findings on a good collaboration and coordination of project activities.

Reviewer 4

Collaboration with potential industry partners such as Hexcel, Huntsman, and Hexion is anticipated to commence soon.

Reviewer 5

The contributions from industry (providing CFs and resin building blocks) and national labs (polymer and composite synthesis, property study) are clear.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The future work program is clearly defined. The project would benefit from benchmarking against competing technologies in order to determine the commercial viability of the chemistry being developed. A comparison with thermoplastic polymers would be useful as the targeted performance appears closely aligned to these materials which are already recyclable.

Reviewer 2

The performance and property measurements such as: moisture absorption, effect of moisture absorption on mechanical properties; fatigue resistance; creep resistance; freeze-thaw exposure; and surface energy need to be included in the coming year. Results would indicate whether this vitrimer could perform equal or better than conventional epoxy.

Reviewer 3

Future research is well stated.

Reviewer 4

The proposed future research is important. It would be good to consider the environmental durability of this material, UV and water effects, and creep behavior. It is not clear whether the material can self-heal and repair microcracks that may reside in hydrogen storage tanks.

Reviewer 5

The proposed future research is very clear and would directly contribute to the final goal of this project. Given the current progress, the future work is anticipated to achieve its targets.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project reports to be aligned with the past report “From Light-Duty Vehicles Technical Requirements and Gaps for Lightweight and Propulsion Materials Workshop Report, February 2013.”

Reviewer 2

This project success will be very important to achieve national goals of circularity and energy reduction.

Reviewer 3

The project is relevant.

Reviewer 4

The project relevance could be enhanced if sufficient material properties are obtained to provide route for material recovery for both fiber and matrix. Cost and environmental durability are two key questions to be addressed.

Reviewer 5

The goal of this project is to develop fast-processable, repairable, recyclable and affordable carbon fiber reinforced polymer (CFRP), which are highly desired for vehicle manufacturing, thus supporting the overall VTO subprogram objectives.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The project resources and funding appear to be sufficient to complete the remaining milestones.

Reviewer 2

Resources appear to be adequate but the percent time allocated to each of the project participants needs to be identified.

Reviewer 3

Resources were sufficiently utilized.

Reviewer 4

It appears the team has adequate resources for the project.

Reviewer 5

The team has the necessary resources to achieve the proposed milestones in time.

Presentation Number: mat205
Presentation Title: Adopting Heavy-Tow Carbon Fiber for Repairable, Stamp-Formed Composites
Principal Investigator: Amit Naskar, Oak Ridge National Laboratory

Presenter

Amit Naskar, ORNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

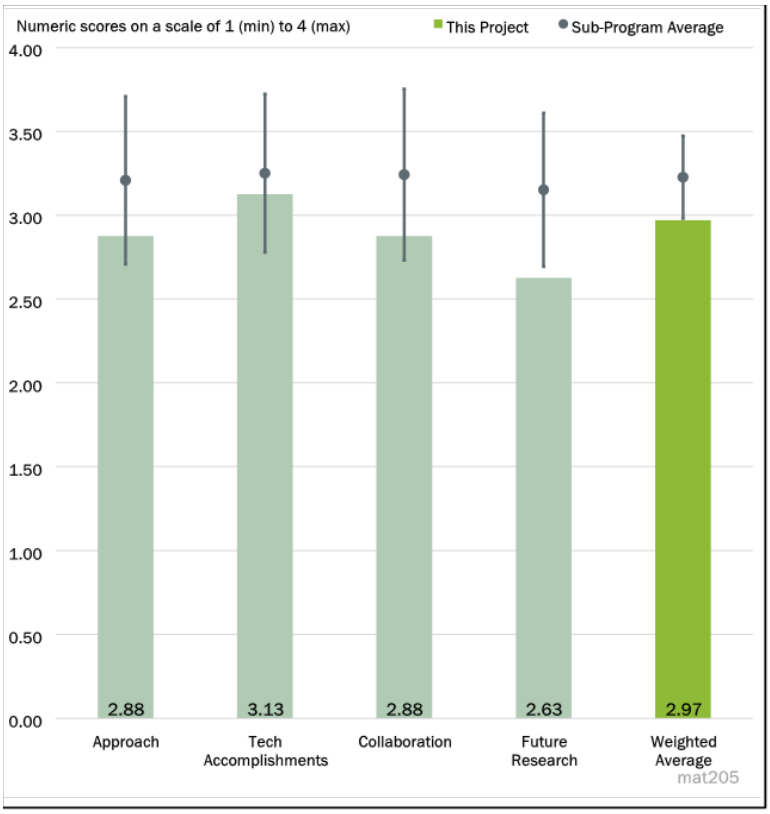

Figure 5-20 - Presentation Number: mat205 Presentation Title: Adopting Heavy-Tow Carbon Fiber for Repairable, Stamp-Formed Composites Principal Investigator: Amit Naskar, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project appears to be lacking nano-level information about the CFr structure and atomic and molecular information relevant to the factors important for polymer adsorption and nucleation. For example, the size and orientation of the graphite crystallites changes with the CF modulus, i.e., larger, and oriented more parallel to the CF surface. The sites for chemical functionalization are the edges of the graphite crystallites and the polymer molecular weight (Mw) and its distribution would be important. Low Mw of the polymer would migrate faster to the CF surface preventing the higher Mw from nucleating in an optimum manner.

Reviewer 2

The approach adopted in this project comprises of understanding interfacial chemistries, their effect on composite processability, develop stamp-formed structures and perform technoeconomics, covering the all aspects of material and process development. It contributes to overcoming most of the technical barriers identified.

Reviewer 3

Milestones and go/no decision matrix are clear.

Reviewer 4

The work is interesting but seems to be a bit unfocused by bringing carbon nanotubes (CNT)s into the program. It can add significant complexity and environmental, health, and safety concerns as well as cost that may not be compatible with vehicle applications. The strength values obtained for the baseline are impressive although very low but with the notable % gain. Sub 100MPa strength is below for a quality epoxy resin and the reduced strain to failure may limit the significance. Data sets need to be large to generate statistically significant data. The bound PP on the fiber surface, may not Xylene will dissolve PP and 'image b' appears to show some material at the bottom of the flask. It is not clear how the PP was bound to the fiber surface and the technique used.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The project has made good progress on the processing aspects of the project. It appears that nano-level information about the CF structure and atomic and molecular information with the polymer as well as the polymer Mw are not considered.

Reviewer 2

The project has made good progress on process development and mechanical performance testing. It would be good to see how this composite performs with equivalent materials especially in the automotive context.

Reviewer 3

Some of the key issues with fabrication process have been addressed along with appropriately identifying characterization methods with nano-indentation mapping.

Reviewer 4

The program needs to have a focus with a few approaches instead to accomplish the goal. The actual innovation needs to be clear for this level of investment because the CF mats are commercial and the laminating process is not innovative. The It is not clear how the PP was bound to the fiber surface and the technique used. It is not clear whether the project goal is it to modify the fiber surface, to manufacture random CF mats, or to add CNTs for interfacial strength. The objective of 1GPa nylon strength seems optimistic given that the high-count carbon tows being used would require very high-volume fraction. Similarly, the currents results indicate the objective to reach 500 MPa may be optimistic as well. The surface chemistry and the methods to attain improved interfacial strength are important and CNTs may not be a good idea with little commercial viability.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The team appears to be adequate. The background and expertise of the team members and the time that they have devoted to the project need to be identified. This information would be helpful to determine the rating of the collaboration of the team members.

Reviewer 2

Good collaboration is with University of Tennessee (UT). It would be great to see OEMs participate at least in an advisory capacity for such a large project.

Reviewer 3

Collaboration appeared reasonable in supporting project objectives.

Reviewer 4

The work distribution is not clear. It would be good to indicate whether the work performed at UT is by graduate students or ORNL. The CF mats are commercial so the actual advances or innovation being offered by the team may be small.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The formation of chemisorbed species has been identified as an important project future research area. Identification of the surface properties important for functionalization and nucleation including specification of analytical techniques to quantify them is necessary. The change to a nylon matrix need to be explained in sufficient detail. The processing and the development of the cost model seem premature.

Reviewer 2

The plan is good for the next set of activities.

Reviewer 3

The proposal and evaluation are detailed.

Reviewer 4

High future milestones are unlikely to be met based on progress made so far. It is unclear how strong ideas would improve the performance.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project supports the VTO subprogram objectives.

Reviewer 2

Development of thermoplastic based CFRP is relevant research for the VTO portfolio.

Reviewer 3

The study is aligned with VTO objectives.

Reviewer 4

The program is relevant but the properties being generated are not so far. The use of CNs is not relevant to vehicles and the laminating process proposed required 30 minutes in the press which is not relevant to high volume components.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The resources directed to the projects are very difficult to judge based on the available information.

Reviewer 2

Sufficient resources are available to complete the rest of the project.

Reviewer 3

Resources are appropriately utilized.

Reviewer 4

The budget is high for the results generated.

Presentation Number: mat206
Presentation Title: Soft Smart Tools Using Additive Manufacturing
Principal Investigator: Jay Gaillard, Savannah River National Laboratory

Presenter

Jay Gaillard, SRNL

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

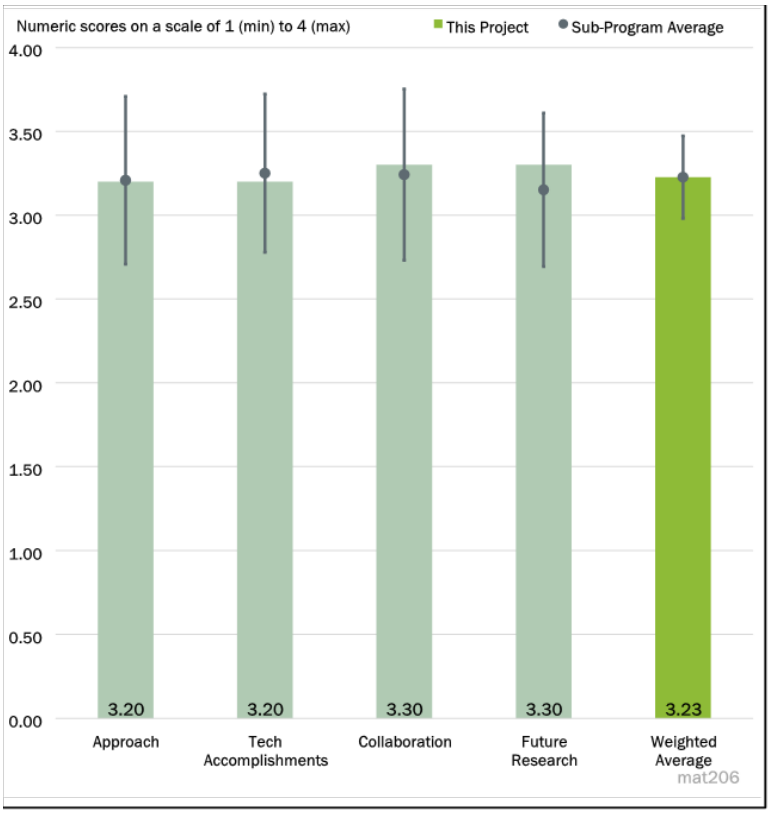

Figure 5-21 - Presentation Number: mat206 Presentation Title: Soft Smart Tools Using Additive Manufacturing Principal Investigator: Jay Gaillard, Savannah River National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

Overall, it is a well-designed project. Technical barriers were sufficiently addressed and the project is well-planned. Sufficient studies on the temperature changes due to the different CNTs was a good study and it led to good mechanical improvements in the parts.

Reviewer 2

The technical barriers have been clearly identified for this project. The approach is reasonable and results are positive.

Reviewer 3

The project team used AM for smart tooling, which is an interesting approach. It would be interesting to know how microwave annealing helps sensing capability. The project aims to reduce tooling costs and curing times using AM techniques. Cost analysis would be interesting for the real application ability.

Reviewer 4

The science is interesting and may have use for other applications beyond the proposed use in tooling seems to be rather abstract. The tool application needs to be defined initially to follow and review the project. Stamping and matched profile tools are in compression, thus interlaminar tension strength is of little concern. The mold profile needs to be constrained in a press or coffin format for RTM tooling to be under transverse tension. It is

not clear how the strain gage will be utilized and thermocouples to control the process besides monitoring. Traditional thermocouple placement or scanning of the tool after use to check dimensions may also be used. CNT use as a receptor is well established and so its use as an example may enable uniform heat distribution at the tool surface for more efficient composite cure. Poor vacuum integrity for this type of polymeric AM tooling has been a key issue in the related work by others and so a simple run for a leak check on vacuum bagged printed plate may be considered. The annealing may help solve this problem.

Reviewer 5

Savannah River National Laboratory (SRNL) project seeks to 3-D print CNT-coated carbon-carbon fiber (CCF) and post-process via microwave. The general approach is good, and potentially custom-designed 3-D objects with decent properties utilizing this specific microwave process could also be created. The project target is for tooling, which seems to have a gap for the goal and their plan. Careful selection of the resin, fiber loading etc. needs to be made if the tooling is the goal unlike the focus at this stage has been the demonstration of printing and microwave process. It is also not clear about the benefits of the composite tooling. To use composites for tooling molds, its life like metal tooling or low coefficient of thermal expansion (CTE) need to be known.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The project has good quantitative milestones and criteria to measure the success. All targets look to be successfully met. The microwave annealing is showing some very promising results in terms of tensile strength and temperature rate increases. The reviewer would like to know as a part of the undergoing durability studies, the durability target for the developed material and what level of durability would make this approach competitive with conventional tooling.

Reviewer 2

Progress has been good as well as the ability to incorporate strain and temperature sensors. The change from Nylon to polyaryletherketone (PAEK) is warranted to produce a more robust system.

Reviewer 3

The team made good progress compared to the project plan. It was interesting to note the tensile property after microwave annealing improved. A new stable ink formulation using fillers but the agglomeration of fillers that may have a detrimental effect on real-life applications need to be considered.

Reviewer 4

The printed TC using silver and CNT ink is interesting and should have other applications in smart structures. The microwave post processing enhanced with CNTs is also an interesting approach and may be more useful to support actual composite cure. It is simpler from a practical perspective to scan and measure dimensions after a molding cycle instead of printing a strain gage. It is not clear about the plan for dimensionally shape the mold in-situ.

Reviewer 5

The progress is good being able to successfully print CNT-coated CCF with improved mechanical performance after microwave processing. They have also made significant progress on adding sensor to the system. It was not clear if there are significant advantages in their approach. The traditional manufacturing and post-attachment of functions such as sensors may exhibit similar or even better performance. It was suggested

to think through what the major advantages of the approach are compared to a conventional manufacturing with the same functionality.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The project has a good group of collaborators/partners that should help to push the research to commercialization. It will be interesting to see how the scale up of the CNT coating process goes with Mainland Solutions.

Reviewer 2

The research team made good collaboration for this research project with Clemson university and Mainland Solutions.

Reviewer 3

Mainland Solutions seems to be providing strong support to deliver on the 3-D printing filaments and embedded sensors. It is not clear whether Clemson will support tool design and requirements in addition to the mechanical testing already being provided. Critical concerns for RTM process include CTE dimensions and non-isotropic Z expansion in composites. Vacuum integrity and seals are issues with these fused deposition modeling FDM tools and so it is not clear whether tool cavity be placed in compression using press or coffin tooling. Also, it is not clear whether the tool will be heated to promote cure or the microwave oven cure will be done.

Reviewer 4

The project team has collaborated with others well. It may be important to get clear feedback from OEMs and adding them as a collaborator will be good for future, as stated in Clemson's role.

Reviewer 5

The reviewer said that data is lacking on the role of each team member, their expertise, and time devoted to the project making evaluation of this project difficult.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The future research is well-planned and is logically organized. The remaining barriers were identified and matched with the corresponding future work to address each of those problems. The use of CNTs in the sensor ink and for coating the CF, it would be good to evaluate the estimated cost of the different CNTs used for its commercial feasibility of the ink to make sensors. It is important to present the tech-economic analysis (TEA) results that will be performed for this work. Progress made over the next year in the plan for the continuous CF 3-D printed parts in PAEK matrix instead in a nylon matrix today, would be a valuable addition to the research.

Reviewer 2

Future research is reasonable considering accomplishments made to date. The project would be more valuable if a cost-model would be developed so that the economics of this approach could be monitored and area for cost reduction could be identified.

Reviewer 3

The team identified the problems and proposed future work to address them and barriers. The reviewer would like to see the stability of the tooling in different environmental conditions.

Reviewer 4

It is critical to select a demo part and accordingly tool design and requirements be considered to address key requirements. The criteria can vary widely based on demonstration case. Sensor work is interesting but for this application it is of little value compared to more proven traditional methods.

Reviewer 5

The future work for this specific scope is good. The choice of materials and composition may be not be appropriate for the tooling target. A map of specific target tooling and their desirable properties (thermal stability (CTE), thermal conductivity, and mechanical stability for repeated use etc..) may be developed.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

Increasing durability of 3-D printed tooling is relevant to DOE objectives and to the automotive industry.

Reviewer 2

The project nicely bridges materials and manufacturing areas.

Reviewer 3

The project aims to reduce the tooling cost that addresses the DOE missions.

Reviewer 4

Project is doing some interesting materials science which may have applications in smart structures. The application toward tooling is limited with the exception of using CNT's and microwave to heat the tool for part cure.

Reviewer 5

The project is relevant to VTO.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The resources are sufficient to achieve the remaining milestones of the project in a timely fashion.

Reviewer 2

It is difficult to answer the question due to the lack of information about the expertise and time commitments of the participants

Reviewer 3

The team has sufficient resources to accomplish the project goals.

Reviewer 4

Sufficient time and funding to adequately design, fabricate and test a tool for taking advantage of the new technology to address the current very low Technology Readiness Level (TRL) work may not be there.

Reviewer 5

The resource is sufficient.

Presentation Number: mat207
Presentation Title: Multi-Material, Functional Composites with Hierarchical Structures
Principal Investigator: Christopher Bowland, Oak Ridge National Laboratory

Presenter

Christopher Bowland, ORNL

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

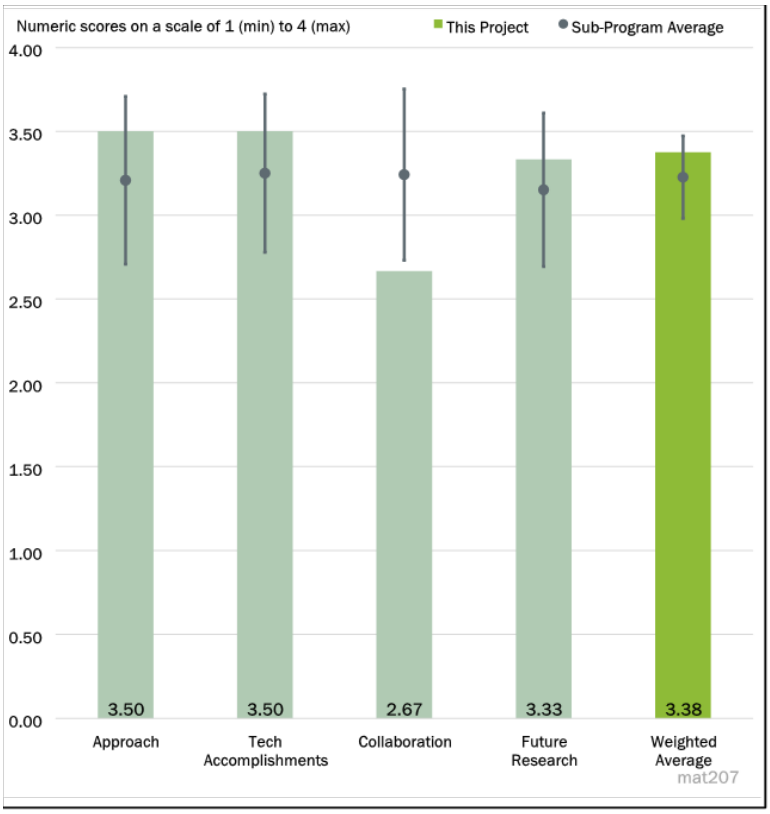

Figure 5-22 - Presentation Number: mat207 Presentation Title: Multi-Material, Functional Composites with Hierarchical Structures Principal Investigator: Christopher Bowland, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

Overall, this team has a good approach and plan. The project team has developed their own test to assess interfacial strength of the fibers in the polymer matrix. More work is necessary to demonstrate the measurement types can the test allow to measure.

Reviewer 2

Approach is well-established.

Reviewer 3

This project, compared to the others reviewed, has thorough data collection and analysis. Strong progress is evident and some level of success has been shown in energy harvesting, structural health monitoring, and interlaminar enhancements.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The project is approximately halfway complete and appears to be on track to complete its milestones successfully.

Reviewer 2

Great progress has been made on the interfacial characterization techniques and confirmation of nanofiber bridging.

Reviewer 3

Project shows significant results for all three approaches.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

All work in this project has been done by a single performer (ORNL), but plans to work with a subcontract collaborator in the second half of the project for fatigue testing.

Reviewer 2

Reasonable collaboration and coordination and the encouraging results from Columbia university were presented.

Reviewer 3

The work by Columbia University has not yet begun.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The future work plan includes well planned and diverse tasks, ranging from scalability studies to computational modeling and techno-economic analysis. The future work plan is well focused on tackling the critical barriers.

Reviewer 2

Excellent outline with supporting details.

Reviewer 3

Demonstration of laminate with low velocity impact, SHM sensor response, and reduced delamination zone would be good to see. Identification of SHM pick-up damage after the event by looking into change in applied excitation would be good to consider. In practice an auto garage needs to run a scan and trace potential damage location.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project is well aligned with DOE objectives in composites for vehicle lightweighting.

Reviewer 2

The project is relevant to VTO objectives.

Reviewer 3

As this technology is low TRL, other more mature existing methods for energy harvesting, SHM, and property enhancement may be considered. Commercialization feasibility study will be important to determine relevance in comparison to current SOA methods.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

Resources are sufficient.

Reviewer 2

Results of the studies being planned at Columbia university is awaited.

Reviewer 3

The team has the adequate capability to conduct the research work.

Presentation Number: mat208
Presentation Title: Efficient Synthesis of Kevlar and Other Fibers from Polyethylene Terephthalate (PET) Waste
Principal Investigator: Daniel Merkel, Pacific Northwest National Laboratory

Presenter

Daniel Merkel, PNNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

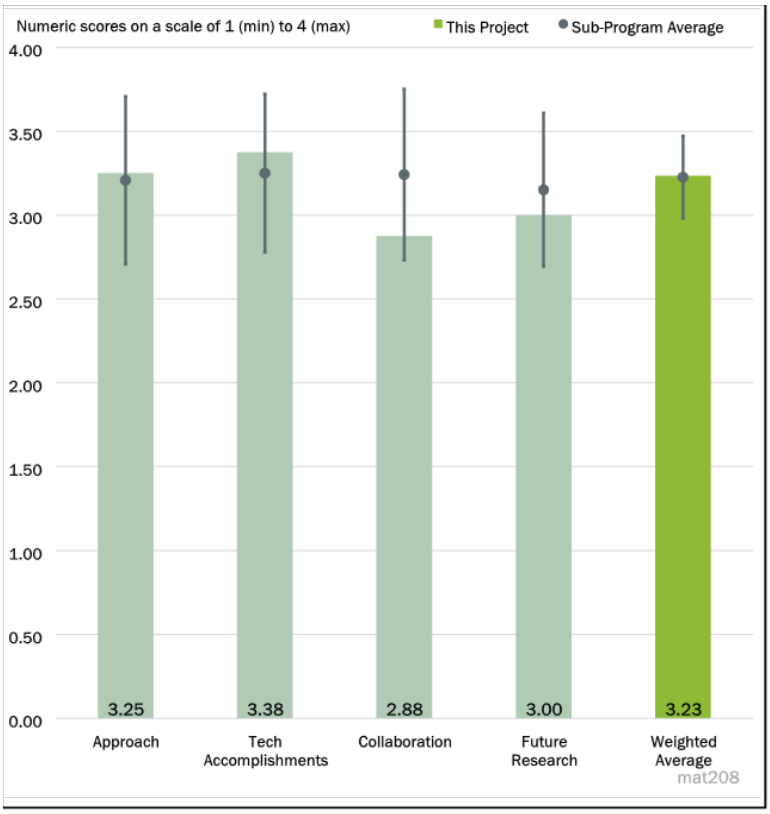

Figure 5-23 - Presentation Number: mat208 Presentation Title: Efficient Synthesis of Kevlar and Other Fibers from Polyethylene Terephthalate (PET) Waste Principal Investigator: Daniel Merkel, Pacific Northwest National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The work had a good approach to use a mixed PET waste stream to synthesize aramid fibers with the potential to lower their cost. Good characterization work has been performed on the synthesized material prior to fiber spinning. All this information is very important to make the fiber spinning tasks successful.

Reviewer 2

The project addressed one of the major issues of fiber-reinforced polymer composites, i.e., the high cost of CF. Replacing commonly used fibers (glass fibers or CFs) with Kevlar-like fibers from PET plastic will help in: (1) creating a cost-effective alternative for carbon-based fibers and matrix and (2) a more sustainable approach because of higher recyclability. The key challenges of this approach will be: (1) developing high-performance fibers continuously without defects, (2) complete deconstruction and repolymerization of PET, and (3) ensuring the minimum hazardous by-products.

Reviewer 3

The approach to preparing kevlar or other fibers from PET waste seems very interesting as it could reduce the cost of fiber production and plastic wastes from the environment. The project team has already demonstrated the synthesis of aramid from PET and optimized the molecular weight by changing the amine structures. However, the major challenge that appeared to the reviewer is to prepare the fiber with optimum properties.

Reviewer 4

The timeline is reasonable; however, the team needs to be on the project timeline on fiber spinning which is critical to the proposed work. The mechanical properties of the fiber are necessity to demonstrate the performance of the materials following refinements. It would be reasonable to cast aramid films and test these to show the materials produced have good mechanical properties. Chemical analysis to show the obtained materials have the proper structure including nuclear magnetic resonance, and Fourier transform infrared or another technique for its purity is necessary in demonstrating the technique can yield high performance materials in the long run. It is noted that irregularities are often desired (see aramos fiber) in aramid fibers and therefore could provide a benefit if reproducible.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The team has quantifiable milestone targets to assess the success of the project. All milestones seem to have been successfully met and the project seems to be on schedule. There has been a slight delay in the fiber spinning task progress including some difficulties with that milestone but that is not surprising for this difficult task. It is good that the team has identified Washington State University as a collaborator to help with the spinning scale up and Oak Ridge National Laboratory to help with the dope characterization. These collaborations should help achieve the spinning milestone.

Reviewer 2

Good progress has been reported in terms of polymerization of various diamines at a small scale and synthesis of Kevlar polymer and other similar branched polymers. A partial successful fiber spinning is also reported but large defects in the fibers remain serious concerns.

Reviewer 3

The team has made good progress on the deconstruction of PET from mixed plastics and the synthesis of polyaramid. It would be great to see more progress on the fiber preparation and its properties, especially fiber with consistent diameters and geometries along the fiber length.

Reviewer 4

It is impressive to see PET recycled with considerable impurities into aramid. It is hard to judge the materials without chemical analysis or mechanical testing and therefore too early to comment on the success but the refinement and polymerization is a very strong accomplishment.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

There has been a good collaboration and coordination across the team. It was good to see that other entities have been involved to help with the spinning process.

Reviewer 2

The roles of ORNL and WSU project partners in this project has been limited and not well-defined as their roles come into the picture later in the project for the delivery of the spinnable polymers from the PET.

Reviewer 3

The team has established collaboration with ORNL and WSU on fiber production.

Reviewer 4

The team needs to have a formalized collaboration.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The future milestones are effectively planned in a logical manner with an exception with the composite milestone. It was not clear how the fibers to be spun at WSU in 40-filament tows will be produced in high-tow lengths in order to combine the tows to get a sufficient fiber loading in the composite. This problem needs to be taken into consideration during the next year beyond this review stage. The cost target for the fibers is yet to be determined fibers although it was stated to be below the cost of CF. The cost of CF is also the milestones for other projects that may create a moving target for this project. This issue can be addressed when performing the techno-economic analysis.

Reviewer 2

The project has defined the most critical future steps, including studying various sulfuric acid and N-methyl pyrrolidone polymer concentrations, composite fabrication, and techno-economics analysis. However, the plan to counter the scale-up process remains to be covered.

Reviewer 3

The project team identified the challenges and demonstrated a future plan to address those issues well.

Reviewer 4

The future work plan needs to be clear and evaluation of mechanical properties is critical to show success. It would be significant if Nomex like properties were obtained although probably not VTO relevant.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This project is very relevant to DOE objectives. It aims to provide fibers for vehicle lightweighting at a competitive cost while also utilizing recycled waste streams.

Reviewer 2

The goal of the project is to develop kevlar-like polymers and fibers from polyethylene terephthalate plastic waste, therefore addressing the high cost and sustainability problem at the same time. Project also plan to study processing techniques for high-performance polymer composites, which is directly relevant to the VTO objectives.

Reviewer 3

The project supports the overall goal of the DOE mission and VTO objectives as their main goal is to prepare alternative CF from PET waste. Most importantly, it addresses the plastic waste pollution that will benefit the society.

Reviewer 4

Kevlar is not widely used in automobile applications and is therefore not a significant material. This could be a very important development with a consideration of the cost reduction in the approach. The issue is not will the cost of the raw materials for Kevlar but in the manufacturing for which the fiber spinning cost needs to be

addressed. Alternative aramid fibers such as Armos (not many people are familiar with this technology developed by Russia in the Cold War) have far greater potential than Kevlar and so may be and considered to create disorder to disrupt hydrogen bonding to improve both processability and properties.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The resources are sufficient to achieve the remaining milestones.

Reviewer 2

The funding amount is sufficient to develop the technologies.

Reviewer 3

The budget is sufficient to meet the current milestones.

Reviewer 4

Funding level seems to be sufficient to excessive without any available budget information.

Presentation Number: mat209
Presentation Title: Bio-based, Inherently Recyclable Epoxy Resins to Enable Facile Carbon-Fiber Reinforced Composites Recycling
Principal Investigator: Nicholas Rorrer, National Renewable Energy Laboratory

Presenter

Nicholas Rorrer, NREL

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

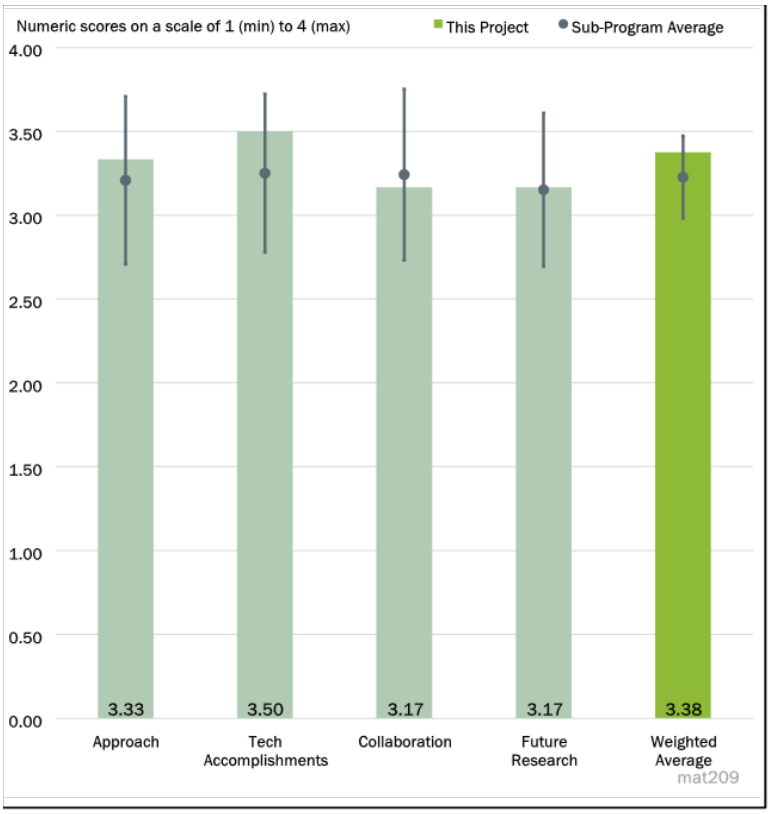

Figure 5-24 - Presentation Number: mat209 Presentation Title: Bio-based, Inherently Recyclable Epoxy Resins to Enable Facile Carbon-Fiber Reinforced Composites Recycling Principal Investigator: Nicholas Rorrer, National Renewable Energy Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The bio-derived approach was well-designed and well-planned to address the technical barriers. The project has a logical approach of developing the adaptable networks, developing fiber sizing, validating the materials at scale, and performing the TEA.

Reviewer 2

The project aims to produce recyclable-by-design CFRCs that leverage a bio-derivable epoxyanhydride covalently adaptable network for better material and environmental performance. For this purpose, the main focus is on resin development and, later on, the demonstration of composite recycling. The approach is satisfactory.

Reviewer 3

The project aims to incorporate bio-based precursors using a covalently adaptable network to reinforce fiber that could lead to re-processible and recyclable lightweight composites for vehicle manufacturing. The project team recycled CF by losing the matrix. It would be more cost-effective if they could recycle both fiber and matrix to make closed-loop recycling.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

All technical accomplishments for this year are likely to be met and the project is on schedule. The TEA and lifecycle analysis (LCA) were excellent to include at this stage of the process to make sure the team is on the right track for commercialization. When reporting on the milestones achieved. It would be good to show the criteria of each milestone when reporting its completion for a better understanding of the metric of success for each. The quantitative target for each milestone should also be considered.

Reviewer 2

Successful resin material development and its recyclability have been demonstrated successfully in fiscal year 21. TEA/LCA also showed promising outcomes from the project. Also, all the milestones before the presentation submission date have been met.

Reviewer 3

The team delivered good results in synthesizing CFRPs and recycling of CF. A good progress has been made on composite scale-up, validation, and cost analysis. Additional results of the matrix mechanical properties and recyclability would be good to consider. One of the matrix components was linear poly(ethylene glycol)-based epoxied which are known to absorb water and can have detrimental effects on vehicle applications.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

There was a good list of collaborators on this project. However, it was unclear what specific collaborative efforts were being performed on this specific project to achieve the milestones. The collaborators listed in the presentation seemed more aligned with larger consortium instead of collaborators specific to this project.

Reviewer 2

Good coordination between the national labs, industry partners, and universities is evident in work. A more task-specific work distribution is needed to discuss the responsibilities of so many partners involved in this project.

Reviewer 3

Good collaboration exists with the National Renewable Energy Laboratory (NREL) It would be great to have industry partners to validate the data and large-scale composite manufacturing.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The future research milestones are logical to address the remaining challenges and barriers that were clearly stated. For future work, it might be good to compare the team material performance to other vitrimers that have been developed instead of comparing to just non-recyclable resins.

Reviewer 2

The project is dedicated to developing a recyclable thermosetting resin system. Thermoforming chosen for the composite manufacturing process which is a thermoplastic composite manufacturing process may not be

appropriate in this project. A complete and clear explanation of the selection of thermoforming manufacturing process thereby should be presented.

Reviewer 3

The proposed future works are demonstrated well. Particularly, the scale-up, and thermoforming of the vehicle part will play critical role for the success of the project.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project supports the overall DOE objectives. It was shown in the TEA that in the second life of the CF would be less than $5 per kg, which is a sought-after goal within VTO to achieve more economical vehicle lightweighting.

Reviewer 2

The goal of the project is to develop materials and processing techniques for high-performance recyclable polymer composites, which is directly relevant to the VTO objectives.

Reviewer 3

This project clearly supports DOE objectives, especially, recyclable composite preparation from biobased feed stock reduces the cost of CF but also the carbon footprint.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The resources are sufficient to achieve the remaining milestones.

Reviewer 2

The funding amount is sufficient to develop the technologies.

Reviewer 3

The resources are sufficient for the project team to achieve the stated milestones in a timely fashion.

Presentation Number: mat210
Presentation Title: A Novel Manufacturing Process of Lightweight Automotive Seats - Integration of Additive Manufacturing and Reinforced Polymer Composite
Principal Investigator: Patrick Blanchard, Ford Motor Company

Presenter

Patrick Blanchard, Ford Motor Company

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

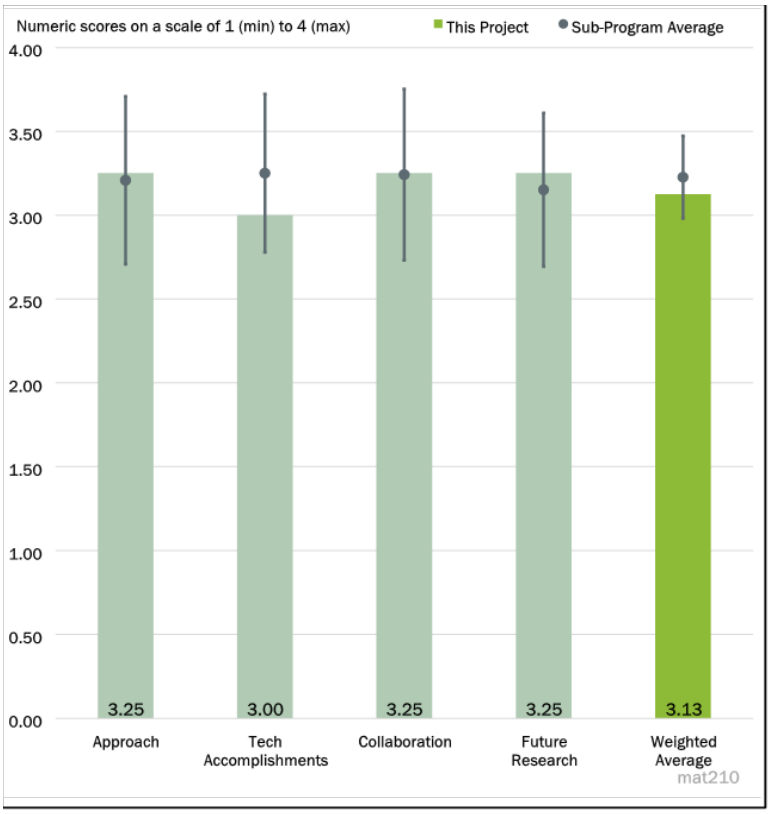

Figure 5-25 - Presentation Number: mat210 Presentation Title: A Novel Manufacturing Process of Lightweight Automotive Seats - Integration of Additive Manufacturing and Reinforced Polymer Composite Principal Investigator: Patrick Blanchard, Ford Motor Company

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project team has identified and addressed the key technical barriers. The lightweight seat design was novel and the timeline is reasonable. The hybrid metal /composite seats are lightweighting and fuel saving.

Reviewer 2

The project team aimed to replace the metal frame with lightweight composites. The project was well designed even though the progress was not enough.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The project has accomplished the milestones as planned. The seat back reinforcement ribs panel is lighter and stronger. The digital image correlation (DIC) mechanical testing identifies high stress/strain concentration sites that in turn helps modify the design and printing.

Reviewer 2

The overall progress was satisfactory despite anticipation of more progress on milestones by the project team.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The collaboration between ORNL and Ford has been going well. The team works closely to optimize the design and processing which will help scale up and improve TRL

Reviewer 2

The project has good collaboration with the Ford Motor Company.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The proposed future research makes sense. The decision points for go/no-go are clear. The scaling plan is reasonable and achievable.

Reviewer 2

This is the final year for this project and so no future research was proposed.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project supports the VTO overall objectives. The hybrid metal/composite seats provide weight savings and design and manufacturing flexibilities. This may be extended to other vehicle structures.

Reviewer 2

The project supports the DOE mission as they intended to develop efficient and sustainable transportation technologies.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

ORNL and Ford have the required resources for the project to achieve the stated milestones in a timely manner.

Reviewer 2

The resources were sufficient to achieve the stated milestones.

Presentation Number: mat211
Presentation Title: Sustainable Lightweight Intelligent Composites (SLIC) for Next-Generation Vehicles
Principal Investigator: Masato Mizuta, Newport Sensors, Inc.

Presenter

Masato Mizuta, Newport Sensors, Inc.

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

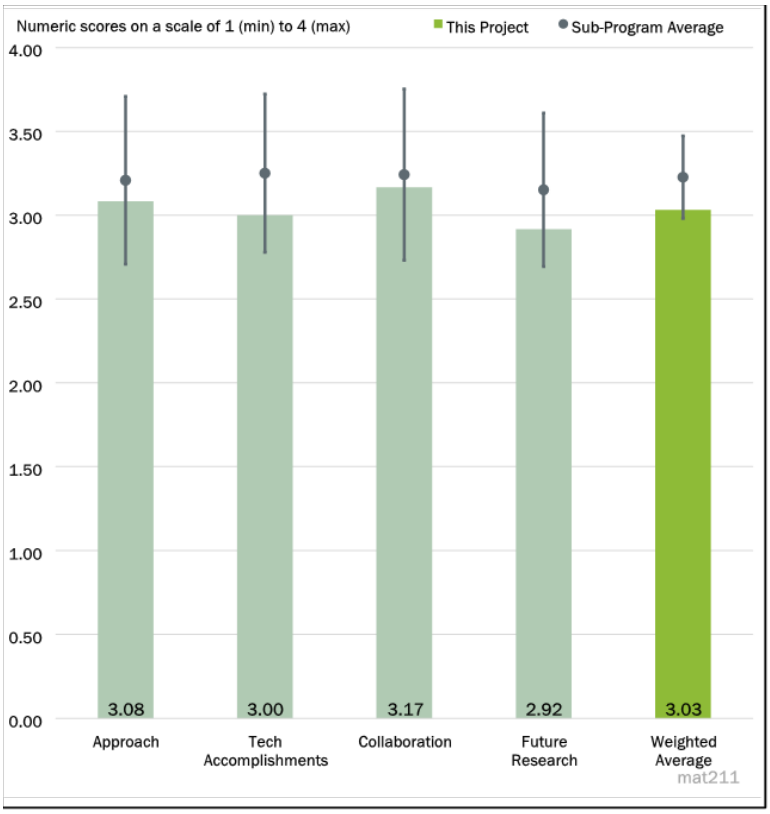

Figure 5-26 - Presentation Number: mat211 Presentation Title: Sustainable Lightweight Intelligent Composites (SLIC) for Next-Generation Vehicles Principal Investigator: Masato Mizuta, Newport Sensors, Inc.

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The work appears to be on track with project timing plan with sufficient progress made on the sensor development. The gateways are clearly defined with quantifiable objectives.

Reviewer 2

The technical barriers were addressed and the project was well-planned. The project lacks novelty as the polyvinylidene fluoride (PVDF) use as a sensor on a composite may not be unique.

Reviewer 3

The approach is well designed to address the VTO requirement to develop a technology to detect damage in composite structures. This includes embedding static and dynamic sensor into a multi-component composite material that can be used in automobiles. The project is in the early stages of development; but the approach allows for scale up to actual automobile components. The ultimate sensing system would be capable of instantaneously detecting stimuli produced by an impact of a foreign object and sending a signal to the automobile onboard computer or to the owner's cell phone. This system is applicable to the next-generation of transportation vehicles as was also evident in project's title. This could be the first step towards developing a technology that could also facilitate the repair of damaged components.

Reviewer 4

The technology to detect damage in CF composites is identified in the referenced 2013 Workshop report as a Technology Gap along with methods to repair damage in CF composites. A comparative performance of the hybrid composite versus current commercial alternatives needs to be addressed for the combination of natural fiber and CF composites in the project claimed to increase crashworthiness and presumably thereby the high-cost issue of CF. The goal of 100% damage detection in CF composites is tied to the goal of reliable repair and the reduction in the overall cost of weight-saving CF composite by detecting and repairing defects to extend the useful lifetime of the composites. It would be good to include strain and impact sensors into a composite or as an adhered layer atop a composite part in this project clearly tied to weight and cost savings through enabling repairs and extending life. Onboard sensing circuits may add weight and adhering sensors onto composite surfaces may interfere with repair of defects.

Reviewer 5

The overall approach is well designed, and the work progress shown in the poster matches the project plans (milestones). The preliminary results show that integrated strain sensor detected the failure and even early signs of the failure. However, it is not clear what challenges (or technical barriers) the team had to overcome in order to achieve the current progress.

Reviewer 6

The approach involving both dynamic and static strain monitoring is theoretically a great idea. However, it is not clear why static strain monitoring is critical. As the dynamic load detecting system is based on PVDF layer applied as the middle layer of the composite structure, it is not clear whether it can be integrated within the whole structure, and subsequently in a scaled up designed part.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The ability of the sensors to detect substrate failure has shown the presence of microcracking after tensile testing. Use of the PVCF film appears to provide advance warning of failure when compared to DIC strain measurement methods.

Reviewer 2

All technical accomplishments have been met and the project remains on schedule. More technical accomplishments were anticipated for the commitment of a significant DOE cost share of the project. The quantitative criteria for the milestones should also be discussed to assess the success of the work.

Reviewer 3

The two-year project is new and work has been performed for only 10 months. Designs of the SLIC system have been initiated. Sample configurations for tensile testing and the test method (ASTM D3039) have been selected. Electronic components for amplifying the signals from the sensors were selected. The initial test setup was tested and successfully measured strain and detected micro cracks in the test samples and identified their location. This progress is very good for the start of this project. Concerns raised by the reviewers remain to be addressed in the next part of the project.

Reviewer 4

A reviewer comment on transitioning to sensors as a coating or layer helps to separate composite production and mechanical performance from sensing and does not create problem for the former with the latter. Strain and failure have been detected with applied sensors, but it is not clear how the detected signals might relate to

phenomena experienced by an installed automotive composite part. Its strain history may enable prediction of fatigue-based lifetime limit. The PVDF piezo sensor was reported to detect microcracks 20 seconds before failure, the value of which depends on strain rate needs to be reported. It is likely that piezo-detected microcracks might be identified and repaired prior to complete failure and thereby save lifetime composite costs by enabling repairs by life extension. The tie to lowering costs of carbon-fiber enabled lightweight materials needs to be explicitly discussed.

Reviewer 5

The researchers manufactured CFRP composites with an embedded strain sensor. The sensor is described as a self-powered device by vibration, but the tensile test remains to be performed with vibration. It was not clear whether there were sensing issues (e.g., noise or insufficient power) when the power was provided from an external source for the test and for the self-powered case in the future.

Reviewer 6

The team successfully fabricated and tested specimens. The hypothesis has been tested using small specimens. The team needs to find out challenges with fabrication of large structures and testing.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

Collaboration across the project partners is shown in addition to roles and responsibilities.

Reviewer 2

A good collaboration between the University of North Texas was established including its role in the project was clear.

Reviewer 3

Collaboration and coordination necessary for only two performers of this project, i.e., Newport Sensors and Univ of North Texas is a minimal effort. The collaboration could be improved by involving a Tier 1 supplier of the materials that would have the sensors embedded and an automotive OEM for integrating the sensor system into body components.

Reviewer 4

North Texas production of the hybrid composite and Newport Sensors testing of sensors appear to be well coordinated. It is not clear about the involvement of Tier 1 or OEMs partners in this project and whether any OEMs will be interested in picking up the technology if the project is successful.

Reviewer 5

Composite manufacturing and testing are done by a collaborator (Univ. of North Texas). The sensor designing and manufacturing are done by the PI team (Newport Sensors).

Reviewer 6

The team involves University of North Texas that conducts fabrication and ASTM testing of specimens. The role of Newport Sensors was not clear and the intellectual property (IP) owner.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

Proposed work plan is satisfactory. However, it would be interesting to understand if the speed of response for the sensing technology could be used to initiate post-crash technologies such as air bag deployment. This would eliminate the need for supplemental sensors that are usually mounted to metallic substrates.

Reviewer 2

The future work is effectively planned in designing and fabricating a miniature bumper beam. More details should be discussed about the design of the electrical system that is needed to collect the signals. It would be good to know what electronics need to be added to the composite since this will add weight and complexity to the composite. More details should also be discussed about how the multifunctional composites will be fabricated in industry in terms of the level of necessary extensive electroding process and its feasibility to achieve in high volume production. A techno-economic analysis would be good to add in future work to assess the feasibility of commercialization.

Reviewer 3

The proposed future research is only for the remaining testing and designs to be performed in the second year of the project. Information is needed about the design approach and materials integration that will be needed for the miniature prototype component and the necessary research and development beyond testing the miniature prototype to transfer the technology to a Tier 1 supplier or to an automotive OEM.

Reviewer 4

It is necessary to consider the sensing function that forms the basis of this project in the fiber composite production. Composite samples for the purpose of only comparing the mechanical properties of the [sensor free] samples to plain CFRP baseline materials may not be meaningful. The scope of production goal to demonstrate novel natural fiber/CF composites with advantageous weight, crashworthiness, or cost, seem unconnected to the scope of monitoring and detecting composite damage. Similarly, production of a bumper from the hybrid material and putting a sensor on it seems like a combination of two different projects. It would be more appropriate to apply the sensor to a standard composite bumper with well characterized performance to evaluate the sensor and disconnect the natural fiber hybrid composite development from the sensor development.

Reviewer 5

The team plans to combine an energy-harvesting feature with the sensor system. As in the previous years, the energy-harvesting feature has already been developed in their earlier version of the sensor system, so the plan future plan seems achievable.

Reviewer 6

Additional details are necessary for the future research stated plan of completion of remaining specimen testing.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The sensing work is aligned to VTO's mission of promoting lightweight materials technology for automotive applications.

Reviewer 2

This project is relevant to the overall DOE objectives as it focuses on vehicle lightweighting to reduce GHG emissions.

Reviewer 3

This project supports and is relevant to the overall VTO subprogram objective to develop technologies that rapidly detect damage after impact based on non-destructive evaluation approaches. This requirement is described in the Light Duty Vehicles Technical Requirements and Gaps for Lightweight and Propulsion Materials Report.

Reviewer 4

Hybrid composites have the potential to combine the contrasting performance and cost benefits of natural fiber composites with those of CF composites. This could help address objectives relating to the cost of liqhtweighting. Detecting damage in fiber reinforced composites is relevant to the goal of lowering the cost of lightweight composite materials if it can be tied to extending use lifetime through combination with repair technology. Detection of damage alone may make composite cars safer by alerting drivers to repair or replace before failure, but only saves costs if repair is more efficient than replacement.

Reviewer 5

The project is highly relevant to VTO objective, because the goal of this project is to develop materials for vehicle applications.

Reviewer 6

This is an important topic and relevant to VTO subprogram objectives.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

There appears to be sufficient resources to complete all outstanding tasks based upon the partner collaboration.

Reviewer 2

The resources are sufficient to achieve the remaining milestones.

Reviewer 3

The project funding is $1.1M for only two performers, i.e., a company and a university for 24 months. This funding level seems excessive to incorporate already developed sensors into existing composite materials and perform minimal laboratory tensile, bending, and impact testing.

Reviewer 4

Spending is behind schedule. Resources might be focused on commercial scale sensor development and connection with damage repair instead of production of and testing of composite coupons and bumper independent of the targeted sensors. Partnering with a Tier1, molder or OEM to obtain parts for testing with the sensors and development of strategy for sensor-enable repair decisions would be a good future plan.

Reviewer 5

The funding is sufficient. The project is in its 30% progress mark point for the $1.1 million in funding. With the budget so far, they developed two sensor systems and made polymer composites integrated with a strain

sensor. Technical details of the sensors and challenges for composite manufacturing with the sensor need to be included in the presentation.

Reviewer 6

Total budget of $1.1 million appears excessive in comparison to the volume of work shown.

Presentation Number: mat212
Presentation Title: Integrated Self sufficient Structurally Integrated Multifunctional Sensors for Autonomous Vehicles
Principal Investigator: Amrita Kumar, Accelent Technologies, Sunnyvale

Presenter

Amrita Kumar, Accelent Technologies, Sunnyvale

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

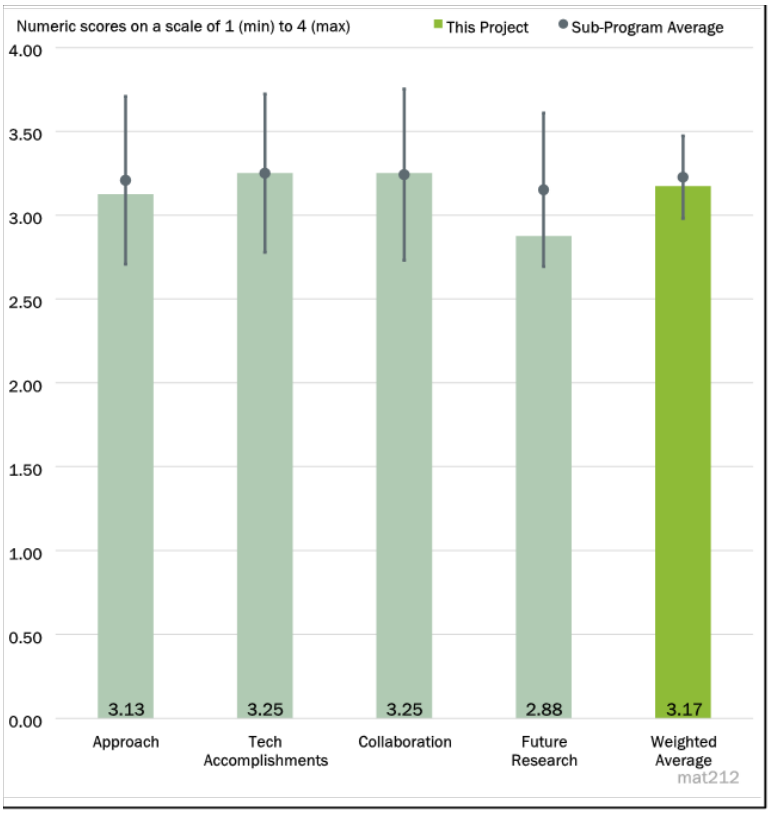

Figure 5-27 - Presentation Number: mat212 Presentation Title: Integrated Self sufficient Structurally Integrated Multifunctional Sensors for Autonomous Vehicles Principal Investigator: Amrita Kumar, Accelent Technologies, Sunnyvale

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The post application of sensor to components appears to be a viable approach. However, the cost of application remains a concern in addition to the durability of termination methods. It would be beneficial to understand what the total installation cost would be for such a system if implemented on the bumper beam as described.

Reviewer 2

The approach is to develop two monitoring systems, i.e., pedestrian impact with the front bumper and battery life, both of which would be integrated with the automobile's onboard computer system. These systems will provide functions beyond other systems and materials for load carrying of automobile structural components. The project is in its second phase and the plan is to work with an automobile OEM to test the monitoring systems in prototype components over the 2-year performance period. This approach is well designed to achieve the goals of testing prototypes, and the timeline is well planned to achieve these goals and provide the data that the OEM will need to accept the monitoring systems in future automobile designs.

Reviewer 3

The project purports to reduce weight and cost of vehicle composites by providing composite functionality in addition to load carrying. Reference is made to partner Stanford University ARPA-e fund work to develop

structural composites that provide energy storage. Aerospace-focused technology in this project now will be extended to automotive composites in Phase 2. Such technology might save vehicle weight by incorporating energy storage into structural components thereby reducing the separate energy storage component requirement on the vehicle. The results and plans for the automotive composites applications effort need to be detailed in the poster and under the listed proposed future work items. The focus of this work on pedestrian contact detection and battery charge status monitoring needs to address also the DOE priority and industry technical barriers of material cost and manufacturing throughput to reduce fuel consumption and greenhouse gas emissions.

Reviewer 4

The team lays out a clear need for developing smart detection systems and two very applicable scenarios for detection systems relevant to batter applications. The approach has been described well by a description of their experiments with figures and data.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The team has made good progress in testing the sensor capability in a real-world application.

Reviewer 2

The project has been performing for only10 months. Sensors have been selected and sensor networks have been designed to be used in testing for the pedestrian protection system. A prototype plastic bumper from the OEM was received and sensors were installed. The test setup has been selected and algorithms were developed for detecting impacts and preliminary tests were conducted. Development of the battery monitoring system was initiated and tests are being designed in collaboration with Stanford University. Progress is in accordance with the plans outlined in the Approach and is outstanding for the short period of performance.

Reviewer 3

Sensor response to artificial leg versus response to weight were characterized toward discriminating pedestrian impact from non-pedestrian impact. Considering the variety of ways that a human might present to a vehicle during impact, it is difficult to believe that the nature of the piezo sensor response will be able to discriminate human vs non-human impact in a meaningful way. It is not clear how success in this effort and by Standford University partners will increase use of weight-reducing composites in vehicles. Stanford University partners monitored the charge characteristics of a battery with an attached piezo sensor.

Reviewer 4

The project team has acquired and built a wonderful testing setup for this work and are developing methods to speed up sensor response time. All tools seem to be in place for future success.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The presentation shows a clear collaboration with the OEM leading to experimental verification of the technology under development.

Reviewer 2

The team consists of a Tier 1 supplier, an automotive OEM (Ford), and an academic institution (Stanford University). Collaboration and coordination appear well developed and continuous for the development and testing of the systems. It is appropriate to have an OEM involved in the component tests and a university involved in the battery health monitoring system concept. Addition of a National Laboratory with experience in automotive systems as a consulting collaborator would possibly minimize any risks in the design and testing of the system.

Reviewer 3

Collaboration with technology-provider Stanford University and OEM Ford strengthen the project team and a case for interest in the project outcomes. An additional key partner such as part fabricator or Tier1 supplier for the implementation of the developed technology would be useful.

Reviewer 4

The collaborations are established, including relevant IP rights, and have resulted in the procurement of bumpers for their testing. It seems that work with collaborators is yet to be started.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The proposed work plan is clearly defined and will allow a complete technical and commercial evaluation of the technology at the conclusion of the project.

Reviewer 2

The slide on future research should also address the research beyond the current project besides what will be done for the remainder of the project. Completion of a pedestrian protection system and a battery monitoring system are expected deliverables, although the pedestrian system is a second level of sensing and warning that complements technologies for collision warning systems in currently produced automobiles. Commercialization plans and cost targets is a great final deliverable for this project. Development of a unified multifunctional sensing system for cars could possibly be research required beyond the current project but details are necessary.

Reviewer 3

The future work addresses well to include the consideration of commercialization plans and cost estimates. However, the mentioned part of the project that directly addresses DOE technical barriers of cost/weight reduction, development of integrated structural/energy storage composites, needs to be mentioned in the proposed Future Work. On the other hand, current focus remains for future work on pedestrian detection and battery charge monitoring. A clear connection needs to be made between these goals and achieving DOE targets for reduced energy usage and emissions from lightweighting.

Reviewer 4

Some of the ongoing work seems to be a part of the future work, but multi sensing integration is very relevant future work. It might be good to understand the alternative options of the current detection, if there are any, and how that may inform future work.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

The technology under development promises to be a key enabler to using lightweight composite components in future vehicle applications.

Reviewer 2

This project supports the overall VTO subprogram objective to provide functions beyond other systems for monitoring of structural automobile components as described in the Light-Duty Vehicles Technical Requirements and Gaps report.

Reviewer 3

The project tangentially supports weight reduction through potential combination of energy storage and structural function, but the primary focus elements of making autonomous vehicles safer and battery maintenance more efficient may not be directly relevant to lightweight material goals.

Reviewer 4

The project seems aligned both with the sup program and has implications to other programs, such as detection in batter systems.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

An excellent team leading the project by leveraging their own resources but also receiving OEM guidance on the relevance of the technology. Available resources should be sufficient to make a final evaluation on the technology viability.

Reviewer 2

The $1.14 million of DOE funding over 2 years is sufficient for the three collaborating activities to develop the two systems described in the presentation. The performer, the original equipment manufacturer (OEM, and the university have sufficient resources to complete the design and testing of both systems.

Reviewer 3

The project appears underspent and the majority of budget is still available.

Reviewer 4

The project appears to be on track with adequate resources.

Presentation Number: mat215
Presentation Title: Short Fiber Preform Technology for Automotive Part Production
Principal Investigator: Dirk Heider, Composites Automation, LLC

Presenter

Dirk Heider, Composites Automation, LLC

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

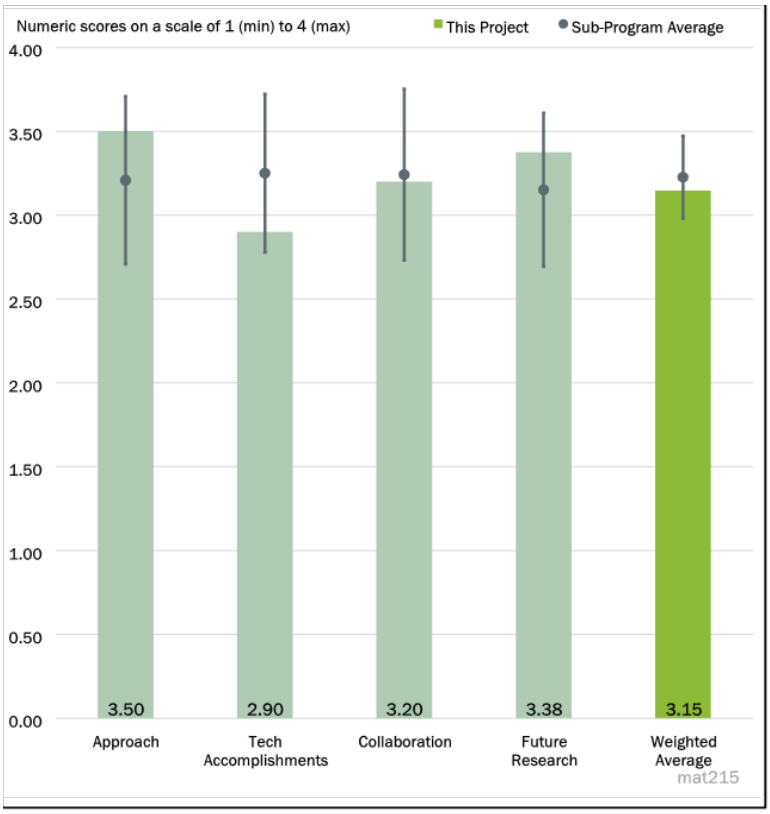

Figure 5-28 - Presentation Number: mat215 Presentation Title: Short Fiber Preform Technology for Automotive Part Production Principal Investigator: Dirk Heider, Composites Automation, LLC

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This project is clearly focused on development of high throughput, cost saving techniques for high performance carbon fiber composite production, including those capable of incorporating recycled fiber. This focus addresses DOE and industry technical barriers of material cost and manufacturing throughput for carbon fiber composites.

Reviewer 2

This reviewer stated that the use of recycled/waster carbon fibers hybrid with glass fibers is excellent. That approach addresses the needs of sustainability as well as cost competitiveness.

Reviewer 3

According to this reviewer, the poster was not presented in a way that made it easy to ascertain information on the process or project. The reviewer intimated that the poster was more like a set of PowerPoint slides put together in random order rather than a cohesive presentation. The reviewer further stated that while this comment may not seem applicable to the approach of the work, it applies to all the questions included in the review.

The reviewer believed that the presentation had omitted too much information to enable actually understanding the process and how the PIs are achieving the target performance. That being said, the reviewer stated that the modulus of their materials is impressive and that the wet compression approach seems to result in the best properties. The poster showed a lack of definition regarding cycle time, which is one of the project's main goals. The reviewer indicated that this section is scored higher as the overall approach to work in using waste or recycled fibers is strong.

Reviewer 4

According to this reviewer, the processing methodology for incorporation of recycled carbon fiber reinforcements promises to provide a lower cost preforming option. The reviewer stated, however, that it is not clear how much shape complexity can be achieved with this material format, particularly when considering out-of-plane features such as ribs.

Reviewer 5

The technical barriers are addressed well but the overall configuration of the slides is very confusing. The slide numbers are not in order. The slide number should increase like 1, 2, 3, …, final slide. Instead, the slide number changes as 1, 12, 11, 10, 9, 8, …, 2. Also, the font is blurry and the pictures are in low resolutions.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer stated that, while the poster presentation was not perfectly clear, the project team seems to be accomplishing excellent performance and moving into commercialization trials.

Reviewer 2

This reviewer found that the team made progress on validating some of the scalability issues. However, the reviewer believed that it is not clear whether a significant advantage over existing commercially available short fiber products such as a carbon fiber based sheet molding compound would remain after scaling. The reviewer stated that there is also no mention of lass transition temperature (T_g), which could be a barrier depending upon where parts are installed during the assembly process (i.e. body shop versus trim and final).

Reviewer 3

This reviewer referenced prior comments and said that too many data have been omitted or not provided in a digestible way to assess performance. It was apparent that the tailorable universal feedstock for forming (TuFF) process results in robust composites, but as the goal of the work is to reduce cost or time, some of that data needs to be provided.

Reviewer 4

This reviewer stated that the project plan and accomplishments are difficult to ascertain from the submitted poster as it is an image consisting of several slides copied and pasted from another presentation in apparent random order to create a poster. The reviewer noted that slides are numbered, but not in the order in which they are shown and some slide numbers are missing.

The reviewer believed that the plan for the recent period was apparently to produce material for testing and to create a full database of properties as well as to work on commercialization. The reviewer does not see any

report of progress on production, testing, or commercialization. The reviewer mentioned that these activities were undertaken, but one does not find them reflected in the chaotic poster.

Reviewer 5

This reviewer stated that the slide contents are the same as last year's slides, indicating that the progress over this year has been minimal. For example, according to the reviewer the work involving fabrication of TuFF preforms with different fibers is shown in this year's presentation as it wash in last year's presentation; mechanical performance of waste fiber composite is shown in this year's presentation, and the same result was shown in last year's presentation; complex geometry TuFF forming demonstration is shown in this year's presentation, and the same demo was shown in last year's presentation; The close-up photos showing complex features in this year's presentation are the same as in last year's presentation. Because of this, the reviewer could not identify the new developments and progress in the project.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer found that collaboration appears a strength of this project, between small business technology provider, university, OEM, resin and fiber suppliers, and industry groups.

Reviewer 2

This reviewer stated that the team's collaboration is excellent, which sets a path for commercialization.

Reviewer 3

This reviewer said that collaboration across the partners has been clearly demonstrated.

Reviewer 4

This reviewer, while noting that Composites Automation is leading the project, partnered with the University of Delaware, the role of each organization is not clear.

Reviewer 5

According to this reviewer, the project team has collaborators listed, but it is not clear who does what or how that has led to success in various components of the project.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer said that the project is ending in a couple of months and that the team has achieved most of the original targets and explained plans for the remaining effort.

Reviewer 2

This reviewer concluded that the plan of hybrid layups and the proposed demonstration seems to be work worth pursuing.

Reviewer 3

This reviewer concluded that the team has completed most of the project and that its future plan is good.

Reviewer 4

This reviewer noted that the remaining portion of work is well defined, although automotive applications may be limited due to the shell style construction of molded parts because efficient designs in composites usually incorporate ribbing and other features that can be molded to enhance section stiffness. The reviewer believed that this does not appear to be easily achieved using the TuFF materials.

Reviewer 5

This reviewer has not found a Future Work section in the materials provided, stating that the project period appeared to end at August 2022, while the Phase2 proposal was submitted in April 2022.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer stated that the technology is aligned with VTO's mission for the development of lightweight materials for automotive applications

Reviewer 2

This reviewer noted that the project focuses on the primary priorities of the VTO Lightweight Materials Subprogram: reducing the cost of carbon fiber composite materials and of production methods and increasing production throughput.

Reviewer 3

The reviewer said that the team developed a composite manufacturing technique for recycled and waste fibers, which is highly relevant to the VTO Materials program.

Reviewer 4

This reviewer stated that the re-use of fibers, especially those that might not immediately maintain their orientation, is highly interesting and necessary for the field at large.

Reviewer 5

This reviewer stated that the project is highly relevant to VTO.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

Sufficient resources have been deployed which have since led to the submission of a follow up Phase IIB application.

Reviewer 2

The reviewer stated that the project appears to have concluded.

Reviewer 3

This reviewer believed that the resources are sufficient for the project.

Reviewer 4

This reviewer assessed that the project is progressing at a reasonable pace with adequate resources.

Reviewer 5

This reviewer said that the resource are sufficient.

Presentation Number: mat216
Presentation Title: Low Cost Resin Technology for the Rapid Manufacture of High-Performance Fiber Reinforced Composites
Principal Investigator: Henry Sodano, Trimer Technologies, LLC

Presenter

Henry Sodano, Trimer Technologies, LLC

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

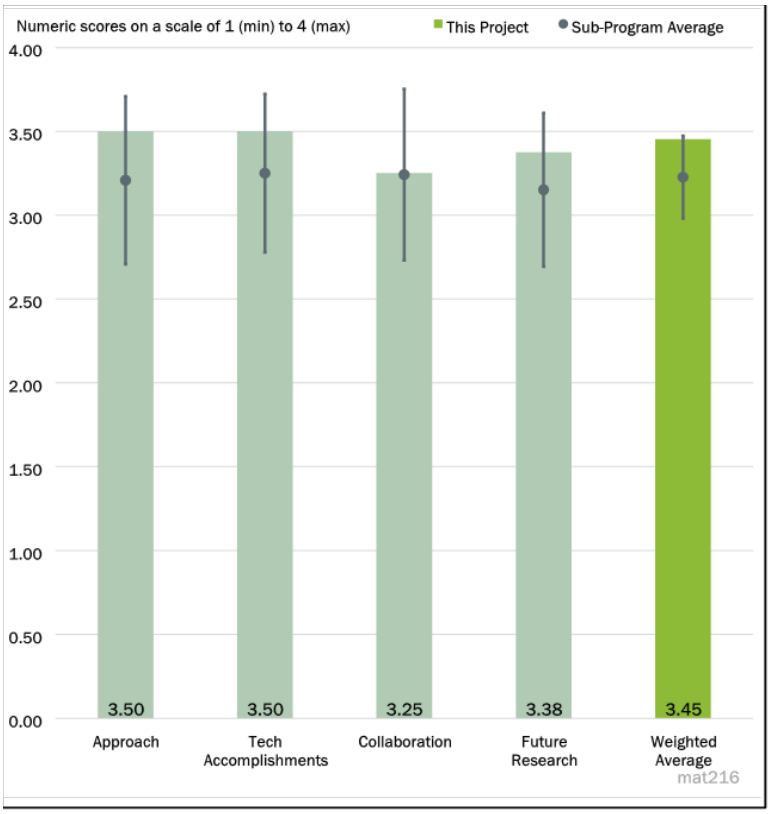

Figure 5-29 - Presentation Number: mat216 Presentation Title: Low Cost Resin Technology for the Rapid Manufacture of High-Performance Fiber Reinforced Composites Principal Investigator: Henry Sodano, Trimer Technologies, LLC

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer stated that this project focuses on development of a high performance resin for carbon fiber composites that has a very rapid cure time to facilitate high throughput production of carbon fiber composite parts. It includes comparisons with relevant baseline resins and evaluates many important cure and performance characteristics. The project work is being performed through partnerships with an industry group, a molder and an OEM. and are evaluated.

This reviewer stated that the only thing not seen to be addressed is the anticipated cost and availability of the novel resin. The reviewer questions whether its appealing performance will be cost prohibitive to make an impact on DOE goals, even with rapid cycle time?

Reviewer 2

This reviewer noted that the team has thermoset resin that can provide a fast cycle time via rapid curing chemical kinetics. Using the resin, the team manufactured composite panels and performed mechanical tests as well as environment tests. He judges the project to be well designed.

Reviewer 3

This reviewer found that the work seems very strong in that the team has developed a low cost, fast cure resin that results in robust composites. The amount of material property testing performed, with the team's systems is impressive . The reviewer found it hard to assess the team's approach as the presentation did not disclose any information about the resin's or composites 'chemistries, only that it meets the target specifications. As different resins have concerns with safety the chemical information should have been provided. Moreover, there may be other benefits from the chemistry. In one section the results were compared to Crestapol, a urethane acrylate, which has ester linkages, suggesting possible recyclability. Additionally, the chemistry often informs the approach, making it useful for evaluating it.

Reviewer 4

This reviewer stated that, while the detail has not been disclosed, the trimer yields rapid cure thermoset resins with high mechanical performance, along with flame retardancy. He states that the approach is promising, and will meet various needs of composite materials.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The reviewer said the amount of testing and demonstration of fast cures is simply impressive. The reviewer said prior comments about a lack of chemical detail is still valid; however, the data provides clarity.

Reviewer 2

This reviewer found that the team's thermoset resins allow rapid cure, with mechanical performance as high as 105 MPa tensile strength, which is very good. The tensile strain is 4%, which indicates that their brittleness is handleable. It also shows flame retardancy without additional additives. This technology shows promise and can address some needs in vehicle applications.

Reviewer 3

This reviewer stated that the poster is 90% identical to the poster shown at the 2021 VTO AMR, with the differences being the addition of Ford as a partner, production at Institute for Advanced Composites Manufacturing Innovation (IACMI)- Scale-Up Research Facility, and achievement of faster cure time. The demonstration of thirty seconds improvement in thick part curing from 120 seconds to 90 seconds is impressive and good progress.

Reviewer 4

This reviewer said that the team showed high mechanical performance results of the composite made with its resin as compared to another fast curing resin. The reviewer said that the team claimed that its composites have higher performance than composites with an aerospace resin (Hexcel 8552), but those data are not shown in the presentation. The reviewer said that the major issue of this presentation is that it showed no progress or difference from the last year's presentation. According to the reviewer, all the results and figures and data in this year's presentation are the same as those in last year's presentation.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer states that the collaboration with a molder, an OEM, and the composite industry incubator well position the development resin technology for commercialization.

Reviewer 2

This reviewer noted that the team has various collaborators for the application of this technology.

Reviewer 3

This reviewer noted that the team listed IACMI, Ford, and TOP as partners, but finds the roles of the partners to be not clear.

Reviewer 4

This reviewer noted that there are collaborators in place but the division of work is not apparent.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer said that the proposed investigation of resin scale up and component level testing is clearly relevant and necessary for understanding cost and commercialization potential and for attracting commercial partners.

Reviewer 2

This reviewer found that the component testing and resin scale up is needed but that it is hard to comment on the scalability of the resin with no details about its chemistry (even its material class)._

Reviewer 3

This project is almost at the end. With the current data, the team have a promising path for commercialization.

Reviewer 4

This reviewer pointed out that the time remaining until the project end date is limited, but the future plans do not require significant efforts. Therefore, the team will likely accomplish the plans.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer states that slow curing has been a persistent barrier for carbon fiber composites for vehicle applications. Development of a high performance, rapid curing resin for fiber reinforced automotive components directly supports VTO lightweight material subprogram objectives for enabling increased use of weight-saving carbon composites on vehicles.

Reviewer 2

This project utilizes a fast curing resin for short cycle time in composite manufacturing. Therefore, it aligns well with the VTO material subprogram's objectives.

Reviewer 3

The work focuses on making robust lightweight materials with short cycle time and thus is highly aligned with office goals.

Reviewer 4

This is highly relevant technology for VTO.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer states that milestones of sufficient mechanical performance and reduced cure time have been met but proposed future work, including scale up and component level testing, may require additional funding and time beyond this project, which ends 8/2022.

Reviewer 2

This reviewer says that the funding is sufficient for the project.

Reviewer 3

This reviewer says that the team has made fantastic progress with the current budget.

Reviewer 4

This reviewer says that the resources are sufficient.

Presentation Number: mat221
Presentation Title: Lightweight and Highly-Efficient Engines Through Al and Si Alloying of Martensitic Materials
Principal Investigator: Dean Pierce, Oak Ridge National Laboratory

Presenter

Dean Pierce, ORNL

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

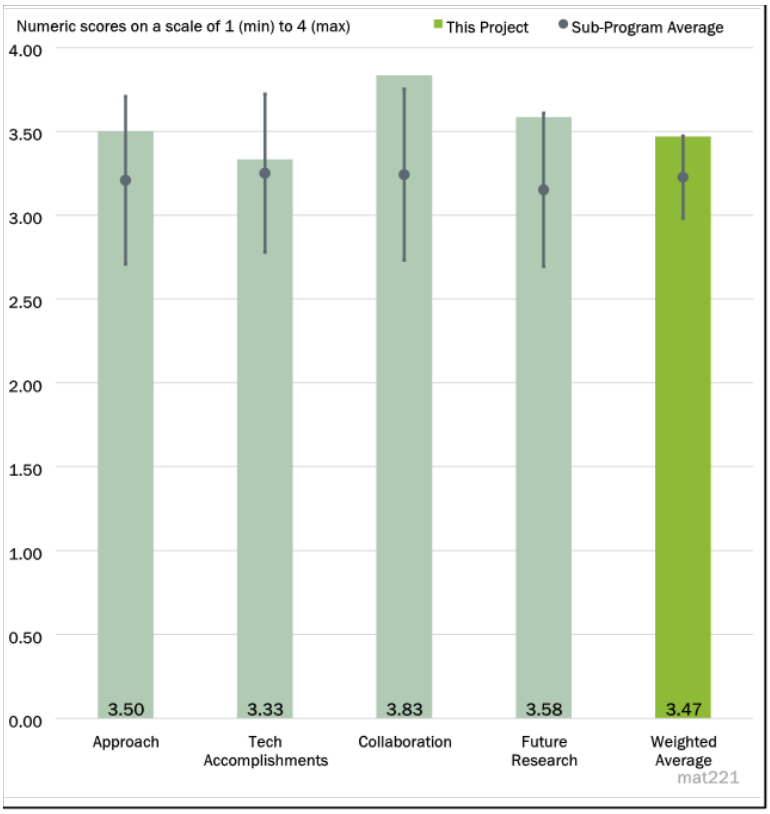

Figure 5-30 - Presentation Number: mat221 Presentation Title: Lightweight and Highly-Efficient Engines Through Al and Si Alloying of Martensitic Materials Principal Investigator: Dean Pierce, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer found the presentation gave a clear description of the challenge with the trade-off between mechanical and thermal properties. Integrated computational materials engineering (ICME) design of alloys is a real strength of this project.

Reviewer 2

This reviewer notes that the project has considered the development of new higher-temperature alloys at lab-scale in the first 2 years, with the focus shifting to scaling up the alloy processing and manufacturing of prototype pistons for engine testing in the third and fourth years. Entering the final year, the project has seen significant progress in the scale- up activities and is now focusing on manufacturing prototype pistons with industry partners. The reviewer believes that many technical barriers have already been overcome and remaining challenges are well addressed, with a reasonable timeline for the manufacturing and engine testing planned for the final year. The reviewer pointed out that there was no discussion of tests of the oxidation resistance of the scaled-up alloy in the future plans described in the slides, but it was mentioned verbally that these will be undertaken. Such oxidation tests, according to the reviewer are viewed to be an important addition to the planned work.

Reviewer 3

This reviewer stated that the overall effort leverages the concepts of computational materials design with good old-fashioned physical metallurgy for a specific need within ICE.

Reviewer 4

This reviewer believes that working to improve the efficiency of HD vehicles is paramount in lowering carbon emissions in the short term, as there is no current strategic consensus on how to move freight using battery electric vehicles. Other types of propulsion systems require infrastructure that is not present or easily available. So, the reviewer believes that this offers a real opportunity to improve the environment.

Reviewer 5

This reviewer states that the scope and approach for the planned work has been well laid out. There are several technical barriers such as the machinability/weldability, creep, corrosion performance and cost of the alloys. Some of the results were not reported, so the reviewer believes that it is difficult to make a judgement as to whether the technical barriers have been fully addressed or not. In terms of progress, the most promising alloy has been down selected and has been fabricated at high temperatures. The alloy is yet to be tested in an engine environment. The other challenge that needs to be addressed is the manufacturing of the piston prototypes.

Reviewer 6

Slide 2: This reviewer believes that the key barrier to the subject technology is thermal fatigue at the sharp corner of the bowl rim, which is not mentioned in the presentation. This is the specific reason why steel is used. The project needs to include testing for thermal fatigue with samples that have sharp corners.

Regarding Slide 8, the reviewer understands that the authors do not wish to disclose the alloy compositions. However, the approach for alloy development should be mentioned considering 35 alloy chemistries were made. What are some of the alloying elements used and ranges etc. The reviewer asked was this a design of experiments of some sort with some prior knowledge of effects of the alloying elements.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer observed that the ability to create in-cylinder components that can allow further increases of cylinder pressures and higher cylinder temperatures has been shown clearly to be a lever to decrease emissions and increase power density. The reviewer states that this project offers the next logical extension to this process by enabling the move even further up in both these critical parameters.

Reviewer 2

This reviewer found that the team had made excellent progress including the identification of an alloy for scaleup in the first 2 years leading to a worldwide patent application submission. The reviewer anticipates successful scale-up in year 3, with initial steps completed towards piston manufacturing, which will be continued in the final year.

Reviewer 3

This reviewer found that, overall, the progress has been excellent and 75% of the work is complete. However, as the reviewer discussed above, a couple of key items on the engine testing and manufacturing aspects for

pistons remain to be completed. Several project activities listed need to be completed by April 2023, which the reviewer believed could be a bit challenging.

Reviewer 4

This reviewer believed that upscaling of the down-selected alloy is very exciting. Fatigue life is very encouraging. However, even if the actual thermal conductivity values cannot be shown, it is important to at least discuss them or show data without numbers as was done with fatigue life, since a major point was made of the tradeoff between mechanical and thermal properties. It would be good to show the FEA predictions of how the new alloy will perform. Oxidation testing of the scaled-up alloy would be very important.

Reviewer 5

The reviewer said regarding Slide 11, the need to not disclose any details makes it difficult to determine the extent of actual improvement. The reviewer also pointed out that only six fatigue data points are shown and asks if the fatigue samples are polished and what the fatigue initiation sites for the three that failed are. The reviewer asked whether some Alloy 4140 and micro-alloyed steel (MAS) data could be added to put the alloy data in perspective.

The reviewer found the data and information provided to be sparse considering that the project started in 2019, asking if there has been any microstructural work.

Reviewer 6

This reviewer found the technical accomplishments thus far to be considerable in terms of showing promise but without really demonstrating success against defined targets. The reviewer questions why program milestones cannot be released, saying that it makes the evaluation of program progress considerably more difficult. According to the reviewer, alloy 4140, for its part, is not an overly exotic alloy or even an exotic steel. The reviewer concludes that cost is clearly a strong consideration, which is why more capable and proven alloys are not already being utilized. He states that clarifying the effort relative to the present limitations of the state-of-the-art (even if qualitatively) would be helpful.

The reviewer notes that Slide 11 shows exceptional fatigue strength, but no baseline fatigue value (or even a direct comparison with Alloy 4140 within the 4140 operating range) is provided.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer states that the team has developed a productive collaboration between ORNL, Cummins and Mahle, with clear delineation of the synergistic tasks to be led by each partner being well identified.

Reviewer 2

This reviewer says that the team at ORNL has clearly been working with a large team at Cummins, and this collaboration increases the opportunity for innovation and novel solutions.

Reviewer 3

This reviewer notes that the effort has been divided among the partners based on their expertise and capabilities. Alloy production has been completed at the national lab and now the characterizations/manufacturing/engine testing will be conducted at the industry partners. Based on the progress so far, the project team has been functioning well in their roles.

Reviewer 4

This reviewer found a good balance of work across lab and industry partners (Cummins and Mahle).

Reviewer 5

This reviewer believed that the involvement of both Cummins and Mahle is an excellent reflection on the efforts of the proposal group to build a strong team with a significant industrial component.

Reviewer 6

This reviewer says that the collaborators are well engaged, based on Slides10 and 15.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer anticipated that bringing Mahle on-board with the team will further increase the team's knowledge and capability, and this will offer greater opportunities for a true commercial success from this important research.

Reviewer 2

This reviewer said that the future work and its purpose for achieving the goals of the project are well defined. Excellent progress made in scale-up and initial steps toward manufacturing suggest that the team is likely to achieve the remaining targets in the final year.

Reviewer 3

This reviewer opined that if manufacturing and testing are the largest remaining barriers to relatively short-term success, then the project overall has done well. The other more obvious barriers have been overcome.

Reviewer 4

This reviewer pointed out that future work is clearly outlined and is mostly development focused but asks if any modeling will be done?

Reviewer 5

This reviewer noted that future work will focus on the manufacturing of prototypes for engine testing and that the details on these activities were quite limited in the presentation, perhaps, due to IP related concerns. Nevertheless, future effort will primarily be carried out by the industry partners who have significant experience in the area, and risks for completion of the work are low.

Reviewer 6

This reviewer says that the future work seems reasonable.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer found that the project supports the objectives in the Propulsion Materials portfolio associated with enabling increased operating temperature and engine efficiencies in HD diesel engines. It advancing these goals through an alloy design effort that is responding to specific requirements that include increased high-temperature strength, fatigue and oxidation resistance.

Reviewer 2

This reviewer said that the work is clearly an immediate need and has potential to provide the type of benefit the DOE seeks with VTO efforts. The bridge between electrification and the short and intermediate term needs of heavy transportation is nicely defined.

Reviewer 3

This reviewer found the project to be clearly aligned with Energy Efficient Mobility Systems, and should contribute to the successes in that program.

Reviewer 4

This reviewer stated that the project well supports a class of engines that will continue to rely on internal combustion for some time into the future.

Reviewer 5

This reviewer stated that there are challenges with electrification of heavy duty vehicles and ICEs are still the most viable option. Development of new engine high temperature alloys will allow for increased engine temperatures/pressures and fuel efficiency. In this regard, the project is well aligned with the VTO's Materials technology program objectives.

Reviewer 6

This reviewer believed that the work is very relevant, due to the difficulty of electrifying long range transport vehicles.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer pointed out that Mahle has been brought in as a partner for the manufacturing efforts, enhancing the resources of the project.

Reviewer 2

This reviewer noted that the resources are bolstered considerably by the impressive industrial cost share.

Reviewer 3

This reviewer believed that the project seems to be well resourced and is well represented by their accomplishments and planning, including a clear focus on future work

Reviewer 4

This reviewer found that the resources appear adequate for the project.

Reviewer 5

This reviewer pointed out that the project is a Lightweight Materials Consortium (LightMAT) project with industry partners. Cummins and Mahle. The effort and the resources are available amongst all the partners for successful completion of the project milestones.

Reviewer 6

This reviewer said that the resources provided are reasonable for the proposed work.

Presentation Number: mat222
Presentation Title: Extending Ultrasonic Welding Techniques to New Material Pairs
Principal Investigator: Jian Chen, Oak Ridge National Laboratory

Presenter

Jian Chen, ORNL

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

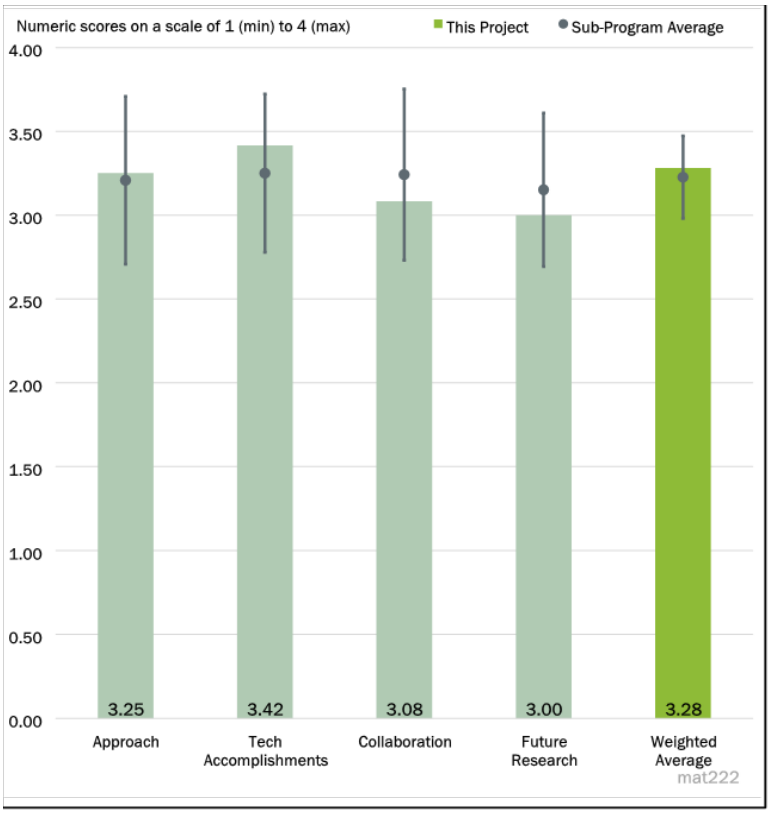

Figure 5-31 - Presentation Number: mat222 Presentation Title: Extending Ultrasonic Welding Techniques to New Material Pairs Principal Investigator: Jian Chen, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer said that the project objectives and timeline are reasonably planned, and the team is on track. The project plan addresses major challenges to multi-material joining.

Reviewer 2

This reviewer said that Jian Chen is doing a good job and that the program is well defined with real life applications.

Reviewer 3

This reviewer stated that the project approach seems novel as past attempts with conventional approaches have been unsuccessful to ultrasonically weld large parts. This project used a model-based engineering strategy to guide the development of a new process using multi-scale modeling, ultrasonic joining processes, in-site measurements, and post-weld characterization.

Reviewer 4

This reviewer stated simply that the project attempts a model based engineering approach to extend ultrasonic welding to new pairs of materials like Mg and steel.

Reviewer 5

This reviewer stated that the project is investigating important joining processes to examine multi-material joining. However, the go/no go structure is a bit confusing as the tasks don't appear to really build upon each other. They actually seem like three very separate tasks. For example, the reviewer stated that it is not really clear how the Mg-steel joint development, which had to utilize adhesive, really influenced the multi-joint development of the Mg-Al and Al-steel Ultrasonic spot welding (USW) joints. That said, the tasks have all appeared to generate or be likely in future to generate valuable information.

Reviewer 6

This reviewer reported being a little unclear on the barriers being addressed by the project. According to the reviewer, Slide 5 says that "past attempts with conventional approaches are unsuccessful to ultrasonically welding large components." The reviewer suggested that, perhaps some more background on what is "conventional" and is meant by unsuccessful would be useful; The reviewer asked what is the problem that caused earlier efforts to fail to join dissimilar materials.

The reviewer also expressed confusion over the observation that, when joining materials with multiple spots along a joint line, what the joint strength varies with , whether position .or proximity to the coupon edge. In either case, the reviewer asks whether this occurs both with joints between similar and dissimilar materials? The reviewer opines that the approach would have been clearer if the problem being addressed was better defined.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer stated that the joining of Mg-steel components was accomplished, with consideration to the associated corrosion challenges. The team was able to achieve their target peak lap shear loads. One of the major challenges of the project was inconsistent heat generation during USW at different locations, and the team was able to replicate and resolve this challenge in the model by varying welding energy based on location. This was a significant accomplishment, as multi-joint coupons were able to perform as well as single-joint coupons in terms of peak lap shear load. Collectively, these (among other) accomplishments have kept the team on track relative to the project plan. The next milestone will involve similar work on component-level structures, and there are no current "red flags" to indicate that the team will not be able to complete it. The modeling appears to be strong, and it will be a powerful tool moving into the upcoming milestone with more complex geometries.

Reviewer 2

This reviewer believes that the team has followed a good technical process and that it was a good idea to create MAT225 because I think that corrosion has been a distraction for this program toward target goals.

Reviewer 3

This reviewer says that the project has had several significant accomplishments, including single-joint USW coupons with different welding conditions, quantification of galvanic attack on Mg, and a preliminary corrosion mitigation approach. In-situ measurements and post-weld characterizations showed the difficulty in joining multi-joint large coupons. A new model-based approach was developed to determine process

parameters for welding large coupons which resulted in consistent joint quality. Additionally, USW was applied to Mg-Al and Al-steel coupons based on insights from numerical modeling and experimental trials.

Reviewer 4

The tam showed excellent progress in joining immiscible elements (Mg and iron [Fe]) and also extended USW to Al-Mg and Al-steel pairs. Galvanic corrosion was also addressed in the activities.

Reviewer 5

This reviewer stated that the project achieved its goals of making joints in large Mg-steel components, although having to utilize adhesive did appear to set back the original goal of not using a third material for joining. The adhesive was used for corrosion mitigation but the reviewer questions whether it also contributes to the lap shear strength. The presenter indicated that the USW parameters could be tuned to consistently give a higher lap shear strength; the reviewer questions whether that due to a change in the failure mechanism itself (e.g. button pullout versus delamination). Also, the multi-weld joint simulation and experimental work showed required changes in process parameters to generate a good weld. While agreeing that lap shear strength is a good destructive measurement tool, the reviewer asks whether the simulation is really predicting button size of the weld. The reviewer believed that either that or some other non-destructive metric would be a better output in order for this model to be used for production parts, , not being sure that there a correlation.

Reviewer 6

This reviewer opined that the observation that samples with the highest lap shear strength were made at the highest weld temperatures was interesting and a good use of in situ thermal imaging. The fact that the welds closest to the coupon edge were the hottest (reduced thermal mass) is probably not surprising and the conclusion that welds made in the center of the coupon need more energy to reach some critical temperature also follows well, even without modeling. But the reviewer believed that a simple geometric-driven, empirical model does not seem to be where the project should stop, asking instead whether there might be more to it, Including, possibly why does higher temperature give a better joint; and what the underlying mechanism is. The reviewer posits that if answers to these questions were incorporated into the model it could be more easily generalized to new systems.

On Slide 13, the model is applied to new material pairs Mg-Al and Al-steel. The reviewer stated that he was not clear how the data presented was related to the model. The graphs on the right appear to be experimental results only. The reviewer asks if Slide 15 trying to convey that the model is making predictions of the weld energy needed for new material pairs or whether not this work had been validated or not.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer says that each of the national labs involved has clearly-enumerated responsibilities. Perhaps further input from industry would maximize the project's impact.

Reviewer 2

This reviewer believed that the labs are using their strengths and coordinating well. The project might benefit from some industrial involvement.

Reviewer 3

This reviewer stated that the effort appears to be mostly an ORNL experimental effort with an empirical model to predict thermal response of the process, validated by thermal imaging. This work is directed at generating consistent mechanical response in lap shear testing. There were a few slides on characterization efforts but I am not sure how the characterization work was integrated into the other efforts. This may be simply a result of the limited presentation time available at the AMR. I look forward to seeing more detail in the Annual Report or in publications.

Reviewer 4

This reviewer said that the team is comprised of ORNL as a lead focusing on joining process, evaluation and characterization as well as modeling. ANL is investigating joint tomography and chemical composition while PNNL is using advanced electron microscopes to evaluate microstructures of the joint interface (both significantly smaller tasks than ORNL's work). Collaboration seems to be an appropriate leveraging each of the laboratories' core competencies in relation to this project.

Reviewer 5

This reviewer stated that, while this is a team of multiple national labs, the roles of the participants other than ORNL was not clearly laid out in the presentation.

Reviewer 6

This reviewer noted really good collaboration between national labs on this program but that it could use SME in welding such as TWI, etc.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer said that the proposed future research is exactly on-par with the overall goals of the project. It seems likely that the team will make good progress towards these goals. However, it should be mindful of "failing fast" when it comes to exploring other non-USW material pairs that are relevant to automotive applications, as new and significant challenges may arise, especially when it comes to lap shear performance of the pairs. The team will need to identify the related challenges as quickly as possible.

Reviewer 2

This reviewer noted that there had not been a lot of time for questions and it was unclear whether the substrate surfaces were cleaned before being joined. This reviewer suggested that future work continue with the Thrust 4 modeling effort and make the ultrasonic rivet joining or ultrasonically assisted self-piercing riveting another subprogram.

Reviewer 3

This reviewer opined that there is a lot of work left to do to extend the project to a USW joint involving a mechanical fastener. The concept is good but it will be tight to finish in the allotted time.

Reviewer 4

This reviewer believed that future work seems appropriate to address the project goals. Fiscal year 2022 work will extend USW to join Mg-Al and Al-steel pairs based on findings from numerical models. Fiscal year 2023 will select one variant of the ultrasonic based joining technique to join other materials pairs that are not feasible with USW.

Reviewer 5

This reviewer said that future work needed clarification but the speaker had used up most of the time in the presentation leaving no time for reviewers' questions.

Reviewer 6

This reviewer thought that the thermal model validation, using different material pairs, will be an important proof point for the effort, although this type of model will always struggle with the geometric variability of each part/joint modeled. Future work should be directed at making the model versatile enough to be useful across all systems and geometries. To do that it might have to incorporate more of the fundamental mechanisms that make an ultrasonic joint strong.

The reviewer believed that the second bullet on the proposed future work slide on exploring new joining techniques feels somewhat out of scope. If the project is developing better and better conventional ultrasonic welds in dissimilar materials, that suggests continuing this work. There is a well know problem with spacing of ultrasonic welds and joint reliability. Solving that problem before moving to a new technique (ultrasonic riveting or ultrasonic self-piercing rivet [SPR] might be more valuable.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer stated that advanced joining will enable increased use of lightweight materials.

Reviewer 2

This reviewer said that the Al to galvanized DP590 steel joint is very relevant today, as this multi-material stack up is the most cost-effective way to lightweight vehicles. However, the Mg market price is so high today that it has driven applications to only high-performance niche vehicles.

Reviewer 3

This reviewer said that multi-material joining is an important and highly relevant topic and this project addresses some potentially useful solutions

Reviewer 4

This reviewer found that the work is relevant. Methodologies to join dissimilar materials are critical to enabling lightweight strategies across the VTO Materials mission space. Dissimilar joining strategies also have application in powertrain, electric drive systems and in an electrified infrastructure. Efforts here will have broad impact in multiple VTO subprograms.

Reviewer 5

This reviewer believed that the objective of this project is relevant to VTO materials subprogram as it aims to develop new solutions to multi-material joining to enable lightweighting. Ultrasonic spot welding is being

investigated due to its fast welding cycle, low clamping force, and parts can easily be recycled due to no third material.

Reviewer 6

This reviewer believed that the project is relevant for developing multi-material joining that can be a key enabler for lightweighting.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer commented that the team appears to have the necessary technical background and experience to complete the work.

Reviewer 2

This reviewer said that program resources are being used sufficient.

Reviewer 3

This reviewer said that the resources should be sufficient to complete the project provided that the collaborators down-select quickly on the final tasks.

Reviewer 4

This reviewer expressed a little initial confusion about the project budget. The reviewer believed that the $983,000 was for the full 3 years, not just for fiscal year 22 as stated in the slides. The reviewer believes that this $328,000 per year seems adequate.

Reviewer 5

This reviewer noted that this is a three year lab annual operating plan funded project with a total fiscal year 2022 budget of $1 million, which seems appropriate for the outlined scope, the challenge it is addressing, and the opportunity ultrasonic spot welding presents for multi-material joining.

Reviewer 6

This reviewer said that the resources are sufficient.

Presentation Number: mat223
Presentation Title: Extending High Rate Riveting to New Material Pairs
Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

Presenter

Kevin Simmons, PNNL

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

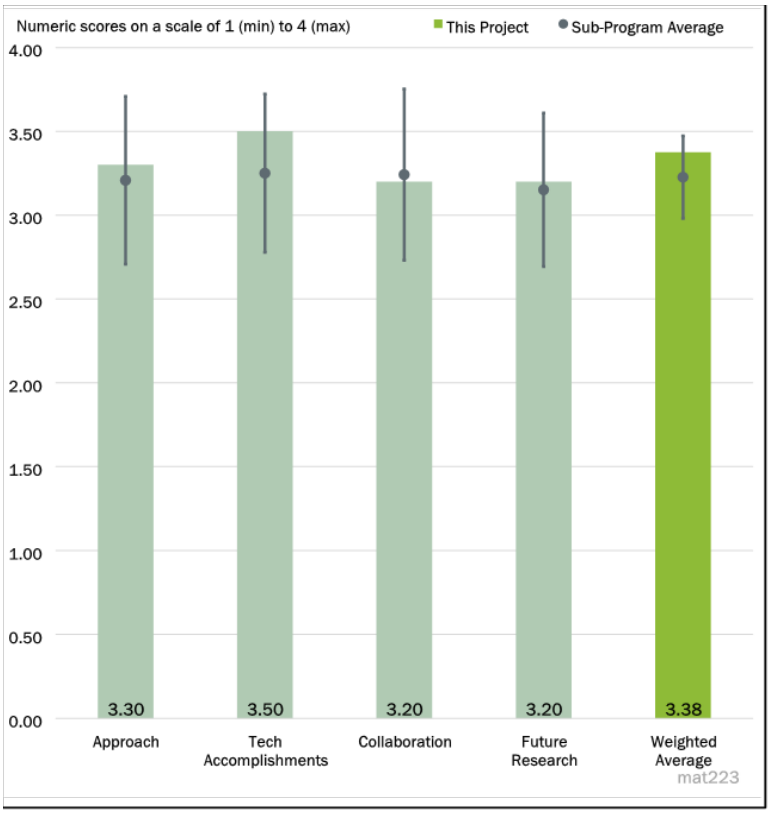

Figure 5-32 - Presentation Number: mat223 Presentation Title: Extending High Rate Riveting to New Material Pairs Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer found the approach to be sound and comprehensive. Several technical barriers were clearly identified relating to joint quality and corrosion, but it appears that further investigation into corrosion will be part of future work. The team showed good use of the virtual environment to guide its work, and the suite of shear strength testing was well-designed to address technical barriers. However, the reviewer noted that peel testing does not appear to have been pursued at all.

The reviewer stated that the use of vacuum sealing to slow the degradation of plasma treatment was well-presented. However, the reviewer found the slides to be unclear as to whether this mitigation strategy can last for the lifetime of the part. It would also be interesting to know if this can be predicted through modeling.

Reviewer 2

This reviewer found that the tasks designed are adequate to address the barrier of the project. The efforts among modeling/mechanical test/characterization/process are well balanced.

Reviewer 3

This reviewer characterized the project as a comprehensive approach to correlate the effect of process joining on joint microstructure and bond strength for high-velocity rivet (HVR) and high-rate friction rivet (HFR).

Characterization, mechanical fastening, hybrid joining, modeling, and mechanical testing are integrated in the approach to develop new and novel high-speed joining techniques with multi-material systems.

Reviewer 4

This reviewer said that the technical barriers are well addressed. The project is well designed for achieving the milestones. Experiment and modeling are combined for investigating the processes. The connection with and role of industry are less clear.

Reviewer 5

This reviewer believes that the team is doing a good job. Program and testing of joints are proceeding. The project is well planned and the timeline is reasonable. The reviewer noted that reverse engineering to create the model for the cohesive properties of the bond that better recreate the experimental behavior will be determined using an FE model (riveting + lap shear).

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer felt that the team did well addressing their first two milestones, and based on the progress presented, the team appears to be on track for milestone 3- milestone 5. The improvement in lap shear performance using plasma treatment is very clear in the team's experimental results, and the model correlation looks strong so far. It is impressive and impactful that the team developed a new method to enable calculation of fracture energy of dissimilar material joints, but further discussion of the mechanism behind the size-effect method would have been helpful.

Reviewer 2

This reviewer found the structure/interface characterization and performance evaluation of HVR/HFR of dissimilar material to be of high quality. The use of advanced characterization tools at national laboratories improves mechanistic understanding of the joining process.

Reviewer 3

This reviewer found accomplishments, including development of nitrile rubber (NBR) adhesives and surface modification and use of plasma treatment to increase joint strength to be significant and noted that the milestone for surface modified Al optimized for lap shear adhesion with HVR had been met.

Reviewer 4

This reviewer noted that the Technical Milestones 1 and 2 have been achieved within the planned timeline and found he progress to be on track.

Reviewer 5

This reviewer was unclear about the total number of tests completed asking if it is approximately 150+ including replicates at different geometries.

The reviewer found it interesting that finding that the conventional ASTM method of modified beam theory did not yield good results due to scatter while the size-effect method (G_{IC}) had good results.

Regarding the rivet break off, the reviewer noted that it was flush with the material while sometimes it would be desirable to have mechanical lock on top surface. The reviewer liked the X-ray component testing scan results.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer fount that the responsibilities for collaboration/contribution have been clearly enumerated for PNNL, ORNL, and ANL. The team included several commercial materials in their research, in collaboration with industry stakeholders.

Reviewer 2

This reviewer stated that the collaboration is strong within the project team.

Reviewer 3

This reviewer said there was good collaboration between national labs and industry but that it would possibly be desirable to get fastener SME involved (Stanley, Henrob, etc.).

Reviewer 4

This reviewer said that several collaborations were noted, including with ANL on joint characterization, with ORNL on NBR adhesive and plasma treatments, with corrosion team to investigate corrosion inhibition, and with HVR and HFR teams at PNNL to develop hybrid joining methods.

Reviewer 5

This reviewer said that Argonne doing some characterization was mentioned, but exactly what was the significance of Argonne National Laboratory contributions was not explained. The future plan does not call out what the different labs are doing. The industry contributions as advisors are unclear.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer said that the proposed future work addresses several different aspects of the project and will require very carefully managed collaboration.

Reviewer 2

This reviewer suggested that the fading of plasma treatment is worth looking into as it has a strong impact on the actual use of the NBR adhesive.

Reviewer 3

The reviewer said Al substrate sometimes uses a conversion coating (zirconium, etc.) to help with adhesive bonding strength instead of tape maybe look to overcome paste adhesive with/without glass bead that did not improve the performance of HFR joints and/or laser treatment methods for surface modifications.

Reviewer 4

This reviewer found that the proposed future work seems appropriate to address the outstanding barriers and meet the objectives of this project. Demonstrating joining on the component level and industrial engagement are important.

Reviewer 5

This reviewer pointed out that the future work was rushed during the presentation, but the plan forward is clear. The connection with industry needs to be clarified.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer believed that the project may enable further use of lightweight materials by enabling joining of dissimilar materials that are presently difficult to join.

Reviewer 2

This reviewer was not sure how relevant substrate to same substrate joining is compared to dissimilar materials joining. In addition, HFR process development for new material combinations with different surface modifications is a good idea but I am not certain how relevant.

CFRP-AA5052 or AA5052-DP590 would be / what is the application?

Reviewer 3

This reviewer says that the project clearly supports the objective of "Materials" subprogram in VTO.

Reviewer 4

This reviewer found that the project is relevant to the lightweighting materials subprogram objectives as joining multiple dissimilar materials of Al, steel, and composites is complex. Successful demonstration of high-rate riveting will increase process efficiency, enable innovation and sustainable manufacturing process and joining of dissimilar materials to enable creation of high-performance lightweight structures.

Reviewer 5

This reviewer answered that the project supports the program objectives. The work of this project supports the lightweight materials objective and supports development of sustainable manufacturing methods.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer said that the resources available across the three national labs should be sufficient, given the collective equipment and expertise available.

Reviewer 2

This reviewer said that the program resources being used are sufficient.

Reviewer 3

This reviewer said that the resources are sufficient to address the goal of the project.

Reviewer 4

This reviewer said that the project funding seems appropriate ($2 million over 3 years) given the scope and collaborations among partners.

Reviewer 5

This reviewer said that the resources for accomplishing the milestones of the project seem adequate.

Presentation Number: mat224
Presentation Title: Solid State Joining of Multi-Material Autobody Parts Toward Industry Readiness
Principal Investigator: Yong Chase Lim & Piyush Upadhyay, Oak Ridge National Laboratory/Pacific Northwest National Laboratory

Presenter

Yong Chase Lim & Piyush Upadhyay, ORNL/PNNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

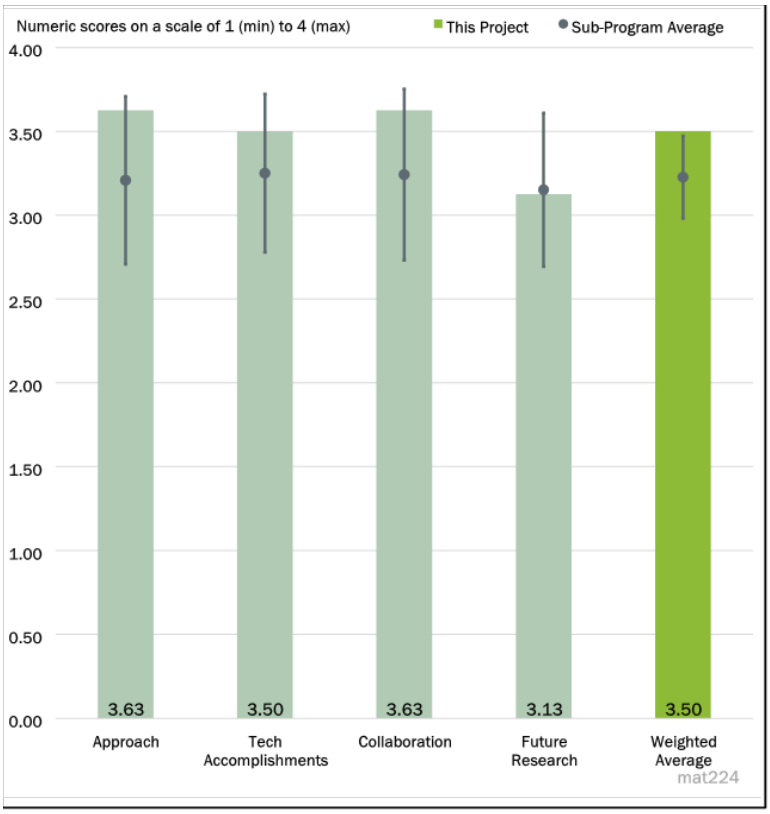

Figure 5-33 - Presentation Number: mat224 Presentation Title: Solid State Joining of Multi-Material Autobody Parts Toward Industry Readiness Principal Investigator: Yong Chase Lim & Piyush Upadhyay, Oak Ridge National Laboratory/Pacific Northwest National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer said that the project is well designed to overcome the barriers. The goals and milestones are very clear, and they seem to be on track.

Reviewer 2

This reviewer felt that the team is doing a great job. The program is well defined with real life applications, noting that it is not easy to take samples from the lab and scale up to production rate robotic platform (1 m/min).

Reviewer 3

This reviewer suggested that to enable scaling up production, perhaps the project can also provide recommendations/guidance on the QC methods that the production line can adapt for efficient examination of the joint, based on the likely failure mode found in the study. The process window should be accessed as well.

Reviewer 4

This reviewer said that the approach consists of maturing two national lab-developed solid state joining processes towards industrial readiness.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer found that the first two milestones have been achieved. The progress was very well demonstrated. Repeatability of welding process is demonstrated and connection with industry transfer was made. Progress on both friction stir linear welding (FSLW) and friction self-piercing rivet (F-SPR) processes was well presented.

Reviewer 2

This reviewer said that the team had developed a good technical process.

Reviewer 3

This reviewer said that the project team successfully demonstrated two joining process using a robot.

Reviewer 4

This reviewer noted that the team of multiple national labs has made good progress towards implementing FSLW and F-SPR towards higher volume production.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer said that there is really excellent collaboration on this program but suggested that involving Hitachi for FSW high volume production scale up lessons learned would be desirable.

Reviewer 2

This reviewer noted that the contributions of the two labs and of the industry partners are very clear. The synergy for the project needs is great.

Reviewer 3

This reviewer noted that this a large team with multiple key players to make this project successful.

Reviewer 4

This reviewer noted that the goal is to implement stir based joining methods in a production environment, but the involvement of industry seems to be minimal and questioned what the major barriers are for industry to adapt the developed technique.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer found that the proposed work is very clearly defined and connected to barriers and to the goal for high volume production.

Reviewer 2

This reviewer found a need to model more of how to deal with thermal effects on table and secure x, y, z forces at higher welding speed/temperature. The reviewer urged that the difficulty of achieving the 6022 outer class A surface finish not be underestimated and suggested looking at beryllium (or other lightweight, stiff materials) fixtures to address robotic arm stiffness issue.

Reviewer 3

This reviewer said that the process window of the technique should be evaluated, specifically that the recommendation of a quality control tool will be valuable for the industry. Evaluation of corrosion performance is included in the future work. The fatigue performance of the joint is also important.

Reviewer 4

This reviewer said that the proposed research is satisfactory but still focused on lab scape coupon evaluation.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer said that the project is very relevant today, as multi-material is the most cost-effective way to lightweight vehicles.

Reviewer 2

This reviewer said that the project objective is in-line with VTO's goal.

Reviewer 3

This reviewer said that the project supports the light-weighting mission through joining technology development.

Reviewer 4

This reviewer said that the work supports the program's objectives for lightweight materials and potential for commercialization.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer found that the funding is sufficient for the proposed work.

Reviewer 2

This reviewer found that the resources are sufficient for project execution.

Reviewer 3

This reviewer found that the resources seem to be adequate for the proposed work.

Reviewer 4

This reviewer believed that the program clearly needed more resources but that the program is on target because industrial partner(s) increased resources to meet those needed to be successful.

Presentation Number: mat225
Presentation Title: Surface Modifications for Improved Joining and Corrosion Resistance
Principal Investigator: Yong Chae Lim & Vineet Joshi, Oak Ridge National Laboratory/Pacific Northwest National Laboratory

Presenter

Yong Chae Lim & Vineet Joshi, ORNL/PNNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 25% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 50% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

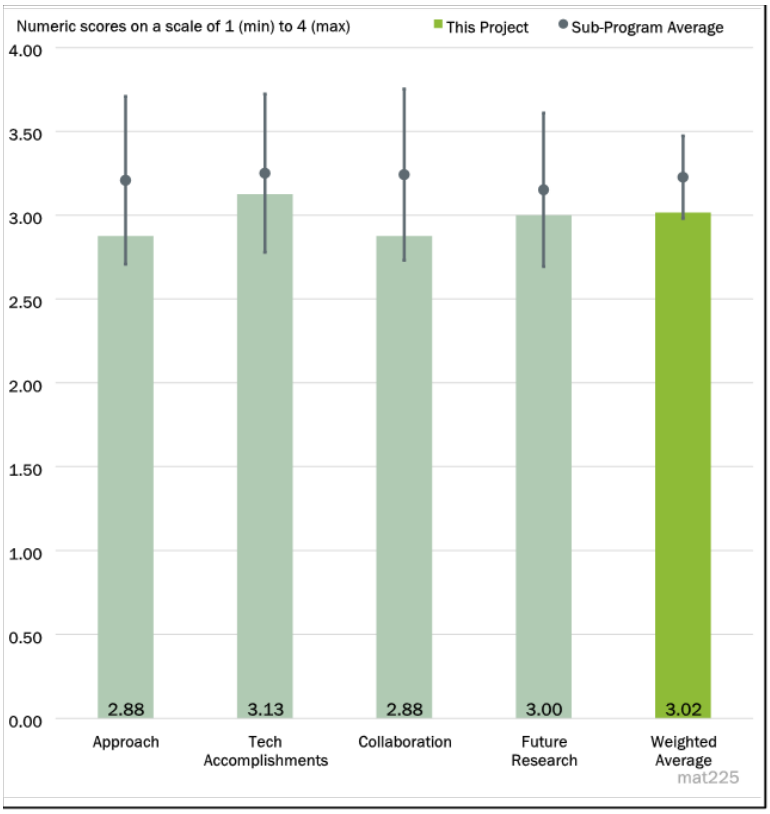

Figure 5-34 - Presentation Number: mat225 Presentation Title: Surface Modifications for Improved Joining and Corrosion Resistance Principal Investigator: Yong Chae Lim & Vineet Joshi, Oak Ridge National Laboratory/Pacific Northwest National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer found the approach to be all very good but that more ties with contemporary research would be welcome, as would motivation for exact methods used in experiments and modeling. Investigation of crevices under rivets also seems to be appropriate, in-scope, and not explored yet.

Reviewer 2

This reviewer said that the proposed approach is comprehensive, including process, characterization and numerical modeling. A model validation could be included.

Reviewer 3

This reviewer said that the approach is a shotgun approach to the topic and is too broad in the reviewer's opinion to address some of the fundamental questions. This project attempts to do too much with too little. The team uses Comsol to provide a direction in respect to corrosion. However, there are two other projects focused on corrosion modeling which the reviewer believes should be investigated for potential leverage opportunities (an ongoing project with WPI, and one already completed led by UofM).

Reviewer 4

This reviewer said that the reliance on corrosion simulation and electrochemical impedance spectroscopy (EIS) measurements (which have not always shown good correlation to real world field corrosion experience or to automotive industry standard accelerated corrosion aging evaluation procedures) would be better if some automotive industry accelerated aging (corrosion) tests were used for validation. The reviewer believed that use of vacuum sealing (as shown on one of the backup slides) to prevent (or at least slow) surface energy deactivation is not a feasible production solution to the rapid degradation in surface energy. Even with vacuum sealing, the drop-off of surface energy on AA6061 was substantial and may completely negate the value of the process for this material for real world production use. This drop-off should have been discussed in the main body of the report (at the very least included on the "Remaining Challenges and Barriers" slide) and not hidden away in the backup slides.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer found that good progress had been made in all regards.

Reviewer 2

This reviewer noted that on the slide of "milestones" only checks are marked on the status. It is unclear this refers to a 100% completion or that work is proceeding on it.

Reviewer 3

This reviewer found that the project team has made good progress in scientifically evaluating and characterizing plasma treatments on Al, steel, and CFRP. However, the report does not include any lap shear test results even though they were supposed to have been completed as part of the go/no-go decision from 9/30/21, or results from the quarter 6 dissimilar material joining feasibility task, even though that work should have been completed in time for inclusion in this report.

Reviewer 4

This reviewer noted that the project has continued work despite COVID and in that context, appropriate progress has been made. A continuous laser was employed because of technical failures. However, the industry standard is a pulsed laser. This should be considered in planning for future work.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer said that the project team has made connections across labs and across topics. However, the reviewer believed that these connections, only scratched the surface at the cost of depth—exploring some of the fundamental issues facing industry in this area.

Reviewer 2

This reviewer felt that deeper collaboration with industry, beyond periodic conversations, would better assure use of these results in commercial applications.

Reviewer 3

This reviewer noted that the project is now in its second year, suggesting that the team should possibly speed up finding/reaching the industrial partner.

Reviewer 4

This reviewer said that the project indicates good collaboration within the project team of laboratory partners. However, while "periodic interactions with other thrusts within JCP with close coordination/ties to automotive industries" are mentioned on the "Collaboration and Coordination" slide, there is no mention anywhere in the report of how that information is being shared or used in the project.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer stated that the proposed future work meets the research goal and addresses the research challenges.

Reviewer 2

This reviewer found the approach to be steadfast and quite good but subject to the reviewer's comments above.

Reviewer 3

This reviewer said that the project needs to include some automotive industry standard accelerated corrosion evaluation and mechanical testing to validate the modeling and EIS evaluations.

Reviewer 4

This reviewer noted that the proposed future work touches on interesting topics but did not see a well thought out, integrated approach. For example, control of oxidation is noted under atmospheric plasma but laser ablation also creates a new oxide layer. The reviewer asked why not include that process or even alodine coated surfaces as the baseline oxide in an investigation of what oxide surface is best and why. Also, the project did not use a pulsed laser for their ablation work (which is the norm for industry) which may limit the applicability of their learnings.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer pointed out that the DOE is interested in greenhouse gas emission reductions. Application of lightweight materials supports this goal. In order to actualize application of the right material in the right form in the right application, it is imperative to achieve dissimilar material joints. The current strategy for such joints are hybrid joining solutions involving adhesive bonding. According to the reviewer, the understanding of the adhesive/substrate interface under environmental exposure is imperative to dissimilar material joints.

Reviewer 2

This reviewer said that corrosion is essential to future vehicles, making this an important topic area.

Reviewer 3

This reviewer said that joining of dissimilar materials is an important area in advanced manufacturing for DOE to reduce the structural weight and improve component performance and energy efficiency. Corrosion is a critical barrier in broadening the application of dissimilar materials joints. This research aims to address this issue by modifying the bonding surfaces to improve the galvanic corrosion resistance.

Reviewer 4

This reviewer said that the project supports VTO objectives by investigating methods to reduce galvanic corrosion and improve adhesive bonding for multi-material joining.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer believed that the funding seems to be aligned with work being performed.

Reviewer 2

This reviewer believed that the amount of resources is too little to address the scope of fundamental questions in the space the project explores. The reviewer suggested that the project team should define the starting and ending Technology Readiness Level, which would help to define the resources needed.

Reviewer 3

This reviewer believed that the national laboratories have enough resources to fulfill the research goals on time.

Reviewer 4

This reviewer found that the project budget ($3.225 million) seems excessive for the relatively narrow scope of the project and the almost complete reliance on modeling and small scale laboratory tests with very little in the way of actual dissimilar joint mechanical testing and automotive industry standard corrosion evaluation, and, importantly, mechanical testing after exposure to automotive industry accelerated corrosion exposure.

Presentation Number: mat226
Presentation Title: Machine Learning for Joint Quality and Control
Principal Investigator: Zhili Feng and Keerti Kappagantula, Oak Ridge National Laboratory/Pacific Northwest National Laboratory

Presenter

Zhili Feng and Keerti Kappagantula, ORNL/PNNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

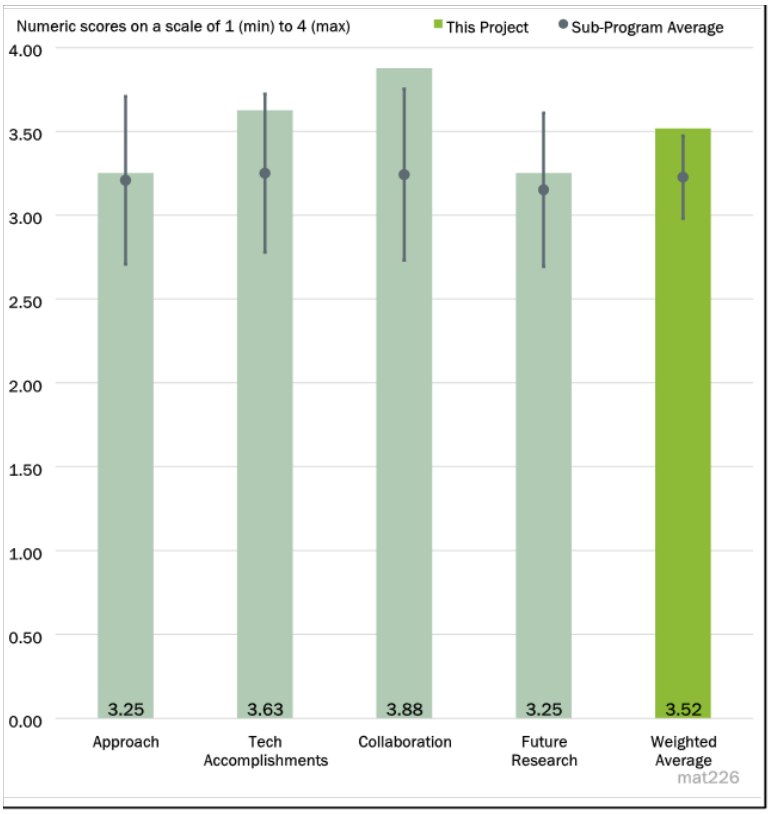

Figure 5-35 - Presentation Number: mat226 Presentation Title: Machine Learning for Joint Quality and Control Principal Investigator: Zhili Feng and Keerti Kappagantula, Oak Ridge National Laboratory/Pacific Northwest National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer believed that the project represents very modern, innovative and industry supported work. Great to have such a large a data set with machine learning.

Reviewer 2

This reviewer believed that this is an excellent project and the large dataset from General Motors (GM) is a major asset for the work. The reviewer was curious about the scale of the joint specimens included in the dataset (whether they were samples or full-scale specimens) as this relates to the CTE mismatch and "unexpected" thickness-dependent baking effects. Length scale (not just of the joint but also the interfacing components) will be important to validate accuracy and extensibility of the thermal stress models being developed in the mechanistic portion of the work—particularly considering that the plate thicknesses were found to be some of the most important predictors of weld performance.

Reviewer 3

This reviewer pointed out that machine learning is an effective approach to link the materials/process conditions, microstructure, and joint properties. PNNL tested random forest model to link materials/process

conditions and joint properties. ORNL applied a deep neural network to identify the important features and revealed unexpected thickness-baking effects. How to link the process to microstructure is unclear.

Reviewer 4

This reviewer said that the project is well designed and the timeline is reasonably planned to accomplish the stated goals. But, it is not obvious that this project will help to significantly reduce process delays for developing and optimizing new joining process/substrate combinations beyond those being evaluated as part of the project because the methods used in this project presuppose a large existing database (GM provides over 30 GB of resistance spot welding data) that is then used to train the ML for providing predictive capabilities for very minor variations (for example, replacing 1.2 mm thick Al with 1.1 mm thick Al) to the original test.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer found the project to be a very impressive use of new technology (neural network [NN]) to address an old problem (RSW).

Reviewer 2

This reviewer believed that the technical accomplishments (substantial predictive validations with over 80% accuracy) are impressive and seem to support the project approach very well.

Reviewer 3

This reviewer believed that excellent progress is being made in this project, especially relative to project size.

Reviewer 4

This reviewer noted that PNNL has accomplished one milestone and has four left; and ORNL finished two milestones and has two milestones left. The process is on the right track.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer found that there appears to be excellent collaboration with GM. It would be great if students could be involved to improve technology transfer.

Reviewer 2

This reviewer said that the collaborators appear to be very well coordinated in this project.

Reviewer 3

This reviewer said that , the partners/collaborators seem to be working well together in a complementary fashion, and did not identify any potential improvements in this area.

Reviewer 4

This reviewer said that the team consists of two national laboratories and one industrial partner. PNNL and ORNL will work with the weld data provided by GM with different machine learning methods.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer believed that there was not too much real detail given but the project seems on a very good track.

Reviewer 2

This reviewer said that the proposed future work meets the research goal very well.

Reviewer 3

This reviewer said that the proposed future work is well suited to overcoming remaining barriers to achieving the project goals.

Reviewer 4

This reviewer said that the future work plan specifies identical future work for both laboratories and believed that this will need to be well coordinated.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer noted that RSW remains the dominant mode for metal joining. Extensive study of this area is very appropriate.

Reviewer 2

This reviewer believed that joining of dissimilar materials is a critical area in advanced manufacturing for DOE to reduce the structural weight and improve component performance and energy efficiency. Machine learning will accelerate the understanding of process-structure-performance relationships and the development of dissimilar material welding processes. Machine learning will also help identify unexpected important parameters, as the results presented by ORNL.

Reviewer 3

This reviewer said that the project is well aligned with DOE objectives in multimaterial joining.

Reviewer 4

This reviewer said that the project is relevant in that it is aimed toward helping to reduce process development delays for joining lightweight dissimilar materials. However, concerns about the ability to successfully adapt this work to other joining methods may reduce the relevance somewhat.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer found that the budget seems to be appropriate.

Reviewer 2

This reviewer said that the national laboratories and industrial partner have enough resources to fulfill the research goals on time.

Reviewer 3

This reviewer found the resources to be sufficient.

Reviewer 4

This reviewer said that, given the scope of the project, the budget and timing seem to be about right. The reviewer would expect this project to be completed successfully and on time.

Presentation Number: mat229
Presentation Title: Development of a Novel Magnesium Alloy for Thixomolding of Automotive Components
Principal Investigator: Govindarajan Muralidharan and Bryan Macek, ORNL/FCA LLC

Presenter

Govindarajan Muralidharan and Bryan Macek, ORNL/FCA LLC

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

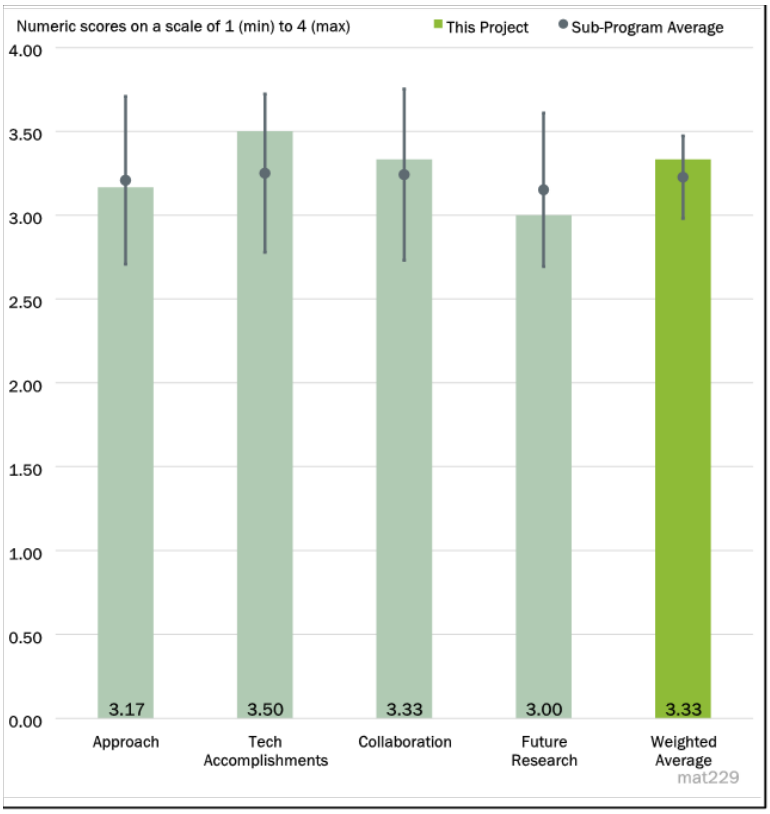

Figure 5-36 - Presentation Number: mat229 Presentation Title: Development of a Novel Magnesium Alloy for Thixomolding of Automotive Components Principal Investigator: Govindarajan Muralidharan and Bryan Macek, ORNL/FCA LLC

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer said that the approach taken to execute the work is good. The technical barriers seem to be addressed in a way that would result in meeting the stated goals of the project.

Reviewer 2

This reviewer said that the project is set up well, targeting an alloy, with clear metrics and an industrial application. This is a good blend of research and engineering. The reviewer thought that it would be useful to have one or more component level tests as part of the test plan, perhaps a structural test if the application has one. Also useful would be to have a list of metrics for the performance of the thixomolding process itself. The parts will go to Stellantis for analysis but the reviewer found it not clear what that analysis entails (surface quality, absence of cracking, wall thickness consistency, etc.). Those metrics should be applied to determine the efficacy of the alloy development method and confirm the hypothesis that something that blends the best properties of AM60 and AZ91 is really the best alloy for thixomolding.

Reviewer 3

According to this reviewer, while the approach to designing the new alloys seems to be clear, the project leaders reasons for choosing extrusion over thixomoulding to confirm the benefits of the new alloy compositions are not. It is clear that extrusion will yield different results to thixomoulding. Thixomoulding trials appear to be part of the project plan.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer noted that the alloys have been downselected and the project is proceeding to produce the chips and fabricate the part. The delay due to COVIDCOVID protocols is recognized and the no-cost extension is already in place so it appears the project is still on track.

Reviewer 2

This reviewer stated that the PIs have developed the compositions of Mg alloys that look very promising. Tests carried out to date validate the initial optimism surrounding these alloys. The accomplishments and progress of the work are good.

Reviewer 3

This reviewer said that the benefits of the new alloy systems at lab scale seem to be clear.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer believed that the project team appears to be taking guidance and working well with the industrial partners. Modeling analysis has provided many candidate alloys for down-selection and seems to be a good example of the use of ICME for alloy development. It will be interesting to see how well these downselect parameters are good a predicting thixomolding performance.

Reviewer 2

This reviewer said that the collaboration seems to be good.

Reviewer 3

This reviewer said that the collaboration between ORNL and FCA (corrosion testing) was evident. Less evident are the synergies with Magnesium USA and Leggera. The reviewer is not saying that it does not exist, just that it was not highlighted beyond mentioning them on Slide 20. However, the synergies that are shown appear to work well.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer found the plan to look good overall. However, in addition to the three proposed items, a quantitative analysis of the thixomolding process parameters impact on part properties such as surface quality, defects, filling, etc. would be an important output as well.

Reviewer 2

This reviewer thought that corrosion testing on prototypical specimens, as opposed to just coupons, will be prudent. Corrosion that is more severe or more localized sometimes shows up on prototypical specimens (that does not show up on coupons) due to the processing and prior strain history of the fabricated part.

Reviewer 3

This reviewer stated that, while the project end appears near, it is important to include the right process as planned.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer opined that thixomolding is a good candidate for the production of Mg alloy parts that can overcome a lot of the challenges of die casting and other processes to produce components in this alloy.

Reviewer 2

This reviewer believed that the work touches on Materials and Efficient Mobility Systems because the lightweight alloy formulations will contribute to weight reduction and better fuel efficiency in vehicles.

Reviewer 3

This reviewer pointed out that the ductility level achieved shows great promise to expand the field of application of Mg in vehicles.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer noted that the project was delayed but the participants have taken this into account and the project is well scoped to complete in the remaining time needed.

Reviewer 2

This reviewer said that, by the PI's own admission, the resources are adequate. This reviewer sees no reason from the work presented to dispute this claim. More time will be needed to complete the work as evidenced by the no cost extension applied for by the PIs (and granted by VTO).

Reviewer 3

This reviewer found that there seem to be sufficient resources.

Presentation Number: mat235
Presentation Title: Light Metals Core Program - Thrust 4 - Residual Stress Effects
Principal Investigator: Ayoub Soulami, Pacific Northwest National Laboratory

Presenter

Ayoub Soulami, PNNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

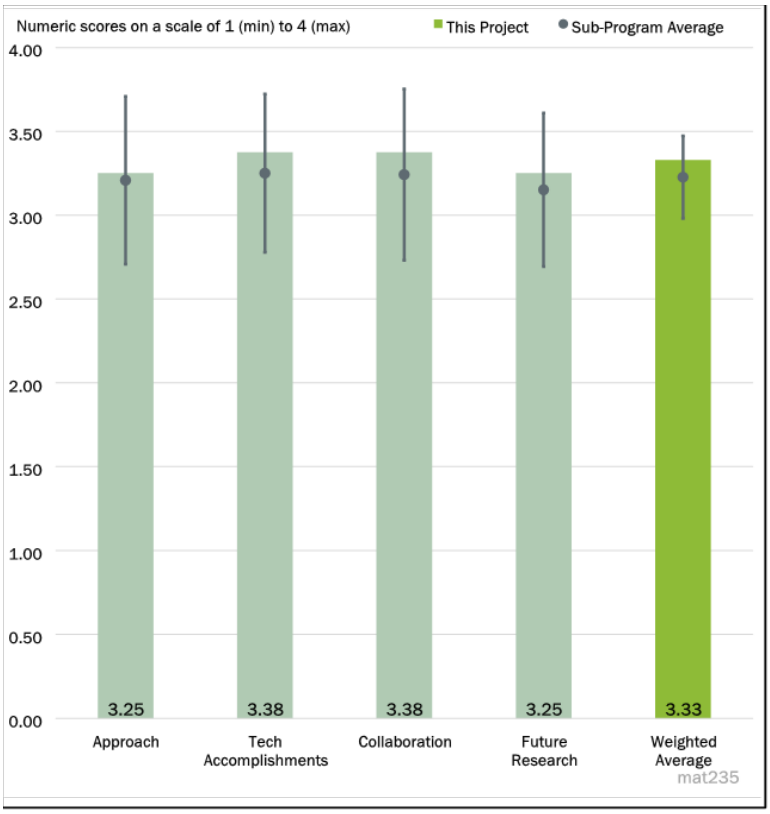

Figure 5-37 - Presentation Number: mat235 Presentation Title: Light Metals Core Program - Thrust 4 - Residual Stress Effects Principal Investigator: Ayoub Soulami, Pacific Northwest National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer said that the goals and objectives are clear. The plans for modeling and experimentation to understand and characterize residual stresses are very well-developed. The one remaining milestone (M2.0) appears to have been allotted sufficient effort, particularly because many of the learnings from M1.0 can be applied.

Reviewer 2

This reviewer described the project as a cross-cutting ICME effort, supporting several different projects within the Light Metals Core Program (LMCP). It is developing computational modeling approaches to predict residual stresses resulting from friction-stir processing, ShAPE tube extrusion, and bending-unbending processing, with an ultimate goal of guiding design of processing methods to reduce residual stresses and ensure dimensional stability. It has pursued a mix of Thermo-Pseudo Mechanical (TPM), Smoothed Particle Hydrodynamics (SPH), and FEA methods and imports constitutive models as needed. It would be helpful in future reviews to define the technical barriers associated with the development of these ICME methods with the level of accuracy required to meet the goals in the different programs it is supporting.

The reviewer asked how good is good enough in the computational predictions; are the constitutive models sufficiently well developed or do they need to be further improved; and what the tradeoff is between accuracy

and computational speed required. Although the progress demonstrated was impressive, it is not clear to the reviewer what technical barriers had to be overcome and will need to be overcome in the development of the ICME models.

Reviewer 3

This reviewer believed that the work needs to start with some baseline manufacturing processes where the residual stress effects are more experimentally measured and understood. It is important to validate the computational models in the baseline processes before tackling the residual stress prediction in the new processes with local enhancement.

Reviewer 4

This reviewer observed that the project is an effort within LMCP and focuses on residual stress measurements and modeling although the focus so far has been on the modeling within the project.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer found impressive progress to have been demonstrated in the prediction of residual stresses and on the use of the models to test how they could be reduced in friction-stir processing (FSP) through design of processing parameters and clamping conditions. In the validation tests, some notable discrepancies with experimental measurements (e.g., in Slides 10 and 11) were noted and it was not clear whether these are significant for the intended use of the models in the relevant projects, and, if so, what would be the plan to improve the model accuracy.

Reviewer 2

This reviewer noted that the team has made great progress and appears to be on track. M1 is complete, and there are no major "red flags" that would prevent progression from M1 to M2. The model appears to work fairly well as-is, but will likely need further iteration and improvement to accommodate a broader range of component sizes and geometries. Iterative correlation using both the virtual and experimental environments should be a major priority moving into M2.

Reviewer 3

This reviewer found the results to be impressive despite being on small and simple samples.

Reviewer 4

This reviewer said that several good examples were provided where successful residual stress models were developed (e.g., ShAPE tube extrusion).

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer pointed out that, since this is a cross-cutting project, it involves collaboration with the other LMCP projects and such collaborations are essential to drive the model development and for the models to be

used to advance the goals of the other LMCP projects. The examples presented suggest these collaborations are well coordinated.

Reviewer 2

This reviewer said that as a cross cutting project, the project is supporting several projects within the LMCP program. The reviewer suggested that the team could develop collaboration with universities to leverage more expertise in the area.

Reviewer 3

This reviewer noted that PNNL, ORNL, and ANL collaborated on this project. Further coordination with industry as tests are being developed would be beneficial in order to maximize the impact of the work.

Reviewer 4

This reviewer said that all examples were provided from one national lab's projects and the project will interface with another national lab in the future.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer found the proposed future work to be clear and reasonable, and that it addressed key technical barriers. The reviewer opined that improving predictive modeling and focusing on larger components will increase the reliability of the method and validate its usefulness to industry stakeholders.

Reviewer 2

This reviewer suggested planning to focus on more complex components.

Reviewer 3

This reviewer suggest that it would have been helpful to see more detail on Slide 19 about the future research plans and specific targets Including what specific model development efforts will be needed, what defines success, what are the anticipated challenges and risks to achieving the targets.

Reviewer 4

This reviewer said that the proposed plans are good.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer said that this cross-cutting project appears to be well integrated to support the goals of the LMCP program, through advancing ICME approaches that can guide the development of scalable, cost effective, processing methods to locally enhance the properties of Al and Mg to enable broader implementation of lightweight alloys.

Reviewer 2

This reviewer believes that helping designers predict and reduce residual stresses will enable further use of locally-enhanced lightweight materials in high-strength applications.

Reviewer 3

This reviewer said that the project is supporting many light-weighting projects.

Reviewer 4

This reviewer said that the project is relevant for the light-weighting mission as local property enhancement may lead to unforeseen residual stress effects.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer noted that, given the level of progress realized in the first year, the evidence is that the resources are sufficient. However, related to comments in response to Question 8, it is difficult to assess if the further resources might be necessary going forward in the absence of more detailed milestones.

Reviewer 2

This reviewer believes that it does not appear that further resources will be required.

Reviewer 3

This reviewer found the resources to be sufficient.

Presentation Number: mat236
Presentation Title: Advanced Characterization and Computational Methods
Principal Investigator: Thomas Watkins, Oak Ridge National Laboratory

Presenter

Thomas Watkins, ORNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

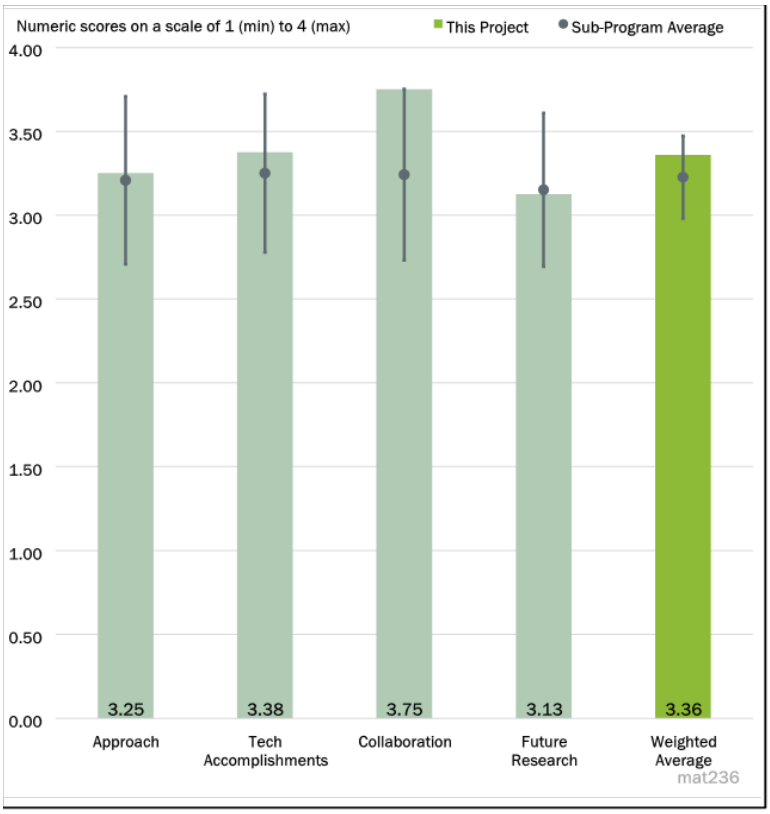

Figure 5-38 - Presentation Number: mat236 Presentation Title: Advanced Characterization and Computational Methods Principal Investigator: Thomas Watkins, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer said that the cross-cutting approach to Thrust 4 is a good example for other projects and that the team's integration throughout the program is impressive.

Reviewer 2

This reviewer believed that the team had developed a tremendously powerful model for how resources should be set aside for distinct characterization and computational support. The results across a number of programs is noteworthy.

Reviewer 3

This reviewer noted that resources from several labs are being applied. The tools for both the experimental observation of the molecular structure and the supporting computation demonstrate impressive capability.

Reviewer 4

This reviewer believed that, in many cases, the project lacks identification of key microstructural features to the properties they are controlling. In other cases, the reviewer thought that the work is relevant to internal

combustion engines and not EVs. Regardless, before applying a particular characterization technique, the specific controlling microstructural feature(s) should be identified.

According to the reviewer, in Slide 3, the focus appears to be EVs, which do not see high temperatures and pressures. This is why getting heat into the passenger compartment is a problem and auxiliary heating is needed, unlike with internal combustion engines that provide all the heat needed for heating the passenger compartment in winter. EVs do not see 900°C so the need to study creep-resistant austenitic alloys is not clear.

The reviewer says that the team is going after lightweight, conductive, improved magnetic properties, and lubricants. The reviewer is not sure why lubricants are included.

The reviewer questions the purpose of developing coarsening-resistant additive manufactured Al-cooper (Cu)-Mn-zirconium (Zr) alloys. Specifically, which EV components need this property. Regarding Slide 16, the reviewer asked what is the ceramic material, how was it made, and what is the application. Regarding Slide 18, the reviewer finds that the purpose of carbon within ShAPE formed Al conductor is well described. However, the reviewer said that there is no mention of correlating the high resolution microstructure to properties. The reviewer asks how the electrical conductivity of these materials compares with the base materials.

Regarding Slide 25, the reviewer said that the slide talks of electrical properties but then goes into precipitates, which are generally not favorable for conductivity.

Regarding Slide 28, the reviewer asks why does the modeling mingle light duty engines with EVs.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer pointed out that the support given to the extensive publications tally over the past few years certainly underscores the importance of the computational component to the VTO program efforts. The characterization component is equally critical, particularly from the standpoint of providing an avenue for singular capabilities that would otherwise be difficult to incorporate into shorter-duration programs.

Reviewer 2

This reviewer noted that Task 4B1-22 is making thermophysical data available for commercial software distribution. This facilitates dissemination of lab findings in a relevant and useful form for industry designers. That several publications have come out of this effort also demonstrates a focused effort to disseminate knowledge gained.

Reviewer 3

This reviewer found that all of the experimental examples are impressive and provide useful insights into the material behavior. Using scanning transmission electron microscopy (STEM) to improve the density functional theory (DFT) predictions is impressive. It is interesting that only STEM was able to identify the configuration of the lowest energy state for the interface.

Reviewer 4

This reviewer suggested that the microstructural work appears to be singular and no sample set with an experimental variable is included, which may show a property trend that can be related back to microstructure.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer believed that the presentation demonstrated how the computation team and experimental team in Task 1A1-21 are joining together to interpret and resolve molecular structure behavior questions around semi-coherent interfaces that could previously not be explained by modeling alone. This collaboration shows both effective utilization of the tools available and excellent cross collaboration between traditional workflow 'silos'. The tools for both the experimental observation of the molecular structure and the supporting computation appear to the reviewer to be well utilized in this collaborative environment.

Reviewer 2

This reviewer said that this is a well-structured team.

Reviewer 3

This reviewer said that the collaboration is impressive, since each project involves many different institutions.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer suggested that more details on proposed future work could be shared, noting that only 1out of 34 slides addresses future work, despite 15 months remaining in the timeline, and that a mapping of baseline characterization milestones for each task would be good to see.

Reviewer 2

This reviewer found the future plans to be clear and to make sense.

Reviewer 3

This reviewer requests that the team provide clear statements that mention studies which include the effect of chemistry or process on properties and which specific microstructural feature(s) will be studied for correlation.

Reviewer 4

This reviewer found that the thrust within the Powertrain Materials Core Program is an excellent example of how high-performance computational capabilities and expertise can be deployed to support a wide range of research and development efforts. The format can certainly help future VTO programs and, maybe more importantly, provide a framework for how this approach can be successful in other areas.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer said that the efforts within this thrust are relevant largely because of the significant contributions to the other more applied thrust areas.

Reviewer 2

This reviewer pointed out that increased electrical conductivity, increased magnetic properties, and improved high temperature performance in electric vehicle propulsion components leads to downsizing, light weighting, and thus range-extending ability.

Reviewer 3

This reviewer said that all projects point to materials developments that improve energy efficiency.

Reviewer 4

This reviewer said that the work is relevant, since it is driven by needs of the other thrusts

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer found it difficult to quantify some of the efforts in this area, but the accomplishments indicate that the resources are providing an appropriate ability to support the needs of various programs from this thrust area.

Reviewer 2

This reviewer said that the resources appear sufficient for the project goals.

Reviewer 3

This reviewer said that the resources are reasonable.

Reviewer 4

This reviewer said that the team is very large and was not sure whether so many are needed.

Presentation Number: mat237
Presentation Title: Materials, Lubricants, and Cooling for Heavy Duty Electric Vehicles
Principal Investigator: Jun Qu, Oak Ridge National Laboratory

Presenter

Jun Qu, ORNL

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

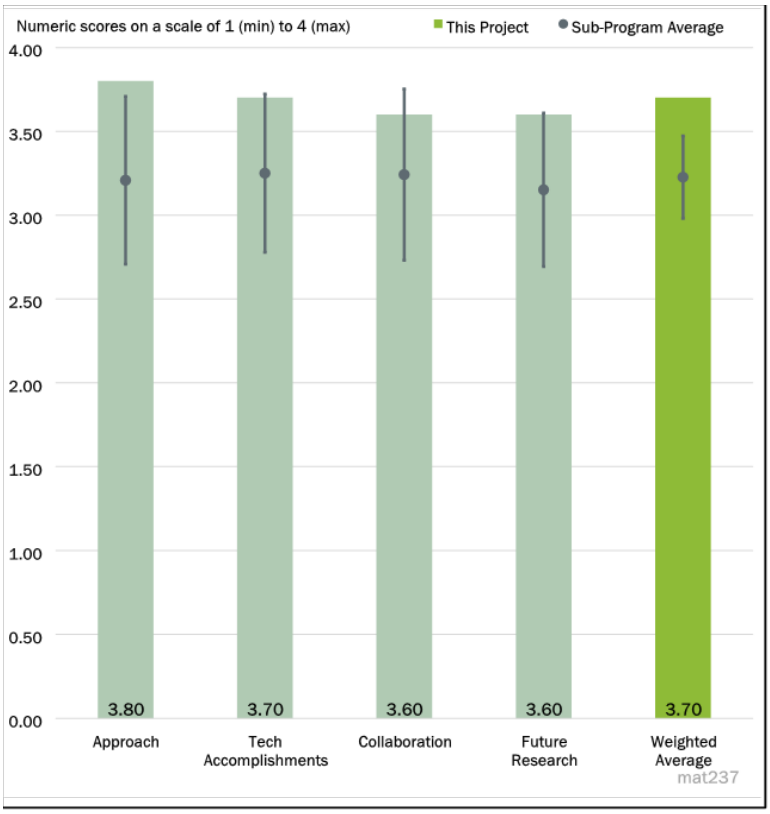

Figure 5-39 - Presentation Number: mat237 Presentation Title: Materials, Lubricants, and Cooling for Heavy Duty Electric Vehicles Principal Investigator: Jun Qu, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer noted that the project aims at improving thermal conductivity and reducing the friction of the lubricants. The proposed approach is to add CNT to the lubricant oil. CNT is modified by adding ligands to make it compatible with oil, i.e., to suspend and disperse in oil. This project is creative. It properly addressed the technical barrier in thermal and frictional management in EV power train

Reviewer 2

This reviewer said that the need for thermal and frictional management in the electric vehicle space cannot be overstated. This is a critical space to allow success of future propulsion systems to thrive and decrease carbon emissions by society. According to the reviewer, the novel use of CNTs to address these two critical key issues is a great idea, and the issues are clearly addressed.

Reviewer 3

The use of CNT in lubrication is a novel approach, and depends on the organic molecule approach being effective. The sacrificial CNT coating is also novel. While it was mentioned that the coating could be used for lubrication OR for improved thermal transport, progress was only shown for its use for lubrication.

Reviewer 4

This reviewer said that CNTs show promise in thermal and lubrication properties improvement if they can be suspended in oil.

Reviewer 5

This reviewer found that the necessary pivot was made to support the new emphasis on EVs.

The team used existing knowledge from the ICME database to address issue encountered with EVs in regards to cooling and parasitic friction challenges. The reviewer believes that innovative basic science research is needed to understand the reaction of CNTs in lubrication fluids and their ability to improve cooling. This approach addresses two challenges with a single solution.

The reviewer believes that long term CNT suspension in oil will be the biggest challenge to overcome and if coating technology is not possible, it should be a focus going forward.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer found that the team has made good progress. For the lubricant task, CNT types were selected, about 7% increase in thermal conductivity has been demonstrated, and the modified CNT clearly shows evidence of suspending in lubricant oil. For the coating task, powertrain alloys for coating have been identified, CNT coating on Al has been demonstrated, and super-lubricity of coated CNT was demonstrated to be sustainable. The two proposed mechanisms explaining the origin of super-lubricity (CNT breakdown forming mini rollers and CNT/graphene coating by stress) are sound.

Reviewer 2

This reviewer believes the work of the team to identify and deploy the CNTs by selecting types and sizes for lubricants is a critical step to allow the next steps in this important research. The reviewer also believes that the identification of both a ferrous and a non-ferrous alloy for CNT coating is the correct approach in my view, as it allows this coating technology to be deployed in a wide range of EV applications.

Reviewer 3

This reviewer found that good progress has been demonstrated on steel and Al alloy selection and CNT surface coverage, along with good progress showing a 7-10% increase in thermal conductivities and initial success in oil suspension. Improved surface wear from sacrificial CNT coatings show super-lubricity for 27 hours.

Reviewer 4

This reviewer noted that initial trials showed a 7%-10% increase in thermal conductivity. CNTs allow use of thinner oil through improved lubrication by the CNTs. Organic modification improved suspension in oil, holding for 2 days and settling after 2 weeks. Super-lubricity was obtained (u less than 0.01) in micro scale sliding in an ambient environment and is hypothetically attributed to a CNT-induced graphene ultra-low friction surface film. It sustained ultra-low friction for 27 hours with only one droplet of oil.

Rapid CNT coating using chemical vapor deposition (CVD) showed some success at 600C or above, but below 600C, the CNT coating was unsuccessful.

Reviewer 5

This reviewer thought that the preliminary increase in lubricant thermal conductivity in PAG is encouraging. Improvement from treatment is encouraging. The reviewer believed that there is a need to study the lubrication properties of CNT coatings and their impact on thermal transport for parts that don't experience wear

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer said that significant interest from industry in this technology is being shown—cooperative research and development agreements (CRADAs) with Valvoline and industry project partners Ford and Honeywell demonstrate this interest. Ford, Tesla, and others are asking for this cooling capability.

Reviewer 2

This reviewer said that it is clear that the team is working well together and sharing ideas as well as tasks, given the extensive list of technical accomplishments

Reviewer 3

This reviewer said that the collaboration within ORNL resources was demonstrated and that external partners are showing strong interest in CRADAs.

Reviewer 4

This reviewer noted that ORNL plans to work with Valvoline, CRADA pending.

Reviewer 5

This reviewer said that the collaborations seem reasonable and more are underway.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer said that the proposed work appears to be reasonable.

Reviewer 2

This reviewer found that the work proposed in both the coatings and lubricants space is clearly explained, and seems very relevant to the overall proposed tasks. The team has obviously collaborated well and has done a significant amount of research on the opportunity.

Reviewer 3

This reviewer opined that the planned coating below 575C is a good initiative for maintaining Al heat treatments while reducing friction. Quantitative characterization of CNTs' suspension and dispersion in oil is planned, as well as collaboration with CRADA partner for EV fluid requirements.

Reviewer 4

This reviewer stated that future research should continue to overcome the barriers encountered at the start of the project. Since CNTs are difficult to suspend in oil and graphene cannot be easily placed on surfaces since

the orientation is difficult to control, research to address this challenge should continue. Research should also continue to determine the impact on material properties. Aluminum alloy was not the preferred metal to grow nano particles. A highly catalytic metal (Cr, Fe) is needed for the oxidation process, which should be investigated (and is planned),

The reviewer suggested that CNT life time should be extended. The deposition of CNTs on the surface increases lubrication. If the CNTs are destroyed, the thermal conductivity benefit will no longer occur. On Al, the CNTs are not destroyed, so thermal conductivity occurs.

Reviewer 5

This reviewer said that the future plans seem reasonable

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer observed that a lubricant that can outperform the current state of the art will dramatically impact on materials and system life. This technology will have large impact on many energy efficiency and renewable energy applications, including EV motor bearings, wind turbine bearings, etc.

Reviewer 2

This reviewer believes that the project could impact three of the thrusts: batteries, electrification, and energy efficient mobility systems. The reviewer stated that this work can make a significant difference in the adoption rate of electrification of vehicles by decreasing range anxiety and improving EV performance in non-optimum climates. This is the type of research that is essential to take EVs to the next level of adoption.

Reviewer 3

This reviewer said that increasing thermal conductivity and lubrication properties of oils allows for higher operating speeds, higher power density, reduction in friction losses, and light-weighting of EV drivetrains.

Reviewer 4

This reviewer stated that the project is directly relevant to the VTO Materials subprogram objectives.

Reviewer 5

This reviewer stated that the work is relevant

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer stated that the resources allocated to this project are appropriate.

Reviewer 2

This reviewer noted that clearly a lot of work was reported and data was provided. The resource needs are well documented and seem appropriate to the team size and expectations.

Reviewer 3

This reviewer said that funding appears sufficient for the initial goals and that CRADAs with industry partners should increase allocated funds.

Reviewer 4

This reviewer believed that the innovative approach to lubrication and cooling has significant commercial applicability in the EV space and throughout industry. This creative approach should continue and, if possible, be coordinated with other similar research efforts within and outside of DOE. Establishing a CRADA with Valvoline will increase the funding available for this research.

Reviewer 5

This reviewer believes that the funding level is fairly small but seems sufficient to complete the proposed work.

Presentation Number: mat238
Presentation Title: Advanced Processing and Additive Manufacturing for Electric Vehicle (EV) Propulsion, Ultra Conductor Development for Enhanced EV performance
Principal Investigator: Keerti Kappagantula, Pacific Northwest National Laboratory

Presenter

Keerti Kappagantula, PNNL

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

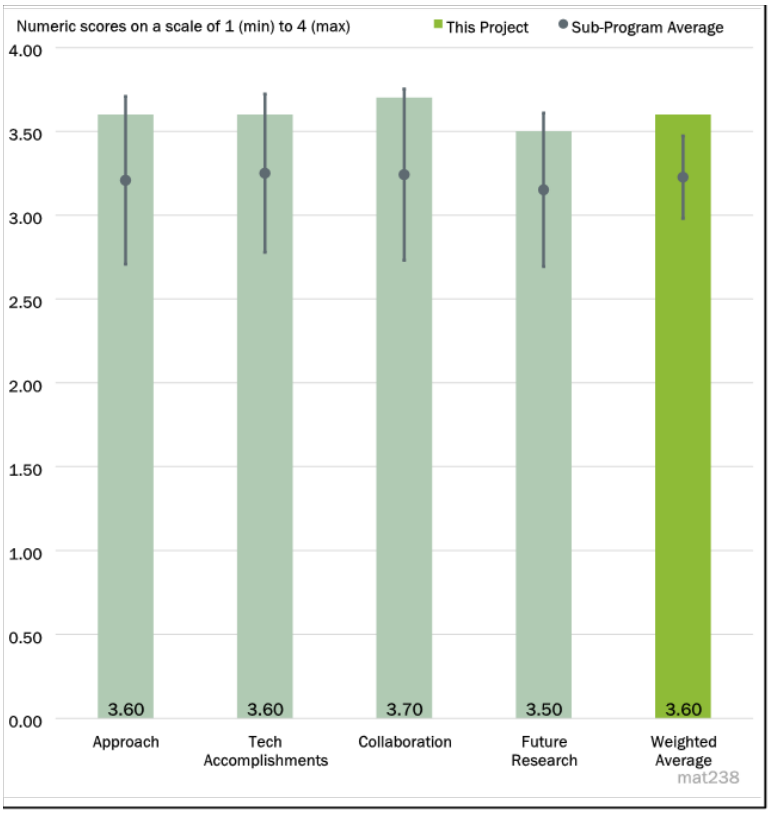

Figure 5-40 - Presentation Number: mat238 Presentation Title: Advanced Processing and Additive Manufacturing for Electric Vehicle (EV) Propulsion, Ultra Conductor Development for Enhanced EV performance Principal Investigator: Keerti Kappagantula, Pacific Northwest National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer pointed out that the proposed approach is solid state processing. It uses a Cu-graphene mix as feedstock, processing it with shear-assisted processing, which is essentially friction induced consolidation and extrusion. The process can uniformly mix the two components and create intimate contact. The process can also create and manipulate extrudate texture.

Reviewer 2

This reviewer found that this project is well-designed and planned. The use of reduced graphene oxide in Al or Cu matrix to enhance conductivity is a clever route. The presence of a very small volume of oxygen in reduced graphene did not affect electrical properties. This material composition has good promise for scaled up manufacturing, which the industries need.

Reviewer 3

This reviewer noted that the project uses the ShAPE extrusion process to produce wire with low cost additives to make ultra-conductors. The project is tackling an important area to improve the electrical performance of current materials to allow for volume reduction of electrical motors in EVs. The reviewer finds that the approach to look at lower cost materials and a process with potential scalability is a good one.

Reviewer 4

This reviewer states that the project is attempting to create ultra-conductor materials with graphene additives through an advanced extrusion process. Metal feedstock and graphene in various forms is processed ShAPE apparatus at PNNL. Post processing, electrical and mechanical property measurements per ASTM B193 are conducted. The project is well designed and the timeline is reasonably planned based on the funding available.

Reviewer 5

This reviewer said that the investigators seem to be taking a reasonable approach.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer believed that the team made good progress. For the Al-graphene composite, about 7% improvement in conductivity has been achieved, and a 3 meter long uniform wire has been extruded; For Cu-graphene composite, an over 3 meter long uniform wire has been extruded. There are no results on conductivity improvement, however.

Reviewer 2

This reviewer observed that the project started nine months ago and has made significant progress. The reviewer likes the fact that high speed ShAPE processing makes the defects on wire surface disappear and asks whether it is the plasticity at high shear that helps to minimize surface defects.

Reviewer 3

According to this reviewer, the project has made good progress in producing samples. The project has found optimized process parameters and has created wire materials for testing. It is not clear from the results how closely the project is getting to its target of 10% improvement in conductivity or if that is the Go/No Go target.

Reviewer 4

Based on the planned milestones presented, this reviewer believes that the project is on schedule. This project has met two of its four quarterly milestones and is on track to meet quarter 3 and the quarter 4 go/no-go milestone.

Reviewer 5

This reviewer expresses concern regarding how long the wires can ultimately be made by this process. The reviewer states that it was never clear if large spools can be made as in traditional wire, despite his having asked the question. The reviewer suggests that it would be worthwhile to answer the questions of, what the end product would look like and how it would be used. It could be that the wires made would be long—but not huge spools that are currently made. The reviewer believes that it would be good to clarify this point.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer said that PNNL works closely with ANL on microstructural analysis of the extrudate. Quarterly meetings were carried out with industrial partners.

Reviewer 2

This reviewer found that the project has a great team and good collaboration between different thrusts within the program. ANL, ORNL and PNNL together are doing a great job.

Reviewer 3

This reviewer noted that the project team is meeting with the advisory panel on a quarterly basis which seems sufficient.

Reviewer 4

This reviewer pointed out that the project team is led by PNNL with participation from Ohio University and Argonne National Laboratory and industrial partners Hydro Extrusions and Rolls Royce. It appears that the bulk of the effort is being conducted by PNNL with consulting by ANL, Ohio, and Hydro Extrusions. Argonne National Lab is supporting the project on Al/graphene and Cu/graphene composites to characterize microstructure. PNNL holds monthly meetings with Argonne to review the status of the work. Quarterly meetings are held with Hydro Extrusions and Rolls Royce.

Reviewer 5

This reviewer believed that the collaborations are excellent, but strengthening the ties to multiple motor design groups might be advantageous. (The PI is already working with at least one group.) Actually, the PI may want to consider establishing formal ties to the VTO motor design group led by ORNL and which includes Purdue, University of Wisconsin, Illinois Institute of Technology, and North Carolina State.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer said that the proposed work appears to be reasonable, suggesting that the team add a task for a feedstock powder quality study, e.g., oxygen level, impurities, etc.

Reviewer 2

This reviewer said that the team is ready to demonstrate scalability with manufacturing of the materials and that it should stick to that plan.

Reviewer 3

This reviewer noted that the future work for this project includes enhancing composite performance through process and composite chemistry variation and determining the effects of post processing techniques on the performance of the ultra-conductors. Understanding the variables involved in processing of the ultra-conductors with the ShAPE extruder will be important to maximizing electrical properties of the materials. The

reviewer believes that this team is well qualified to approach these variables with expertise in material design, electrical property measurement, and microstructural characterization. The reviewer suggests that in the longer term, if successful materials are developed, testing in an electric motor design to prove the concept would be ideal.

Reviewer 4

This reviewer opined that what the PI set forth as a plan makes sense, but it was at a very high level.

Reviewer 5

This reviewer said that the proposed work is important but that it would also be good to see some work around process repeatability and robustness.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer believes that a conductor more conductive than Cu will have direct impact on many energy efficiency and renewable energy applications. The proposed Cu-graphene composite is definitely a promising approach.

Reviewer 2

This reviewer said that the project is very aligned with VTO objectives.

Reviewer 3

This reviewer believes that the U.S. DRIVE Partnership and the Electrical and Electronics Technical Team have identified the reduction in volume of electric motor components as an enabling technology. According to the reviewer, this project, if successful, would increase the flux density capabilities of electric steels and the electrical conductivity of Cu windings, both of which would enable motor volume reductions by necessitating fewer materials. Increases in conductivity could potentially increase overall motor efficiency and reduce motor volume.

Reviewer 4

This reviewer said that the project is aligned with the new materials development goal for vehicle electrification.

Reviewer 5

This reviewer believes that this project is extremely relevant. Obtaining better conductivity, a lower temperature coefficient of conductivity, and high thermal conductivity makes a huge and ubiquitous difference in machine design. The reviewer approves that the project is considering both Cu and Al enhancement.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer said that the resources allocated to this project are appropriate.

Reviewer 2

This reviewer believes that, since the project is using existing working equipment to produce the samples and a known ASTM standard for testing, the resources appear to be sufficient to complete the milestones. According to the reviewer, no major barriers seem to be apparent.

Reviewer 3

This reviewer pointed out that the project is funded at $500,000 per year for 2 years and believed that this amount is sufficient to cover the initial phase (2 years) of research on Al and Cu ultra-conductor extrusions with the ShAPE machine and conducting modeling and testing of the results.

Reviewer 4

This reviewer stated that the resources are sufficient.

Reviewer 5

This reviewer said that it would seem that the resources are adequate.

Presentation Number: mat241
Presentation Title: Advanced Processing and Additive Manufacturing for Electric Vehicle (EV) Propulsion, Advanced Ceramics and Processing for Wireless Charging Systems
Principal Investigator: Beth Armstrong, Oak Ridge National Laboratory

Presenter

Beth Armstrong, ORNL

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

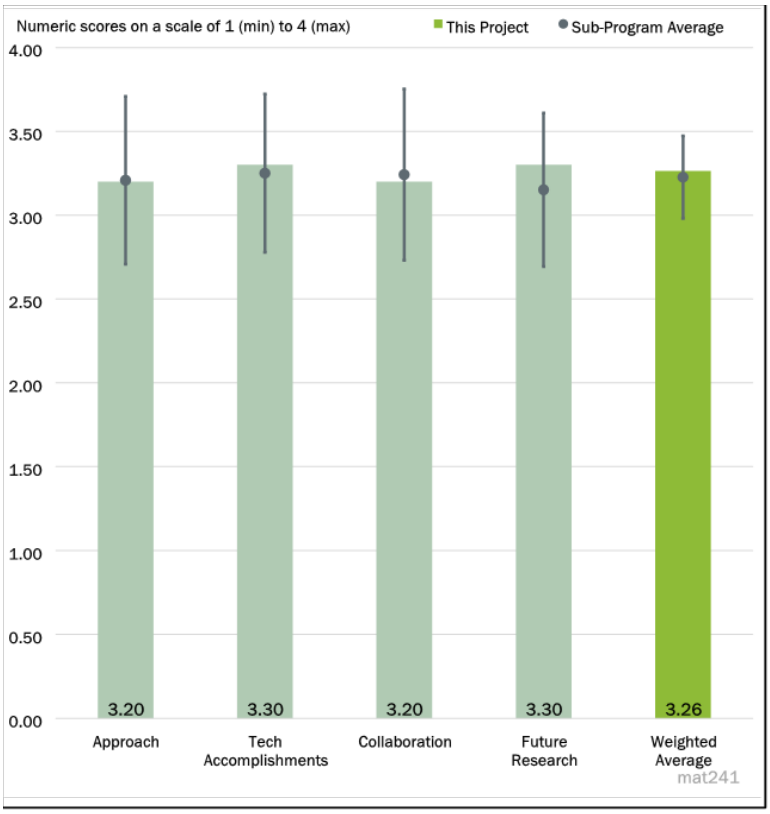

Figure 5-41 - Presentation Number: mat241 Presentation Title: Advanced Processing and Additive Manufacturing for Electric Vehicle (EV) Propulsion, Advanced Ceramics and Processing for Wireless Charging Systems Principal Investigator: Beth Armstrong, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer believes that the PI is doing a good job, program is well designed, but has quite a lot on her plate. US DOE VTO changed from ICE to BEVs quickly and the Materials team had to scramble to find appropriate programs/PIs to enlist on this subject.

Reviewer 2

This reviewer noted that an extensive literature search has been completed on smaller scale systems. The PI acknowledged that prior modeling efforts could have avoided some exploration of unfruitful compositions but was out of scope due to time and budget constraints.

Reviewer 3

This reviewer believes that, overall, the project is attacking an interesting problem. The approach for down-selecting the material is very good and an excellent use of ICME techniques. It is not clear from the presented material, however, how scalable the actual processing method is. That is an important consideration and the

equipment availability challenge could be a major obstacle that will influence the Go/No Go decision. The reviewer questions whether an industry or other partner would be helpful for this. Also, the Go/No Go milestone doesn't seem well defined.

Reviewer 4

This reviewer said that the approach provides a pathway for addressing the technical barriers to using ceramics in wireless charging for lighter weight and more efficient systems. This project aims to develop tunable and lighter weight advanced ceramic materials and processing methods for fabrication of wireless charging systems for EVs. The approach covers various steps needed to go from determining material properties of interest to optimizing ferrite fabrication methods.

Reviewer 5

This reviewer noted that a wireless charging system involves a roadway component and a vehicle component and asked whether light weight really comes to play on the roadway component of the magnetic core. It seemed to the reviewer that two different materials may be needed.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer said that the project appears to have made good progress on the first two tasks, which were the literature survey and the determination of initial down-select parameters.

Reviewer 2

This reviewer found that significant progress has been made on the screening protocol development, which is critical to baselining chemistry and material availability. He noted that doped ferrites seem to be a promising candidate material. Grain alignment and sintering are important fabrication elements.

Reviewer 3

This reviewer said that the project appears to be hitting milestones as per plan. Candidate materials have been identified for further exploration.

Reviewer 4

This reviewer said that progress seems on track, but the critical step of the first iteration of material is still in progress.

Reviewer 5

This reviewer found that the most important technical progress was the spinel ferrite (AFe_2O_4) using A-site doping for better tunability. The team's fabrication used either 1, 2, or 3 elements, then down selected to Binary $Ni_{0.5}$ / $Zn_{0.5}/Fe_2O_4$. The team wanted to use more modeling but the existing models are not adequate to predict magnetic properties.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer noted that the project is in the early stages so currently collaboration efforts are appropriate. The participants may want to involve others as the processing techniques are further refined.

Reviewer 2

This reviewer suggested that it would be good to drive collaboration and show alignment to other DOE wireless charging projects, particularly ELT262 "Long-Range Battery Electric Vehicle with Megawatt Wireless Charging" where large chillers were required to keep ground coils cool. The reviewer asked if higher temperature ceramics could provide value here.

Reviewer 3

This reviewer said that there had been good collaboration during fiscal year 2022 among ORNL as the lead lab (utilizing National Transportation Research Center and Manufacturing Demonstration Facility resources), Steward Advanced Materials (providing commercial powders), the VTO Grid and Infrastructure team, and the Basic Energy Sciences-Material Sciences and Engineering Division.

Reviewer 4

This reviewer said that it seems like a good team, though one could make the case that including some collaborators outside of the national lab might be useful just to gain another perspective.

Reviewer 5

This reviewer said that there had been good collaboration between national labs and industry but that the team could also use university partners to advance the database/modeling portion (Thrust 4).

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer said that the next phase will be looking at shear formation/grain alignment and whether fabrication should be by resin or slurry.

The reviewer stated that morphology for shape, the surface change in front of shear

The reviewer stated that the team should possibly look at selective laser sintering or different types of AM.

Reviewer 2

This reviewer said that the development and refinement of the measuring techniques will be an important next step. The development of the colloidal processing (and sintering) should also include work that will help to translate to scalability, including the manufacture of larger structures.

Reviewer 3

This reviewer said that the project shows good foundational research plans to develop large scale ceramic material processing for wireless chargers.

Reviewer 4

This reviewer said that the proposed future research and development of magnetic testing techniques and colloidal processing techniques will help address inadequate models and limited literature on this subject.

Reviewer 5

This reviewer said that the plan seems to make sense but a little more detail would be nice.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer said that the approach to EVs having to re-charge while in use is interesting but the reviewer is not sure how robust system will be required.

Reviewer 2

This reviewer noted that dynamic charging or wireless charging developments will further the acceptance of EVs because of the passive nature of the charging.

Reviewer 3

This reviewer noted that the project is part of the VTO Powertrain Materials core program as part of Thrust 3 (advanced and additive manufacturing for EVs), as it addresses the advanced ceramics and processing for wireless charging systems (ferrites).

Reviewer 4

This reviewer believed that ceramics provide more flexibility to tune magnetic performance than metallics. Ceramics also provide greater light-weighting capability, which will be key for the vehicle side of the system. The reviewer noted that the PI acknowledges that final solutions may involve hybrid metallic/ceramic materials.

Reviewer 5

This reviewer felt that dynamic charging is an engaging target in the EV world, so this is very relevant. The reviewer also believed that adding structural considerations of material in a roadway would be something to consider.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer said that the project was making good use of limited data/resources.

Reviewer 2

This reviewer said that, because this is a low TRL project, current resources seem sufficient.

Reviewer 3

This reviewer said that the $290,000 allocation seems appropriate for the fiscal year 2022 budget (this is a 3-year effort that started in 2021).

Reviewer 4

This reviewer believed that the resources are sufficient.

Reviewer 5

This reviewer believed that the new Magneto-rheology tools are needed to measure in-situ processing to help develop techniques. Predictive chemistry models are also requested to facilitate efficient experimental use. These will likely require funding expansion.

Presentation Number: mat242
Presentation Title: Advanced Processing and Additive Manufacturing for Electric Vehicle (EV) Propulsion, Novel Ultra High Conductivity Composites for EVs
Principal Investigator: Tolga Aytug, Oak Ridge National Laboratory

Presenter

Tolga Aytug, ORNL

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

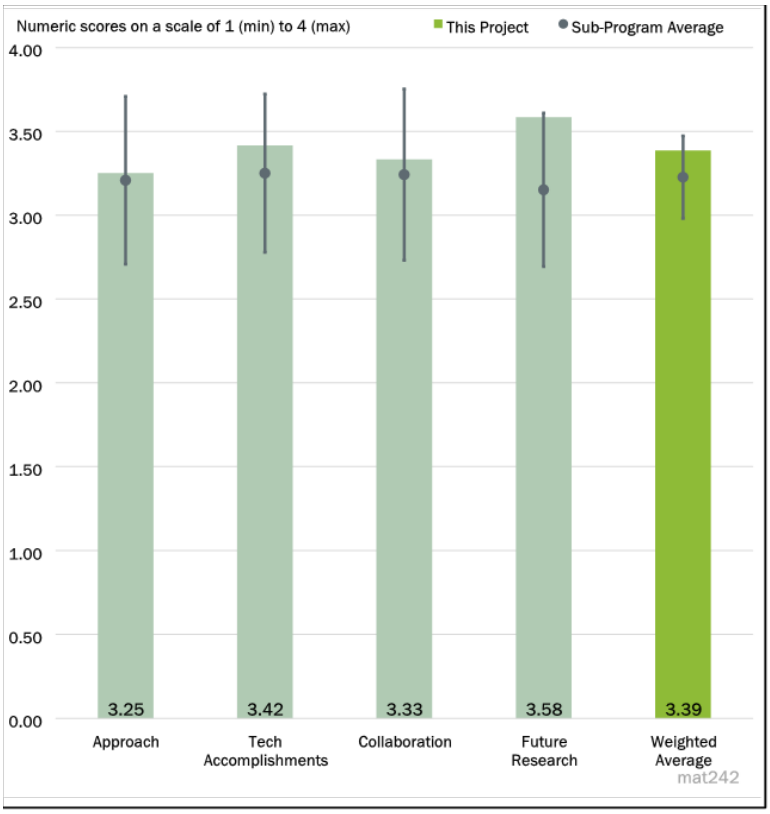

Figure 5-42 - Presentation Number: mat242 Presentation Title: Advanced Processing and Additive Manufacturing for Electric Vehicle (EV) Propulsion, Novel Ultra High Conductivity Composites for EVs Principal Investigator: Tolga Aytug, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer said that the U.S. DRIVE Electrical and Electronics Technical Team and Materials Technical Team roadmaps have identified reductions in electric motor components volume and weight to meet DOE 2025 power density, size, and reliability targets. Electric motor efficiency can be limited by electrical conductivity of the Cu windings. The USDRIVE roadmaps call for new advanced materials with improved capabilities and performance. Specifically, the Materials roadmap calls out carbon-nanotube based Cu materials as a key enabler.

This project proposes to develop high-performance Cu conductors using carbon nanotubes that are higher in electrical conductivity, current carrying capacity and mechanical strength. This directly addresses the technical barriers laid out in the project plan.

This is a new project and the development of the Cu-based tapes are still in process. ORNL has been completing modeling, and theoretical and computational studies of the complex parameters prior to scale-up of CNT deposition. Following CNT deposition, the project will refine and complete optimization of the process. Analyzing the processes and sensitivity to material properties and system parameters.

Reviewer 2

This reviewer noted that the project aims at improving conductivity of electric conductors. The proposed approach of making Cu-CNT composite is adapted from the high temperature superconducting wire process, it has three steps: deposit CNT, then deposit Cu, then anneal. The CNT electrospinning with polyvinylpyrrolidone (PVP) produces orientated fibers, which is key to the conductivity improvement.

Reviewer 3

This reviewer believed that the work is an important analysis of a novel technique to improve the conductivity of Cu tape using composite stacks and the researchers have shown some strong performance results. The project would be improved with more attention to robustness/consistency of the process and cost as compared to current process, in addition to optimizing performance. Overall, the reviewer considers it a strong project.

Reviewer 4

This reviewer said that the PI is doing a good job, bringing his advanced physical and chemical vapor deposition approaches as well as advanced materials characterization skills to the table. The program is well designed. The timing is too short to achieve 2025 advanced materials target.

Reviewer 5

This reviewer recognized the benefits of CNT deposition on a tape substrate, but questions whether a highly conductive Cu tape has a viable path to commercialization in EV powertrains and off-board charging equipment relative to the widely applied round product. The reviewer also asked what barriers exist to implementation of a tape vs round product. The reviewer believes that the mechanical strength of a round profile in bending and tension is superior to a rectangular tape with inherent stress risers, thus possibly negating any added mechanical strength benefits.

Reviewer 6

This reviewer noted that this effort is about ultra-conducting copper (UCC) composites, which are of very high interest in the electrical machinery universe. The reviewer said that the PI has produced material which is impressive.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer believed that the team made good progress. The resulted improvement in conductivity and ampacity were 6% and 15%, respectively. Perhaps more interesting for future improvement, he ORNL team found that nitrogen doping may improve electron density of CNT.

Reviewer 2

This reviewer noted that the PI has produced UCC tape, which the reviewer says is the key to the effort.

Reviewer 3

This reviewer believed that the project has demonstrated a considerable improvement in electrical properties with the addition of CNT in a short period of time. The project appears to be on track to address some of the major issues.

Reviewer 4

This reviewer pointed out that this is the first year of this project. ORNL has completed their first 2 quarterly milestones. Establishing critical design inputs for a single layer Cu-nanotube prototype and theoretical and computational studies. In the second half of the year, it will be establishing key processing needs, setting up tools for scale up of CNT deposition, and refining and completes optimization of the processing steps.

Reviewer 5

This reviewer said that the project achieved a good improvement of 10% decrease in resistivity and a greater than 20% increase in ampacity on Cu foils by embedding CNTs

Reviewer 6

The reviewer said lack of understanding parameters and microscale performance/nitrogenated. It was interesting that the nitrogen signal –4 different conditions which was attributed to CNT materials. 1/3 metal (good) + 2/3 semi conducting (bad).

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer pointed out that ORNL works with several companies including wire manufacturer southwire and materials provider General Graphene.

Reviewer 2

This reviewer noted that suppliers are providing materials and Southwire, as a project partner, shows interest from industry in the work.

Reviewer 3

This reviewer said that the project is collaborating with industry partners, which is important for the transfer of the process and addressing the industrialization of the process.

Reviewer 4

This reviewer noted that the project is led by ORNL with partners Southwire, Chasm Advanced Materials, and General Graphene. The bulk of the work is being completed by ORNL with material support from the other partners. As the project develops and if initial phases are successful, it would be beneficial to see CNT-Cu wires used in real work applications at ORNL or with additional industry partners.

Reviewer 5

This reviewer believed that, while collaboration has been good, the project team could be improved by having some meetings with the ORNL lead electric machinery group (Sandia, Purdue, University of Wisconsin, Illinois Institute of Technology, and ITT, North Carolina State).

Reviewer 6

This reviewer found good Industry collaborations, which were critical to establishing a reliable process, but the team could also use possible additional collaboration(s) to help with scale up to commercial high temperature superconducting wire process

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer said that the proposed work appears to be reasonable.

Reviewer 2

This reviewer said that the future research does include investigating and optimizing repeatability, which is extremely important. Overall, the plan seems sound for addressing the barriers identified.

Reviewer 3

This reviewer found that the project has a clear strategy towards commercial viability for ultra-conducting Cu. The project has developed a new process for fabrication of ultra-conducting Cu. The team is currently in the process of optimizing the fabrication process to achieve high microstructural quality prototypes. It will explore prototypes with various parameters and properties to optimize electrical and mechanical properties. Future work will also include developing tools for scalable roll-to-roll assembly of ultra-conducting Cu composites. In the longer term, it would be interesting to see collaboration with ORNL electric motor and power electronics developers utilizing this technology.

Reviewer 4

This reviewer believes that developing an optimized CNT process solution for tape form is a good foundation. If round vs rectangular tape profile concerns are shared by Southwire, it would be good to outline a future path to a round UCC solution.

Reviewer 5

This reviewer state that the future plan is a bit more specific than others the reviewer has seen, and the reviewer believes that the effort looks well focused.

Reviewer 6

This reviewer noted the use of IA to look at additional layers to achieve long length UCC greater than 50 cm.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer opined that the UCC materials 10 cm in length are nice in the lab but that the timeline is not long enough to be able to address the 2025 ultra-high conductivity materials target for vehicles because making carbon nanotubes work for this application is no small task.

Reviewer 2

This reviewer believed that a conductor more conductive than Cu will have direct impacts on many energy efficiency and renewable energy applications. The proposed Cu-CNT composite is definitely a promising approach.

Reviewer 3

This reviewer said that the project is attempting to address material solutions to improving efficiency in EV systems and also addressing some of the sustainability challenges around Cu. So it fits well with the VTO goals.

Reviewer 4

This reviewer stated that the project is directly relevant to the Electrification and Materials sub-programs at DOE. This project has theoretically shown the potential for remarkable improvements in electrical properties over pure Cu. These improvements in electrical properties will have a direct impact on the volume, power density, and efficiency of electric drive technologies.

Reviewer 5

This reviewer believes that greater efficiency in electric conduction will improve power density and reduce weight for electric drive system components. There is potential for this project to also reduce Cu requirements on future EVs, which are expected to surge.

Reviewer 6

This reviewer said that UCC very much supports the VTO program objectives. and believes that it should be used in electric machine designs.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer found good use of resources and is looking forward to seeing future work on how additional Cu/CNT layers on the structural and electrical properties of UCC prototypes.

Reviewer 2

This reviewer said that the resource required by this project is appropriate.

Reviewer 3

This reviewer said that the resources should be sufficient in conjunction with support of the industry partners for manufacturing samples.

Reviewer 4

This reviewer said that the project funding and resources are sufficient for the proposed level of effort in the first 2 years of this project. If that work is successful, additional resources could be needed to continue testing of samples or incorporate CNT-Cu conductors in electric drive technologies components to verify the utility of this technology.

Reviewer 5

This reviewer said that the resources appear sufficient.

Reviewer 6

This reviewer did not feel completely qualified to answer the question but believed that the resources are sufficient.

Presentation Number: mat243
Presentation Title: Manufacturing Demonstration of a Large-scale, Multi-material Passenger Vehicle Sub-system
Principal Investigator: Srikanth Pilla, Clemson University

Presenter

Srikanth Pilla, Clemson University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

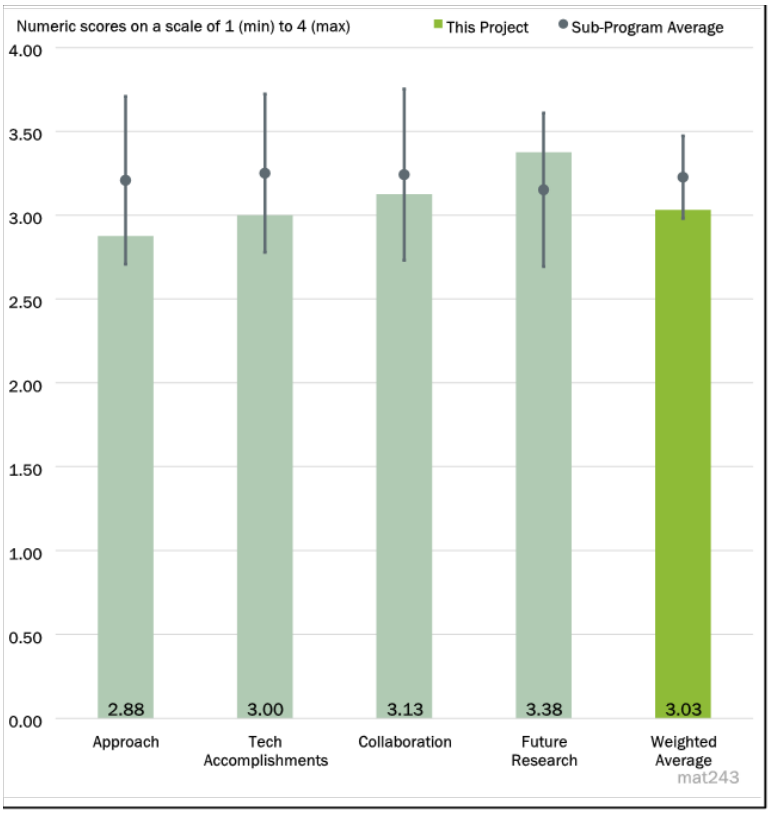

Figure 5-43 - Presentation Number: mat243 Presentation Title: Manufacturing Demonstration of a Large-scale, Multi-material Passenger Vehicle Sub-system Principal Investigator: Srikanth Pilla, Clemson University

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer believes that this is an innovative and comprehensive approach. The reviewer found it less science-based than many of the other programs, but good training for students and good sources of new ideas for all partners.

Reviewer 2

This reviewer stated that the barriers to achieving the project goals are not technical barriers per se. If technical barriers are to be considered, then there should be specific consideration to the manufacturing readiness level of the wet compression molding process and development of the transition joint. The project per se, is well designed to investigate the overall vehicle concept and construction in order to achieve mass savings.

Reviewer 3

This reviewer said that the ultrasonic additive manufacturing (UAM) is unique in bonding metals with carbon fiber reinforced thermoset composites. This is the first year of the project. The presented approaches are listed at high level and comprehensive. The reviewer suggested that possibly go/no-go strategy could be given according to the proposed tasks.

Reviewer 4

This reviewer said that, although the project identifies an OEM partner (Honda), review of the presentation does not give any indication of what the OEM will be doing in the project and leaves this reviewer with the impression that the OEM will not be involved sufficiently to ensure a successful project, in fact, leaving the design and analysis work to be conducted by Clemson University students instead of more experienced OEM engineers and designers.

The technology development and validation is too extensive for application on a complete vehicle glider system at this time and should be validated on a much smaller project before being applied to one of this scope. The processes being proposed do not appear suited for some of the complex shapes required of a full vehicle glider system at this time, including, as an example, a body side aperture (especially the b-pillar), with numerous contour changes in all three dimensions. The project should be focused on developing and validating one or two complex sub-assemblies with the UAM process rather than developing a full vehicle glider system at this time. The reviewer said that no go/no-go points are identified anywhere in the presentation.

According to the reviewer, the joining process complexity of CF to steel, as proposed in the project, as well as the high cost of CF (even recycled CF), make it unlikely that this project will meet VTO cost objectives.

The reviewer believes that vehicle recycling (not just CF recycling) will be virtually impossible (at the very least unaffordable) with this concept since the CF components will have to be separated from the steel flanges before the glider can be recycled.

The reviewer said that the project really appears to be focused more on development and evaluation of new CF material technologies and new joining processes than on developing a light-weight vehicle glider system, which should be investigated after these technologies have been proven on smaller scale subsystems.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer believes that the team has accomplished the proposed tasks completely in the first two quarters.

Reviewer 2

This reviewer believed that, although it is early in the whole process, the team seems to be on track.

Reviewer 3

This reviewer said that the reported progress seems to be in line with expectations for a project kicked off only six months ago.

Reviewer 4

This reviewer said that, because the project has just begun, it is premature to evaluate this.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer stated that the program brings together a large comprehensive team with great partners.

Reviewer 2

This reviewer pointed out that the team is composed of ten partners, which include the technical know-how to make the project successful, except for the fact that the team does not have a molding partner to provide the technical and cost input for the wet compression molding process. The project needs to have a plan in place to secure this gap. This will be critical to the business case when considering annual volumes of 200,000 vehicles.

Reviewer 3

This reviewer found that the team is well formed, including collaborators from university, an OEM, global n-tier partners, and recycling partners. However, the role or associated tasks of each partner are not very clearly presented in this presentation.

Reviewer 4

The reviewer believed that the overall list of collaborators appears well suited to developing CF composite intensive structures. However, according to the reviewer, there is little evidence of the type of expertise necessary to fully design, build, and validate a full vehicle glider system, with the exception of the OEM, which does not appear to be involved to the extent necessary for this project to achieve its stated goals (at least in the design and analysis, which are being conducted by Clemson University students).

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer found that the team had put forward an excellent plan And is looking forward to their achievements.

Reviewer 2

This reviewer said that the future research is comprehensive and aligns well with the proposed milestones. The proposed work should address the challenges and barriers.

Reviewer 3

This reviewer said that the proposed future work is focused on meeting some of the needs to ultimately develop a CF/steel multi-material glider system, although more actual physical validation of the transition joints should be conducted prior to starting the multi-material glider optimization.

Reviewer 4

The project is well thought out in a logical sequence. The only point that I would add is that the cost analysis needs to consider not only the cycle time but also the investment which would be required to achieve a volume of 200,000 vehicles/year.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer answered that the project is centered around enabling mass reduction at minimum disruption to existing infrastructure. Mass reduction is an integral component of the DOE target of reducing greenhouse gas emissions.

Reviewer 2

Innovative manufacturing belongs in the DOE portfolio.

Reviewer 3

This reviewer believed that the joining of dissimilar materials is a critical area in advanced manufacturing for DOE to reduce the structural weight and improve component performance and energy efficiency.

Reviewer 4

This reviewer found that the project proposes to develop a multi-material vehicle glider to achieve a 160 lb. (73 kg) weight reduction with no compromise on performance targets, at a cost increment of no more than $5 per pound saved, at a production volume of 200,000 vehicles per year, using recycled carbon fiber. This clearly is relevant to stated VTO subprogram objectives, although the likelihood of achieving the VTO cost objectives is poor.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

Without an understanding of the in-kind and cost allocation, it is difficult to make an informed comment here. Although the total project is $11.5M, there will be significant analysis time, coupon testing, and component fabrication. However, given that Honda has significant experience in vehicle program development I would assume it has a good handle on the resources required to achieve their goals.

Reviewer 2

This reviewer said that the budget should be able to carry out the tasks described.

Reviewer 3

This reviewer said that the team has sufficient facilities, expertise, and human resources to achieve the stated milestones.

Reviewer 4

This reviewer believed that the budget of $11,500,000 should be sufficient if the work is conducted efficiently. However, the timeline of slightly more than 3 years is likely to be insufficient, given the number of new technologies being investigated, developed, and proven(transition joint process and recycled CF properties) before serious design and analysis of the glider can be considered. Additionally, more involvement from the automotive OEM will likely be required in order for this project to achieve its stated goals.

Presentation Number: mat244
Presentation Title: LMCP P1A - Sheet Materials with Local Property Variation
Principal Investigator: Scott Whalen, Pacific Northwest National Laboratory

Presenter

Scott Whalen, PNNL

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

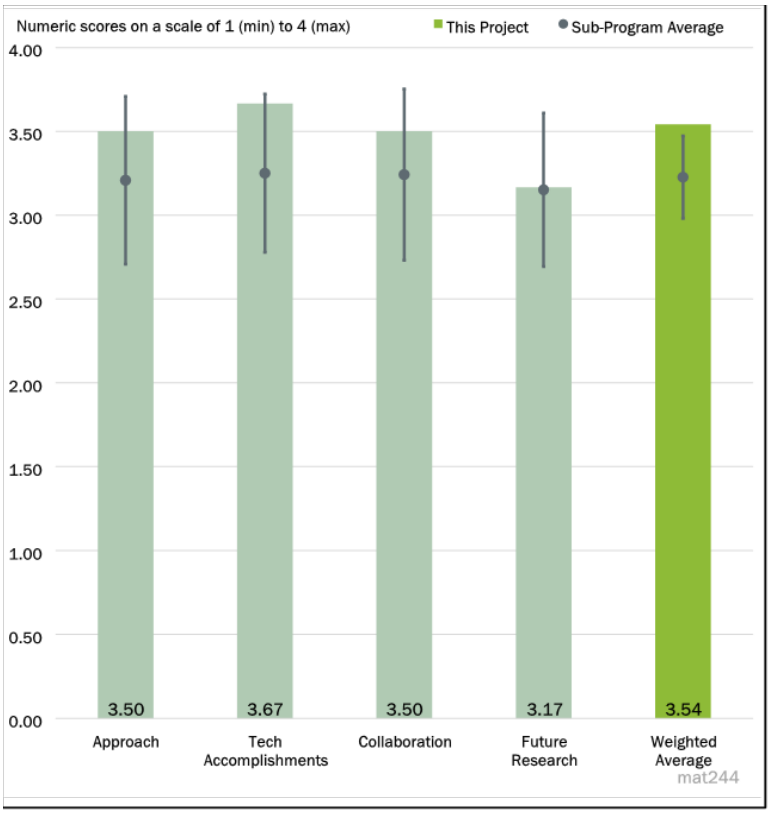

Figure 5-44 - Presentation Number: mat244 Presentation Title: LMCP P1A - Sheet Materials with Local Property Variation Principal Investigator: Scott Whalen, Pacific Northwest National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The technical barriers that are being addressed are well defined and the project is set up with clear milestones designed to advance the ShAPE approach in the context of manufacturing of Al tube and strip.

Reviewer 2

The shear extrusion process is used to test the ability to produce Al tubes with variable thickness. Eventually these tubes will be sectioned to produce strips which can be used similar to tailor weld blanks for sheet forming; the validity of this approach is questionable but obtaining tubes with variable wall thickness and properties could be useful for some applications.

Reviewer 3

The project is clearly defined with clear milestones to address the barriers. There is no modeling component , but the PI mentioned that there is collaboration with another project as far as the modeling is concerned. It would be useful for a connection with these efforts to be made and to see the contributions from modeling.

Reviewer 4

The shear extrusion process is used to test the ability to produce Al tubes with variable thickness. Eventually these tubes will be sectioned to produce strips which can be used similar to tailor weld blanks for sheet

forming; the validity of this approach is questionable but obtaining tubes with variable wall thickness and properties could be useful for some applications.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

The program appears to be on track to complete the planned milestones for this FY. This has included notably the successful completion of the design of the variable wall extrusion system, and demonstration of the extrusion of Al 6082 with T6 properties using T5 heat treatments, consistent with the first two milestones.

Reviewer 2

Shown the usefulness of the process to produce variable wall thickness and/or property enhancements. The process parameters such as feed, speed were varied and their impact on performance is validated.

Also possibility of producing composite material tube is explored. Recyclability of this material will be a problem but the technology can be useful in certain applications.

Reviewer 3

The project plan is on track. Multi alloy extrusion has been achieved. Mechanical properties tuning has been demonstrated. The variable wall thickness goal is on track.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer found that, given the progress of each of the tasks assigned to each of the team members at PNNL, collaboration within the team seems to be well managed. The PIs are encouraged to enhance the collaboration with industry to continue to guide the process design in a way that will enable the research to have maximal impact.

Reviewer 2

This reviewer said that the material supplier, research lab, and end user are actively involved in this project, making the knowledge dissemination easier.

Reviewer 3

This reviewer said that the collaboration between the lab and the industry partners is clear. Their roles are well defined and the synergy seems very effective.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer said that the proposed work appears to be well designed to address the remaining identified barriers and challenges. The reviewer suggested that it would be helpful to understand the degree to which the ICME approaches being developed in the cross-cutting LMCP project could be used to guide the process design as the work evolves to consider other materials systems.

Reviewer 2

This reviewer said that the project's future work is well defined and connected directly to the remaining barriers. Some goals have been achieved earlier than planned. The project's targets are likely to be achieved on time. The reviewer believed that it would be useful to see the connection with or contributions from modeling, which is being performed in collaboration with another project.

Reviewer 3

This reviewer pointed out that a structure with variable wall thickness and/or variable property limits will react to uniform loads differently than monolithic material. The reviewer questioned what the design criteria are for using such a structure and suggested that a design and test approach is needed to confirm that this is a safe process.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer said that the work is developing a methodology of locally modifying properties during extrusion processes and is consistent with the goals of the LMCP to develop scalable, cost effective processing methods to locally enhance the properties of Al and Mg in order to enable broader implementation of light-weight alloys.

Reviewer 2

This reviewer believes that light-weighting is an enabler to improve energy efficiency or range in vehicles. Aluminum can be used to reduce the weight of vehicles. The using less energy intensive manufacturing processes and air cooling to achieve T6 properties can reduce the carbon and energy footprint of the material as well.

Reviewer 3

This reviewer found that the project supports the subprogram's objectives. The project supports the need for light-weight materials and for environmental gains in vehicle manufacturing processes.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer said that an important development was the design and the procurement of the components to develop the variable wall extrusion system, which will provide a necessary resource for the future work.

Reviewer 2

This reviewer said that the resources are adequate.

Reviewer 3

This reviewer said that the resources seem sufficient for completing the work.

Presentation Number: mat245
Presentation Title: LMCP P1B - Form-and-Print - AM for Localized Property Enhancement of High-strength Al sheet
Principal Investigator: Alex Plotkowski, Oak Ridge National Laboratory

Presenter

Alex Plotkowski, ORNL

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

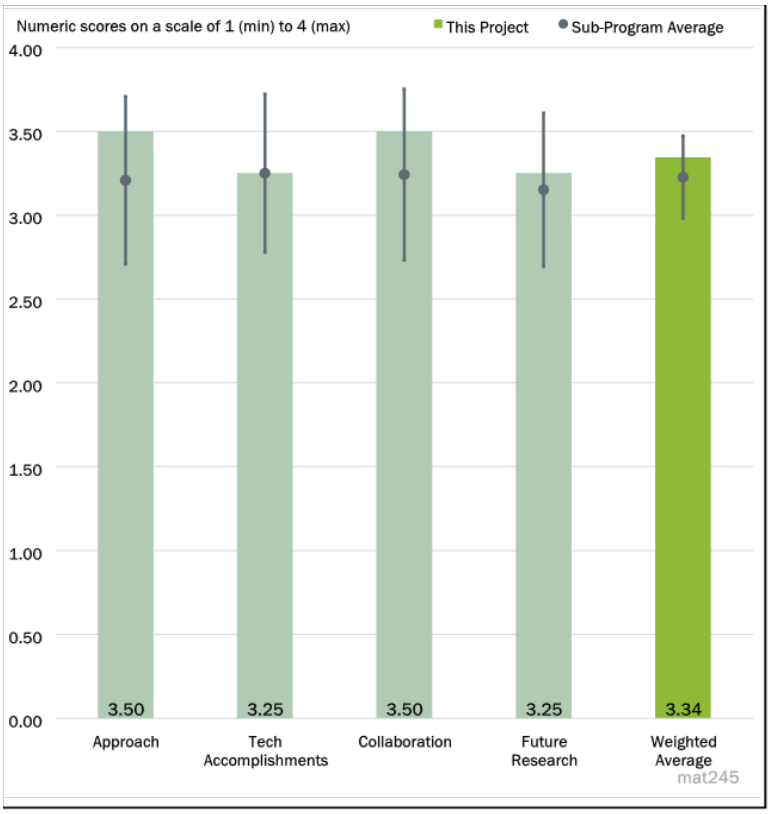

Figure 5-45 - Presentation Number: mat245 Presentation Title: LMCP P1B - Form-and-Print - AM for Localized Property Enhancement of High-strength Al sheet Principal Investigator: Alex Plotkowski, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer said that the project is a novel investigation exploring a wide open space of opportunity to align and integrate additive manufacturing into automotive design and production.

Reviewer 2

This reviewer said that the project is testing AM techniques to add/modify local features and microstructures to enhance performance of Al sheets. This is more of a fundamental study than an application, suitable for the lab funded project. All aspects of the work are being planned, including alloys, process variables, and characterization. One aspect missing is long term performance testing, such as corrosion and fatigue.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer said that progress has demonstrated that fundamental opportunities exist and warrant exploration.

Reviewer 2

This reviewer noted that the team has developed an equipment and tested it for operation and has completed various alloy depositions and conducted testing. The reviewer said that it has developed models on the depositions, air flow, and other aspects of the process. The knowledge generated will be useful for further understanding of the laser deposition process.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer said that the team has made strong efforts to communicate with industry and to use industrial perspectives to inform the development plan. The reviewer disclosed that he participated in this industrial engagement.

Reviewer 2

This reviewer reported good integration with other labs and that an equipment supplier and OEM are involved in advisory roles.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer found that the future workplan considers relevant materials, manufacturing roadblocks, and timely topics in the area of sustainability.

Reviewer 2

This reviewer suggested that long term exposure tests could be incorporated into the tasks

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 3

This reviewer believes that the project is aligned with VTO's objectives and seeks to explore a topic not previously investigated by industry or university in a meaningful way.

Reviewer 4

This reviewer believes that increasing the performance of Al sheets can make them more attractive for enclosures and this will make light-weighting of the vehicle easier.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer said that the project's resources appear to be appropriate and sufficient to accomplish objectives.

Presentation Number: mat246
Presentation Title: LMCP P1C - Local Thermomechanical Processing to Address Challenges to Implementing High Strength Al Sheet
Principal Investigator: Efe Mert & Govindarajan Muralidharan, Pacific Northwest National Laboratory/Oak Ridge National Laboratory

Presenter

Efe Mert and Govindarajan Muralidharan, PNNL/ORNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

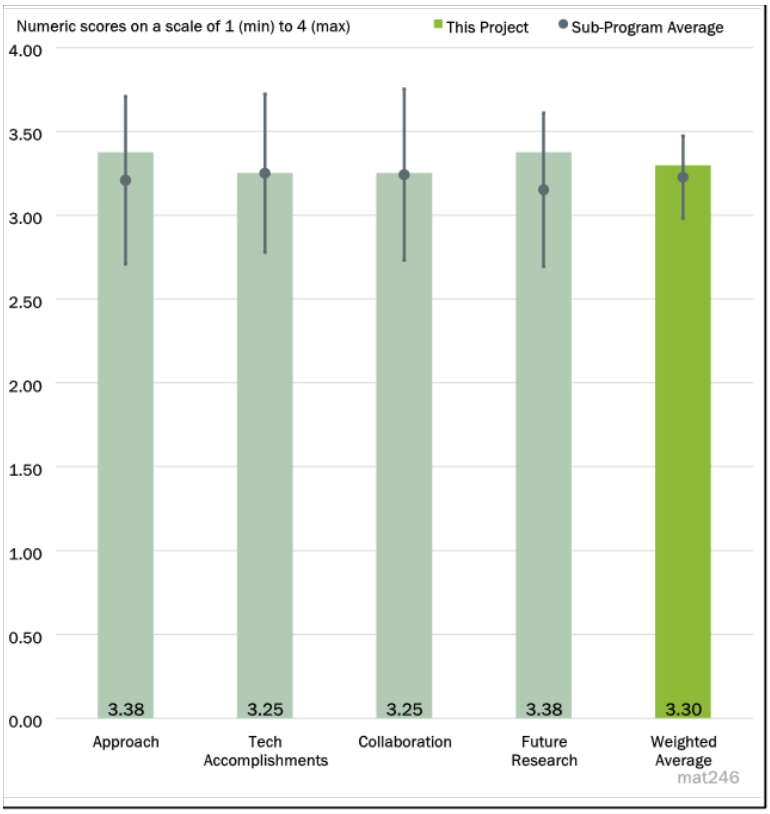

Figure 5-46 - Presentation Number: mat246 Presentation Title: LMCP P1C - Local Thermomechanical Processing to Address Challenges to Implementing High Strength Al Sheet Principal Investigator: Efe Mert & Govindarajan Muralidharan, Pacific Northwest National Laboratory/Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer noted that the program explores three distinct approaches to increasing formability of Al sheet locally. Good progress has been demonstrated. Over the past year, the focus has been on a specific component, which, along with initial work exploring cost, will be helpful in the goal of developing processes that can be adopted in industry. Going forward, closer work with industry partners is desirable. Further, since the project is part of a larger portfolio that involves advanced characterization and simulation, the reviewer suggests that the PIs should be encouraged to ensure that these tools are being exploited to advance progress. The reviewer found it difficult to tell from the presentation whether this is already occurring to significant extent.

Reviewer 2

This reviewer said that the technical considerations as well as the approach on an experimental level are on a high level. However, additional clarifying the exact field of application would be useful. The reviewer asked how far the proposed route of local microstructural alteration is being implemented in an industrial process and what the implications on process times and surface quality are.

Reviewer 3

This reviewer noted that the project proposed to evaluate three different routes to introduce localized surface/bulk microstructure/strain modifications to improve the formability of Al sheets. All three methods were rigorously selected and applied. The sheets were characterized using standard test methods and the performance was modeled. The reviewer suggested that long term performance such as fatigue, corrosion could be evaluated for completeness.

Reviewer 4

This reviewer noted that the project targets local thermomechanical processing to deliver local formability and can be delivered by the current plan.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer said that the team has achieved important progress in the overarching goal of local property modification (namely formability) in Al sheet using three different processes that it has demonstrated can be integrated with robots. Initial progress has been made on the assessment of feasibility and potential applications.

Reviewer 2

This reviewer noted that, while the effect on bendability is reported, the information on the development of strength is not complete.

Reviewer 3

This reviewer believes that, thus far, results suggest friction stir and laser processing will deliver local formability with potential industrial application but that it is not yet clear how roller processing would be industrialized.

Reviewer 4

This reviewer said that the performance of the sheet after the surface/bulk modifications was evaluated in all test conditions. Results indicate improved benefits of the processes. However, localized strains may impact the overall performance in long term use, suggesting a need for corrosion and fatigue testing.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer said that, within the team, there is sharing of materials and development of common test methods across the two participating labs. The right kind of industry collaborations are mentioned, but it was hard to assess whether more could or should be done in this regard. Finally, the reviewer said that collaborations with Thrust 4 in the LMCP portfolio were mentioned but the impact of these collaborations was not clear from the presentation, nor was whether closer collaborations could accelerate progress and understanding.

Reviewer 2

This reviewer said that there appears to be good collaboration amongst the project team.

Reviewer 3

This reviewer said that the project team is demonstrating collaboration among the lab partners and maintaining dialogue with the industry.

Reviewer 4

This reviewer found that, as of now the project is a collaboration between DOE labs; participation from OEM and from tier 1 and 2 suppliers could improve the reliability and usefulness.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The proposed future research seems well designed to address remaining barriers underlying the project goals. The connections to industry are encouraged to assess process feasibility and potential for applications.

Reviewer 2

This reviewer fully agrees with the proposed next steps.

Reviewer 3

This reviewer said that future investigations will include alloys of interest and will explore the influence of local thermomechanical processing on global formability.

Reviewer 4

This reviewer suggested that it should be useful to include long term exposure tests and fatigue.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer said that the project is well aligned with the Lightweight Materials Program goals.

Reviewer 2

This reviewer said that the project bears relevance.

Reviewer 3

This reviewer said that this project is relevant to application of lightweight materials.

Reviewer 4

This reviewer said that more use of Al sheets can make light-weighting possible; improving the formability will reduce the cost of material substitution.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer said that the resources available to each partner lab appear adequate based on the progress realized to date.

Reviewer 2

This reviewer said that there do not seem to be any shortages in resources.

Reviewer 3

This reviewer said that the resources are sufficient.

Reviewer 4

This reviewer said that, if additional testing for long term performance is added, then additional resources may be necessary

Presentation Number: mat247
Presentation Title: LMCP P2A - Solid Phase Processing of Aluminum Castings
Principal Investigator: Jana Saumyadeep & Zhili Feng, Pacific Northwest National Laboratory/Oak Ridge National Laboratory

Presenter

Jana Saumyadeep and Zhili Feng, PNNL/ORNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

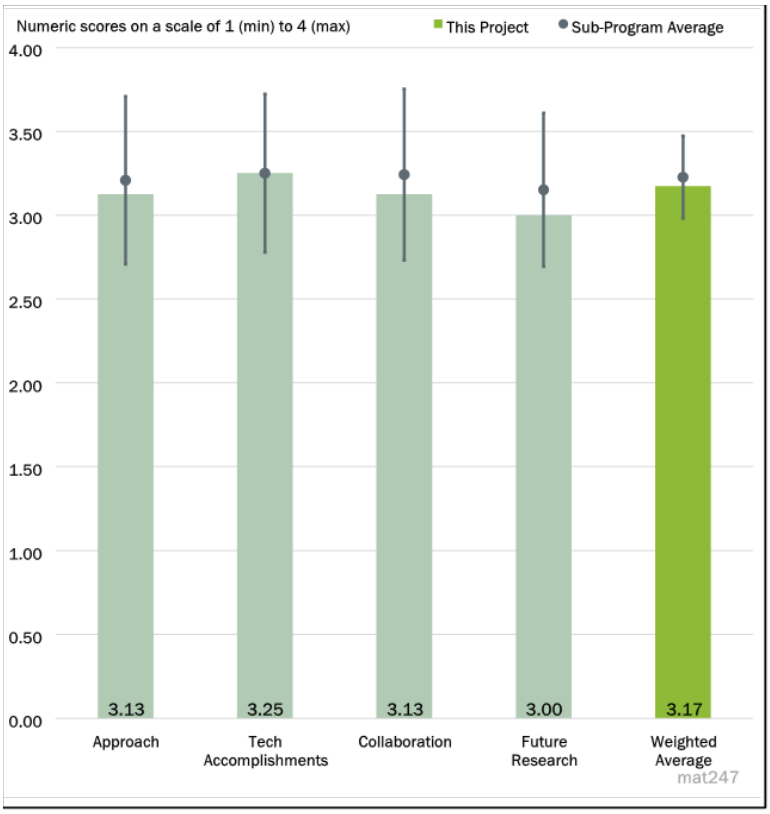

Figure 5-47 - Presentation Number: mat247 Presentation Title: LMCP P2A - Solid Phase Processing of Aluminum Castings Principal Investigator: Jana Saumyadeep & Zhili Feng, Pacific Northwest National Laboratory/Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer found that the results presented so far show great promise in terms of improving the material performance. In the future, focus should be placed on an adaptability of the process to real components and processes. This appears in parts to be included in the current project plan.

Reviewer 2

This reviewer said that the technical barriers are being evaluated using the right methods of material testing.

Reviewer 3

This reviewer said that the project involves surface modification of die casting to improve the quality and performance. According to the reviewer, the team has accepted that the surface is the best part of the high-pressure die casting (HPDC) component, so that modifying it may not be the best option. However, by using the techniques to close internal pores the performance can be enhanced.

Reviewer 4

According to this reviewer, thus far, the work is good. The reviewer, however, sees potential issues in modifying the FSP and power ultrasonic surface processing (PUSP) platforms to work on real demonstration parts with complex shapes, as opposed to simple sample shapes. The reviewer suspects that it will take great efforts to develop the robotic tools to work on complex shapes of real parts in the time of the project.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer says that progress seems to be proceeding according to plan.

Reviewer 2

This reviewer feels that the project plan has demonstrated the opportunity for these technologies.

Reviewer 3

This reviewer says that the team had shown that it is possible to improve performance of die cast coupons but that the economic advantage of the procedures needs to be validated.

Reviewer 4

This reviewer believes that the researchers are making consistent progress on their respective tasks related to FSP and PUSP, and have been successful in meeting their milestones thus far. The reviewer, however, would like to see more microstructural characterization to detail the mechanisms that are leading to enhanced mechanical properties.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer said that the project has demonstrated collaboration among the lab partners as well as being informed with industrial perspective.

Reviewer 2

This reviewer found that the project is really parallel projects studying two separate methods for processing Al castings. Given the nature of the proposed research being two parallel projects, the level of collaboration seems satisfactory.

Reviewer 3

This researcher found that the approach of contrasting two competing processes by the two project partners provides good overlap.

Reviewer 4

This reviewer believes that lab to lab collaboration is good but no external partners are involved in this project.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer believes that the future of the project is aligned with industry needs.

Reviewer 2

This reviewer agrees with the next steps proposed.

Reviewer 3

This reviewer said that automation of the process to make it easier is a good idea, possibly reducing the cost during manufacturing.

Reviewer 4

This reviewer suspects that the research team will need to go to great efforts to develop the modifications to their experimental setups for processing realistic part shapes. According to the reviewer, it should also be studying the "heat affected zone" in FSPs as well. While this is not friction stir welding, there are still significant microstructural changes around FSP regions, particularly in Al with its relatively low processing temperatures.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer found that the project is relevant to the Materials subprogram, particularly the Lightweight Materials Area 1: improving the properties and manufacturability of light metals. The project is developing processing techniques to increase the viability of Al, which is directly relevant to lightweight materials.

Reviewer 2

This reviewer points out that the relevance is backed by examples of current developments in the automotive industry.

Reviewer 3

This reviewer says that the project is aligned with VTO objectives for materials.

Reviewer 4

This reviewer finds that the goal is very highly stretch; die cast Al is already improving energy efficiency. Property improvements may not justify using thinner sections but the reliability of the components may improve by the surface treatment.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer believes that the resources are sufficient, though suggesting that it may be difficult to make significant progress in developing methods for processing realistic shapes in the proposed time period.

Reviewer 2

This reviewer says that the resources seem to be fine.

Reviewer 3

This reviewer says that sufficient resources are being applied.

Reviewer 4

The reviewer remarked adequate resources.

Presentation Number: mat248
Presentation Title: LMCP P2B - High Intensity Thermal Treatment
Principal Investigator: Aashish Rohatgi, Pacific Northwest National Laboratory

Presenter

Aashish Rohatgi, PNNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

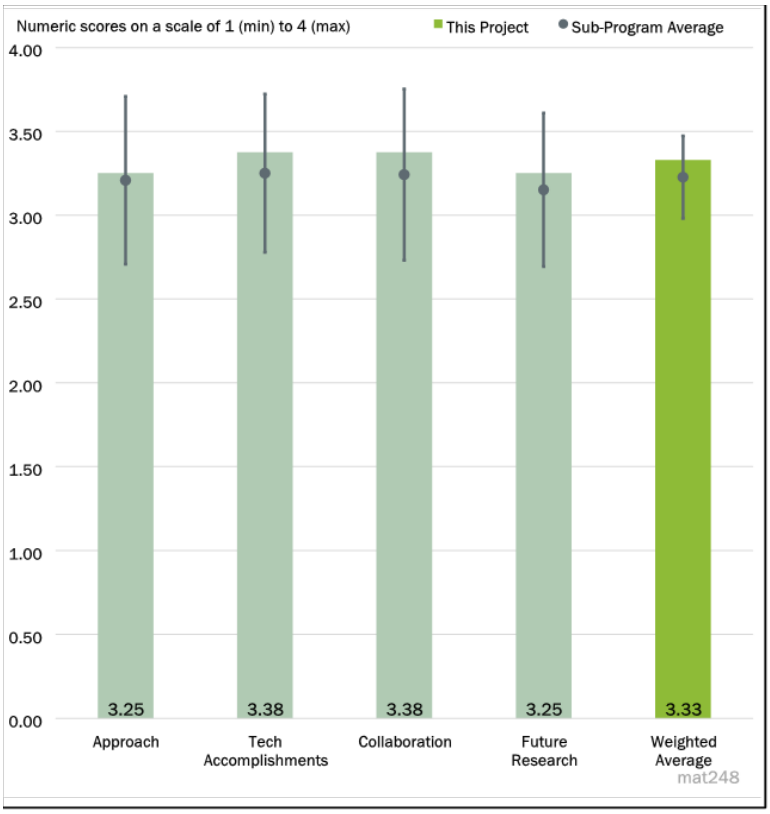

Figure 5-48 - Presentation Number: mat248 Presentation Title: LMCP P2B - High Intensity Thermal Treatment Principal Investigator: Aashish Rohatgi, Pacific Northwest National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer said that the project consists of three distinct tasks, each addressing different strategies related to casting; heat treatment: and surface treatment. The overarching goal is to enable broader use of Al castings for light-weighting. The three tasks explore different routes to improving casting microstructures and enhancing local mechanical properties through cost-effective processes compatible with existing industrial casting approaches.

Reviewer 2

This reviewer said that the project has a reasonable plan and has been well designed.

Reviewer 3

According to this reviewer, the project is well designed. The reviewer found it encouraging that the researchers are considering the variation in properties as a function of distance from the treated region in their plans, which is important for real parts.

Reviewer 4

This reviewer believed that the work accomplished so far greatly shows the feasibility and microstructural effect of this new processing technique. Further work should include a more detailed characterization of the

benefits, especially property improvements, at a broader scale. The hypothesis of higher effectiveness for secondary alloys should find some deeper focus, as this has the potential to greatly expand the field of application of recycled alloy material.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer believed that most of the accomplishments described were related to Task 1 and involve demonstration of impressive progress in the use of ultrasound to achieve microstructural refinement in cast alloys, as well as refinement of brittle Fe-containing phases that could enable greater use of recycled materials. Progress under this task includes collaborative work with the modeling thrust and in-situ characterization, which will greatly advance understanding of the origin of the effects of ultrasound.

Reviewer 2

This reviewer said that the work seems to be on track.

Reviewer 3

This reviewer said that progress made is aligned with the project plan.

Reviewer 4

This reviewer said that the results so far are impressive and they have shown a significant change in the microstructure due to ultrasonic processing during casting.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer noted that the project features strong collaborations with ORNL and ANL on solidification modeling and in-situ characterization at the Advanced Photon Source (APS), as well as PNNL for modeling and ultrasonics and microstructure analysis. The collaborations with Eck Industries are viewed as important for maximizing the potential for adoption of the processes investigated in this project.

Reviewer 2

This reviewer believed that the researchers are collaborating via discussions with an industrial partner, and experiments with other national labs. The proposed work with ORNL on applying their method to A356, and the in-situ diffraction experiments that were successfully proposed with APS will be enlightening for the project and for future work in this area.

Reviewer 3

This reviewer said that the project is well informed by industry perspective.

Reviewer 4

This reviewer said that the collaboration seems to work well.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer said that understanding the mechanism of microstructural refinement is particularly important for this research, and the proposed in-situ diffraction experiments at APS should help understand these mechanisms. The reviewer believed that it will be beneficial if the researchers can demonstrate microstructural refinement with a realistic demonstration part.

Reviewer 2

This reviewer said that the future research plan is rightly targeting opportunities in high pressure die casting.

Reviewer 3

This reviewer found the proposed work in Task 1 to be well designed to address the remaining barriers. For Task 2, not enough detail was given for this reviewer to judge the likelihood of achieving targets. Task 3 is to be commenced, but given that the project is half way over, and the remaining work to be done under the other two tasks, this reviewer wonders if a refocusing would be worthwhile that de-emphasizes Task 3.

Reviewer 4

This reviewer favors having the team focus on a full characterization of the mechanical property spectrum.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer found that the project is well aligned with the LMCP goals and appears unique within this portfolio in its focus on cast alloys.

Reviewer 2

This reviewer said that the project is particularly relevant to the lightweight materials portfolio of the Materials Technology Subprogram of the Materials Program objectives. It has shown success so far on research samples, and if successfully applied to realistic parts, will increase the recyclability, and thus cost, of Al for castings.

Reviewer 3

This reviewer believed that the aspect of secondary alloys shows great promise.

Reviewer 4

This reviewer said that the project supports the overall VTO subprogram objectives in lightweight materials.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer said that the progress demonstrated suggests that resources for Task 1 are adequate. The reviewer asked whether, given the challenges described with the HPDC sample, other sources of material will be required to enable progress in Task 2. The reviewer was unable to judge the resources for Task 3.

Reviewer 2

This reviewer said that the resources seem to be sufficient and the researchers are leveraging collaborations with other labs effectively.

Reviewer 3

This reviewer said that the resources seem sufficient.

Reviewer 4

This reviewer said that the project resources are sufficient for the plan.

Presentation Number: mat249
Presentation Title: LMCP P2C - Cast-and-Print - AM for Localized Property Enhancement of Al castings
Principal Investigator: Alex Plotkowski, Oak Ridge National Laboratory

Presenter

Alex Plotkowski, ORNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

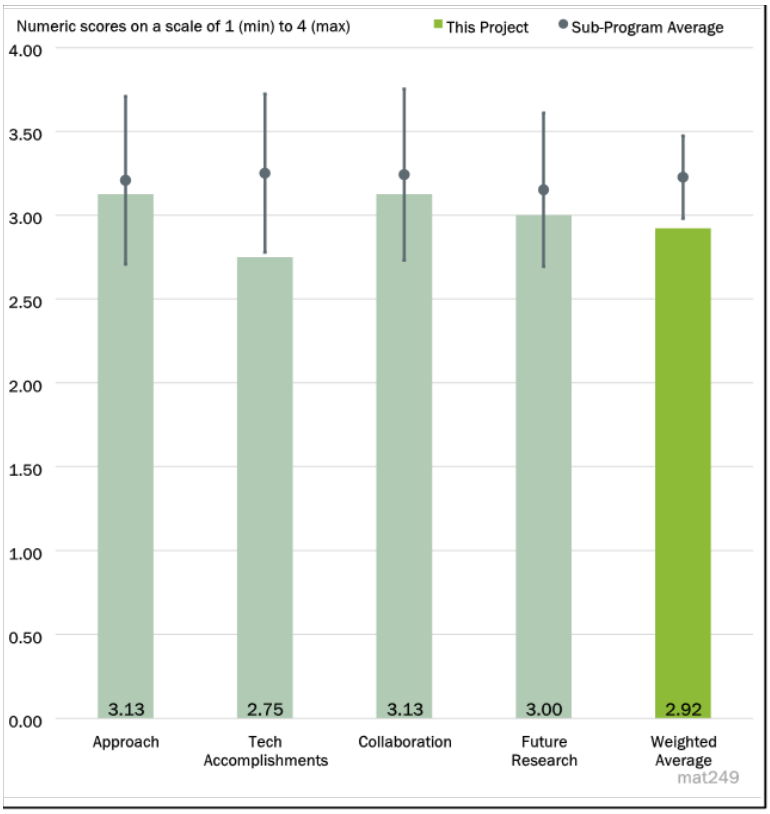

Figure 5-49 - Presentation Number: mat249 Presentation Title: LMCP P2C - Cast-and-Print - AM for Localized Property Enhancement of Al castings Principal Investigator: Alex Plotkowski, Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer found that the approach taken to execute work is good. The technical barriers seem to be addressed in a way that would result in meeting the stated goals of the project.

Reviewer 2

This reviewer said that the PI identified a good approach for determining the effect of printing on cast surfaces. The reviewer did not find it clear what drives the choice of 4X and 5X alloys as the printed material on 356 castings and asked if there is a specific part or assembly that is driving this research.

Reviewer 3

This reviewer said that the research team successfully identified technical barriers that arose while evaluating their printing process by adding a machining step between each step. It is effectively leveraging a parallel project in computation to study and potentially improve their procedure by optimizing gas flow during the process. It is, however, unclear how a change in the part's geometry will change the gas flow locally, so this may be something the team needs to consider as well when it has determined the demonstration part's geometry.

Reviewer 4

This reviewer expressed difficulties understanding the scope of this project, having missed the presentation due to illness. The reviewer asked what the benefits of introducing an additional, slow AD-manufacturing step are, as opposed to proper alloy selection or a multi-component design. and whether a cost benefit can be expected. The reviewer said that the benefits in terms of mechanical properties are not clearly presented.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer believed that, at this stage of the work (50% complete), the progress in addressing the technical barriers is good. Some issues, like the oxide film that deposits on the surface of each pass, have been identified and are being dealt with. Other issues like the shrinkages and material strains that are experienced in the solidified material have also been identified as needing a solution/attention.

Reviewer 2

The reviewer said it would be great to see the effects of process conditions on the different sample performance, especially in terms of mechanical properties at the cast/print interface. The reviewer questioned how the performance of the cast/print parts would compare with other joining methods, such as welded 356/4043 or 356/5356 joints and asked what the alternate plans are if the deposition gas issue is not resolved.

Reviewer 3

This reviewer said that the quality of AM does not seem to be great in showing sufficient dimensional accuracy.

Reviewer 4

This reviewer stated that the results shown in the presentation demonstrate that progress has been made. The team has been able to identify issues with the formation of oxide during the process and alter the procedure accordingly. It was able to print a "simple" geometry part using the print and machine procedure. The reviewer would like to know how the machining step will alter the time requirements for their method.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer found excellent coordination between the different thrusts of the LMCP project.

Reviewer 2

This reviewer found that the collaboration with the parallel LMCP Thrust 4 is good, and, hopefully, can be a substantial addition to understanding the process, especially as printed parts' geometries and sizes are altered. The reviewer felt that it would be good to demonstrate more collaboration with the industrial partners; hopefully, this will occur naturally as the later tasks are being completed. Choosing a representative part should necessitate significant communication with the industrial and research partners.

Reviewer 3

This reviewer said that the partners appear to be well coordinated. There appear to be good and effective synergies.

Reviewer 4

This reviewer said that there appears to be good collaboration amongst the project partners, including contact with industry.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer found it encouraging to see demonstration of automotive relevant geometries as a future plan.

Reviewer 2

This reviewer believed that a good path forward has been laid out. It will address a majority of the technical barriers that still remain, including the quantification of strain, shrinkage in the build and how to mitigate them. The reviewer noted that a cost analysis for the end product(s) will also be needed.

Reviewer 3

This reviewer felt that the benefits of the approach need to be clarified.

Reviewer 4

This reviewer said that the researchers have been successful in identifying and addressing issues with the printing procedure by adding a machining step. The team is working with DOE collaborators as well for computational modeling of parts of the process, which should provide good feedback for the process in the future. The reviewer believed that it would be useful to see more collaboration with their industrial partners.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer said that the project is relevant to the Materials Technology Subprogram, addressing directly lightweight materials, as it can directly lead to improved manufacturability of Al metals with superior properties. The reviewer also said that the results can provide relevant and required data to collaborators working on ICME tools for modeling the manufacturing process, and for modeling the microstructure in AM parts for virtual testing.

Reviewer 2

This reviewer said that the deposition process contributes to materials engineering advancement. It also contributes to light-weighting, which improves fuel efficiency in vehicles.

Reviewer 3

This reviewer believed that developing cast/print process for complex automotive part geometries is relevant research for the VTO portfolio.

Reviewer 4

This reviewer was uncertain of the relevance, finding, the benefits to be unclear at this stage.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer said that the resources are sufficient. The team is also leveraging the results of collaborators from another thrust, which may provide a better return on the research investment.

Reviewer 2

This reviewer said that there is no indication at this point that the available funds will not be adequate to complete the targeted scope

Reviewer 3

This reviewer said that sufficient resources are available for the completion of upcoming tasks.

Reviewer 4

This reviewer noted that no insufficiencies were reported.

Presentation Number: mat250
Presentation Title: LMCP P3A - Cast Magnesium Local Corrosion Mitigation
Principal Investigator: Joshi Vineet & Jiheon Jun, Pacific Northwest National Laboratory/Oak Ridge National Laboratory

Presenter

Joshi Vineet and Jiheon Jun, PNNL/ORNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

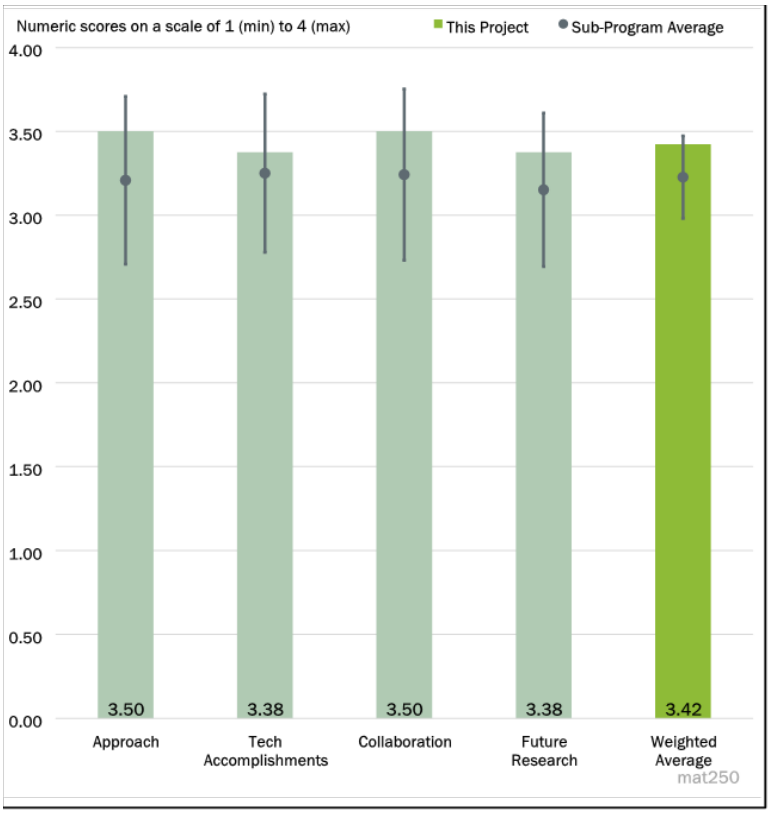

Figure 5-50 - Presentation Number: mat250 Presentation Title: LMCP P3A - Cast Magnesium Local Corrosion Mitigation Principal Investigator: Joshi Vineet & Jiheon Jun, Pacific Northwest National Laboratory/Oak Ridge National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer said that Mg cast parts offer excellent opportunities for vehicle light-weighting, reduced part and alloy count, and lowered assembly costs, but cast Mg is prone to corrosion. This project seeks a novel cost effective surface coating method to improve the cast Mg part's corrosion properties. Two approaches were used: reactive surface treatment (ORNL) and surface alloying (PPNL). Both have solid scientific foundation. The original 3 years' plan was reasonable. It seems that the team has overcome the COVIDCOVID-19 situation and managed to keep the project schedule on time.

Reviewer 2

This reviewer noted that the parallel 3A2 projects have well defined milestones, which the researchers are meeting. The team has shown an improvement in corrosion resistance using each surface treatment technique.

Reviewer 3

This reviewer stated that the testing approaches of Thrust 3 are comprehensive to evaluate the corrosion and mechanical behavior.

Reviewer 4

This reviewer believed that the project is directly addressing the technical barriers. However, the reviewer suggested that it would be very helpful for all involved if the project clearly communicated the team's assessment of the technology readiness level the technology is at and where the team expects to be at the end of the project.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer said the team made good progress. The plasma surface treatment achieved 2.4X corrosion reaction resistance for AZ91D alloy; the lithium-salt and thermal CO_2 treatment even demonstrated 10X improvement for AZ91D. The cold-spray of Al on Mg substrate improved corrosion resistance by 6X; reactive Zn coating improved corrosion resistance by 3X. These examples of progress are impressive.

Reviewer 2

This reviewer pointed out that, on the slide of "Milestones" only checks are marked on the status. The reviewer found it unclear whether this refers to a 100% completion or that it has been initiated.

Reviewer 3

This reviewer said that the researchers have successfully improved the corrosion properties in both project 3A1 and 3A2. The team has also shown better wear properties in samples from the cold spray technique of 3A2. The reviewer would find it interesting for the researchers to study in more detail the area of severe plastic deformation between the AZ91 and commercially pure Al coating on the samples from 3A2 to verify the phase and level of damage in the region.

Reviewer 4

This reviewer stated that, overall the work is interesting and making progress, though, in general, it seems that this project is attempting to cover a lot of ground. The reviewer believes that knowing what TRL the project is at and what it is trying to achieve will assist in setting expectations. According to the timetable for A1, "optimal" process parameters have been developed, though on Slide 8 there are only 2 Nyquist plots. So, it is difficult to make an assessment that optimal parameters have been developed or what is the fundamental mechanism behind what determines the optimal process parameters. Regarding A2, Slide 11 it is not clear why the data was collected at such higher pressures and temperatures since the reviewer believes that the project is not to develop a new cold spray system. The reviewer asks whether the equipment performance is relatively new compared to the published literature, suggesting that a bit more elaboration is warranted.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer was gratified to see ORNL and PNNL working so closely. However, Industry's contribution is yet be shown. I guess once the project is a bit more mature, industry will be more engaged?

Reviewer 2

This reviewer found the collaborations between national labs, university and companies to be well addressed and integrated for this Thrust 3.

Reviewer 3

This reviewer noted that there is collaboration between ORNL and PNNL researchers for their parallel coating processes. 3A is also supported by computation studies from Thrust 4. It would be good in future to discuss some of the input, feedback, or insight the team has obtained from the computational results. The microstructural characterization is being performed by Project 3B. The team has also received materials and cast parts from an industry partner. There appears to be a very good level of collaboration between the groups working on or providing materials and results for this work.

Reviewer 4

This reviewer found that there is clear collaboration across projects with materials and analysis in addition to external industry collaborators.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer believed that the proposed work, long term corrosion tests, multimodal corrosion test, and coating on actual parts are spot-on.

Reviewer 2

This reviewer said that the proposed future work meets the research goal and addresses the research challenges.

Reviewer 3

This reviewer said that the proposed future work is good. The team is aware of the challenges with scale-up and is applying its methods on real parts, and working towards those goals.

Reviewer 4

This reviewer believed that the project would benefit from incorporation of baseline industrial solutions to help understand if there is a performance and/or cost benefit to the technologies investigated in this project. Otherwise, the reviewer said that the future work is a logical extension of the work to date.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer found that the project is clearly relevant to the Materials Technology Subprogram, and aims to improve the corrosion and wear properties of Mg. It is directly supporting the VTO subprogram objectives.

Reviewer 2

This reviewer found the work relevant because the application of Mg provides significant mass savings opportunities which is in-line with the DOE roadmap of greenhouse gas emission reductions via mass savings. And since the single most significant technical roadblock to implementing Mg is corrosion performance, this project can clearly be seen to support the DOE objectives.

Reviewer 3

This reviewer said that the project aims at enhancing corrosion resistance and improving the wear resistance of cast Mg to address shortcomings of typical commercial Mg alloy castings.

Reviewer 4

This reviewer noted that joining of dissimilar materials is an important area in advanced manufacturing for DOE to reduce the structural weight and improve component performance and energy efficiency. Corrosion is a critical barrier in broadening the application of dissimilar materials joints. This research aims to address this issue by modifying the bonding surfaces to improve the galvanic corrosion resistance.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer said that the resources are sufficient, and the researchers are also able to leverage the results and work of two other projects, one from Task 3 and one from Thrust 4.

Reviewer 2

This reviewer said that the resources appear to be sufficient, given that the last year is focused on long-term corrosion testing, which requires less HC to manage, albeit over a greater duration than the first half of the project. However, a deeper dive into some of the fundamental questions around what constitutes an optimum oxide layer and why would certainly require significantly more resources.

Reviewer 3

This reviewer said that the resource for the project is appropriate.

Reviewer 4

This reviewer said that the team has enough resources to fulfill the research goals on time.

Presentation Number: mat251
Presentation Title: LMCP P3B - Thermomechanical Property Modification of Mg Castings
Principal Investigator: Mageshwari Komarasamy, Pacific Northwest National Laboratory

Presenter

Mageshwari Komarasamy, PNNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

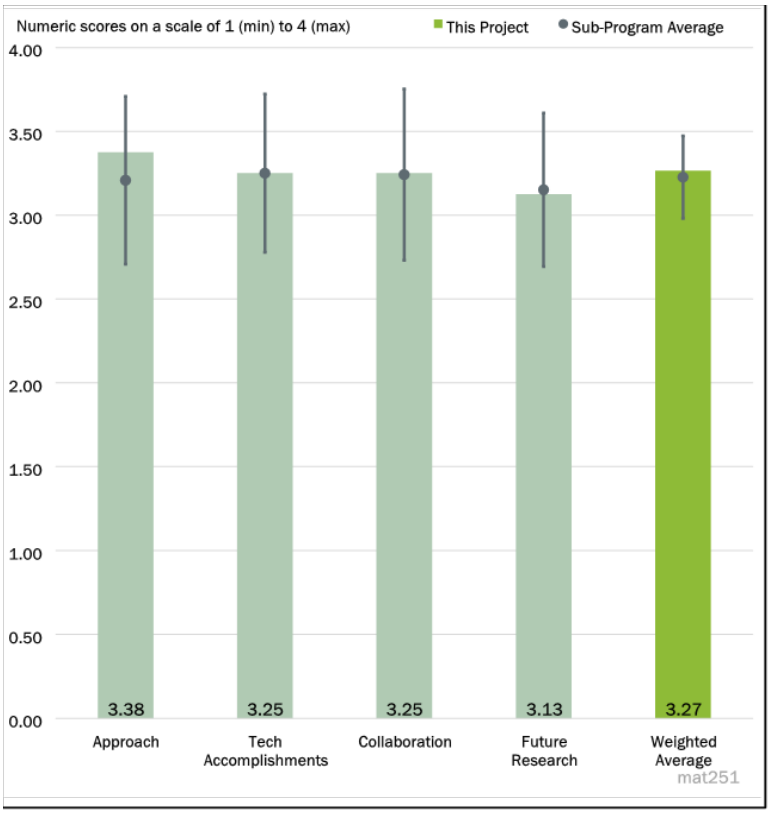

Figure 5-51 - Presentation Number: mat251 Presentation Title: LMCP P3B - Thermomechanical Property Modification of Mg Castings Principal Investigator: Mageshwari Komarasamy, Pacific Northwest National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project design addresses critical barriers to local property enhancement, namely the complexity of the geometry of automotive components. The timeline appears fairly sufficient with 3 months of spacing between milestones, although investigation into curved geometry would require more rigorous testing and should be conducted on multiple types of geometries, so perhaps more time could have been allotted. Task 3 in FY23 will address component-level processing and local alloying for 3-D components.

Reviewer 2

This reviewer found that the project clearly addressed the barriers and exceeded most targets. Strength was increased by up to 40% and the improvement in fatigue life was better than targeted (20X achieved vs. 5X targeted) for alloy AZ91. The improvement in properties was the result of friction stir processing, reducing porosity of AZ91 from 1.6% to 0.0003%. The elongation percent of AZ91 increased from 4% as-cast to 18% with a double pass, but decreased back to near 4% after double pass and various T5 heat treatments. It wasn't clear to the reviewer how the combination of FSP single or double pass and subsequent heat treatment(s) relate to the final practical goals for an AZ91 casting. It also was not clear what condition of AZ91 FSP specimen from Slide 8 was fatigue tested in Slide 9 to offer these remarkable lifetime increases but the reviewer believed that it was one of the higher ductility conditions. The reviewer believed that it would be even better to have

seen fatigue life as a function of the various processing and heat treatment conditions, particularly since ductility was quite variable after heat treatment.

The AM60 alloy seemed to show clear improvements in ductility after FSP, but yield strength decreased vs the as-cast condition, although ultimate tensile strength increased. The AM60 also showed a 10X improvement in fatigue life, but again it wasn't clear under which FSP condition(s). Porosity was again drastically reduced (1.6% to 0.01%) after FSP, which enabled the improvements in ductility and fatigue life.

Reviewer 3

This reviewer found that the project is improving the local properties of Mg alloys (AZ91 and AM60) by reducing the porosity level via the friction stirring process and found that the approach is well-designed and appropriate.

Reviewer 4

This reviewer believed that the technical barriers have been, thus far, addressed. However, the change to the FSP setup for processing real parts and curved plates with curvature greater than 15 degrees will likely take significant development. The team is aware of this, but it would be useful to see how it plans to address these issues.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer pointed out that the first milestone is complete, and it addressed one of the primary challenges of the project. The significant increases in ductility and fatigue life demonstrate the efficacy of the FSP process. However, automotive components will involve complex geometries that were not addressed by the first milestone. While the team successfully demonstrated FSP on curved surfaces as planned, they had not completed mechanical property investigation of the curved FSP material at the time of the AMR, and this milestone was set to be completed by 6/30. The milestone was listed as on-track, so it was possibly completed on time.

The team was very effective at ascertaining the process parameters needed to avoid defects. The 53% increase in yield strength of AZ91 is impressive, as is the improvement in fatigue life. Overall, the mechanical benefits of FSP were well-demonstrated. It is promising that defects could be avoided with the 15 degree curved surfaces. However, the 45and 90 degree curves may pose more significant challenges.

Depending on the target components for local alloying, it may be relevant to study the temperature behavior of the treated components and conduct mechanical tests at varying temperatures. For instance, a brake component may get very hot, so the part should be able to maintain its integrity at high temperature.

Reviewer 2

This reviewer said that the results, thus far, are impressive, and the researchers were able to achieve an order of magnitude increase in fatigue life versus high pressure die cast material without skin. The researchers should consider the heat affected zone at the boundary of the FSP nugget in order to see if there was any deleterious effect on the microstructure there, and predict if it could have a negative side effect on mechanical or fatigue properties. FSW materials will sometimes fail at the boundary between the nugget and surrounding material.

Reviewer 3

According to this reviewer, the project has made excellent progress toward meeting most project goals. The project is now incorporating a commercial cast component via Meridian, which is an outstanding addition for evaluating commercial feasibility for this process. The ability to process curved plates further elevates the potential practical value of the FSP process.

According to the reviewer, there were a few issues that were not clearly addressed. First of these was the anticipated effects of the entry and exit points of the FSP tool. The plate shown in Slide 13 shows a clear discontinuity at the tool entry point on the right side. It would be of value for potential industry adopters to know how such features might impact the fatigue life of the material, and whether/how such effect would be mitigated (perhaps by post processing via one or more subsequent finishing steps). Second, the reviewer suggests that it would be very helpful to see simulations of the range of anticipated minimum tool loads normal to the processing surface relative to the stress/strain anticipated for a range of expected wall thicknesses and related component geometry of die cast Mg components. The reviewer asks whether the FSP process is anticipated to induce plastic deformation in the range of expected thin wall hollow AZ91 or AM60 die cast components. Such loading information would assist in defining the range of applicability of this intriguing processing method for thin-walled, hollow, lightweight cast components.

Reviewer 4

The reviewer said that the project has accomplished proposed milestones and making a good progress.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer noted that the national labs involved collaborated on corrosion testing and advanced characterization, and an industry partner (Meridian) provided coupons and components.

Reviewer 2

This reviewer found that relevant and valuable collaborations, at various stages of maturity were briefly described between PNNL, ANL, ORNL, and Meridian. These involve corrosion, advanced characterization, and provision of HPDC coupons and components.

Reviewer 3

This reviewer said that the researchers are collaborating with others at PNNL, ORNL, and ANL through Project 3A and Thrust 4, as well as with an industrial partner, which has provided high pressure die cast samples. The team reports having discussions with its industrial partner as well. Hopefully it is engaging in active dialogue with regard to this project and how to target certain regions in automotive castings.

Reviewer 4

This reviewer stated that, as of AMR 2022, only the collaboration between Meridian and PNNL is presented, and the contribution from other participants (ORNL and ANL) is barely introduced.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer said that the proposed future research is clear, within scope, and achievable.

Reviewer 2

This reviewer said that the proposed future work has been clearly defined. The researchers are aware that there will be significant challenges in applying the FSP methods on real castings, and plan to work towards these goals, while also quantifying the effect of the process on properties.

Reviewer 3

This reviewer said that the description and intent to apply FSP to alloy local areas is interesting but any advantages relative to simpler and lower cost coating methods were not clear.

Reviewer 4

This reviewer said that the proposed future work tasks are reasonable and within the overall project scope.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer said that local strengthening of lightweight materials will enable their use in high strength applications.

Reviewer 2

This reviewer said that the project is clearly relevant to the Materials Technology Subprogram, and aims to improve the mechanical properties of Mg, having so far shown an increase in the fatigue and mechanical properties of samples through FSP. It is directly supporting the VTO subprogram objectives.

Reviewer 3

This reviewer said that the project clearly supports overall VTO subprogram objectives.

Reviewer 4

This reviewer said that the objective of the project is well-aligned with the overall VTO program.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer found that the resources are sufficient, considering the equipment, expertise, and personnel available.

Reviewer 2

This reviewer believed that, while the next steps in the project will be difficult to achieve, the researchers have sufficient resources, and appear to be collaborating effectively with the other Project 3 and Thrust 4 researchers.

Reviewer 3

This reviewer believed that resources appeared sufficient for the described research.

Reviewer 4

This reviewer said that the resources of the project are sufficient to perform all the proposed tasks.

Presentation Number: mat252
Presentation Title: LMCP - Thrust 4 - Materials Lifecycle
Principal Investigator: Jeff Spangenberger, Argonne National Laboratory

Presenter

Jeff Spangenberger, ANL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

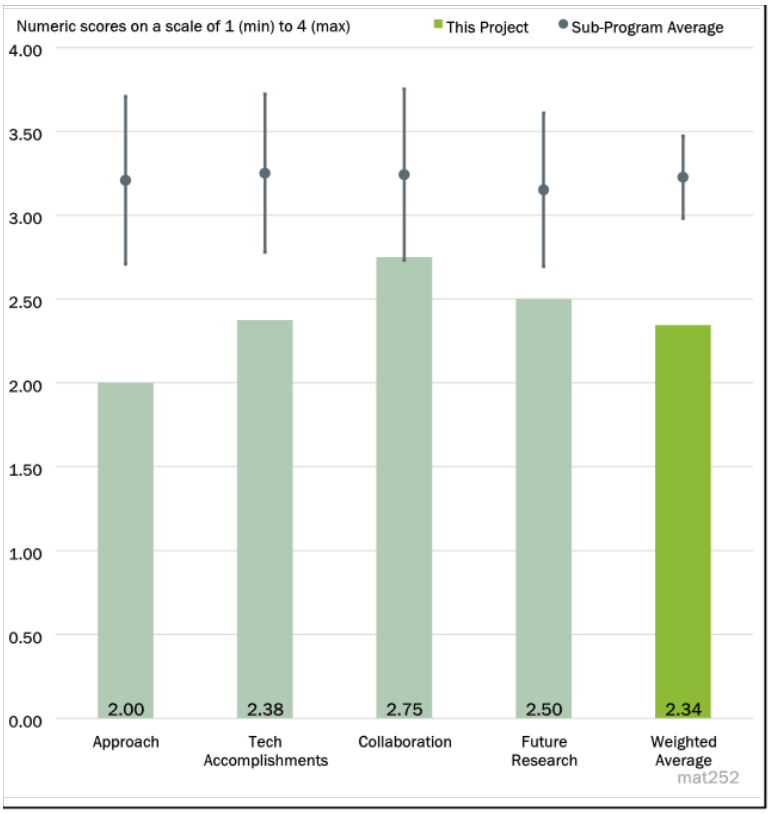

Figure 5-52 - Presentation Number: mat252 Presentation Title: LMCP - Thrust 4 - Materials Lifecycle Principal Investigator: Jeff Spangenberger, Argonne National Laboratory

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer found the goals and objectives of the project to be somewhat vague and suggested that the team should consider how it would know if/when it had been successful in terms of tangible outcomes. is the reviewer also found it unclear if the overall objective of the project is to reduce the use of alloys or, generally, to ensure that light-weighting efforts do not negatively impact recyclability. The reviewer believed that, if it is the latter, then there may be other solutions besides reducing use of alloys, such as reducing use of adhesives or tertiary materials.

The reviewer noted that, although a timeline is presented, the milestones lack specificity. The most notable technical barrier addressed is understanding the needs and capabilities of end-of-life industry stakeholders. More clearly enumerated/quantified technical barriers would be helpful.

Reviewer 2

This reviewer said that the project would benefit from identifying specific materials whose lifecycle infrastructure can be examined in a scoping study rather than performing them for ‘all materials’ in a vehicle. As an example, the reviewer favored looking at the Al alloys being used predominantly amongst the LMCP projects and aligning s the scoping study accordingly.

The reviewer also believed that it would be preferable to identify who the various stakeholders are relating to non-ferrous materials who will be interviewed to understand the recyclability, separations, and material lifecycle considerations.

Reviewer 3

This reviewer believed that the approach seems to be limited to scoping in the evaluation period. The reviewer suggested that, while the project size is small, some recommendations for life cycle analysis will benefit other PIs and the larger community.

Reviewer 4

This reviewer said that the presentation provided zero examples of specific conversations, specific technical examples, specific activities, or specific technical recommendations related to any of the multiple tasks within the program. All information provided was remarkably generic or commonly available information.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer said that, as this is a scoping study, the technical accomplishments are mostly related to understanding the potential for increasing recyclability across the Materials Program. The team uncovered opportunity areas through conversations with other researchers. That is sufficient for the purposes of this study. However, some quantification of the opportunity would make the technical accomplishments clearer, such as the percentage of light materials projects that can contribute to reduction in the number of alloys, at various scales. These values, even if only preliminary, would clarify the impact of this work.

Reviewer 2

This reviewer said that the project presents the premise of the LMCP as a key finding and that this messaging may have to be modified. The reviewer expressed a need to understand what alloys/materials were discussed as part of the conversations with the industry stakeholders.

Reviewer 3

This reviewer noted that it is difficult to evaluate progress when the metrics and milestones are so qualitative. Visiting companies, having conversations, etc. are difficult to assign a score to.

Reviewer 4

This reviewer said that there were no examples of progress or specific contributions, other than conversations with industry (nothing specific described) as a milestone and a visit to a heavy media recycling plant as a quarter 3 milestone. But, the reviewer said, the examples of technical accomplishments, particularly as a Year 2 effort, did not provide unique contributions. For example, under Technical Accomplishments and Progress the following were provided: 1) “Aluminum recycling enjoys a huge energy and GHG benefit compared to steel;” 2) “We need to ensure that recyclability doesn’t get sacrificed, instead improve recyclability;” 3) “The main findings during meetings and interaction with the teams demonstrated that it is possible to increase the amount of lightweight metals in vehicles while reducing the number of alloys.” The reviewer pointed out that these are statements of well-known facts, known from the launch of the program, are not actual accomplishments, and they provide no clear picture of Year 2 activities or progress.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer pointed out that collaboration is the name of the game for this project. The team worked extensively with other research teams and industry stakeholders to understand the problems and opportunities.

Reviewer 2

This reviewer was gratified to see this project interacting with the various teams and the industry stakeholders but asked how often collaboration meetings occur, saying that this is not clear from the presentation.

Reviewer 3

This reviewer said that there were conversations described with some of the program tasks, but no details of which tasks or what specific details were discussed or what recommendations were made to impact the tasks. The most specific detail offered was "Local treatments change performance as needed to reduce multiple alloys."

Reviewer 4

It was not clear to the reviewer how other LMCP projects are benefitting from this effort.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer said that most of the proposed future work is a logical continuation of the work that has already begun. However, development of a lifecycle cost and environmental impact tool seems to widen the scope or be somewhat tangential. The team will need to carefully manage their goals to stay on track.

Reviewer 2

This reviewer said that a tool to identify the changes in material lifecycle corresponding to process changes, especially in the context of the LMCP, is a great approach for future work.

Reviewer 3

This reviewer said that the metrics and milestones need to be SMART for this project.

Reviewer 4

This reviewer noted that the proposed future work stated that it would continue current efforts with program thrust groups and industry, as well as visit the heavy media plant. These were all generically included in the current presentation; thus, their continuation offers no clearly defined purpose. The reviewer agreed with the team that a lifecycle cost and environmental impact tool should be developed, but found that the development of such a tool is not clearly proposed beyond stating- the need for it.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer said that the project is relevant because it supports increased sustainability of materials.

Reviewer 2

This reviewer stated that the concept of the project is definitely relevant and important but the execution of the project needs substantial clarification and improvement in order to deliver relevant outcomes in Year 3.

Reviewer 3

This reviewer said that the project is very relevant to the LMCP and VTO portfolio.

Reviewer 4

This reviewer said that the project is relevant for LMCP.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer said that the team appears sufficient as-is. However, if a lifecycle cost and environmental impact tool will be pursued, then additional expertise may need to be brought in.

Reviewer 2

This reviewer opined that the resources appear more than sufficient for the outcomes described. This could be a very impactful task to the Light Metals Core Program with appropriate planning and effort.

Reviewer 3

This reviewer said that sufficient resources are available for the upcoming tasks.

Reviewer 4

This reviewer said that the resources are sufficient for the progress made.

Presentation Number: mat253
Presentation Title: Flexible, Lightweight Nanocomposites for EMI Shielding Suppression in Automotive Applications
Principal Investigator: Carla Lake, Applied Sciences

Presenter

Carla Lake, Applied Sciences

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

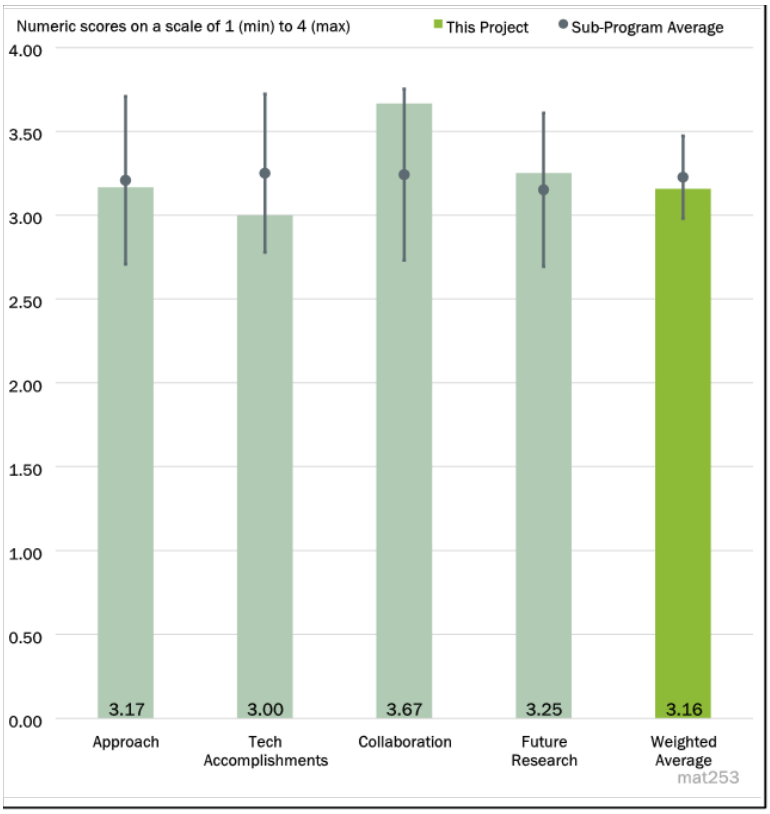

Figure 5-53 - Presentation Number: mat253 Presentation Title: Flexible, Lightweight Nanocomposites for EMI Shielding Suppression in Automotive Applications Principal Investigator: Carla Lake, Applied Sciences

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer said that the project team clearly laid out its work, how it approaches its experimental design, and the motivation for certain vehicle components to have and need shielding. The team also showed a lot of results in bullet points; however, where performance was improved over the state of the art materials, more data should be provided. The selected production method is both low cost and scalable, aligning with VTO goals

Reviewer 2

This reviewer noted that this was a small one year project and has now been completed. The project focused on validation and structure/performance tailoring for the industrial performer's lightweight electromagnetic interference (EMI) shielding material. The composite product developed here would replace heavier metal braid harnesses. This project is compelling, as it focuses on a light-weighting application area that has been relatively little pursued.

Reviewer 3

This reviewer noted that the intent of the project is to develop nanocomposites for EMI shielding. The approach is good, but it is not perfectly clear if commercially competitive high performance EMI shielding materials can be achieved.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer found that the project made good progress over the one year timeframe, especially given the limited project size and budget.

Reviewer 2

This reviewer said that the team laid out its approach to the work clearly and mentions a wide variety of successes. The main goal of EMI shielding at a respectable scale has been achieved. It would have been great to see more data supporting the claims of enhanced performance over the incumbent materials, which could lead to faster adoption.

Reviewer 3

This reviewer said that it appears that the team has demonstrated 99% shielding efficiency. Since the detail is not visible, it is hard to tell what kind of samples achieved sufficient performance, which depends on material thickness, composition, etc. If commercially viable performance and materials' costs had been clearly defined, the performance could be evaluated in a fair fashion but that information was not available.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer stated that collaborations/partnerships were very valuable in this project considering the small size of the business involved. The partnerships developed here may result in commercialization of this lightweight product.

Reviewer 2

This reviewer said that the team clearly laid out all of its collaborators and their roles.

Reviewer 3

This reviewer said that the team has partners relevant to the vehicle applications.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer held that the project had accomplished the target and will end soon. Such future plan is appropriate.

Reviewer 2

This reviewer commented that it is not clear how much of the glider these materials could be used for and how much light-weighting they would impart making the value of the future research questionable. Recyclability is possibly one of the more exciting comments; however, these materials may not be suitable for recycling, especially if they contain PVC.

Reviewer 3

This reviewer noted that the project has ended but the future work suggestions, such as the recycling investigation, are good. An environmental life cycle assessment would also be helpful in understanding the overall potential benefit of a lightweight material in this application.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer said that the project is well aligned with DOE objectives in light-weighting and composites.

Reviewer 2

This reviewer said that the work combines light-weighting with battery relevant considerations, delivering enhanced performance. Thus, the reviewer believed that it can be viewed to align with the sub program objectives.

Reviewer 3

This reviewer said that the technology is relevant to VTO.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer said that the resources were sufficient.

Reviewer 2

This reviewer found that the team has made good progress with their budget.

Reviewer 3

This reviewer said that the team has completed most of the milestones and the resource is sufficient.

Presentation Number: mat255
Presentation Title: Graphene-enriched Hierarchical Polymer Additives Derived from Natural Gas
Principal Investigator: George Skoptsov, H. Quest Vanguard, Inc.

Presenter

George Skoptsov, H. Quest Vanguard, Inc.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

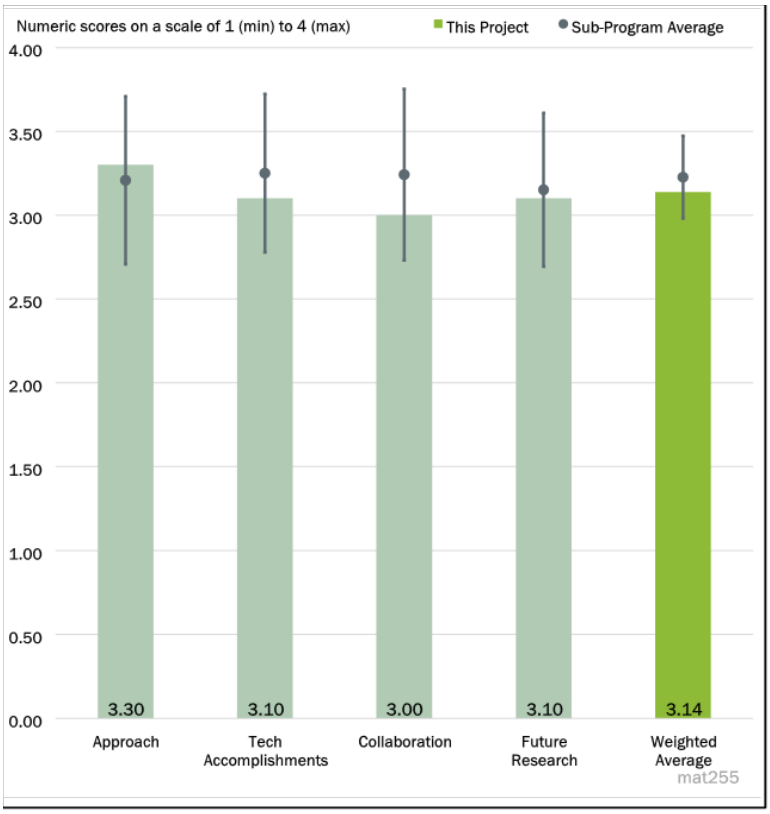

Figure 5-54 - Presentation Number: mat255 Presentation Title: Graphene-enriched Hierarchical Polymer Additives Derived from Natural Gas Principal Investigator: George Skoptsov, H. Quest Vanguard, Inc.

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer believed that the project's approach is a great is great for increasing the tensile strength of injection-molded composite parts. Being that this is a rapid process to increase the carbon fiber surface area, the reviewer can see how this would enable adoption by the automotive industry.

Reviewer 2

This reviewer said that the approach does not directly contribute to the technical barriers described in the presentation for mass and weight reduction. These are usually achieved simply by using any type of carbon or composite fiber. The novel aspects of this approach is that it uses recycled carbon fiber, which could potentially reduce costs because an expensive precursor is not needed and uses a unique thermochemical process to rapidly treat carbon fiber and improve the tensile and shear strengths of the resulting thermoplastic composite material. The target of 70%-100% increase in ultimate tensile strength may be unrealistic, but any significant increase in strength for recycled carbon fiber would be an accomplishment. The project timeframe is less than a year, so the timeline to demonstrate the initial goal of an effective thermochemical process is reasonable.

Reviewer 3

This reviewer found that the project has identified and addressed the technical barriers. The microwave plasma approach was novel and well designed. The timeline is reasonable and achievable.

Reviewer 4

This reviewer said that the project layout and process tasking are adequately described at a high level. It would be useful to have a better description of targeted performance and what tests will be utilized to demonstrate progress towards those goals. It would be expected that dispersing carbon black into a composite would increase the Brunauer-Emmett-Teller [BET]-measured surface area regardless of how well-attached it is to the carbon fiber. Actual test data would inspire confidence in the reported observations.

Reviewer 5

This reviewer pointed out that the premise of the technology is that current grades of carbon fiber reinforced thermoplastic composites do not meet the performance requirements for automotive applications. Accordingly, it is proposed that improvements in interfacial strength are required to achieve a corresponding increase in composite strength. According to the reviewer, in practice, many automotive applications are limited by stiffness and not strength. Therefore, application of the microwave plasma ad graphene is likely to be cost prohibitive.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer found that all technical accomplishments have been met with very promising results and the project remains on schedule. The reviewer would like to see more on the mechanical property improvements; the preliminary results look great, so more testing would help convey the impact this research could have.

Reviewer 2

This reviewer said that the project is on track and has accomplished 80%. The milestones are achievable.

The project may do Raman spectroscopy on the graphene found on the recycled carbon fibers to confirm the sheets (attached on the fibers) are indeed graphene.

(2) The reviewer suggested that the project study the effect of etched surface on the mechanical properties such as strength and modulus. The etched surface may have high stress concentration, leading to low strength.

Reviewer 3

This reviewer found minimal technical accomplishments described in the presentation and said that the Principal Investigator did not attend the poster session to explain any further accomplishments. The accomplishments are more of a description of the process under development. Development of the thermochemical process stated in the approach was achieved and micrographs show uniform fiber treatment. A result was that the carbon fiber surface area was increased by a factor of ten. There were no data presented for results of tensile strength tests, however, a graphic is displayed on the Relevance Slide that shows the relationship of the 10x improvement to increase in tensile strength. If the data on the graph are accurate, the 10x improvement still does not increase the strength to anywhere near the strength of continuously processed new carbon fiber. There is a statement on the Accomplishments Slide that preliminary results of tests indicate

that the gained interfacial strength exceeds the tensile strength of the filaments, but there were no data provided to substantiate this statement.

Reviewer 4

This reviewer said that the project is projected as 80% complete; however, no significant data are provided. It is not difficult to believe that that some interfacial strength improvements are achieved via surface activation of the carbon fibers alone and this increase translates into some higher strength of discontinuous carbon fiber reinforced high-density polyethylene (HDPE) as others have demonstrated. However, it is not clear that the claimed interfacial strength gain exceeds the tensile strength of the filaments themselves as reported without data. One would expect some improvement in the reinforced HDPE strength with addition of adequately dispersed, but even non-treated carbon fiber. It would be useful to have such data to evaluate efficacy of the treatment process and especially data to support the pathway towards the project expectation of achieving 50% mass reduction at equal affordability.

Reviewer 5

This reviewer found that surface modification of the carbon fibers has been demonstrated but using a filamented form could limit the fiber volume fraction in the final composite.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer found that good collaborations were formed with Pennsylvania State University and support was received from the Composites Application Group and Carbon Conversions, Inc. A little more discussion of each collaborator's role in the project would be useful to see in the next AMR. It was stated that pilots with carbon fiber and composite companies were being actively pursued so that is a step in the right direction to get this technology closer to commercial adoption.

Reviewer 2

This reviewer said that the collaborations with Pennsylvania State University (PSU) and the Composites Applications Group have been going well. The partner Carbon Conversions provided recycled carbon fibers. The joint efforts will help scale up.

Reviewer 3

This reviewer noted that the project team consists of the company (H Quest Vanguard, Inc.) and a university (Pennsylvania State University) with consultation for commercialization from a company that coordinates between manufacturers and supply chain companies (Composites Applications Group). Carbon fiber for this project appeared to be donated from a commercial entity (Carbon Conversions, Inc.). The only collaboration seemed to be between the company and the university, which is limited collaboration for process development. According to the reviewer, involvement of an OEM or a Tier 1 supplier for coordination toward commercialization rather than a third party to advise on commercialization would benefit the project.

Reviewer 4

This reviewer found there to be really no discussion of the primary project team (Huest and PSU) interaction via roles and responsibility; Carbon Rivers provided some samples of recycled carbon fiber and Composites Applications Group provided some commercialization support.

Reviewer 5

This reviewer stated simply that the project partners are clearly defined

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer found that the future work is effectively planned in a logical manner. The future scope expansion into recycled carbon blacks makes this technology even more attractive to the automotive industry and the reviewer would like to see how that research pans out. The reviewer's only concern is with achieving all of the future work in the short time remaining in the project.

Reviewer 2

This reviewer said that the proposed future work makes sense. The project plans to scale up and extend the microwave plasma to recycled carbon blacks. This will help decarbonization.

Reviewer 3

This reviewer said that the future steps are pretty well described. At this point it is not clear to the reviewer whether the recycled carbon black mentioned in future work can achieve significant performance improvement and what cost would be assigned to recovered material, but it is laudable to target this approach rather than synthesizing the materials for this application. The reviewer questions, however, if the carbon black requires synthesis from methane, whether zero CO_2 emissions can still be claimed for the process. The reviewer suggested that future work needs to include additional characterization of the fiber itself (to assure minimal property degradation) and interfacial properties, as well as some early more detailed techno-economic modeling to evaluate cost-effectiveness of the solution package.

Reviewer 4

This reviewer said that the future steps appear adequate but a meaningful increase in composite performance should be established before increasing the scope of the project.

Reviewer 5

This reviewer pointed out that there were two slides for future work: (1) Future Steps and (2) Future Scope Expansion. The first one appears to be research that will be needed beyond the current project and the second appears to propose a new research effort for using the thermochemical process developed in this project to expand into carbon black in rubber products and away from carbon fiber and composites. The reviewer expressed not being aware of a VTO requirement for carbon black as it relates to composite materials. The future steps are clearly defined to scale up and commercialize the product from the current project. With the small amount of funds ($206,500) and the current project being 80% complete, the future steps would require significant additional funding. If adequately funded, it is very probable that the future work will achieve its targets, according to the reviewer.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer said that the technology is aligned with VTO's mission to develop lightweight material solutions for automotive applications

Reviewer 2

This reviewer said that the project is relevant to the overall DOE objectives in that it focuses on vehicle light-weighting.

Reviewer 3

This reviewer found the project relevant and supportive of some of the overall VTO subprogram objectives for lightweight materials because it addresses the treatment of carbon fiber to improve its strength and the recyclability of carbon fiber to reduce the high costs associated with using virgin carbon fiber in composite materials.

Reviewer 4

This reviewer said that the project supports the VTO overall objectives. The microwave plasma presents a new route to carbon fiber recycling. This also help reintegrate end of life carbon fibers into the supply chain and decarbonization.

Reviewer 5

This reviewer said that, although the 50% mass reduction goal at equivalent cost is not fully supported, it appears that there are some opportunities for at least some performance improvements. However, findings of significant mass savings need to be supported with actual property data. It is not clear to the reviewer how specifically synthesized graphene-enriched carbon black (GCB) in combination with the equipment necessary to assure consistent deposition of energy and the GCB throughout a "web or mat" product stream of material starting out as an aligned form of fiber stuck together would not affect the cost. (The reviewer noted that the indicated cost of $0.25/kg for particle materials did not include equipment costs but still sounds low and said that it is hard to imagine that it would be lower than most sizings, as mentioned.)

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer said that, at 80% complete, there appear to be sufficient resources to finish all outstanding tasks.

Reviewer 2

This reviewer said that the resources are sufficient to achieve the remaining milestones.

Reviewer 3

This reviewer said that the funding of $206,500 for a company and a university for consulting is sufficient for this short-term project (less than 1 year). The contribution of raw materials from a carbon fiber manufacturer certainly helped with keeping the cost of the project low.

Reviewer 4

This reviewer said that H Quest Vanguard and its partners PSU, Composites Applications Group, and Carbon Conversions have the required resources for the project to achieve the stated milestones in a timely manner.

Reviewer 5

This reviewer said that the key remaining activity is getting at least some solid data and it sounds as if resources are adequate for achieving that goal in this phase.

Presentation Number: mat256
Presentation Title: Game Changing Resin/Coating/Adhesive Technology for Lightweight Affordable Composites
Principal Investigator: Scott Lewit, Structural Composites, Inc.

Presenter

Scott Lewit, Structural Composites, Inc.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

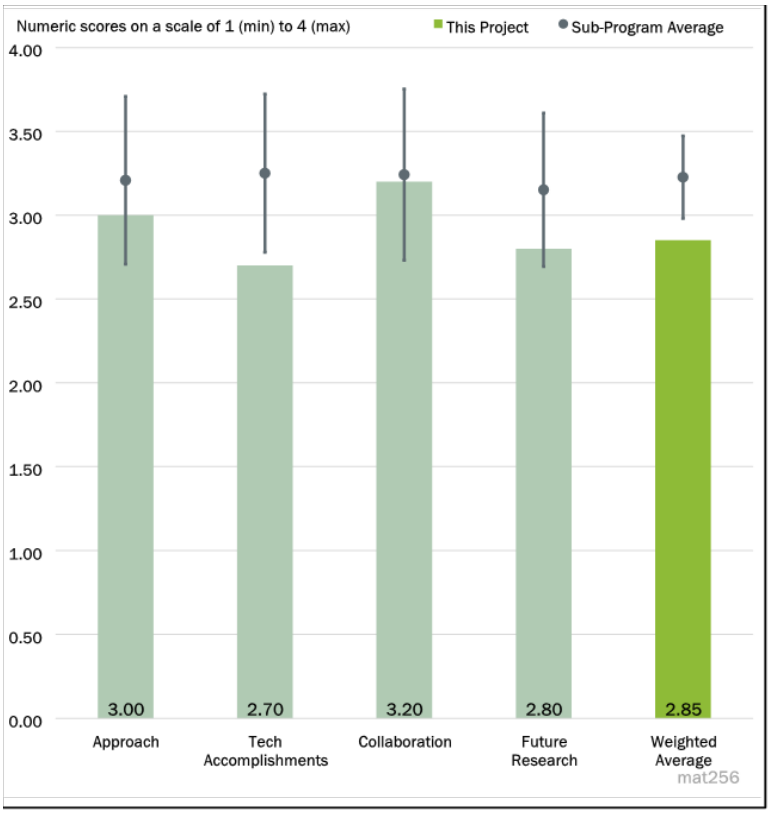

Figure 5-55 - Presentation Number: mat256 Presentation Title: Game Changing Resin/Coating/Adhesive Technology for Lightweight Affordable Composites Principal Investigator: Scott Lewit, Structural Composites, Inc.

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer found the idea of co-curable hybrid formable laminates to be excellent, but that not enough support was presented in the poster to justify the approach . The reviewer was not sure what kind of polyurethane was used in this work. Nonetheless, the reviewer said that the idea is great and has very good potential.

Reviewer 2

This reviewer said that the project has identified and addressed the technical barriers. The project was well designed and the timeline is reasonable.

Reviewer 3

This reviewer said that the approach is well-designed and well-planned to meet the technical barriers of metal/thermoplastic laminate structures. Images of the synthesized materials would be beneficial to the reviewer since it is a little unclear from the poster what the final product looks like. A little more visual representation of the project would help fully understand the approach and its results.

Reviewer 4

This reviewer said that the concept is sound but there were no data presented. The project data should be 75% complete even with COVID and supply chain issues. The reviewer believes that, because there are no data to substantiate the claims, it is difficult to decide if the project is well designed. The reviewer found the poster to be more like a white paper than a results presentation.

Reviewer 5

This reviewer pointed out that Structural Composites, Inc. (SCI) has issued press releases touting past development, introduction, and commercialization of the CoCure process. For this project, the target focus and approach are not at all clear, with a very general listing of potential general pathways to implementation, including: hybrid thermo set resin/metal hybrid composites laminates that are low-cost, high-performance, pre- and post-cure formable; get cost and adhesive and matrix; urethane, polyester, polyols; graphene, nano tubes, biofibers, starches, nano powders; and estimates of targeted cost or performance and how these might factor into approach.

According to the reviewer, there was no discussion of technical barriers to be addressed or estimates of targeted cost or performance and how these might factor into approach.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer pointed out that the project got a no cost extension. The project is on track and making progress toward the milestones. The reviewer suggested that DIC be used in mechanical testing to study the resin/coating/adhesive system with the goal to optimize the structure design.

Reviewer 2

This reviewer noted that the project was behind schedule due to supply chain issues and COVID-19 restrictions and a no cost extension has been requested, but the project is back on schedule. More data should be shown on the progress of the project to assess the mechanical property enhancements that were mentioned.

Reviewer 3

This reviewer found not enough data presented to support 75% completion of the project. The poster refers to 35% graphene containing compositions of “thermoplastic precursor of unsaturated polyester.” The reviewer is not sure what is meant by “thermoplastic precursor of unsaturated polyester” and asks whether such composition will be able to wet high content (35%) of graphene?

Reviewer 4

This reviewer said that, without data, it appears there has been no technical progress. The team did state that it has achieved high volume, high performance, and low cost ultra-lightweight composite and hybrid materials but gave no examples and no metrics. The team could have shown data showing how the PU/nanoenhanced hybrid coating increases fracture toughness, hardness, Tg, flexural strength, flexural stiffness, and/or adhesive strength for starters.

Reviewer 5

This reviewer said that the project is projected to be 75% complete, but no data are provided to judge the progression toward the (unstated) goals. The reviewer understands that there were severe impacts from COVID

and chose to give a Satisfactory score for that reason. The poster indicates that targets have been identified and fab and testing are underway based on plans for evaluating fiber bridging additives of graphene and carbon nano tubes, environmentally friendly bio fibers and starches dispersed in polyols, polyesters, and urethane resin blends for enhanced mechanical properties, among potentially others. One accomplishment that was mentioned was that compounding of a polyester with 35 % graphene has been achieved, but there was no mention of performance results or expectation for an achievement that seems well above levels of graphene most researchers target, considering typical cost and performance projections for that approach.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer said that the project had a good list of collaborators. It would helpful to mention each collaborator's role or contribution to the project.

Reviewer 2

This reviewer believed that the collaboration has been going well. The project team includes several industry partners. The reviewer suggested future research include collaboration with academy as well.

Reviewer 3

This reviewer pointed out that a large number of team members is listed. However, roles of team members are not clear. Also, the budget amount is very low compared to the size of the team.

Reviewer 4

This reviewer pointed out that the authors list Interplastics, Mainstream, Wabash, Applied Science, Carbon Rivers, MITO, TLC, Trinity, and THOR as partners. The reviewer believed that it is quite an achievement to have all of those partners on a relatively low funded program like this one but said that it would be interesting to see what each role is, however.

Reviewer 5

This reviewer found this difficult to evaluate as there is no indication, according to the reviewer, of how SCI is interacting with the very large numbers of partners listed other than brief mention of interest and discussion of large OEM partners and "Wabash is deployed using our Navy SBIR technology."

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer said that the topic and idea have tremendous future opportunity. Plenty of things can be done.

Reviewer 2

This reviewer noted that the proposed future research is built upon the success of Phase I. The targets are reasonable and achievable.

Reviewer 3

This reviewer said that the proposed future work focuses on securing commercial partners for further development, but it was unclear what future research was going to be performed within this project.

Reviewer 4

This reviewer said that it is difficult to have sound future work plans when there hasn't been much data, if any, developed over the original program to go off of. The reviewer believes that it would be technically significant if the team could show proof of their claims on this program before delving into future work.

Reviewer 5

This reviewer reiterated that only general comments about plans for completing this project (the development of enhanced resin properties, a low cost high performance adhesive, and metal alloy hybrids) and potential interest from others are provided, with lack of any specificity. Although it appeared to be mentioned in the context of the ongoing Wabash commercialization of the CoCure approach on their trailers, the comment about that focus now is reducing cost and weight should receive significant attention in future work related to this project.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer said that the project is relevant to the overall DOE objectives to reduce the weight of vehicles to reduce fuel consumption.

Reviewer 2

This reviewer said that the combination of a gel-coat with a PU/nano-enhanced coating would aid not just the automotive industry but other industries as well. The potential of having a more durable surface coating, especially if it can achieve Class A, is beneficial in a variety of areas including appearance and abrasion/impact resistance.

Reviewer 3

This reviewer said the project supports the overall VTO objectives. The CoCure hybrid thermo set resin/metal hybrid composites laminates provide low cost, high energy efficient and lightweight materials for fuel efficient vehicles and EVs.

Reviewer 4

This reviewer said that the idea and the topic is relevant to VTO subprogram objectives.

Reviewer 5

This reviewer said that, although it appears that the ongoing commercialization is primarily for large trailers, one can see potential applications for other vehicles. However, cost-performance tradeoffs need to be better understood and efforts directed at specific barriers identified as part of that analysis.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer found the resources are sufficient to achieve the remaining milestones.

Reviewer 2

This reviewer said that SCI and its collaborators have sufficient resources for the project. The project is on track and will achieve the milestones in a timely manner.

Reviewer 3

This reviewer said that it is hard to evaluate adequacy of resources without a better understanding of specific goals and plans, but it sounds like there are adequate resources available to tackle key issues of not the broader technical interests that can be imagined for a new tool.

Reviewer 4

This reviewer said that it appears with the partners listed that sufficient resources exist to have a successful program but that has not been demonstrated yet or at least not revealed in this poster presentation.

Reviewer 5

This reviewer said that the budget is low. The team should pursue next phase to complete several tasks.

Presentation Number: mat257
Presentation Title: Changing the Design Rules of Rubber to Create Lighter Weight, More Fuel Efficient Tires
Principal Investigator: Kurt Swogger, Molecular Rebar Design

Presenter

Kurt Swogger, Molecular Rebar Design

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

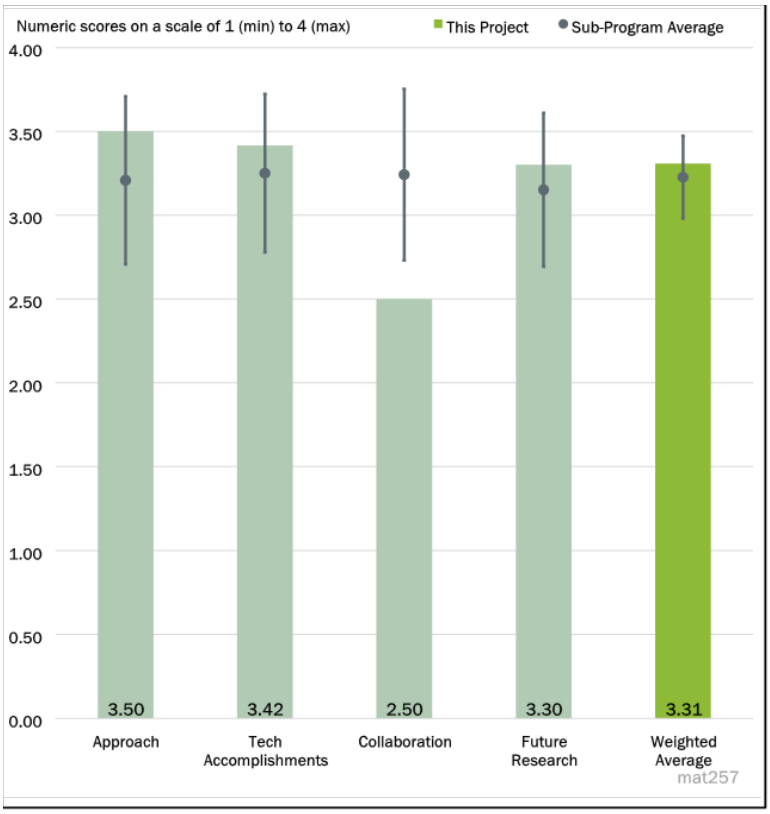

Figure 5-56 - Presentation Number: mat257 Presentation Title: Changing the Design Rules of Rubber to Create Lighter Weight, More Fuel Efficient Tires Principal Investigator: Kurt Swogger, Molecular Rebar Design

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer said that the concept and approach are great. The reviewer's only concern was the cost of the compound, whether the team can assure availability of the MOLECULAR REBAR® (MR) at reasonable cost for large scale manufacturing.

Reviewer 2

This reviewer said that the work was a good approach to overcome the technical barriers of electric vehicle tires. With the faster wear rate of tires on EVs, this approach tackles a problem that needs to be solved. The work built off of prior success with substituting in carbon nanotubes in carbon-filled tires and translates it to silica-filled tires using a new chemistry. Overall, it was a well-designed and well-planned project.

Reviewer 3

This reviewer said that the team stated its technical targets and explained how it addressed them precisely in the poster. It demonstrated that the team was able to add carbon nanotubes to elastomers. Data shown corroborated its conclusions but there was no explanation of what tests were used to obtain the data.

Reviewer 4

This reviewer noted that improving tire properties to increase fuel efficiency and EV drive range is novel. The project identified and addressed the technical barriers. The project is well designed and the timeline is reasonable.

Reviewer 5

This reviewer said that the objectives are clearly identified and the activities appear laid out well to demonstrate how technology advancement translates towards meeting programmatic objectives and end-user benefits. The only thing missing is expected cost in commercialization and maybe it is too early to project.

Reviewer 6

This reviewer said that modification of the elastomer compounds for improved energy efficiency appears to be a logical approach to improve tire performance.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer said that the data presented in the spider chart show significant progress compared to the state of the art. Achieving improved rolling resistance and abrasion resistance without compromising tear strength is a great accomplishment.

Reviewer 2

This reviewer noted that all technical accomplishments were met. Good enhancements in abrasion resistance, rolling resistance and density were reported using the carbon nanotubes. The reviewer questioned what the cost of adding the carbon nanotubes is, noting that it could be a trade-off to get the better performance.

Reviewer 3

This reviewer felt that, for the level of funding, the team made excellent progress and demonstrated its technical targets.

Reviewer 4

This reviewer said that the project has accomplished much. The results from Phase I are encouraging. The reviewer suggested that systematic friction and wear tests be carried out in the future study.

Reviewer 5

This reviewer pointed out that the project has been completed. Key data on abrasion resistance and rolling resistance have been acquired in this project and appear promising but it is not clear why that did not translate to cut and chip resistance.

Reviewer 6

This reviewer pointed out that the project team has demonstrated improvements in both rolling resistance and abrasion resistance, although there is no mention of the cost implications of the modified tire compounds.

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer believed that, for this short project, collaboration is not really needed. Rather the applicant needs to protect IP.

Reviewer 2

This reviewer said that the Phase I project did not have collaboration, suggesting that future study involve collaboration with academics and the tire industry for scaling up.

Reviewer 3

This reviewer said simply that no other partners were included on this project.

Reviewer 4

This is no real collaboration discussed, but not sure at all that it is necessary considering the performer apparently has capability to formulate, produce samples, and test key attributes. Collaboration with manufactures should be included in a potential Phase 2 to assure commercialization relevance.

Reviewer 5

This reviewer said that no collaborators were listed on this project but it was less than a one year project.

Reviewer 6

This reviewer recounted that the authors stated that there was no collaboration due to the low level of funding.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer suggested that it would be beneficial to demonstrate this technology on actual tires and test tracks.

Reviewer 2

This reviewer found that Phase I has demonstrated promising results. The proposed future work makes sense and the targets are achievable.

Reviewer 3

This reviewer considered that the project is complete. This poster highlights the Phase II goal. It, however, lacks any commercialization plan.

Reviewer 4

This reviewer said that the outline was good, identifying most critical activities, including design a commercially viable prototype product form of the functionalized molecular rebar, for delivery into tire compound processes; develop guiding principles of use for the material, focusing on composite composition

property relationships; and design, build, and test prototype tires, demonstrating that tires last at least 25% longer and make the EV at least about 7% more energy efficient.

However, the reviewer found key missing aspects to be the involvement of a commercialization partner and getting the true economics assessed. There are certainly tradeoffs in terms of IP control that need to be managed, but at least getting some commitment to interest in commercialization would be helpful and probably timely, considering data already produced.

Reviewer 5

This reviewer said that future research appears appropriate, albeit that the existing program of work is complete.

Reviewer 6

This reviewer said that the project has ended.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer said that the technology under development fulfills VTO's mission to reduce energy consumption for improved fuel economy.

Reviewer 2

This reviewer said that the project is relevant to overall DOE objectives to improve electric vehicle efficiency by targeting improved wear resistance and energy efficiency of tires.

Reviewer 3

This reviewer said that the technology would have immediate impact in automotive and other sectors' tire technology. Additionally, this technology could improve the backbone of other chemistries of almost all fields.

Reviewer 4

This reviewer said that the project supports the overall VTO objectives and that the project is especially timely for increasing fuel efficiency and EV drive range.

Reviewer 5

This reviewer said that the project is relevant to the VTO subprogram objectives.

Reviewer 6

This reviewer said, citing these characteristics makes a clear tie to VTO programmatic goals: 20% improved rolling resistance = 7% gain in EV efficiency =1.5 cents/mile savings in EV operating costs and saving 32,300 MWh of electricity in 2030, which would be enough to power 1 million homes. The reviewer believed, although the poster did directly address it, that the claim of potentially achieving tires that last 25+% longer would have additional benefits in reducing landfill use, provided that this approach not impede recycling.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer noted that the project is short term and is 100% complete.

Reviewer 2

This reviewer said that the project has ended so no more resources are available.

Reviewer 3

This reviewer said that the team demonstrated technical competence and achievement with the level of funding provided and recommended that it work with other partners on future work, specifically for tire research in the near future and other areas, such as thermoplastic and thermoset resin chemistry, for later work.

Reviewer 4

This reviewer said that Phase I had the needed resources and future research may need to leverage the resources in academia and industry via collaboration.

Reviewer 5

This reviewer said that resources are sufficient.

Reviewer 6

This reviewer said that the project appears to have been successfully completed within the resources allocated. It did not appear that the amount of funding was in excess of what should have been necessary so resources were sufficient.

Presentation Number: mat258
Presentation Title: Hierarchical Micro/Nano Reinforced Multiscale Hybrid Composites for Vehicle Applications
Principal Investigator: Shawn Beard, Advent Innovations, LTD

Presenter

Shawn Beard, Advent Innovations, LTD

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

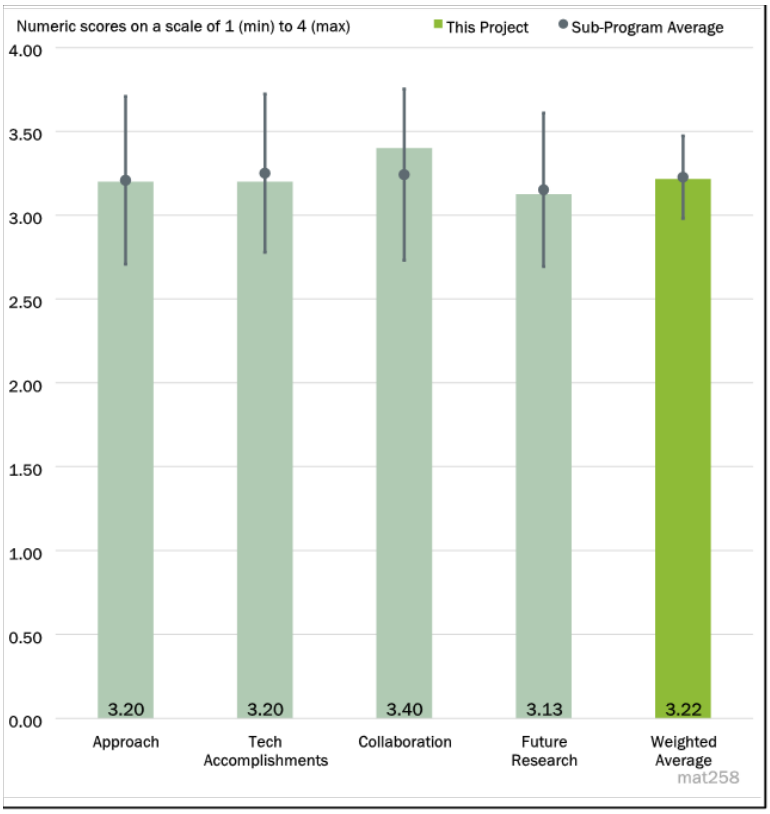

Figure 5-57 - Presentation Number: mat258 Presentation Title: Hierarchical Micro/Nano Reinforced Multiscale Hybrid Composites for Vehicle Applications Principal Investigator: Shawn Beard, Advent Innovations, LTD

Question 1: Approach to Performing the Work: Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer said that the approach is unique and promising to making high-strength fibers with self-sensing capabilities. Good processing images were presented to clearly convey the synthesis process and the resulting fibers. The reviewer would have like to have seen the composite properties compared to other fibers fabricated with the same process.

Reviewer 2

This reviewer said that Advent Innovations and Georgia Southern University (GSU) were teamed up to address the critical needs and technical barriers in polymer composites. The project was well designed and the timeline is reasonable.

Reviewer 3

This reviewer said that the approach, as described, has significant merit. However, it seems to be difficult to realize. With four gigapascal (GPa) strength fibers, the team accomplished only 600 megapascal (MPa) strength in unidirectional composites. The reviewer was not sure why the chopped fiber composites are very poor performing, exhibiting only 6-7 MPa failure strength.

Reviewer 4

This reviewer found that the project is well designed but the presentation does not directly specify what the fibers being coated are made of, Suggesting that it can possibly be assumed that only the nanofibers were being coated, but that was not stated directly. There is also a lack of real data. One stress vs strain curve was presented, but it did not specify which material was being tested or how. Additional testing curves were provided later, but did not show the properties calculated from them. It would be beneficial if the team could directly provide: the exact fiber composition; and the test results comparison between uncoated and coated fibers. The reviewer qualified these comments by noting that the objective was apparently mainly to synthesize these coated fibers, for later testing was mentioned as the 3rd objective.

Reviewer 5

This reviewer said that the approach was laid out with a logical general progression, but justification and specific targets were not identified. Lots of steps and material combinations were listed, along with a good many general objectives, such as increasing energy efficiency, increasing crashworthiness, reduced noise, vibration, and harshness, along with claims of 50% lower cost and 70% smaller carbon footprint, which are not immediately obvious (or supported at all in the poster). The reviewer expressed having been left to speculate that the potential baseline for comparison might be something like Spectra, another UHMWPE, and most of what the team is doing is compatibilizing with a potential composite matrix.

Question 2: Technical Accomplishments and Progress: Comments on the technical progress that has been made compared to project plan.

Reviewer 1

This reviewer believed that, with potential follow-on funding, it would be important to perform a techno-economic analysis of this material. The reviewer stated that the coating process itself should not be cost intensive, but the material costs were the reviewer's major concern.

Reviewer 2

This reviewer said that Phase I was well done. The results are encouraging and the project milestones were all met.

Reviewer 3

This reviewer believed that the interfacial properties of the composites are likely not adequate and that that could be why both directional composites and discontinuous composites reinforced with fiber of strength 4 GPa exhibit poor mechanical properties.

Reviewer 4

This reviewer found that the progress hinges on the actual objectives. The team was successful in synthesizing the hybrid nanocomposite fibers (HyFi), but the reviewer was not exactly sure in which format. The poster did not mention the fiber length of these fibers, according to the reviewer. It showed the fabrication of test specimens, which meets the second objective. It did mention testing, but showed no test results, which would be necessary for excellent achievement.

Reviewer 5

This reviewer noted that the project is described as completed, yet, very, very little data was actually presented according to the reviewer. Fiber strength is stated as four GPa and strain-to-failure of 1300% (which the reviewer found questionable), but the data format does not reveal whether this is the one best fiber or an

average of more than one. There are four "specimen" plots without much detail about the specimens (resin, fiber architecture, fiber fraction, etc.) provided in the presentation and backup slides. This seems inconsistent with Accomplishment page, which indicated: 1) Both long unidirectional fiber and chopped short fiber composite specimens were manufactured and tested; and 2) Specimens were made with various fiber resin ratios and architectures, including all-carbon fibers, all-HyFi fibers, and hybrid carbon-HyFi fibers. Thus, the plots do little to support the claim that "HyFi specimens exhibited high toughness and energy absorption properties".

Question 3: Collaboration and Coordination Across Project Team: Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer found that Advent Innovations and GSU formed a great team for this work.

Reviewer 2

This reviewer found good collaboration with Georgia Southern University, and that GSU's role in the project was clearly stated. Beyond Phase I, a well-organized list of collaborating partners was presented with each company's contribution to the future projects.

Reviewer 3

This reviewer said that the team showed excellent collaboration between Advent, GSU, Ford, and Steelhead Composites.

Reviewer 4

This reviewer said that the collaborations between Advent Innovations and GSU went well. The project team has been working with Ford and JTEKT North American Corporation, which helps scale up.

Reviewer 5

This reviewer said that the collaboration was not really described other than that GSU synthesized and processed fibers, including surface treatments, The reviewer apparently assumed that Advent made and tested composites. According to the reviewer, three other partners were listed but described as not participating until Phase 2. The reviewer was not sure that this is a major weakness at this point, but would like to see Ford involved to assess how much of this might be of real commercial interest to it considering that the project is focusing on PE fibers that may be expensive (especially with required post treatments) and likely to have stiffness/durability concerns as temperatures go up.

Question 4: Proposed Future Research: Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer noted that the project has ended, but a plan for future work was laid out in a logical manner for further developing this research if additional funding is awarded.

Reviewer 2

This reviewer said that future work focusses on more process improvements, including scale-up, automation, and application of fiber treatments. The reviewer said that the presentation also mentioned testing but did not

see real need to focus on testing much more to show the advantages of this technology . Finally, the plan is for running a cost analysis, which is perfectly in-line with DOE objectives.

Reviewer 3

This reviewer said that the proposed future research makes sense. The targets are reasonable and achievable.

Reviewer 4

This reviewer noted that the team is planning for scaled up R&D. However, it seems the composite compositions and interfaces are not optimized yet.

Reviewer 5

This reviewer said that the activities are largely logical but they are very broad and seem to be more focused on expanding targeted features than on actually getting key testing ad cost/performance assessments. It is clear to the reviewer that production higher than the fifteen grams listed as an accomplishment will be required to get some of these data but jumping ahead to piezoelectric properties (presumably for sensing) and standardizing the VARTM process before clarifying achievable properties and associated market interest is getting the cart before the horse, according to the reviewer.

Question 5: Relevance: Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer said that the project supports the overall DOE objectives, specifically improving vehicle efficiency and enabling structural health monitoring capabilities.

Reviewer 2

This reviewer said that this is mostly a material development and can have advantages in many areas in the automotive industry and others.

Reviewer 3

This reviewer said that the project supports the overall VTO objectives. The developed polymer composites enable making vehicles lower cost, more energy efficient, smarter, and safer.

Reviewer 4

This reviewer said that this project is relevant to the VTO subprogram objectives.

Reviewer 5

This reviewer said that the project appears to be relevant, but needs focus on cost/performance tradeoffs with respect to specific applicability.

Question 6: Resources: Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer said that the project has ended so there are no remaining resources.

Reviewer 2

This reviewer said that the team utilized its resources well, with the exception of the need for more physical testing.

Reviewer 3

This reviewer found that Advent Innovations, GSU, Ford, and JTEKT North American Corporation have the necessary resources for accomplishing the proposed milestones and future research goals in a timely manner.

Reviewer 4

This reviewer said that the resources are sufficient.

Reviewer 5

This reviewer said that, without focused objectives and better planning, it is difficult to assess sufficiency of resources. The reviewer believed that there would probably not be enough resources for all of the general objectives listed, but if the objectives were sharpened, the resources probably would be sufficient.

Acronyms and Abbreviations

°C	Degrees Celsius
3-D	Three-dimensional
AI	Artificial intelligence
Al	Aluminum
AM	Additive manufacturing
AM	Additive manufacturing
AMR	Annual Merit Review
ANL	Argonne National Laboratory
APS	Advanced Photon Source
ASTM	American Society for Testing and Materials
BEV	Battery electric vehicle
CCF	Carbon-carbon fiber
CF	Carbon fiber
CFRC	Carbon fiber reinforced composite
CFRP	Carbon fiber reinforced polymer
CFTF	Carbon Fiber Technology Facility
cm	Centimeters
CNG	Compressed natural gas
CNT	Carbon nanontube
CO_2	Carbon dioxide
COVID-19	Coronavirus disease 2019
Cr	Chromium
CRADA	Cooperative research and development agreement
CTE	Coefficient of thermal expansion
Cu	Copper
Cu	Copper
CVD	chemical vapor deposition
DFT	Density function theory
DFT	Discrete Fourier transform
DIC	Digital image correlation
DOE	U.S. Department of Energy

EDAX	Energy dispersive X-Ray analysis
EERE	Energy Efficiency and Renewable Energy
EIS	electrochemical impedance spectroscopy
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
EV	Electric vehicle
Fe	Iron
FEA	Finite element analysis
FSLW	Friction-stir linear welding
FSP	Friction-stir processing
F-SPR	Friction self-piercing rivet
FSW	Friction-stir weld(ing)
GCB	Graphene-enriched carbon black
GHG	Greenhouse gas
GM	General Motors
GPa	Gigapascal
GSU	Georgia Southern University
HDPE	High-density polyethylene
HFR	High-rate friction rivet
HPC	High-performance computing
HPDC	High-pressure die casting
HTC	High temperature carbonization
HVR	High-velocity rivet
HyFi	Hybrid nanocomposite fibers
IACMI	Institute for Advanced Composites Manufacturing Innovation
ICE	Internal combustion engine
ICME	Integrated computational materials engineering
INL	Idaho National Laboratory
IP	Intellectual property
kg	Kilogram
ksi	Thousand pounds per square inch
LCA	Life-cycle analysis

LightMAT	Lightweight Materials Consortium
LLNL	Lawrence Livermore National Laboratory
LMCP	Light Metals Core Program
MAS	Micro-alloyed steel
MAT	Materials Technology Program
Mg	Magnesium
ML	Machine learning
mm	Millimeter
MMC	Metal matrix composite
Mn	Manganese
MPa	Megapascal
MPa	Megapascal
MR	MOLECULAR REBAR®
MRL	Manufacturing Readiness Levels
msi	Million pounds per square inch
MSU	Mississippi State University
MTT	Materials Technical Team
Mw	Molecular weight
MWh	Megawatt hour
NBR	Nitrile rubber (nitrile-butadiene rubber(
Ni	Nickel
nm	Nanometer
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer
ORNL	Oak Ridge National Laboratory
OSU	Ohio State University
PAEK	polyaryletherketone
PAG	polyalkylene glycols
PAN	Polyacrylonitrile
PE	Polyethylene
PEAK	Polyaryletherketone
PI	Principal Investigator

PNNL	Pacific Northwest National Laboratory
PP	Polypropylene
PSU	Pennsylvania State University
PU	Polyurethane
PUSP	Power ultrasonic surface processing
PVC	Polyvinyl chloride
PVDF	Polyvinylidene fluoride
PVP	Polyvinylpyrrolidone
R&D	Research and development
SBIR	Small Business Innovation Research
SBIR	Small Business Innovation Research
SCI	Structural Composites, Inc.
SEM	Scanning electron microscopy
ShAPE™	Shear Assisted Processing and Extrusion
SPH	Smoothed Particle Hydrodynamics
SPR	Self-piercing rivet
SRNL	Savannah River National Laboratory
STEM	Scanning transmission electron microscopy
SURF	Scale-Up Research Facility
TEA	Techno-economic analysis
TFP	Tailored fiber placement
T_g	Glass transition temperature
TiB_2	Titanium diboride
TPM	Thermo-Pseudo Mechanical
TRL	Technology Readiness Level
TuFF	Tailorable universal feedstock for forming
U.S. DRIVE	United States Driving Research and Innovation for Vehicle efficiency and Energy sustainability
UAM	Ultrasonic additive manufacturing
UCC	Ultra-conducting copper
UCLA	University of California at Los Angeles
UHMWPE	Ultra-high-molecular-weight polyethylene

UNT	University of North Texas
USAMP	U.S. Automotive Materials Partnership
UT	University of Tennessee
UV	Ultraviolet
VARTM	Vacuum assisted resin transfer molding
VFAW	Variable frequency arc welding
VTO	Vehicle Technologies Office
Zn	Zinc
Zr	Zirconium
µm	Micrometer

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