5. Materials Technology

The Vehicle Technologies Office (VTO) supports research, development, demonstration, and deployment (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 innovations in connected infrastructure for significant systems-level energy efficiency improvement); innovative powertrains to reduce greenhouse gas (GHG) and criteria emissions from hard to decarbonize off-road, maritime, rail, and aviation sectors; and technology integration that helps demonstrate and deploy new technology at the community 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), VTO 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 VTO's goals of achieving 100%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 (EVs) through weight reduction and enabling faster charging and sensing technologies. The materials research also contributes to the goal of reducing GHG emissions and recyclability, helping reduce the overall embodied energy of vehicles.

Lightweight Materials activities support 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. 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.

Lightweight Materials activities support these VTO program level goals:

- Enable a 25% weight reduction for light-duty vehicles including body, chassis, and interior as compared to a 2020 baseline by 2030, without significantly increasing costs; and
- Develop lightweight alloys with improved strength and fatigue performance for cast and additive manufacturing methods resulting in a 25% weight reduction in powertrain and suspension components by 2030.

Powertrain Materials activities similarly support research to develop higher performance materials needed by electric and hydrogen fuel cell vehicles to increase efficiency and decrease manufacturing cost, helping transition to all electric light duty vehicles by 2035. Weight reduction and electric powertrain system efficiency improvements for heavy-, medium-, and light-duty vehicles are being advanced through this work, addressing challenging components such as inverters, motors, and geartrain. Current priority focus areas for the subprogram include: (1) lightweight alloys with high fatigue strength for suspension components, (2) high temperature materials for lighter brakes, (3) predictive models for powertrain materials, and (4) Integrated Computational Materials Engineering (ICME) tools that use high-performance computing (HPC) capabilities, multi-length scale (atoms to components) material models, and boundary layer resolved thermo-kinetic models.

Project Feedback

In this Annual Merit Review (AMR) 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. Table 5-1 presents the average numeric score for each question for each project.

Table 5-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
MAT146	Ultra-Lightweight, Ductile Carbon-Fiber Reinforced Composites	Seokpum Kim (Oak Ridge National Laboratory)	5-9	3.17	3.33	3.17	3.00	3.23
MAT149	Shear Assisted Processing and Extrusion (ShAPE) of Lightweight Alloys for Automotive Components	Scott Whalen (Pacific Northwest National Laboratory)	5-12	3.67	3.67	3.50	2.75	3.53
MAT152	A Hybrid Physics-Based, Data-Driven Approach to Model Damage Accumulation in Corrosion of Polymeric Adhesives	Roozbeh Dargazany (Michigan State University)	5-15	3.25	3.38	3.25	3.00	3.28
MAT159	Cost Effective Lightweight Alloys for Electric Vehicle Propulsion, Fundamental Fatigue and Creep in Advanced Lightweight Alloys	Amit Shyam (Oak Ridge National Laboratory)	5-19	3.13	3.13	3.00	3.13	3.11
MAT160	Cost Effective Lightweight Alloys for Electric Vehicle Propulsion, Hybrid Dispersion Strengthened Al matrix composites for higher efficiency EV powertrains	Mert Efe (Pacific Northwest National Laboratory)	5-23	3.38	3.25	3.38	3.50	3.33
MAT174	Carbon Fiber Technology Facility (CFTF)	Merlin Theodore (Oak Ridge National Laboratory)	5-27	4.00	3.83	2.67	3.67	3.71
MAT196	High Temperature Carbon Fiber Carbonization via Electromagnetic Power	Felix Paulauskas (Oak Ridge National Laboratory)	5-31	3.00	2.50	2.88	2.67	2.69

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
MAT197	Multi-Functional Smart Structures for Smart Vehicles	Patrick Blanchard (Ford Motor Company)	5-35	3.50	3.25	3.25	3.25	3.31
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)	5-38	3.50	3.50	3.25	3.25	3.44
MAT199	Ultra-Lightweight Thermoplastic Polymer/ Polymer Fiber Composites for Vehicles (Inter-Lab Project)	Kevin Simmons (Pacific Northwest National Laboratory)	5-41	3.63	3.63	3.63	3.33	3.59
MAT200	Additive Manufacturing for Property Optimization for Automotive Applications	Seokpum Kim (Oak Ridge National Laboratory)	5-46	3.33	3.42	3.25	3.33	3.36
MAT201	Additively Manufactured, Lightweight, Low-Cost Composite Vessels for Compressed Natural Gas Fuel Storage	James Lewicki (Lawrence Livermore National Laboratory)	5-50	3.17	3.33	3.17	3.50	3.29
MAT202	3D Printed Hybrid Composite Materials with Sensing Capability for Advanced Vehicles	Rigoberto Advincula (Oak Ridge National Laboratory)	5-53	2.67	2.83	2.83	2.83	2.79
MAT203	Low-Cost, High-Throughput Carbon Fiber with Large Diameter	Felix Paulauskas (Oak Ridge National Laboratory)	5-57	3.33	2.83	3.33	3.00	3.04
MAT204	New Frontier in Polymer Matrix Composites via Tailored Vitrimer Chemistry	Tomonori Saito (Oak Ridge National Laboratory)	5-61	3.25	3.38	3.50	3.25	3.34
MAT205	Adopting Heavy-Tow Carbon Fiber for Repairable, Stamp-Formed Composites	Amit Naskar (Oak Ridge National Laboratory)	5-65	2.67	2.67	3.00	2.67	2.71

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
MAT206	Soft Smart Tools Using Additive Manufacturing	Jay Gaillard (Savannah River National Laboratory)	5-69	3.00	3.00	3.25	2.88	3.02
MAT207	Multi-Material, Functional Composites with Hierarchical Structures	Christopher Bowland (Oak Ridge National Laboratory)	5-73	3.50	3.25	2.75	3.25	3.25
MAT208	Efficient Synthesis of Kevlar and Other Fibers from Polyethylene Terephthalate (PET) Waste	Daniel Merkel (Pacific Northwest National Laboratory)	5-76	3.25	3.50	2.75	3.25	3.31
MAT209	Bio-based, Inherently Recyclable Epoxy Resins to Enable Facile Carbon-Fiber Reinforced Composites Recycling	Nicholas Rorrer (National Renewable Energy Laboratory)	5-79	3.50	3.50	2.75	3.00	3.34
MAT210	A Novel Manufacturing Process of Lightweight Automotive Seats - Integration of Additive Manufacturing and Reinforced Polymer Composite	Patrick Blanchard (Ford Motor Company)	5-82	3.00	3.00	3.17	3.00	3.02
MAT211	Sustainable Lightweight Intelligent Composites (SLIC) for Next-Generation Vehicles	Masato Mizuta (Newport Sensors, Inc.)	5-85	2.75	3.00	3.00	3.33	2.98
MAT212	Integrated Self-sufficient Structurally Integrated Multifunctional Sensors for Autonomous Vehicles	Amrita Kumar (Acellent Technologies, Sunnyvale)	5-89	2.83	3.00	2.83	2.50	2.88
MAT221	Lightweight and Highly-Efficient Engines Through Al and Si Alloying of Martensitic Materials	Dean Pierce (Oak Ridge National Laboratory)	5-93	3.60	3.60	3.70	3.50	3.60
MAT222	Extending Ultrasonic Welding Techniques to New Material Pairs	Jian Chen (Oak Ridge National Laboratory)	5-97	3.30	3.50	3.20	2.90	3.34

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
MAT223	Extending High-Rate Riveting to New Material Pairs	Kevin Simmons (Pacific Northwest National Laboratory)	5-102	3.25	3.25	2.75	3.25	3.19
MAT224	Solid State Joining of Multi-Material Autobody Parts Toward Industry Readiness	Piyush Upadhyay (Oak Ridge National Laboratory/Pacific Northwest National Laboratory)	5-105	3.50	3.00	3.50	3.33	3.23
MAT225	Surface Modifications for Improved Joining and Corrosion Resistance	Vineet Joshi (Oak Ridge National Laboratory/ Pacific Northwest National Laboratory)	5-108	3.25	3.00	3.25	2.63	3.05
MAT226	Machine Learning for Joint Quality and Control	Keerti Kappagantula (Oak Ridge National Laboratory/ Pacific Northwest National Laboratory)	5-113	3.50	3.50	4.00	3.50	3.56
MAT229	Development of a Novel Magnesium Alloy for Thixomolding of Automotive Components	Govindarajan Muralidharan (Oak Ridge National Laboratory/FCA LLC)	5-115	3.00	3.25	3.25	3.13	3.17
MAT231	Light Metals Core Program Introduction	Glenn Grant (Pacific Northwest National Laboratory)	5-119	3.25	3.50	3.00	2.50	3.25
MAT235	Light Metals Core Program - Thrust 4 - Residual Stress Effects	Ayoub Soulami (Pacific Northwest National Laboratory)	5-121	3.10	3.00	3.10	3.10	3.05
MAT236	Advanced Characterization and Computational Methods	Thomas Watkins (Oak Ridge National Laboratory)	5-125	3.67	3.50	3.17	2.83	3.42
MAT237	Materials, Lubricants, and Cooling for Heavy Duty Electric Vehicles	Jun Qu (Oak Ridge National Laboratory)	5-128	3.38	3.38	3.25	3.38	3.36

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
MAT241	Advanced Processing and Additive Manufacturing for EV Propulsion	Beth Armstrong (Oak Ridge National Laboratory)	5-132	3.50	3.30	2.90	3.20	3.29
MAT242	Advanced Processing and Additive Manufacturing for EV Propulsion, Advanced Ceramics and Processing for Wireless Charging Systems, Novel Ultra High Conductivity Composites for EVs	Tolga Aytug (Oak Ridge National Laboratory)	5-137	3.67	3.67	3.67	3.33	3.63
MAT243	Manufacturing Demonstration of a Large-scale	Srikanth Pilla (Clemson University)	5-140	3.33	3.00	3.33	3.33	3.17
MAT244	LMCP P1A - Sheet Materials with Local Property Variation	Scott Whalen (Pacific Northwest National Laboratory)	5-143	3.75	3.50	3.50	3.25	3.53
MAT245	LMCP P1B - Form-and-Print - AM for Localized Property Enhancement of High-strength Al sheet	Alex Plotkowski (Oak Ridge National Laboratory)	5-145	2.50	2.50	2.17	2.50	2.46
MAT246	LMCP P1C - Local Thermo-mechanical Processing to Address Challenges to Implementing High Strength Al Sheet	Mert Efe (Pacific Northwest National Laboratory /Oak Ridge National Laboratory)	5-148	3.25	3.50	3.50	3.25	3.41
MAT247	LMCP P2A – Solid Phase Processing of Aluminum Castings	Saumyadeep Jana (Pacific Northwest National Laboratory /Oak Ridge National Laboratory)	5-150	3.00	3.25	2.50	3.00	3.06
MAT248	LMCP P2B – High Intensity Thermal Treatment	Aashish Rohatgi (Pacific Northwest National Laboratory)	5-152	3.67	3.33	3.17	3.50	3.42
MAT249	LMCP P2C – Cast-and-Print – AM for Localized Property Enhancement of Al castings	Alex Plotkowski (Oak Ridge National Laboratory)	5-155	2.75	2.75	2.38	2.50	2.67

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
MAT250	LMCP P3A - Cast Magnesium Local Corrosion Mitigation	Vineet Joshi (Pacific Northwest National Laboratory /Oak Ridge National Laboratory)	5-159	3.40	3.20	2.90	3.00	3.19
MAT251	LMCP P3B - Thermo-mechanical Property Modification of Mg Castings	Mageshwari Komarasamy (Pacific Northwest National Laboratory)	5-163	3.00	3.17	2.83	3.00	3.06
MAT252	LMCP - Thrust 4 - Materials Lifecycle	Jeff Spangenberger (Argonne National Laboratory)	5-166	3.00	2.88	2.63	2.88	2.88
MAT254	Conductive Lightweight Hybrid Polymer Composites from Recycled Carbon Fibers	Yinghua Jin (RockyTech, Ltd.)	5-169	3.50	3.33	3.50	3.17	3.38
MAT256	Game Changing Resin/Coating/ Adhesive Technology for Lightweight Affordable Composites	Scott Lewit (Structural Composites, Inc.)	5-172	2.50	2.25	3.25	1.50	2.34
MAT257	Changing the Design Rules of Rubber to Create Lighter Weight, More Fuel Efficient Tires	Kurt Swogger (Molecular Rebar Design, LLC)	5-174	3.50	3.33	3.33	3.33	3.38
MAT259	Green Composites Fabricated from Bacteria Retted Bast Fiber and PLA for light weight vehicle Components	Lee Smith (Z&S Tech, LLC)	5-177	3.00	3.13	2.25	2.50	2.91
MAT260	Green Composites from Carbonated Bio-based Oils and Recycled Nanofibers	Jesse Kelly (Luna Labs, USA)	5-181	2.67	3.00	3.00	3.25	2.95
MAT261	Multiscale Bioinspired Enhancement of Natural-Fiber Composites For Green Vehicles	Lorenzo Mencattelli (Helicoid Industries, Inc.)	5-184	3.17	3.17	3.33	3.25	3.20
MAT262	Sustainable Automotive Composites Using Surface-Modified Cellulose Fibers	Girish Srinivas (TDA Research, Inc.)	5-187	2.67	2.50	3.33	3.00	2.71

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
MAT263	Green Polybenzoxazine/Natural Fiber Composites for Transportation	Christopher Scott (Material Answers, LLC)	5-190	3.17	3.00	3.33	3.00	3.08
MAT264	Green composites for future vehicles, Vitrimer Matrix + natural and recycled fiber composite Materials for high performance, repairable, recyclable, and bio-sourced automotive components	Philip Taynton (Mallinda, Inc.)	5-194	3.00	2.75	2.75	2.75	2.81
Overall Average				**3.22**	**3.18**	**3.11**	**3.05**	**3.17**

Presentation Number: MAT146
Presentation Title: Ultra-Lightweight, Ductile Carbon-Fiber Reinforced Composites
Principal Investigator: Seokpum Kim (Oak Ridge National Laboratory)

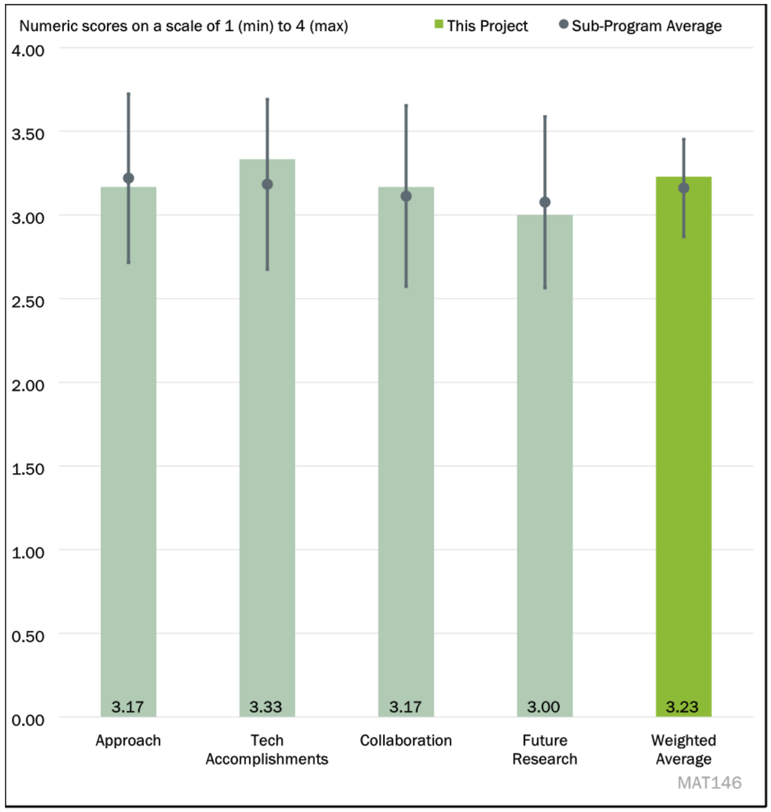

Figure 5-28 - Presentation Number: MAT146 Presentation Title: Ultra-Lightweight, Ductile Carbon-Fiber Reinforced Composites Principal Investigator: Seokpum Kim (Oak Ridge National Laboratory)

Presenter

Seokpum Kim, Oak Ridge National Laboratory

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.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer observed that the project showed significant progress and was aggressive towards scaling the printed objects. The results are very interesting and will contribute good science and engineering. The project showed great progress on printer and part design optimization, according to the reviewer.

Reviewer 2:

The project seems to this reviewer to have been carried out at the right phase, and the milestones reached in a timely and convincing manner with the presented results. The reviewer asks: (1) Whether the effort on the three-dimensional (3D) printer speed of printing has been an important factor in meeting the number of samples, i.e., how fast samples can be printed. The reviewer comments that, other than the print method, related stereolithography and digital light processing [DLP] methods are slow. (2) What is the timeline for the testing with various compositions including how fast is the procedure for preparing the formulation?

Reviewer 3:

This reviewer found that the team has made inroads into some of the criticisms leveled last year, specifically in regard to throughput and cost but that much work is yet needed to completely address these issues in the future. An explanation is needed for the technical progress that has been made compared to the project plan.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer commented that the technical progress was carefully executed leading to some good results. The reviewer feels that it would be good to see the baseline performance metrics for the vehicle bumper to evaluate how close the lightweight print design meets those metrics.

Reviewer 2:

This reviewer applauds the vehicle bumper with graded architecture as an excellent demonstration part for this technology.

Reviewer 3:

This reviewer calls for an explanation of (1) how specific geometries or nature-inspired structures track with the simulation effort on the strength to be achieved on the material itself other than the geometry and (2) whether it is possible to use nanofiller materials together with the resin. This seems to the reviewer to be a good match for future directions.

Question 3: Please comment on the collaboration within the 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 wasn't clear in the presentation to this reviewer where the university partner contributed but several publications had the team lead and the university as authors which, the reviewer believes, shows good collaboration. The reviewer suggests that it may be preferable to identify contributions from each partner in the presentation.

Reviewer 2:

The collaboration seems to this reviewer to have been very productive. The reviewer questions whether there might be any intellectual property (IP) issues that could be problematic.

Reviewer 3:

The collaboration within the project team appears to this reviewer to be adequate, though the reviewer is not 100% clear as to who is doing what work exactly.

Question 4: Please comment on the 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 suggests that the future work include a baseline comparison.

Reviewer 2:

This reviewer notes that there is a healthy balance with the materials and the design development. The reviewer asks if the team could explain the work of ORNL and the partner company on how IP issues have been resolved.

Reviewer 3:

This reviewer believes that the current/expected collaboration with Ford is a positive development that could give the project support toward continuing the improvements in applicability to vehicle designs.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirms that the project supports the VTO overall goals.

Reviewer 2:

This reviewer states that the project is very much aligned with the VTO program goals.

Reviewer 3:

According to this reviewer, the relevance of the project is high, though there are questions related to the applicability of the approach. Aspects of the presentation were not clear to the reviewer, especially in regard to the self-sensing idea and how the ability of the team to tailor stiffness can be used for self-sensing. These ideas were clarified during the Q&A.

Question 6: Please provide comments on the resources of the project. 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 for both the sensing experiments and 3D printer development.

Reviewer 2:

This reviewer found that the resources have been well-utilized in a timely fashion and suggests that there is a need to report any deviation from the original plan and budget.

Reviewer 3:

The resources needed to conduct the project appear to be sufficient in this reviewer's opinion.

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, Pacific Northwest National Laboratory

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.

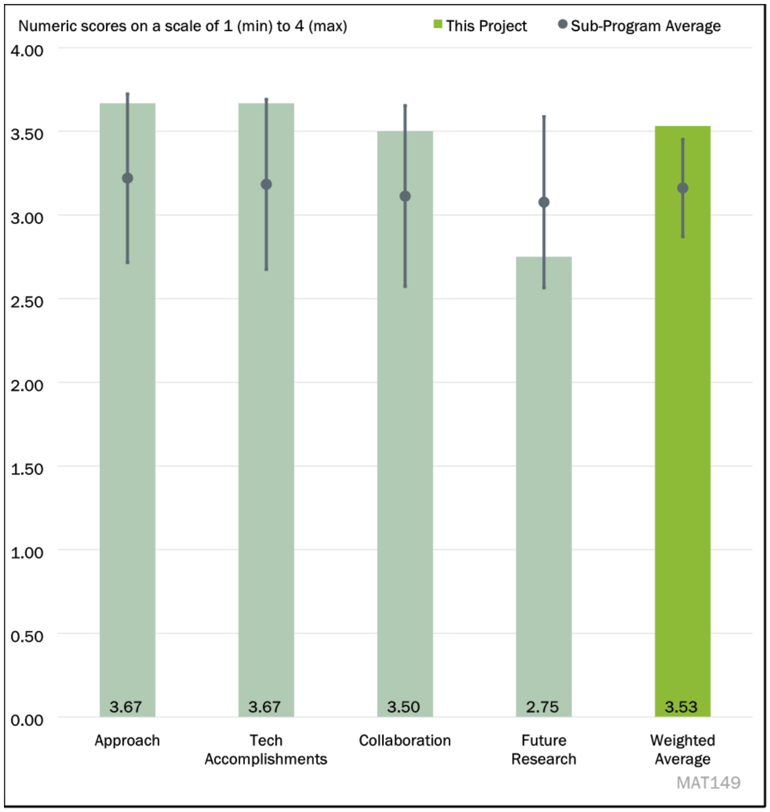

Figure 5-1 - Presentation Number: MAT149 Presentation Title: Shear Assisted Processing and Extrusion (ShAPE) of Lightweight Alloys for Automotive Components Principal Investigator: Scott Whalen (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer praised the project as being complete and having addressed the technical barriers in a timely manner. Specifically, it was demonstrated that the shear assisted processing and extrusion (ShAPE) process can be used to produce components with desired microstructures and properties. Additionally, scrap metal can be utilized to enhance recycling and reduce the carbon footprint for manufacturing.

Reviewer 2:

This reviewer pointed out that the project is completed; the aim was to develop the ShAPE process and demonstrate the feasibility of recycling Al alloys; the objective was completed successfully as the technology is being tested at an industrial partner’s site. The technical barriers were resolved with the demonstration project.

Reviewer 3:

This reviewer suggested that the project should really address the challenge of using post-consumer scrap (not just the manufacturing scrap), which would have more impact to the applications.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer found that the project made good progress in addressing manufacturing scrap.

Reviewer 2:

This reviewer stated that the team had developed and demonstrated the process.

Reviewer 3:

This reviewer said that all the milestones on the project have been met.

Question 3: Please comment on the collaboration within the 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:

To this reviewer, it seems that Magna is very much involved in the collaboration.

Reviewer 2:

This reviewer affirmed that the project is well supported by industry partners; the team had many meetings and technology transfer trials, which were well coordinated.

Reviewer 3:

This reviewer believes that the main collaboration has been with Magna and its subsidiaries.

Question 4: Please comment on the 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 noted that the project is complete; commercialization efforts are underway through negotiations with industrial partners.

Reviewer 2:

This reviewer felt that it would be good to target a product for commercialization in collaboration with Magna or another supplier. It seems to the reviewer that the commercialization aspect is missing from the future work plan. The reviewer mentioned that there will be a new LightMat project to develop a continuous extrusion process and asked whether a target product/component has been chosen.

Reviewer 3:

This reviewer believes that the project should address the challenge of using post-consumer scrap (not just the manufacturing scrap) in the future.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer found the project to be relevant to lightweighting and environment protection.

Reviewer 2:

This reviewer believes that the process development is needed to produce light metals (Al and magnesium) with less difficulties. Lightweighting is needed for the vehicle efficiency and this project develops an enabling technology to produce light metal components with enough performance.

Reviewer 3:

This reviewer affirmed that the project is relevant to vehicle lightweighting for less energy consumption, materials recycling, and lowering of GHGs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer commended the team for having had good delivery of the project and also for having interacted with the industrial partners, as well as for having the results well disseminated.

Reviewer 2:

This reviewer said that the project was completed within the budget and allocated resources.

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. 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.

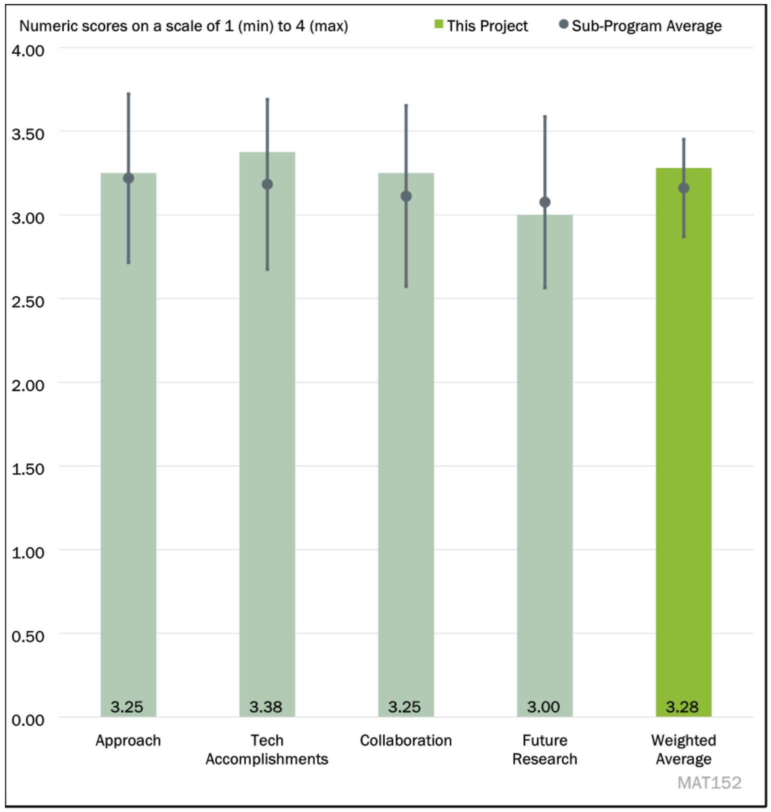

Figure 5-2 - Presentation Number: MAT152 Presentation Title: A Hybrid Physics-Based, Data-Driven Approach to Model Damage Accumulation in Corrosion of Polymeric Adhesives Principal Investigator: Roozbeh Dargazany (Michigan State University)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer wrote that the barriers and technical targets identified were the lack of reliable joining technology for dissimilar materials, the lack of cost-effective tests for evaluation of corrosion, the lack of a constitutive model capable of predicting corrosion, a predictive modeling tools with a prediction error less than 10%, and a lack of validated test protocols for predictive modeling tools. The overall objectives were to develop a theoretical model that describes damage accumulation in a constitutive behavior with respect to deformation, vibration, hydrolysis, thermo-oxidation and photo-oxidation. The model that was developed can be used to predict the failure of cross-linked polymeric adhesives within a 10% error with respect to damage accumulated by environmental and mechanical loads. Predicting failure in adhesives of dissimilar materials is important for the use of lightweight materials leading to vehicle mass reduction and expediting the design of composite joints in vehicle structures for lightweighting to address the VTO Materials subprogram targets and goals for joining of lightweight materials. According to the reviewer, there is also a need to reduce the time and cost required for testing corrosion failure, which makes the use of lightweight materials more attractive to original equipment manufacturers (OEMs) and provide them with an improved computer-aided engineering prediction capability to achieve a reliable service-life of joints. This project addresses the needs for joining dissimilar materials used in 15 different components used in commercial vehicles. The principal effort in Fiscal Year 2022 was to complete the software predictions for sample adhesives exposed to all combinations of corrosion mechanisms under laboratory conditions. This approach addresses the barriers and technical targets for determining reliable joining technologies for dissimilar materials, the lack of cost-effective tests for evaluation of corrosion, and the lack of a constitutive model capable for predicting corrosion, specifically. This was a three-year research and development (R&D) project that appears well designed to address the barriers and targets within a reasonable timeframe.

Reviewer 2:

This reviewer found that, while the project approach includes extensive modeling and validation efforts, it is not completely clear how effective this will be at enabling industry (including adhesive manufacturers and automotive OEMs) to improve on the current state of adhesive development and evaluation in real world automotive OEM usage.

Reviewer 3:

This reviewer commended the team for a good effort with complete results.

Reviewer 4:

According to this reviewer, while the research objective is well-outlined, it is difficult to follow the detail, which makes it very difficult to evaluate the technical approach of the present study appropriately. The present project claims that it is a physics-based data-driven research, but it is hard to understand how or what physics have been incorporated in the data analytics.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer characterized the project was to develop a theoretical model to describe damage accumulation in constitutive behavior with respect to deformation, vibration, hydrolysis, thermo-oxidation and photo-oxidation as well as a combination of these mechanisms, specifically to predict failure of cross-linked polymeric adhesives due to damage from environmental and mechanical loads. A thermal and mechanical model was developed to predict the constitutive behavior of adhesives through thermo-oxidative aging using an approach that assumed a dual network hypothesis. This achieved the first validated model of thermal and mechanical effects covering permanent set and polymer relation. The effects of vibration were added to model the constitutive behavior of thermo-oxidative aging and vibration concurrently, assuming that the mechanical and environmental aging are two parallel mechanisms. Fatigue was added to the thermal portion to model the constitutive behavior of thermo-oxidative aging and fatigue using an accumulated damage approach. A continuous network hypothesis was used to develop a model that predicted the effects of ultraviolet light coupled with thermal and mechanical failure mechanisms. For hydrolysis and mechanical failure mechanisms, silicone was examined as the dominant plasticization and chain scission with decrease in stress and increase in strain. Studies of polyurethane showed high chain scission with decrease in stress and a decrease in strain. The strain energy of the material in all states of aging was modeled for hydrolysis, thermal, and mechanical mechanisms. Machine-learning was used to reduce the order for modeling thermal aging and mechanical effects with a goal of developing a model for the constitutive behavior of adhesives through thermo-oxidative aging. All these efforts achieved the first validated models for each of the mechanisms being studied. According to the reviewer, these were significant accomplishments toward meeting the technical target for the lack of a constitutive model capable for predicting corrosion and was consistent with the project plan.

Reviewer 2:

In this reviewer’s estimation, the project team has substantially met the extensive objectives of their project plan including validation of individual models for predicting adhesive performance degradation resulting from loading, vibration, thermal, ultraviolet, and hydrolysis inputs, as well as others.

Reviewer 3:

This reviewer believes that the progress was very good this cycle.

Reviewer 4:

While noting that very detailed information was provided, this reviewer found it very difficult to understand the accomplishments and progress at a high level. Thus, it was very difficult for this reviewer to properly evaluate the technical accomplishments and progress.

Question 3: Please comment on the collaboration within the 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 lauded the project as outstanding for the level of collaboration that was formed. It included academia (Michigan State University – the project lead), two chemical companies (Dow and Parker-Lord), a high-performance modeling (HPM) group, a testing company (Endurica), a tier one supplier (Bosch), and a firm that deals in quality assurance and test standards (JDV). According to the reviewer, this project had the best collaboration of any of the projects reviewed.

Reviewer 2:

The reviewer concluded that the project has displayed good collaboration and coordination from a sizable group of industry and academic partners to achieve its goals on a timely basis. The collaboration could have been improved by the inclusion of a substantially involved automotive OEM.

Reviewer 3:

This reviewer found good coordination among teams.

Reviewer 4:

This reviewer believed that it appears that the majority of work has been done at the leading institute, but it is unclear what work has been done by other team members.

Question 4: Please comment on the 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 ended in December 2022; however, future research that was recommended included studies on the degradation of adhesion properties at the substrate/adhesive interface, examining other parameters such as conductivity, and investigation of data minimization for training/validation of multi-agent simulators.

Reviewer 2:

This reviewer stated that the project has ended, so there can be no future research as part of this project.

Reviewer 3:

This reviewer said that the project has ended.

Reviewer 4:

This reviewer found that the proposed future works appear to be reasonable.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirmed that the project addresses the Materials subprogram barrier of a lack of reliable joining technology for dissimilar materials, including lack of cost-effective tests for evaluation of corrosion, lack of constitutive model capable of predicting corrosion, and lack of predictive modeling tools.

Reviewer 2:

This reviewer found that the project was very relevant to the VTO Materials subprogram objectives for predicting failure in adhesives of dissimilar materials that is necessary to facilitate use of lightweight material for vehicle mass reduction, accelerating the design of composite joints in vehicle structures for lightweighting, improving computer-aided engineering prediction capabilities to achieve a reliable service-life of joints, and reducing the time and cost required for testing corrosion failure which makes the use of lightweight materials more attractive for OEMs.

Reviewer 3:

This reviewer held that the objective of the project is well-aligned with the EERE VTO's mission space.

Reviewer 4:

Work is relevant to VTO's mission.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer opined that the resources provided by DOE and the collaborators have been sufficient to enable the team to accomplish all of their milestones in 4 years.

Reviewer 2:

This reviewer pointed out that in Fiscal Year 2022, this project received almost $1 million of DOE funding with almost $500,000 from the collaboration partners which is a 33% cost share. The collaborators were well capable of providing the resources needed in their areas of specialization. This was sufficient funding and personnel/facility resources for a project that completed in 2022.

Reviewer 3:

This reviewer confirmed that the project has sufficient resources to carry out the proposed research.

Reviewer 4:

This reviewer found that the project was given good resources across the board.

Presentation Number: MAT159
Presentation Tile: 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 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.

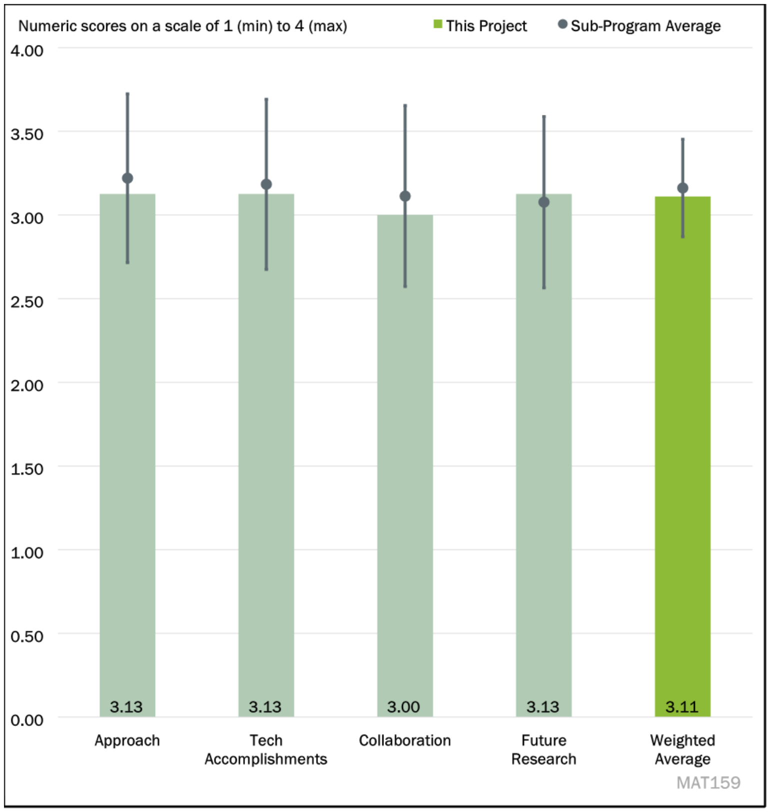

Figure 5-3 - Presentation Number: MAT159 Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion, Fundamental Fatigue and Creep in Advanced Lightweight Alloys Principal Investigator: Amit Shyam (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer found the work scope to be well defined to address the key technical barriers of creep and fatigue for lightweight propulsion materials for electric vehicles (EVs). Using modeling and advanced characterizations, the fundamental mechanisms for the creep and failure in Al alloys have been studied to help design alloys with improved properties for conductor and structural applications in EVs.

Reviewer 2:

This reviewer believes the technical barriers, from the microstructural issues to the materials degradation issues, appear to be systematically addressed. The reviewer is concerned, however, that standards or matrices for materials issues, like creep to be tested, are lacking, for example, the limits of acceptability for creep for instance. According to the reviewer, the Principal Investigators (PIs) admitted that there are none because they do not know what they would be. This is a serious concern for the reviewer.

Reviewer 3:

According to this reviewer, the program presents a classical set of materials issues and a good balance of physical metallurgy and fundamental microstructural assessment. While it has been mentioned in a previous review, the development of the aluminum-copper-manganese-zirconium (ACMZ) alloy for the suggested use in brake rotors seems to be a stretch. Brake performance is measurable as a balance between wear properties and cost (as what is essentially a consumable component…) and less dependent upon traditional high temperature strength. Aging behaviors of Al precipitate structures (even L12) would likely lead to other performance issues (fatigue crack growth, warpage from thermal cycling). According to this researcher, this research is reflective of a great solution still in search of a problem.

Reviewer 4:

This reviewer found the technical barriers outlined to be very broad and did not see a project plan presented. This gap made this question hard for the reviewer to evaluate and hard to discern if the work accomplished was well aligned with the most significant barriers.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer pointed out that *in situ* studies have been completed to understand the creep mechanisms in a cast Al alloy and baseline creep properties have been established. The project is on track with the milestones.

Reviewer 2:

This reviewer found that the program is demonstrating compelling results in direct comparison curves, and the team is revealing some good interpretations of microstructural responses even when property improvements are not being realized.

Reviewer 3:

This reviewer believes that the project made significant progress linking mechanisms to creep resistance, but without a project plan and context for prior work this was hard to benchmark.

Reviewer 4:

To this reviewer, the main concern is the lack of performance targets in this work. It is possible that the PIs are well off the targets that need to be achieved since they are not currently measuring results to such targets. Also, photos of the microstructural analyses that yielded the hypothesis on Slide 10 of the presentation would have been helpful. The reviewer questions why peak hardness temperatures on Slide 15 are different from the aging temperatures employed for aging (Slide 16). The reviewer notes that the material’s hardness between 400°C and 425°C (Slide 15) is over 50 MPa.

Question 3: Please comment on the collaboration within the 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 the project is a collaborative work with three national laboratories as part of the Propulsion Materials Core Program. Within the core program, this project is well aligned with other tasks, including the advanced characterizations using Spallation Neutron Source. Additionally, there has been collaboration with Northwestern University and an industry partner.

Reviewer 2:

This reviewer called the team strong but said that the collaboration is relatively limited. For work with such practical applications (at least in principle), engagement with potential end users would be highly beneficial.

Reviewer 3:

This reviewer complained that the only mention of collaborators is on Slide 20 finding the collaboration efforts not clear from the work presented, or what the role(s) of Northwestern University and Nano Al is/are. It is apparent that they are involved in other tasks under the same project. How exactly they are coordinating is not clear to this reviewer.

Reviewer 4:

This reviewer was also disappointed that, while the various collaborators were identified, what roles they played and how they contributed were not addressed.

Question 4: Please comment on the 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 says that the future research being proposed builds on the results and accomplishments of the program.

Reviewer 2:

This reviewer noted that the future work is defined for only until the end of the calendar year, which entails demonstration of the enhanced creep resistance in alloys with different compositions, *in situ* neutron creep testing, and fatigue properties of the additively manufactured alloys. The reviewer would have liked to see long term plans such as working with an industry partner for development of laboratory scale prototypes to show how the new materials would be transitioning into a product. While the reviewer concedes that it may be early but believes that some kind of a road map would be helpful.

Reviewer 3:

This reviewer believes the tests laid out are great and would help address many unanswered questions. This reviewer assumes future work is the work highlighted on Slide 3 and Slide 21 and not just on Slide 21 but asserts that what is laid out on Slide 21 by itself is inadequate. A technical gap that has not been addressed is the performance targets that are being tested to. For instance, how much creep is acceptable in rotor materials, and do the materials being tested meet the requirements.

Reviewer 4:

This reviewer complains that the proposed future research does not describe what these results would enable and how significant they would be.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirms that this project contributes to materials advancements necessary for efficient electrification of cars.

Reviewer 2:

This reviewer states that the work is highly relevant to the focus of this thrust area.

Reviewer 3:

This reviewer says that the project aligns with incorporating metals with less weight into the vehicle.

Reviewer 4:

This reviewer believes that the project is very relevant for the improved lightweight alloys for structural and conductor application in EVs, which can lead to increased efficiencies and range for the vehicle.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found that the resources and capabilities seem adequate.

Reviewer 2:

This reviewer believes that the mechanical property testing is readily available to the team since the project requires extensive, time-consuming creep testing. Further, beam line time allocation at the neutron source is not an issue in case some experiments are needed in the latter part of the project.

Reviewer 3:

This reviewer referred to having pointed out during the question and answer (Q&A) section that industrial perspective on the acceptable levels of creep was not known to the principal investigator. This seems like a needed collaboration/resource.

Reviewer 4:

This reviewer lamented that there is no way to accurately tell whether the resources provided will be adequate for the remaining research, except for the word of the PIs. Although total share work completed (75%) and total budget ($1.97 million) are provided, the total budget spent to date is missing. The total funding spent in the task presented is not provided either. Thus, the reviewer finds that vital information needed to make this determination has not been provided.

Presentation Number: MAT160
Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion, Hybrid Dispersion Strengthened Al matrix composites for higher efficiency EV powertrains
Principal Investigator: Mert Efe (Pacific Northwest National Laboratory)

Presenter

Mert Efe, Pacific Northwest 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.

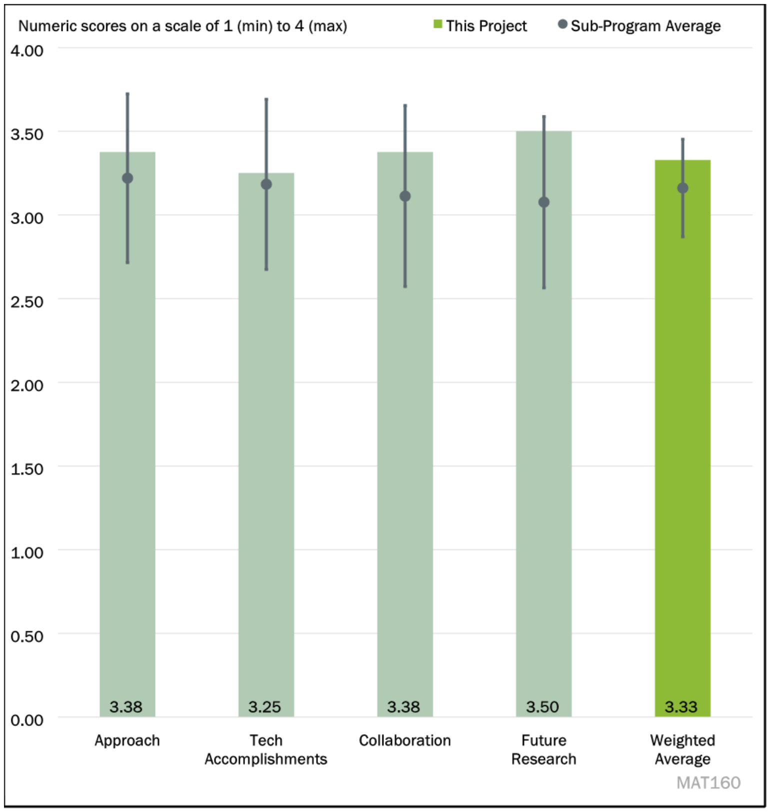

Figure 5-4 - Presentation Number: MAT160 Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion, Hybrid Dispersion Strengthened Al matrix composites for higher efficiency EV powertrains Principal Investigator: Mert Efe (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found the project to be well designed and well-planned with a focus on dispersion-strengthened Al matrix composites for higher-efficiency electric vehicle (EV) powertrains, including brake rotors and gearboxes. The technical barriers below are addressed, including cost of metal matrix composites (MMCs) (including raw material prices), compositing, processing, finishing costs, and the high strength and wear resistance of competing steel and cast-iron parts.

Reviewer 2:

This reviewer called the project scope and timeline well defined. According to the reviewer, however, the target properties for the MMC for a specific application such as brake pads are not clear including what strength and hardness values are targeted, and what target is to achieve the properties of a cast iron brake pad.

Reviewer 3:

This reviewer praised the technical approach as being very well-designed and straightforward. The hypothesis is reasonable and clearly articulated/presented.

Reviewer 4:

This reviewer found that, overall, the project is well designed, and three milestones have been achieved. Technical barriers were addressed, although open questions have also been presented. It was not clear to the reviewer whether this was for work beyond the current project or to be addressed in this project's scope. The reviewer noted that it has not been demonstrated that Al MMCs are close to being used but, rather, it was mentioned that manufacturers state that steels are still better; good comparison with iron was provided.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer found that the team overcame the identified barriers to the more widespread use of Al MMCs for vehicle light-weighting. The approach to performing the work is using *in situ* stir and squeeze casting targeted towards the brake application with lower cost to compete with cast iron. The composites selected were A206 as the matrix and *in situ* titanium diboride (TiB2) for cost and recyclability. The team achieved finer grains and uniform distribution of TiB_2 with squeeze casting. The wear rate testing shows cast iron and MMC have similar wear rates.

Reviewer 2:

This reviewer said that the progress made for processing of the Al-TiB_2 composites is good. Hardness of the MMCs are comparable to the cast iron, but it is not clear what the optimum target volume percent of the reinforcements is. Data have been presented on MMCs with TiB_2 ranging up to 24%, but it was not shown how the higher loadings would impact the cost targets, if at all.

Reviewer 3:

This reviewer believes that the team has made excellent progress, and the results are clearly presented. The team has chosen a benchmarking system (i.e., cast-iron) to compare the results of the proposed materials system.

Reviewer 4:

According to this reviewer, hardness was shown to be close to that of iron. Minimal porosity has been achieved and mixing to 3mm depth with relevance to certain surface applications has been shown. Increase of hardness in reinforced alloys was achieved compared to base alloy. A gear shaped alloy with uniform hardness distribution has been demonstrated, and its hardness increase has been compared to the base material. Al_3Ti needle-shaped particles still appear but the formation/density is suppressed.

Question 3: Please comment on the collaboration within the 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:

According to this reviewer, the team, led by Pacific Northwest National Laboratory (PNNL) partnering with Loukus Technologies, Inc. and Oak Ridge National Laboratory (ORNL) is well organized and progressed the tasks effectively. In addition, a collaboration with a brake rotor manufacturer has been initiated to perform a more detailed evaluation for meeting the industrial requirements.

Reviewer 2:

This reviewer noted that the team has now started a collaboration with a brake manufacturer, which the reviewer believes is good. Additionally, the project in now shifting focus to include ACMZ alloys and collaboration with ORNL has been initiated.

Reviewer 3:

This reviewer opined that collaboration and coordination across the project team appears to be reasonable.

Reviewer 4:

The reviewer stated that the two partners seem to collaborate very well to achieve the milestones. The team is collaborating with another national laboratory, ORNL, for some testing and is reaching out to manufacturers. The reviewer suggests that it would be nice to see what the interactions with manufacturers have so far, and how the collaboration with ORNL works. (The presenter did mention that manufacturers say that the steels are still better than Al MMCs.) Overall, the interactions seem to be working out.

Question 4: Please comment on the 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 pointed out that the team plans for future work focusing on completing wear tests for the brake rotors with new pads and discs, completing tensile tests for the friction-consolidated composites, and obtaining hybrid composites with sub-micron and micron-sized particles with the friction consolidation route.

Reviewer 2: .

This reviewer considers the proposed future research to be reasonable and well-designed to continue the progress made to date.

Reviewer 3:

The future work seems to this reviewer to be reasonably planned for the remaining time. Techniques have been demonstrated as well as gear manufacturing. Project completion seems doable within the next few months.

Reviewer 4:

This reviewer suggested that the proposed future work could have more clarity in terms of developing a core/shell configuration and that it is not clear what is being achieved by taking this approach. It would be good to focus on the development of a specific component (gears/brake pads) and to fabricate such a component and have it tested in an actual environment.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer finds the scope of work is well aligned with the overall VTO subprogram objectives.

Reviewer 2:

This reviewer believes that using new lightweight alloys with improved properties can help with vehicle weight reductions, especially if used for currently high-density components such as brake pads, etc.

Reviewer 3:

This reviewer affirmed that, if successful, Al MMCs can replace heavier cast iron counterparts for weight savings and reduced particle emissions, which is highly relevant with the EERE VTO’s mission space.

Reviewer 4:

This reviewer stated that the project supports the Materials subprogram, as it focuses on improving manufacturing and properties of Al-based alloys while aiming at cost effective approaches.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the team has sufficient resources to carry out the planned tasks.

Reviewer 2:

This reviewer believes that the project has appropriate resources to carry out proposed research.

Reviewer 3:

According to this reviewer, since more than 80% of the project is complete, it seems that there is no need for additional resources to accomplish the remainder of the project.

Reviewer 4:

This reviewer asked, based on his understanding that the work scope now includes looking at ACMZ alloys in collaboration with ORNL, how the ORNL effort is to be supported.

Presentation Number: MAT174
Presentation Title: Carbon-Fiber Technology Facility (CFTF)
Principal Investigator: Merlin Theodore (Oak Ridge National Laboratory)

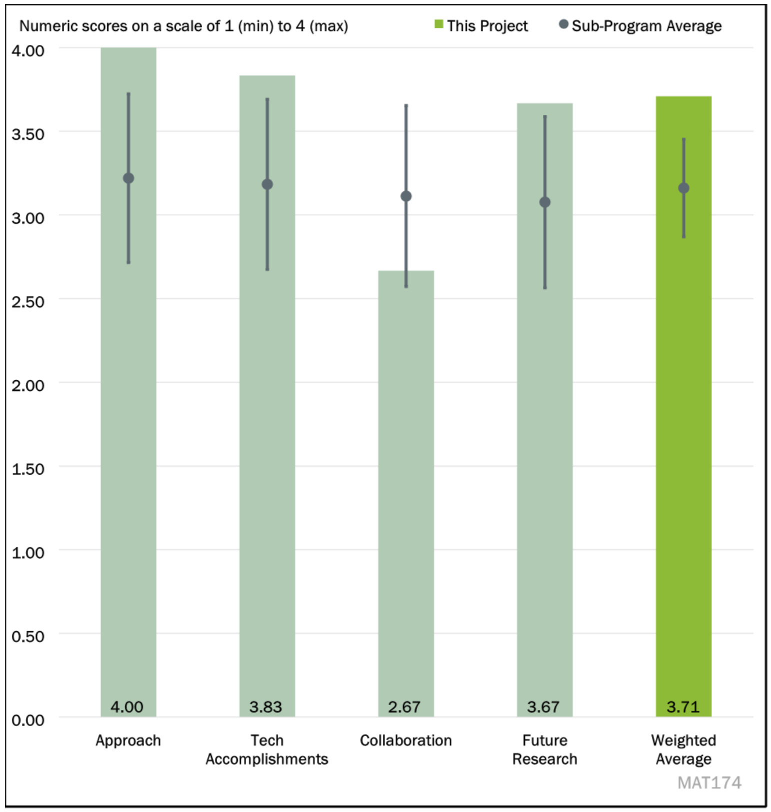

Figure 5-29 - Presentation Number: MAT174 Presentation Title: Carbon-Fiber Technology Facility (CFTF) Principal Investigator: Merlin Theodore (Oak Ridge National Laboratory)

Presenter

Logan Kearney, Oak Ridge National Laboratory

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.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found that the work presented is a nice approach to trying to process pitch-based carbon fiber. This is the type of work that the reviewer would like to see being done through the funding sent to the Carbon Fiber Technology Facility (CFTF). The past AMR presentations just gave a very high-level overview of what CFTF has done over the years. But, this year, actual research was discussed. The reviewer would like to see a similar level of detail about actual research in the future. The reviewer found it nice to have somebody presenting, as distinct from last year's presentation, which was just a recording. The timeline is very short for this project, but the reviewer hopes that it will be successful by the end of the year in order to warrant continued research on the topic.

Reviewer 2:

The reviewer noted that the Technical Integrated Approach in the presentation provided a table that identified high-potential low-cost alternative precursors, such as thermotropic low-cost pitch materials, and the change in cost and energy compared to the baseline polyacrylonitrile (PAN), which addressed the barrier for the cost of CF manufacturing. A stationary catalyst bed based on metal atom-containing carbon foams was planned to be used to enhance mesophase formation in a flow through reactor and, therefore, enhance the pitch quality. A multi-scale approach to develop optimal mechanical properties of resultant CF from alternative (pitch-based) precursors and recycled materials was presented, which should define the pitch quality. The CFTF was proposed as the manufacturing facility to address technology scaling, intermediate formation, composite product validation, and market development and commercialization, including recycling. This CFTF and this type of project has a history going back to 2013 and has, in the view of the reviewer, always included well-designed projects, as evidenced by the flow diagram on Slide 6 showing the steps involved from material identification to market performance and evaluation. The timeline for precursor development is continuous and has been since 2013. The CFTF is funded each year by three EERE offices, so a specific timeline is not applicable.

Reviewer 3:

This reviewer points out that PAN-derived CFs are expensive, and it has been challenging to reduce PAN precursor cost and conversion cost (wet spinning, oxidation and carbonization). It is urgent to find/develop alternative low-cost precursors (to secure supply chains). The project has demonstrated a new route to producing low-cost pitch precursors. With the conversion processes developed in the project, the pitch CFs are expected to meet the cost ($5 per pound) and property targets (strength 250 kilopounds/square inch (ksi) and modulus 25 million pounds/square inch (msi). The project presents a clear scale-up roadmap and a technology transfer (to industry) plan.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer found that, despite this being early on in the project and a short project, great accomplishments were achieved. Significant progress has been made in creating the stationary catalyst bed. The graphite foam inserts with integrated catalysts were successfully synthesized and characterized. The reviewer looks forward to seeing the results from operating the reactor bed and forming the resulting fibers.

Reviewer 2:

This reviewer notes that pitch CFs often exhibit high modulus. To achieve high strength, pitch precursor fibers need to have smaller diameters and lower defects (porosity). The pitch CFs developed in this project exhibit about 15 microns (µm) diameter, this is encouraging. The precursor carbon yield is promising. The reactor construction is novel.

Reviewer 3:

One objective of the project plan noted by this reviewer is to demonstrate advanced fiber production using lower-cost precursors. One task that supports this objective is to investigate potential alternative CF precursors. Thermal characterization of six precursors was completed and the weight percent of CF was determined for each precursor. Heterogenous catalyst coating formulations were identified that will allow functional characterization of the CFs produced. Scanning electron microscopy was used to characterize low, medium and high loadings of the catalyst coating on the CFs. A prototype flow-through reactor was fabricated and tested by producing foam surrogates to be used for initial coating experiments. All these factors indicate good progress for successfully completing the task and meeting the objective of the project plan.

Question 3: Please comment on the collaboration within the 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 not aware of any specific collaborations being mentioned, but this was only a one-year project, which did not need a big collaborative effort, so the reviewer finds it hard to judge this small internal project on its coordination across multiple teams. The reviewer notes that it was mentioned that a couple of companies have been identified that are interested in the technology, but the specific companies were not named, which the reviewer finds acceptable at this stage of the project. If there is another AMR presentation on this work next year, the reviewer would like the presentation to include what companies are working with ORNL on commercializing this.

Reviewer 2:

This reviewer pointed out that this phase of the project is in the early stages of R&D so there is not much collaboration outside the ORNL CFTF. IP development is being driven internally by ORNL. Once the initial proof of concept phase is complete, existing collaborative partnerships directed toward pitch and graphite foam are expected to be initiated to further develop the technology.

Reviewer 3:

The project demonstrates to this reviewer a close collaboration inside ORNL (the team consists of several CF experts). The project team has already reached out to collaborative partnerships in pitch and graphite foam.

Question 4: Please comment on the 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 and remaining challenges are clearly defined to the satisfaction of this reviewer. The targeted goals of producing CF and determining the structure property relationships for the candidate pitches are achievable targets by the end of the project. The targeted properties are clearly described in the milestone table and, the reviewer believes, should be achievable.

Reviewer 2:

The future plan is clear and makes sense to this reviewer. Pitch CFs often show low strength and strain compared to PAN carbon fibers. Pitch precursor quality is of importance to achieving higher strength and strain. The project team is expected to show how to reduce or eliminate defects from the precursor fibers in the melt spinning.

Reviewer 3:

This reviewer found that, because the project is in the early stages of R&D, there is a source-to-source variation for each isotropic precursor. CF structure/property relationships will need to be determined from each of the candidate pitches. The compatibility of the prototype reactor with lower polycyclic aromatic hydrocarbons still needs to be determined. More research will be required in each of these areas, so that the reviewer believes that it is too early to determine the extent that the proposed future work will contribute to achieving the targets for this project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer notes that the project is very relevant to the vehicle lightweighting objectives within DOE. The project has a clear vision of how it will lightweight vehicles at a reduced cost by successfully developing this processing method for pitch-based CF.

Reviewer 2:

The project, according to this reviewer, is relevant to supporting the overall VTO Materials subprogram objectives to address significant technology gaps for lightweight structural materials like polymer composites and is addressing key challenges in electrical conductivity, thermal conductivity, magnetic materials, and high-temperature operation currently limiting advances in lightweight materials. This project also addresses the objective to support RDD&D of materials that will increase recyclability.

Reviewer 3:

This reviewer points out that CFs are critical materials for lighter and smarter vehicles EVs. In addition, CFs enable many functionalities, such as sensing and electromagnetic interference (EMI) shielding. The main barrier is the high cost of CFs. It is urgent to develop low-cost, high-performance CFs in the United States. The project aims to develop low-cost alternative CF precursors and conversion processes. This also helps secure supply chains to ensure economic prosperity and national security, according to the reviewer.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believes that CFTF has sufficient funds to continue projects like this, and they should continue to fund these smaller projects within their large annual budget.

Reviewer 2:

The reviewer points out that CFTF is funded $11 million annually by three EERE offices that support projects like this one. The CFTF includes a 42,000 square foot facility with a capacity of up to 25 tons of CF per year with a R&D staff of scientists, engineers, and manufacturing specialists that are sufficient to execute this project.

Reviewer 3:

This reviewer describes how the CFTF is a unique national resource to assist industry/academia R&D in overcoming the barriers of advanced fiber cost, technology scaling, intermediate formation, and composite product and market development. The CFTF is equipped with all resources needed for the project.

Presentation Number: MAT196
Presentation Title: High Temperature Carbon Fiber Carbonization via Electromagnetic Power
Principal Investigator: Felix Paulauskas (Oak Ridge National Laboratory)

Presenter

Felix Paulauskas, 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.

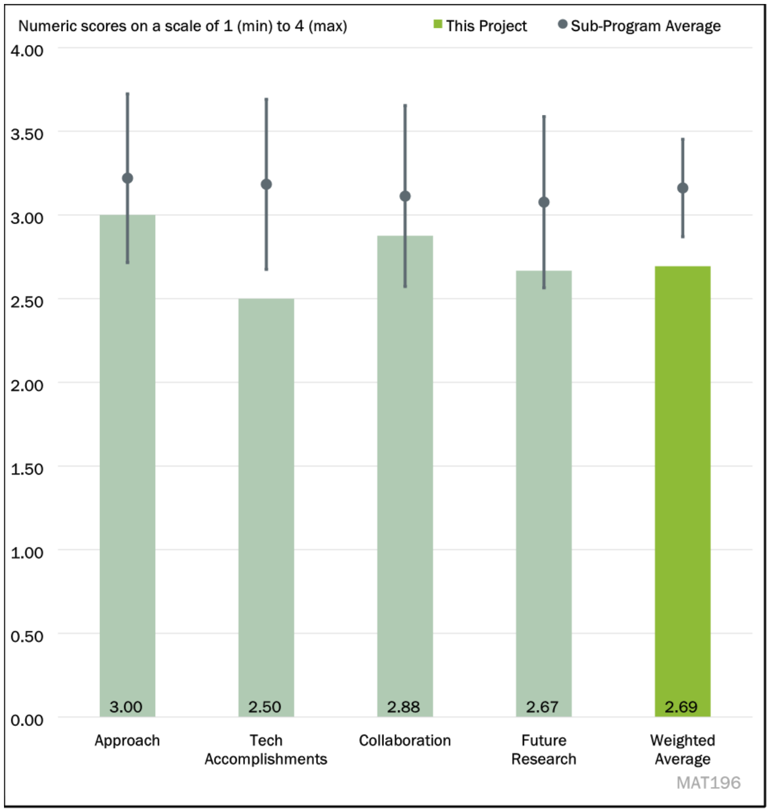

Figure 5-30 - Presentation Number: MAT196 Presentation Title: High Temperature Carbon Fiber Carbonization via Electromagnetic Power Principal Investigator: Felix Paulauskas (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said that the approach is adequate for the goals that have been laid out.

Reviewer 2:

This reviewer found that the technical barriers included the reduction of energy consumption in the CF conversion process and the total CF cost, as well as reduction of the required processing time for carbonization to increase the overall throughput for the manufacturing process. This project is a continuation of a previous project with similar goals, so this project is well designed based on previous results and the original timeline was reasonably planned to accomplish addressing the technical barriers. Delays because of contracting issues and equipment deliveries caused significant slippage in meeting the project milestones. The approach is to directly couple the thermal energy from an energy source to the CF using electromagnetic coupling to realize energy savings. This is considered by the reviewer to be a reasonable approach to overcoming the technical barrier of reducing energy consumption in the CF conversion process.

Reviewer 3:

This reviewer determined that the team has identified a viable approach to the high temperature carbonization (HTC) of pre-cursors for CF production. Its method of directed energy tuned to processing fiber without heating the entire chamber volume is useful and will be an important part of increasing fiber capacity while reducing total energy consumed in fiber manufacturing.

Reviewer 4:

This reviewer considers the project to be an excellent option for using dielectric heating for HTC; however, the milestones are focused on equipment set-up and deployment, rather than assessing the efficacy of the process and parameters on carbonization, CF material performance, and techno-economics, even though they are listed as the objectives to be achieved in the project. The reviewer is unclear as to whether, on a holistic level, material performance and process development milestones were defined for earlier portions of the project, which is believed to be important to know especially since the project is ending in June 2023.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

To this reviewer, it is evident from the work that the energy consumption in this process, compared with conventional methods, is less. However, the team needs to demonstrate that the costs per pound of manufacturing the CF is lower, and by how much, compared with conventional methods.

Reviewer 2:

This reviewer notes that the high-temperature conversion applicator system and its seven sub-system components were described. Some of the sub-system components caused project delays that could not be overcome. Additionally, some equipment was impaired while attempting processing fiber for energy consumption evaluation, causing more delays. This resulted in abnormal operation, causing material damage and contamination, and damage to the transmission line and some internal parts. Although the system was previously demonstrated in 2022 with two 50,000 filament tows achieving 550 ksi tensile strength and 29 Msi modulus, not much else has been accomplished technically, according to the reviewer, toward high-temperature conversion of CF because of problems obtaining equipment and getting the modified system operational.

Reviewer 3:

This reviewer has moderated the scoring as a direct result of the time lost due to the failure of the HTC equipment, which was severely damaged during trials. With that said, the team should be commended, according to the reviewer, for demonstrating the viability of the electromechanical-driven HTC. It is extremely promising that this technology has (without the ability to iterate equipment and improve/tune the process) created CF with comparable tensile strength (550 ksi) and 90% of the tensile modulus of comparable industrial grade CF (29 Msi). The quoted fiber density (1.70g/cc) suggests that conversion has not fully completed (1.8 - 1.82 g/cc expected). Given these accomplishments, the reviewer believes that the technical work is sound; it is simply disappointing to the reviewer that the equipment failure has limited the opportunity to accomplish more trials and iterate the process/equipment design further. Initial reports of energy consumed is encouraging but incomplete for the same reasons as identified above.

Reviewer 4:

This reviewer noted that several milestones have been delayed. The approach to completing the project within the project timeframe is not clear to the reviewer.

Question 3: Please comment on the collaboration within the 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 a good relationship between the partners especially related to capabilities.

Reviewer 2:

This reviewer considers that the only collaboration presented was with a tier 1 supplier of carbon fiber. Nothing was mentioned regarding collaboration with OEMs that would be producing the end product with the new CF material or with other national laboratories or universities.

Reviewer 3:

According to this reviewer, there should be no debate that the laboratory and industry collaboration resulted in the construction of a working prototype. This is found commendable and an important recognition. The shortfall here, according to the reviewer, is the loss of time and the limited accomplishments as a result of equipment failure. The reviewer asserts that a fully documented design failure mode and effects analysis and process failure mode and effects analysis are standard industrial practices aimed at identifying and mitigating risks associated with design and process activities such as this. The reviewer believes that the collaboration would be strengthened by this type of effort and, if not have prevented the failure, would have anticipated and provided a path to recover the milestone events.

Reviewer 4:

This reviewer complained that there was no mention of the role of 4XTechnology LLC in the presentation.

Question 4: Please comment on the 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 cost analyses of the final product to be missing. Energy consumption analyses is great and in line with the goals, but he other part of the goal is the reduction of total CF cost, according to the reviewer.

Reviewer 2:

This reviewer believes that the team has put together a set of recommended future work that meets the objective and deliverables of the project. The reviewer finds this is commendable and will successfully complete the project. The present project is concluding within weeks, so the proposed future research is left for future funding. The reviewer’s fundamental concerns are (1) whether the equipment failure that occurred has been fully understood with a root cause and a means to prevent or anticipate failure conditions and avoid them and (2) whether the HTC equipment and the process that it is expected to operate is robust and sustainable. The reviewer is unclear if the team plans to demonstrate this as it “implements all needed modification toward optimization of the HTC process.”

Reviewer 3:

It is not very clear to this reviewer how the project will overcome the barriers associated with equipment deployment and complete the project on time.

Reviewer 4:

This reviewer noted that, although the project was scheduled to complete at the end of June 2023, the proposed future research was to complete the research to reduce electromagnetic energy reflection to improve the tuning of the system, complete the energy consumption evaluation, implement all needed modification towards optimization of the high-temperature conversion process, and conduct a computer simulation of optimized and final hardware arrangement using commercially-available software to validate the model. These were some of the tasks that were to be completed before the end of the project and will be difficult to complete.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer shared that the work contributes to a reduction in the cost of CF material which is used to reduce the weight and thus increase energy efficiency of vehicles.

Reviewer 2:

This reviewer finds that the project is relevant to supporting the overall VTO Materials subprogram objective to address significant technology gaps for lightweight structural materials like polymer composites.

Reviewer 3:

This reviewer pointed out that an explicitly stated goal of DOE’s Materials research subprogram is to reduce the cost of vehicle lightweighting materials. The ability of CFRPs to both achieve up to a 60% reduction in structural weight and to perform in commercial transportation and consumer automotive applications is well documented. The overarching barrier is the cost of these materials. The present research program clearly aligns with this stated goal and, when scaled and applied by industry, will positively impact cost. Furthermore, the opportunity to expand throughput and improve capital utilization is significant for expanding the availability of fiber as well reducing CO_2 emissions per unit mass/volume of material manufactured.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This project was funded $3.5 million over a three-year period for one national laboratory. The resources are considered more than adequate to develop a CF that would overcome some of the technical barriers. The project’s weaknesses were in the design of a prototype system that could not be made functional during the original project timeline.

Reviewer 2:

According to this reviewer, the team has met the objectives of the project and has suggested that resources provided were sufficient. The comment about the team related to specific gauges and monitoring equipment that failed to anticipate and warn about the potential hardware failure suggests that design details and the opportunity to expand funding to avoid such failures should become a gating element of future projects of similar complexity and scale. It is possible that an infusion of incremental funds to upscale the equipment may have been beneficial and reaped outcomes significantly greater than the incremental cost.

Reviewer 3:

This reviewer found that the information provided by the team is not adequate to determine if the remaining funds are sufficient to complete the work. Vital information is missing.

Presentation Number: MAT197
Presentation Title: Multi-Functional Smart Structures for Smart Vehicles
Principal Investigator: Patrick Blanchard (Ford Motor Company)

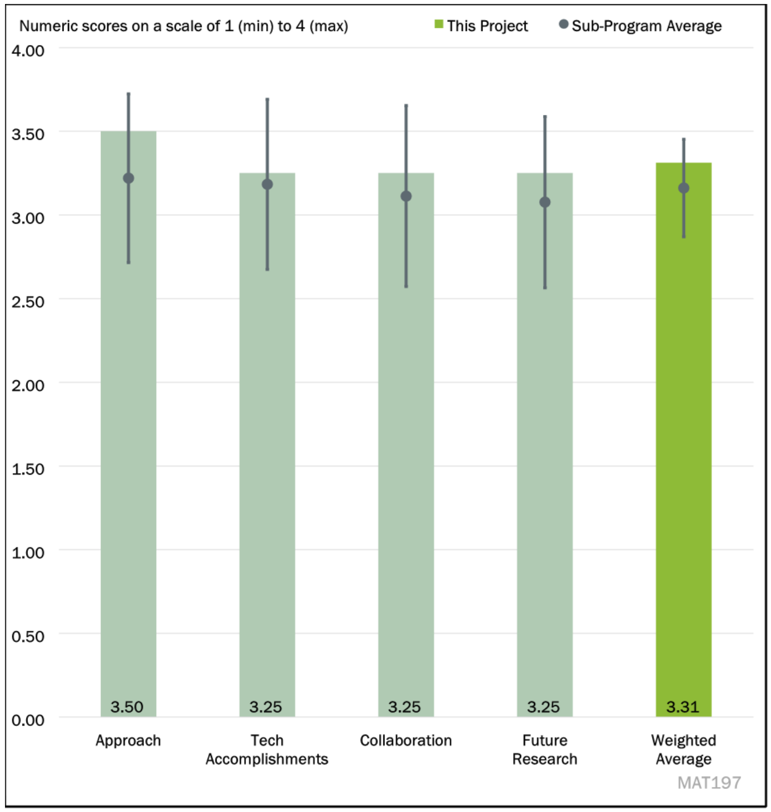

Figure 5-31 - Presentation Number: MAT197 Presentation Title: Multi-Functional Smart Structures for Smart Vehicles Principal Investigator: Patrick Blanchard (Ford Motor Company)

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.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer finds the approach employed in the project to overcome technical barriers commendable. According to the reviewer, the project exhibits a well-designed structure, and the timeline appears reasonable. The strategic combination of high modulus and lower modulus materials offers an optimal solution in terms of material cost and weight. This concept has been effectively utilized in this project and expanded for high-volume manufacturing. Additionally, the project aims to explore new processing innovations for manufacturing hollow closed sections, which have extensive applications in the automotive industry. The reviewer believes that the incorporation of sensors and wiring within the composites to reduce costs is a brilliant idea. This approach enhances the attractiveness of composites as potential candidates for various applications.

Reviewer 2:

This reviewer observed that the key barriers are to make the structure lightweight and add functionality without compromising structural integrity. Several technical aspects were successfully addressed through the concept technology being investigated including weight, cost, and functionalization potential (relative to the baseline). A remaining barrier is mass saving.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

Regarding the business case, it is unclear to the reviewer why a parallel study was not conducted by Yanfeg, one of the team members and a tier 1 supplier. Such a study would have added valuable insight due to Yanfeg's extensive experience, making it a more realistic assessment. The utilization of material characterization for the proposed anisotropic material in simulations was not clearly explained to the reviewer's satisfaction. The reviewer suggests that it would be helpful to understand how this characterization was incorporated and utilized in the simulation process. The validation process for the small-scale demonstrator molding exercise remains unclear. The reviewer states that it would be beneficial to provide details on how the control of wall thickness was achieved in the water-assisted injection molding process. Additionally, information regarding the specific process variables used for both the small-scale and mid-scale demonstrators would be helpful to the reviewer, who asks whether any simulations were conducted to optimize the process parameters. Sensor integration was mentioned, but the reviewer is not sure what kind of sensor and how the integration was tested and validated was not provided.

Reviewer 2:

The reviewer reports that the team is on track to complete the tooling to make full-size demonstrator parts.

Question 3: Please comment on the collaboration within the 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 believes that the project demonstrates strong collaboration among the team members.

Reviewer 2:

This reviewer noted that the collaboration appears to involve all partners, who work collaboratively.

Question 4: Please comment on the 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 tasks make sense to this reviewer as described toward completing the project in the next six months.

Reviewer 2:

On Slide 18, it was mentioned that additive manufactured attachment features are no longer viable due to cost constraints. However, the available alternative path for the project, such as incorporating new tooling, was not specified.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believes that the project holds significant relevance in the field of advanced materials, particularly in supporting the automotive industry's lightweighting requirements.

Reviewer 2:

The project is relevant for VTO Materials program objectives, in the view of the reviewer.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer stated that the project possesses an adequate amount of resources necessary for its execution.

Reviewer 2:

According to this reviewer, the resources are sufficient as described.

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 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.

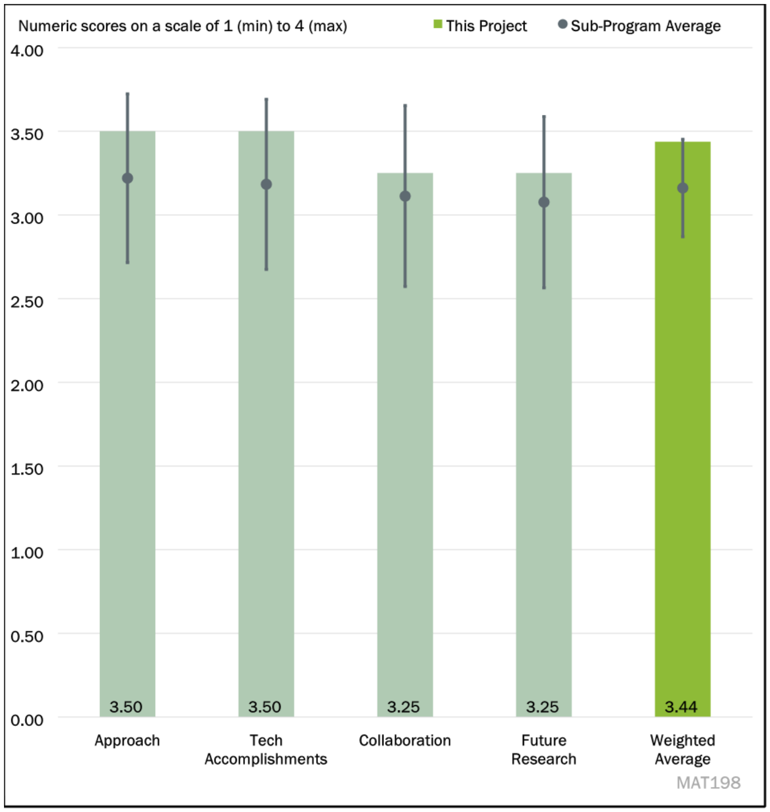

Figure 5-32 - Presentation Number: MAT198 Presentation Title: Development of Tailored Fiber Placement, Multi-Functional, High-Performance Composite Material Systems for High Volume Manufacture of Structural Battery Enclosure Principal Investigator: Venkat Aitharaju (General Motors Company)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer reports that the team has presented a comprehensive and impressive set of tools to address the design challenges associated with fiber reinforced polymers. The team has been innovative and considered glass/carbon hybrid materials to reduce the brittle nature of fracture and addressed computational challenges with reduced models applying ML techniques to inform a neural network approach for predicting behavior. These tools have been validated using relatively simple geometries and address behaviors that are challenging to model (such as resin fill and resin transfer processes).

Reviewer 2:

This reviewer determined that the project addresses a critical issue in the automotive industry in making composite battery enclosures. The approach and timeline are reasonable to the reviewer. A significant effort was made to the hybrid fiber approach. Still, the reviewer found no clear indication of cost savings provided, believing that hybrid tow manufacturing will also cost more than the one fiber tow type.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The research team has done what this reviewer considers a superb job in developing effective models for material performance prediction. The demonstrated use of carbon/glass hybrids to improve ductility and enhance lifetime performance is commended by the reviewer. Process modeling using ML and artificial intelligence (AI) methods to predict mold filling is well done and should drive a successful full-scale demonstration at the stated cycle time goal (3 min). Resistance measurement methods for simple harmonic motion has been implemented well and provides a relatively simple/reliable approach. The reviewer offers only one possible negative comment: There is a lack of specific defined methods or elements of a comprehensive techno-economic model to identify the projected weight savings (over a presumed baseline) and the incremental cost of the composite battery enclosure (to determine the cost per lb. of weight saved). To the extent that such cost/performance modeling can inform decisions related to material selection as well as product and process design for optimizing this parameter, the modeling should be underway presently.

Reviewer 2:

The project seems to this reviewer to be on schedule, with all the milestones having been met, while demonstrating many technical accomplishments. A full-scale battery enclosure is planned, and a tool design is underway. The project will be finished in time as long as the team receives everything on time.

Question 3: Please comment on the collaboration within the 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:

According to this reviewer, the team is an extensive and multidisciplinary one to conduct this program. Additionally, the expertise of each partner is identified. It became a bit less clear which specific activities were led by each partner, but the level of work accomplished, and the technical detail suggests to the reviewer broad participation. A detailed responsible, accountable, supportive, informed and consulted table could always be included to provide a clearer picture of those roles and responsibilities. But the reviewer found that, regardless of such omission, coordination appears good because the project presentation suggests a seamless integration of the multidisciplinary activities.

Reviewer 2:

The project has many partners, but from the presentation, the work scope for each partner was not clear to this reviewer. Slide 20 mentioned mostly the expertise of each partner but their tangible contribution was not clear to the reviewer.

Question 4: Please comment on the 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 feels that the project is moving in the right direction, and the future tasks align well with the technical barriers the team is trying to overcome.

Reviewer 2:

The reviewer comments that the team has provided a reasonably comprehensive set of remaining tasks for project completion. There is not a reference to what activities might be needed to commercialize the resulting battery enclosure and additional comments related to the development of a comprehensive techno-economic model would be appreciated by the reviewer. There remains little reference (other than passing reference to use of phenolic matrix materials and intumescent coatings) to meeting the fire requirements that are necessary for these enclosures, nor strategies to mitigate EMI from the internal batteries, such as a plan for fire testing of materials or structures tied to this project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

There can be no doubt to this reviewer that this project is relevant to the VTO Materials subprogram objectives. Lightweight battery enclosures will require the highly specific material properties offered by reinforced polymers. This project addresses many of the challenges related to commercializing this application. Material hybridization, process modeling and monitoring, as well as structural health monitoring to ensure passenger safety, will enable the transition and adoption of these materials.

Reviewer 2:

The reviewer notes that the project aims to design, develop and manufacture composite battery enclosures. These enclosures are some of the most significant parts in EVs, and their weight optimization is critical for the overall vehicle's weight reduction. Therefore, this project is well aligned with the VTO's overall objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

To this reviewer, on the face of it, this is a very large (and expensive) program; however, given the scope of the work and the extensive research necessary across the large number of disciplines, it appears to be both adequate and necessary. The team has done a good job managing a large cadre of collaborators and integrating the technologies to meet the project objectives. The only glaring omission is specific work on the techno-economic model necessary to assess the value proposition of lightweighting the battery enclosure. This reviewer hopes useful insight related to the capital expenditures, bill of materials, and labor content of the enclosure will be modeled to identify the economic challenges associated with meeting capacity and technical requirements.

Reviewer 2:

The reviewer believes that the project is appropriately funded, and that the resources are sufficient to achieve the project's goals in the stipulated time.

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)

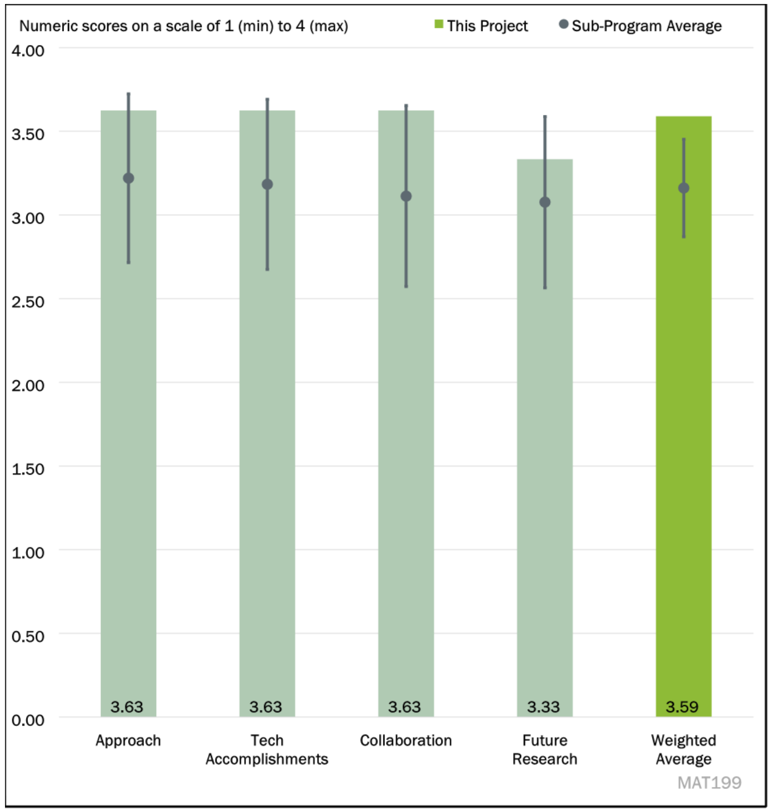

Figure 5-33 - Presentation Number: MAT199 Presentation Title: Ultra-Lightweight Thermoplastic Polymer/Polymer Fiber Composites for Vehicles (Inter-Lab Project) Principal Investigator: Kevin Simmons (Pacific Northwest National Laboratory)

Presenter

Kevin Simmons, Pacific Northwest 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. 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: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer identified the barriers described by the team as the lack of infrastructure for producing lightweight, high-strength materials such as CF composites using low-cost, high-volume manufacturing to produce low-cost CFs with some level of recyclability. Targets included a minimum of 50% cost reduction in materials during manufacture, high toughness for impact performance without loss of strength, infinite shelf-life, excellent environmental safety and health, consistent processing performance, and recyclability. The approach presented was to determine the material system, process parameters, and the modifications to the individual components needed to meet the technical goals for the project. This approach clearly addresses these barriers, according to the reviewer. This project is the final phase of an overall effort that started in 2020, so the timeline was reasonably planned for a four-year R&D period that will culminate in the delivery of a composite system with more than 500 megapascals (MPa) strength, 10 gigapascals (GPa) modulus, and 5% elongation at break.

Reviewer 2:

This reviewer approves that PNNL and ORNL are teamed up to address the technical barriers in lightweight low-cost composites. The team uses low-cost polymer fibers (polypropylene [PP] fibers) to reinforce polymer matrices. This is a smart, alternative approach to CF polymer composites. The results are encouraging; the composites exhibit comparable or even better properties than the expensive CF composites.

Reviewer 3:

This reviewer finds the approach of developing methods to use alternative fibers in composites exciting for the vehicle industry both for reducing the cost of composites and for enhancing their performance, especially in a shift towards EVs. This work cleverly focuses on manufacturing methods for realizing polyolefin-based composites for both strength, ductility, and re-use. The potential work for re-using material is focusing on thermal/mechanical recycling, which is a very de-carbonized approach. The approach could be strengthened by a focus on recycling and the inclusion of analysis to guide activities. Blended composites of polyethylene (PE) and PP are incompatible and thus additives will need to be used in multiple lives of the material. The reviewer suggests that better documentation on the “multiple life” strategy would be beneficial.

Reviewer 4:

This reviewer found that the project is reasonably well scoped and executed but with somewhat inconsistent objectives. For example, the objectives section shows plans to “develop a low cost, high performance thermoplastic polymer-matrix/polymer-fiber composite system… .” However, throughout the presentation, a wide variety of systems are described and evaluated with PP and ultra-high molecular weight PE (UHMWPE) fibers, in woven and unidirectional forms, and with high density PE, PP, and low-density PE matrices, over a wide range of fiber fractions manufactured with a wide range of processes including both continuous and discontinuous reinforcement. The comparative systems were varied as well but had no real cost comparisons. The team did mention during the presentation that the overall goals were more to point out a variety of different ways these composite systems might compete with incumbent systems and the results are fairly interesting and useful, and largely fulfill that objective.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer found that the technical accomplishments were consistent with the project plan and timeline, with all project milestones being met during the development period. Fiber length retention of more than 50% after injection molding was achieved, and the process temperature was determined to be a critical process parameter because fiber melting and shrinkage increased above a specific temperature and injection difficulties increased below a specific temperature. A composite system with 420 MPa strength and 20 GPa modulus was achieved by using ultra-high molecular weight PE fiber. The strength was slightly less than the target of 500 MPa but the modulus was double the target of 10 GPa. The PE fiber outperformed available CFRPs by greater than 26% for one -time impact, greater than 500% for repeated low impact, and 30% recovered by healing after impact, which addresses the target of high toughness for impact performance without loss of strength. Four processes were developed that demonstrated material integrity for recycled composites from chopped or reground virgin composites – three were injection molding and one was compression molding. The reviewer sees the project on track to demonstrate the mechanical properties of the recycled materials. One of the processes demonstrated that a thermoplastic fiber/thermoplastic matrix compression molding compound retains 50% of the original fiber length, which is significant for zero fiber attrition. These technical accomplishments addressed the targets of consistent processing performance and recyclability. The project is also on track, according to the reviewer, to demonstrate a composite system that will meet all requirements for 500MPa strength, 10GPa modulus, and more than 5% failure strain.

Reviewer 2:

The composites from PP/PE and PP/PP injection molding show results encouraging to this reviewer. The team also demonstrated a low cost, low carbon footprint recycling route. The process can be simply inserted into the existing injection molding lines without re-investing in equipment. This, the reviewer believes, will help secure supply chains and reduce carbon footprint.

Reviewer 3:

The approach is well laid out and the achievements are well documented. Interestingly, and impressive, is the enhanced performance relative to CF reinforced composites (CFRCs) across many impacts, The project team should consider also comparing performance to that of the material being replaced, steel or Al.

Reviewer 4:

Although the objectives are not totally clear to this reviewer, the reviewer finds a lot of interesting data presented which have been developed in this project and support different ways that thermoplastic fiber and resin composite systems might be utilized to address varying requirements, especially where recycling is a high priority.

Question 3: Please comment on the collaboration within the 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 lauded the collaboration and coordination between ORNL and PNNL on this project as outstanding. PNNL performed the characterization and matrix interaction for the commercially-available fibers, determined the key panel processing parameters and recycling process, and developed the process for the fiber surface modification. ORNL performed the fiber development that resulted in minimal shrinkage, optimized strength, and provided the composite material to PNNL for additional studies. ORNL also performed the thermal analysis, mechanical evaluation, morphology evaluation, and comparison with commercial fibers from PNNL. Since this is early-stage material development, there was no collaboration with industry, academia, or other external entities.

Reviewer 2:

This reviewer noted that PNNL and ORNL have complementary expertise. The collaboration has been excellent. The project is on track and will be a high TRL for transferring to industry.

Reviewer 3:

PNNL and ORNL collaboration appears to this reviewer to be quite good, taking advantage of the specific unique capabilities in each laboratory. Composite data produced by PNNL mixes a wide variety of approaches, as mentioned above. Although ORNL has excellent fiber development expertise and has produced significant accomplishments with demonstrating UHMWPE fiber, it is not clear to the reviewer what the objectives are for the UHMWPE fiber and how this fiber would be differentiated from those similar commercially-available fibers that are less costly, enhanced performance, etc.

Reviewer 4:

This reviewer observed that the project team provided notes on how the project is integrated and a collaboration between ORNL and PNNL. The reviewer suggests that the work could be strengthened with a larger industrial component or technical advisory.

Question 4: Please comment on the 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 observes that the project will complete all milestones in Fiscal Year 2023. The team will work on recyclability, which is important in terms of securing supply chains and reducing carbon footprint.

Reviewer 2:

This reviewer points out that, since this project will complete at the end of September 2023, the project is basically completed. The proposed future work is completion of the original milestones for this project.

Reviewer 3:

This reviewer notes that the future of the work focuses on recycling approaches. Therefore, it seems to the reviewer that more time may be needed to further understand recycling of the composites, especially regarding issues that may arise. The recycling approach could be a main focus point of work beyond this initial 3-year Annual Operating Plan.

Reviewer 4:

This reviewer finds that the approach does illuminate potential advantages of various thermoplastic systems as usually assumed but does not clearly demonstrate the pathway to specific automotive applications.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer finds that the objective of this project was to develop a low-cost high-performance thermoplastic polymer, polymer-matrix/polymer-fiber composite system with specific mechanical properties comparable to traditional composite systems, 30% lighter than traditional composite systems, low material cost, a short (3 minutes or less) process cycle time, and recyclability. This project addresses VTO goals to develop lightweight materials that addresses significant technology gaps for structural materials such as polymer composites. Technology gaps addressed by this project include formability, manufacturing cycle time, incorporation of new materials into manufacturing processes, and recyclability.

Reviewer 2:

It is clear to this reviewer that the polymer-polymer composite approach addresses many of the VTO barriers such as less than $5/kg-mass saved, low-cost fibers, and durability.

Reviewer 3:

According to this reviewer, lightweight, low-cost polymer composites are essential for lighter and smarter EVs. The polymer fiber/polymer matrix composites by injection molding is a smart alternative to CF polymer composites. The team has demonstrated high TRL which directly supports the VTO objectives.

Reviewer 4:

This reviewer states that the project focuses on broad vehicular goals such as recycling and lightweighting but indicates what still needs to be done to achieve commercial relevance.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer notes that the project was funded $750,000 in Fiscal Year 2023 for two national laboratories to perform fundamental R&D on composite materials. Both laboratories have superb materials development and characterization capabilities, so the resources are considered very effective for overcoming most barriers described.

Reviewer 2:

The project seems to this reviewer to be well funded for the objectives described.

Reviewer 3:

The team seems to this reviewer to have the right amount of resources.

Reviewer 4:

According to this reviewer, PNNL and ORNL have the resources required for the project. The project is on track and will complete all milestones in a timely fashion.

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 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.

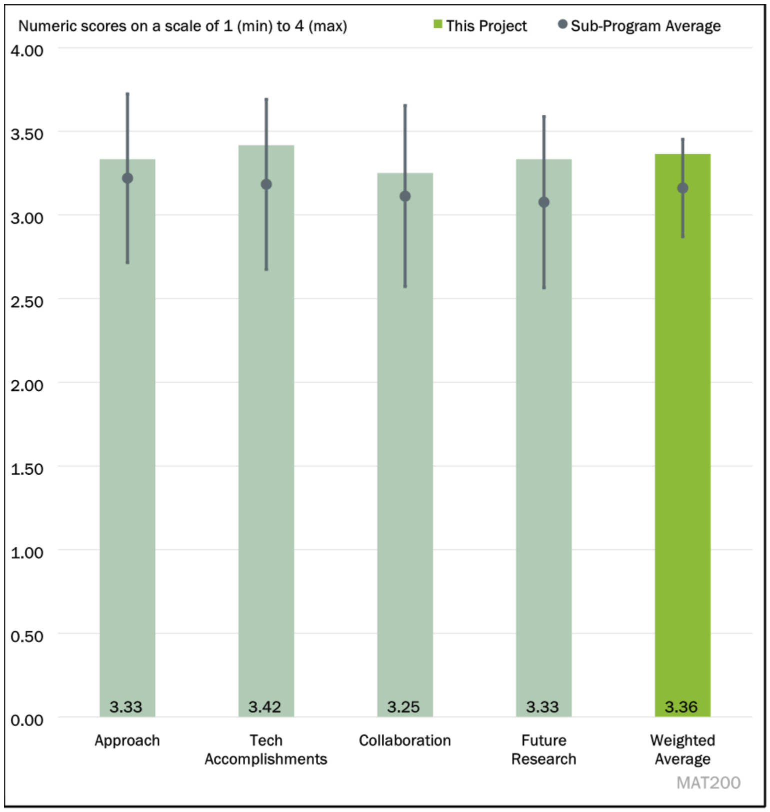

Figure 5-34 - Presentation Number: MAT200 Presentation Title: Additive Manufacturing for Property Optimization for Automotive Applications Principal Investigator: Seokpum Kim (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer considers the project design to be concise and logically planned without excess.

Reviewer 2:

This reviewer praises the additive manufacturing of lattice structures with less and lightweight materials as a smart approach. The printed lattice architectures exhibit an exceptional combination of mechanical properties that are superior to the traditional solid materials/structures. The additively manufactured lattice structures are designable based on the stress and function requirements. This is considered by the reviewer to be an alternative way to reduce weight and realize multifunctionalities.

Reviewer 3:

This reviewer reports that the combined modeling and experimental approach is great and very useful during the performance of the work, but the baseline to compare to the design either is not presented nor clear. One of the goals of the project is reducing costs. There should be a techno-economic analysis/life cycle analysis (TEA/LCA) performed on the approach to indicate that the concept is economically viable at optimal printing speeds and reduced material costs.

Reviewer 4:

This reviewer believes that the approach and work plan are fine but has a primary concern that the apparent poor quality of the 3D printed structure may compromise the actual test results. Another method to develop the ML/AI training is to use the 3DSystems with the process shown on Slide 4, where material modulus can be controlled layer by layer and print results are very high quality.

Reviewer 5:

The technical approach is considered sound overall by this reviewer. A lingering concern of the reviewer is the cost of the process and whether it is compatible with mass-market vehicle manufacturing.

Reviewer 6:

This reviewer called for more details on the relevance of the project, especially the selected 2.5D cellular structure manufacturing via AM would be good for contextualizing the work, especially the need for such parts in vehicles and current barriers that prevent their easy development.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer pointed out that ORNL, teamed up with Ford and University of California-Berkeley, has simulated, designed, and optimized 2.5D cellular structures, and manufactured them with extrusion-based AM. The incorporation of ML techniques in lattice design enables selective design and manufacturing based on the stress and function needs for auto-structures.

Reviewer 2:

The reviewer praised the progress as being very good on the three main tasks.

Reviewer 3:

This reviewer considers that great strides have been made in adopting ML and computational approaches for AM part and process design.

Reviewer 4:

This reviewer remarked that there had been good technical accomplishments but that some of the printed objects appear to not be homogeneous, raising the question of whether the material properties are consistent across the part enough to prevent failure points.

Reviewer 5:

This reviewer commended the team on having made significant progress in the modeling, optimization and demonstration of lightweighted structures with effective use of computer design tools. The choice of printed materials may not, however, meet final application requirements, according to the reviewer.

Reviewer 6:

This reviewer recounted how lattice designs were evaluated and fabricated using big area additive manufacturing (BAAM). The structures were tested for static and dynamic performance. The reviewer’s primary concern is that the armrest structure looks to have many flaws and poor quality, making test results suspect. The reviewer suggests repeated testing just below ultimate failure to see if there is progressive damage during the test which would alter desired test results. More precise extrusion equipment should yield better results than BAAM.

Question 3: Please comment on the collaboration within the 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 feels that the collaboration has been great. ORNL has been collaborating with the University of California-Berkeley and Ford, utilizing the complementary expertise in design, simulation, ML and experimental. Such collaboration accelerates the progress and TRL for technology transfer to industry.

Reviewer 2:

It looks to this reviewer as if the team has good collaboration with Ford and University of California-Berkeley.

Reviewer 3:

It seems to this reviewer that the team is well integrated at least in relation to how the tasks were split amongst the three main entities.

Reviewer 4:

This reviewer noted a great discussion on how the partners collaborate.

Reviewer 5:

The reviewer noted there was sufficient collaboration.

Reviewer 6:

This reviewer found the ORNL/Ford/University of California-Berkeley collaboration satisfactory but another national laboratory in additional to ORNL may have given additional benefit/perspective.

Question 4: Please comment on the 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 determined that the project team has a solid pan for identifying suitable CF/acrylonitrile butadiene styrene (ABS) – thermoplastic polyurethane blends for bumper design and manufacturing. In addition, the team will realize full-scale printing of a performance-optimized multi-material lattice structure frontal bumper by pursuing ML. The milestones for 2023 are achievable.

Reviewer 2:

This reviewer found that the plan is well developed and clear with a good chance of meeting proposed goals.

Reviewer 3:

This reviewer commented that the project is nearly completed with a few milestones left for demonstration.

Reviewer 4:

The proposed work to be conducted is, to this reviewer, reasonable but details on the TEA of the armrest designs would have been useful.

Reviewer 5:

According to this reviewer, the proposed future work should include a cost analysis that would compare this technology to current designs.

Reviewer 6:

This reviewer believes that the objective for using AI to develop an optimized lattice structure based on desired structural performance is valuable, but a better approach would have been to develop and demonstrate this approach first on a simpler and higher resolution material system and printing method. The relatively poor quality of the BAAM structures seems to compromise the approach at this stage of development, according to the reviewer.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The project is considered relevant to lightweighting, but costs could be an issue according to this reviewer.

Reviewer 2:

This reviewer believes that the project is relevant to lightweighting of automotive sub-components using AM technologies.

Reviewer 3:

This reviewer confirms that the project supports VTO Materials subprogram goals for lightweighting vehicle structures. The development of an AI design tool that can take advantage of emergent materials and manufacturing methods is desirable. The reviewer believes that the lattice structures under evaluation would benefit from a higher resolution fabrication method with more test samples fabricated and evaluated to develop the training set.

Reviewer 4:

This reviewer sees the project as relevant to VTO Materials subprogram overall mission.

Reviewer 5:

This reviewer believes that lightweight, high-performance bumpers are critical for lighter and smarter EVs and that the project directly supports these VTO Materials subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer stated that the resources are sufficient.

Reviewer 2:

This reviewer finds the resources sufficient to meet the goals without excess.

Reviewer 3:

The resources appear to this reviewer to be sufficient.

Reviewer 4:

This reviewer considers that the project team has the resources required for accomplishing the project milestones that will be ready for scale-up and transfer to industry via the industry partner, Ford.

Reviewer 5:

This reviewer thinks the resources are sufficient if a simpler starting approach was pursued as indicated in prior comments.

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, Lawrence Livermore National Laboratory

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.

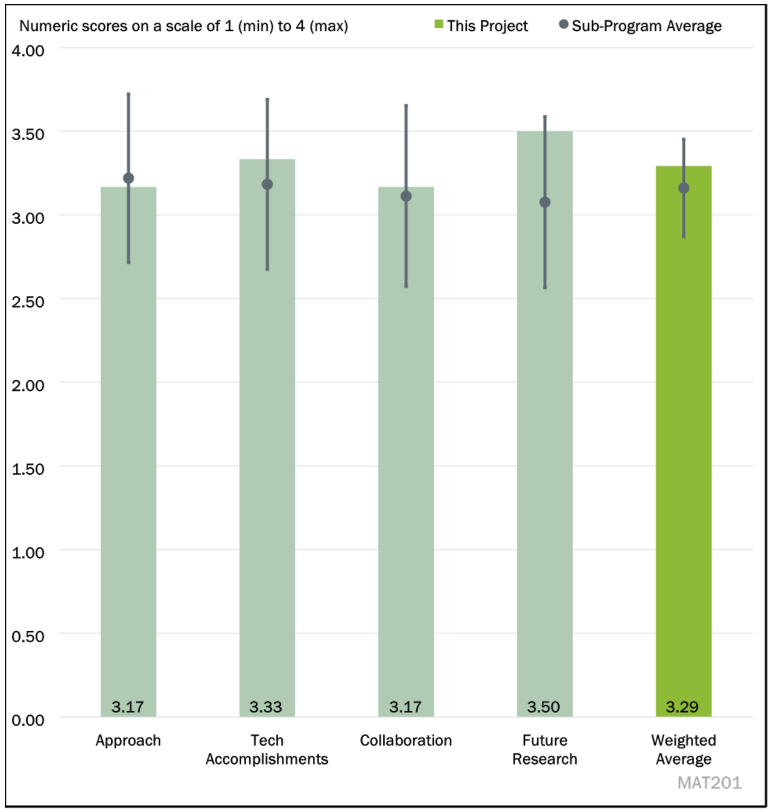

Figure 5-35 - Presentation Number: MAT201 Presentation Title: Additively Manufactured, Lightweight, Low-Cost Composite Vessels for Compressed Natural Gas Fuel Storage Principal Investigator: James Lewicki (Lawrence Livermore National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer pointed out that the project used three types of nanofillers to reinforce resin. The team designed and implemented hybrid long-fiber deposition hardware and realized a unique hybrid print head for composite manufacture. The ‘liner zone’ exhibits high tensile strength structural midzone with enhanced toughness/impact resistance in the outer layers. The initial models suggested 20% fiber reduction, which the reviewer finds very encouraging as an alternative way discovered by the team for reducing the cost.

Reviewer 2:

This reviewer finds the equipment design and research exciting while raising questions such as how the performance compares to a current commercially-produced CF tank and whether the CF baseline is sufficient. The reviewer believes that there needs to be a cost analysis for the approach but that the project otherwise shows very good progress.

Reviewer 3:

This reviewer asserts that the development of 3D printing using CF and ultraviolet light to cure the resin may have some merit and, in fact, is a commercial technology used by several companies, but that the application of this approach to a pressure vessel is misplaced due to the very high-performance requirements. The graded structure may have some relevance in other applications, but its value is not apparent for this application.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer commends the fact that the project team found it possible to use less CFs and reduce the cost using a rationally optimal design. The team manufactured two-inch composite cylinders and achieved a direct ink write toolpath optimization via rigid body dynamics. They improved manufacturability using digital twin approaches. The modular tank manufacturing strategy/task is well planned. The team may further optimize nanofiller dispersion to maximize reinforcing effects.

Reviewer 2:

This reviewer found that technical accomplishments are moving in the right direction. There would need to be future research to verify the validity of the approach.

Reviewer 3:

The team fabricated some structures with its approach, but the process is years behind the industry state of the art according to this reviewer who provided continuous composites as one example.

Question 3: Please comment on the collaboration within the 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 applauds that the collaboration between LLNL, Materials Sciences LLC, the University of Texas High Resolution X Ray Computed Tomography Facility, and Aerojet RocketDyne has been going well. The project is on track and the remaining milestones are achievable, according to the reviewer.

Reviewer 2:

This reviewer believes that the collaborative efforts are sufficient.

Reviewer 3:

This reviewer notes that the team partners provide technical support but suggests inclusion of a tank manufacturer. The project process is far too slow to be used commercially, according to the reviewer, and the ultraviolet cure resins performance is much worse than state-of-the-art toughened epoxy resins used today. The approach may have value for conformal or complex structural shapes.

Question 4: Please comment on the 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 commented that the team will make test prints and further improve the nanomaterials resin, suggesting that the project team may look at the nanofiller dispersion and loading to achieve even higher reinforcing effects.

Reviewer 2:

This reviewer had no comment because the project is ending.

Reviewer 3:

This reviewer observed that the project is near completion.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirmed that the project is relevant to natural gas transportation but believes that a cost analysis is needed.

Reviewer 2:

This reviewer commented that compressed natural gas (CNG) tanks are critical to the reduction of CO_2 emissions for vehicles. The project plan was to find an alternative way to developing low cost, lightweight CNG tanks, which the reviewer believes directly supports VTO Materials subprogram objectives and secures supply chains.

Reviewer 3:

This reviewer said that the project would be better applied to other complex structures such as project MAT200 (lattice structures). The approach is much too slow and performance too poor for a conventional pressure vessel.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer described how the project leverages the resources and expertise of LLNL, Materials Sciences LLC, The University of Texas High Resolution X-ray Computer Tomography Facility, and Aerojet RocketDyne. The 3-pronged approach leveraging AM, design optimization and nanomaterial modification in a graded, single process enables a high performance CNG tank cheaper to manufacture from less expensive feedstocks, according to the reviewer.

Reviewer 2:

This reviewer found the resources are sufficient.

Reviewer 3:

This reviewer opined that the resources are fine for Objectives 1 and 2, but for Objective 3, the pressure vessel was probably not the best choice for project demonstration. The technology may apply better to topology optimized grid formation on a thin shell structure.

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, Oak Ridge National Laboratory

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.

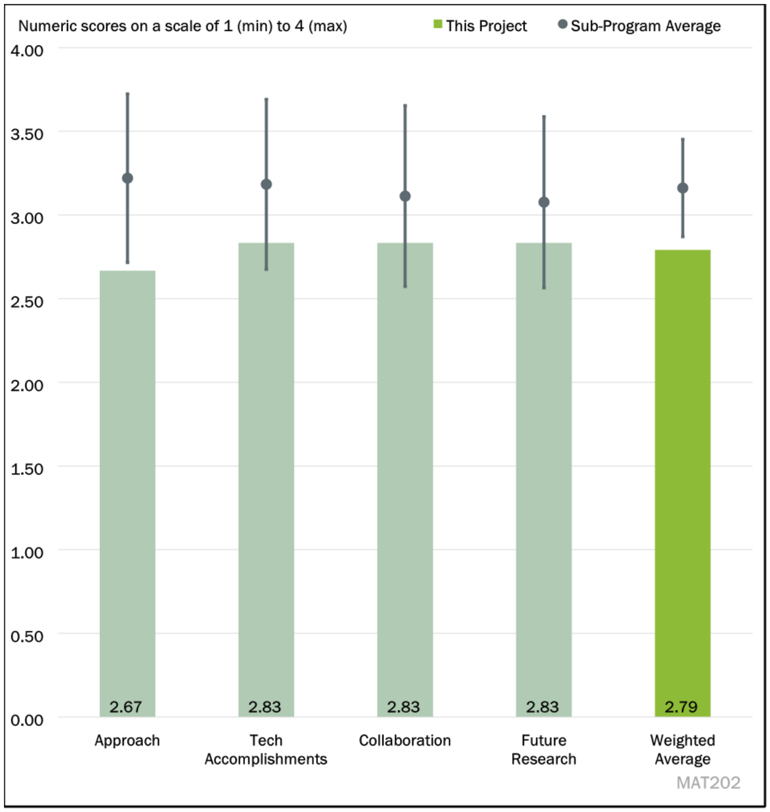

Figure 5-36 - Presentation Number: MAT202 Presentation Title: 3D Printed Hybrid Composite Materials with Sensing Capability for Advanced Vehicles Principal Investigator: Rigoberto Advincula (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer commended the project for having targeted technical barriers that were clearly addressed and that project was well-designed. The presentation clearly divided the project into four tasks to improve interfacial adhesion, perform computational modeling, and design 3D-printed parts with integrated sensing. With this being the third and final year of this project, the reviewer finds that the timeline is reasonable to overcome the remaining technical barriers.

Reviewer 2:

According to this reviewer, the team has done a good job of articulating the progress across the four tasks and the reasons for delaying one of the tasks until Q3 Fiscal Year 2023. Results presented indicated that the project on the right path to overcoming barriers in the four main tasks, namely (1) precise chemical reaction control; (2) computation interface interaction; (3) 3D printing CF polymer composites; and (4) embedded sensor composite printing. The reviewer offered some general observations with a note that the slides are “not numbered” which the reviewer would have found helpful. (Note: the slides are numbered at the lower left of each slide which was probably difficult to read by the reviewer) Also, for the Task 1 objective to develop CF/polymer with enhanced inorganic-organic interface covalent interaction, the chemical structures/reactions shown are so small they are hardly readable by the reviewer. Hence, it was not possible for the reviewer to assess the specific approach used. The reviewer is not clear about the inorganic-organic interface and says that it would help to illustrate/clarify the figure captions and what they are conveying. They are obviously important results but remain largely unreadable. The reviewer had a similar comment regarding Slide 8 because it was unclear what the variants are that the bar graph is trying to compare. Figure captions are inadequate or non-existent. Task 3 is interesting in terms of co-extrusion to the reviewer but raises questions regarding the stability, repeatability, and scalability of the process. The reviewer notes that, presently, it is syringe scale, which is understandable, but the scaling would be important to practical applications. The reviewer raises the same question on Task 4, and that is how fragile or robust are the printed sensors and anode. The presentation shows an automotive example, but not the gap is between the present work and what is needed, according to the reviewer.

Reviewer 3:

This reviewer is concerned that the project appears to be focused on a complex (and unlikely to succeed) means of developing embedded sensing /and or a nebulous means of advancing AM composites technology in general. The technology is unlikely to serve advanced, scaled composites for automotive applications in its present form. The project appears to significantly weigh the development of chopped fiber and continuous fiber 3D thermoset printing; however, the development of these technologies for the stated goals seems excessive/unnecessary. These technology developments are also currently available at a higher TRL/MRL within other research organizations in the United States. This reviewer therefore questions the relevance of developing these technologies in parallel under this program rather than pursuing collaboration with other research and technology groups directly.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer considers that the team met the outlined milestones. Good results were presented for the fiber functionalization work. The reviewer did voice a concern with the acid treatment shown in Slide 8 where the surface roughness was increased significantly. That level of acid etching could reduce the fiber's mechanical strength, so the researchers need to be careful not to etch the fibers too much during chemical treatment. If there is follow-on work for this project that warrants another AMR presentation, the reviewer suggests that it would be good to show the mechanical loading curves that correspond to the voltage and current outputs from the polyvinylidene fluoride (PVDF) on Slide 13. The reviewer would like to see how well the electrical responses correspond to the mechanical inputs, specifically, whether the input mechanical force and output electrical response waveforms match and how repeatable they are over longer cycle times.

Reviewer 2:

This reviewer notes that some earlier comments are relevant to this section, as well. The team has proposed 4 main tasks: (1) precise chemical reaction control; (2) computation interface interaction; (3) 3D printing of CF polymer composites; and (4) embedded sensor composite printing. The reviewer offers some general observations with a note that the slides are "not numbered" that would have been helpful-For Task 1, develop CF/polymer with enhanced inorganic-organic interface covalent interaction; The chemical structures/reactions shown are so small they are hardly readable for this reviewer. Hence, it was not possible to assess the specific approach used. The reviewer is not clear about the inorganic-organic interface. It would help to illustrate/clarify the figure captions and what they are conveying. They are obviously important results but remain largely unreadable. The reviewer offered the same comment regarding Slide 8, questioning what are the variants that the bar graph is trying to compare. Figure captions are inadequate or non-existent. Task 3 is interesting in terms of co-extrusion but raises the question of how stable, repeatable, and scalable the process is. Presently it is syringe scale, which is understandable, but the scaling would be important to practical applications. The reviewer raises the same question on Task 4: How fragile or robust are the printed sensors/anode. The team shows an automotive example, but not the gap between the present work and what is currently in use. The team mentions around a 10x enhancement of piezoelectric output for a shear stress of 8% MoS_2 PVDF. This is impressive to the reviewer, but the question on scaling must be addressed/briefed to show practical significance.

Reviewer 3:

This reviewer sees little tangible progress having been made in the technology development required to meet goals.

Question 3: Please comment on the collaboration within the 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 praises good, effective collaboration with the University of North Texas (UNT) to perform the modeling and sensor characterization, and a great partnership with Hyrel to develop the continuous fiber extrusion in the 3D printer. The project overcame the challenges with that printer by improving on the original design, and it seems that the system is working very well now. The reviewer looks forward to seeing how well this technology is received by commercial partners for further integration into automotive applications.

Reviewer 2:

This reviewer observes that, on Slide 16, the presenter describes the distribution of work between UNT and ORNL. If this project is progressing as planned, it can be inferred that there is good collaboration between the researchers on both sides. Some more concrete exchanges in terms of students/post-docs and more specifics would have been useful to the reviewer. It seems to the reviewer that the presentation is almost like "everything is great," but the actual collaboration is difficult to assess.

Reviewer 3:

The reviewer recounted how the team described collaboration of ORNL with a UNT subcontractor. The reviewer believes that another national laboratory and an industry partner would greatly benefit the effort. Other national laboratories, for example, have significantly more advanced continuous CF thermoset printing capabilities. With proper collaboration, this project could have been enhanced rather than attempting to recreate a similar technology in the same funding stream.

Question 4: Please comment on the 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 is satisfied that the team outlines reasonable remaining future work that should be achievable by the end of Fiscal Year 2023 when the project is expected to end. A cost estimate for the developed materials would be good to show to evaluate the feasibility of commercialization for this work. Additional studies on the poling effects on the PVDF would be good to show. The reviewer notes that the future of demonstrating 3D printing for larger structures with optimized formulations is a little vague, including the size of the structures planned to be printed and whether they will be economical to produce for vehicle applications.

Reviewer 2:

The reviewer noted the proposed future work follows their current work, calling out the following specific aspects. They felt demonstrating optimized continues CF–epoxy 3D printing into larger structures with optimized formations was a fairly general statement. The reviewer asks what are the target scales, which is important in terms of how far this research will get towards TRL 4-7. They also ask what is meant by optimized? This representation is somewhat vague and suggests clearly laying out where are the organic-inorganic interfaces tied to this objective, as presently it was not clear.

The reviewer further noted relative to investigating long term thermo-mechanical properties of CF/polymer composites that there needs to be a more fleshed out description of the metrics and how FEA would complement the optimization effort. Additionally, the reviewer noted there are numerous options for sizing but asked if assessing other sizing and surface modifiers will be feasible before the project ends in October 2023. Finally, the reviewer commented on the sandwiching of 3D printed sensors, noting the research should be highly targeted given the project period and the goals and objectives should be more clearly stated.

Reviewer 3:

This reviewer suggested that the proposed future work seeks to get ahead of project delays but does not address reviewer concerns from previous or current years. The continuous CF process is high risk and a poor investment when this technology is already demonstrated by other groups at a higher TRL/MRL, according to the reviewer.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believed that the project has a multi-functional benefit in terms of value to battery technologies, new materials and energy efficiency. The work is in its early stages and, as the TRL levels emerge, it will be clear which areas would be impacted the most. It is too early to say without scaling or a sense thereof.

Reviewer 2:

This reviewer affirmed that the project is relevant to VTO Materials subprogram objectives for vehicle lightweighting via better fiber adhesion to the matrix and through AM with embedded sensors but is not sure what automotive parts are realistically likely to be additively manufactured or whether the AM process can be used for the high-volume output needed within the automotive industry.

Reviewer 3:

The reviewer felt the technologies under development are unlikely to find broad application in the automotive area where they are targeted due to the cost and difficulty in scaling versus the minor benefits of embedded sensing.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believed that the resources are sufficient to meet stated goals.

Reviewer 2:

Since the project ends this year, this reviewer believed that the funds are sufficient to reach the stated milestones in a timely fashion.

Reviewer 3:

This reviewer finds that the team of ORNL and UNT has adequate resources to conduct the project and they are utilizing it well.

Presentation Number: MAT203
Presentation Title: Low-Cost, High-Throughput Carbon Fiber with Large Diameter
Principal Investigator: Felix Paulauskas (Oak Ridge National Laboratory)

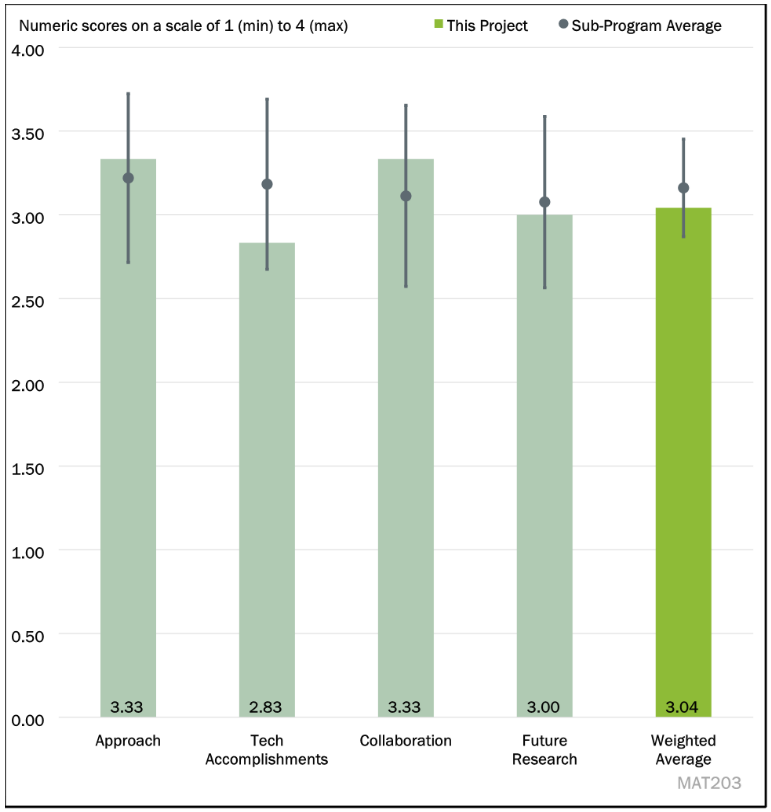

Figure 5-37 - Presentation Number: MAT203 Presentation Title: Low-Cost, High-Throughput Carbon Fiber with Large Diameter Principal Investigator: Felix Paulauskas (Oak Ridge National Laboratory)

Presenter

Felix Paulauskas, Oak Ridge National Laboratory

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.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer pointed out that the project aims to address the production costs of CF and feedstocks. The team has shown a reasonable timeline and some plans to accomplish the project goal in the reviewer’s view.

Reviewer 2:

This reviewer observed that the barriers and technical targets being addressed in this project include the cost of CF feedstock and production and the availability of lower cost CF at a level necessary for large-scale impact for vehicle production. The approach for Fiscal Year 2023 included the demonstration and evaluation of a new CF produced at as close-to-pilot scale as practical. CF composite articles were made with a production-type process and testing was required to fully evaluate and define the advantages of the process. Cost models will be completed and utilized to evaluate the cost versus performance benefits in combining effects of textile PAN fibers produced via dry spinning and with larger precursor diameters. The design of the overall project started in the first year by establishing a baseline for this approach with CF converted from the dry spun textile precursor and demonstrating a fiber that was at least 25% larger in the “effective” diameter. The second year of the project produced CF that was at least 50% larger diameter than the project baseline established in the first year. The performance of the CF was demonstrated to be a minimum of 350 ksi in tensile strength, 33 Msi modulus, and 1% strain. The CF was further developed, and post treatment processes were scaled up at a project partner’s facility. The cost target for the second year was to demonstrate that 25%-30% or greater savings are potentially achievable with this approach. The reviewer considers that the approach and project design supported the targets for the cost of CF feedstock and production and the availability of lower cost CF at a level necessary for large-scale impact for vehicle production. The project also addressed the VTO Materials technical goals for improved strength of composite materials used in vehicles. This was a three-year project, which is a reasonable timeline for this type of development.

Reviewer 3:

This reviewer reported that the project team focuses on dry spun acrylic fibers and plasma conversion that jointly reduce CF cost. Larger diameter fibers have advantages if the fibers can meet the target properties and cost. If successful, the dry spun acrylic fibers may replace the current expensive wet spun PAN precursor fibers and secure supply chains (upstream).

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

Since wet spun PAN precursor fibers are not currently made in the United States, this raises supply chain concerns. The project team seeks an alternative low-cost dry spun acrylic fiber with the goal to make acrylic fibers in the United States. The plasma conversion of large diameter acrylic fibers is encouraging (showing big cost savings). The CF properties and cost have met DOE targets and would be used to encourage making dry spun acrylic fibers in the United States to secure supply chains.

Reviewer 2:

The project made satisfactory progress in this reviewer’s eyes. This is the final year for this project and the team could show more progress. The LCA and TEA would be critical to get an idea of the CF production cost.

Reviewer 3:

This reviewer related how the experiments with plasma oxidized and conventional carbonized 3.3dtex and 5.5dtex precursors (without steam stretching and with 50% steam stretching) produced fiber with very good mechanical properties that met the minimum goals of 250 ksi for tensile strength, 25 Msi modulus, and 1% strain and also met the target strength of more than 375 ksi with most specimens within 15% of 33 Msi target modulus. Conventional processing showed that the material was capable of meeting all minimum and probably all target goals with more optimization. There were limitations with the amount of available precursor, so the project had to be refocused on making larger quantities of CF from 3.3dtex materials that are being processed at one of the project partners, 4XT/4M, using advanced plasma oxidation, conventional carbonization and sizing, and advanced plasma surface treatment processes. The use of a manufacturing partner contributes to the success of transitioning the technology, if successful. The fiber produced at 4XT/4M will be processed into composite panels to be fabricated at a second project partner, the University of Tennessee, and compared with an industrial baseline material. This is considered a good approach for improvements over currently available CF materials. The project was delayed significantly because of COVID and associated business impacts, as well as equipment issues at 4XT/4M. This delayed conducting the cost/performance tradeoffs of leading diameter candidates. Also, the original supplier for the CF, Dralon, went out of business during COVID, so ORNL initiated collaboration with another offshore company, Sudamericana de Fibras (SDF), as a long-term candidate supplier of dry spun textile acrylic fiber. The technical accomplishments were significantly delayed because of these problems and the project is not targeting a U.S. supplier.

Question 3: Please comment on the collaboration within the 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 collaboration involved a national laboratory, ORNL, suppliers of CFs (Dralon, 4XT/4M, and SDF), and academia (University of Tennessee). For this size project ($500,000 per year), the collaborations support a successful development of CF with large diameters.

Reviewer 2:

This reviewer believed that the collaboration between ORNL, 4XT and the University of Tennessee has been great. The scale-up processing has been demonstrated in ORNL and 4XT. It is expected that integration of plasma oxidation and carbonization will further lower conversion cost.

Reviewer 3:

The team has good collaboration with 4XT/4M, according to this reviewer, who, nonetheless, believes that it would be great to have more collaboration with raw materials supply chain industries.

Question 4: Please comment on the 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 team has some future research plans. The future plans make sense and the targets are achievable.

Reviewer 2:

This reviewer noted that, although the project will complete at the end of Fiscal Year 2023, future research was proposed. This included pursuing the utilization of a combination of lower cost dry spun fibers and advanced conversion technologies, assessing a broader range of diameter versus economics and CF production/performance tradeoffs than previously explored, and evaluating projected resin infusion advantages and possibly improved interfacial properties.

Reviewer 3:

The proposed future research identified by this reviewer includes assessing overall technical and economic advantages. This will help establish a strategy plan for United States. CF supply chains (upstream). It is expected that low-cost dry-spun acrylic fibers can be made in the United States. Testing milestones depend upon fiber availability.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirmed that the project supports the VTO Materials subprogram objectives.

Reviewer 2:

This project is believed by this reviewer to be relevant to supporting the VTO Materials subprogram objectives to develop lightweight materials such as composite materials for vehicle parts and to reduce the cost of CF feedstock and production that will improve the availability of lower cost CF fiber at a level necessary for large-scale impact for vehicle production.

Reviewer 3:

CFs are critical, according to this reviewer, to reducing vehicle weight/energy consumption/carbon emissions, and lowering cost for lighter and smarter EVs. The project directly supports the VTO Materials subprogram objectives and secures supply chains.

Question 6: Please provide comments on the resources of the project. 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.

Reviewer 2:

This reviewer commented that this was a three-year project with $500,000 per year in funding for one national laboratory and a university. The industry partner provided services in kind to be able to produce the end product. This is considered by the reviewer to be sufficient resources for this type of project.

Reviewer 3:

This reviewer noted that the project leverages the resources of ORNL, 4XT and University of Tennessee, and is sufficient for the project to achieve the milestones in a timely fashion.

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, 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.

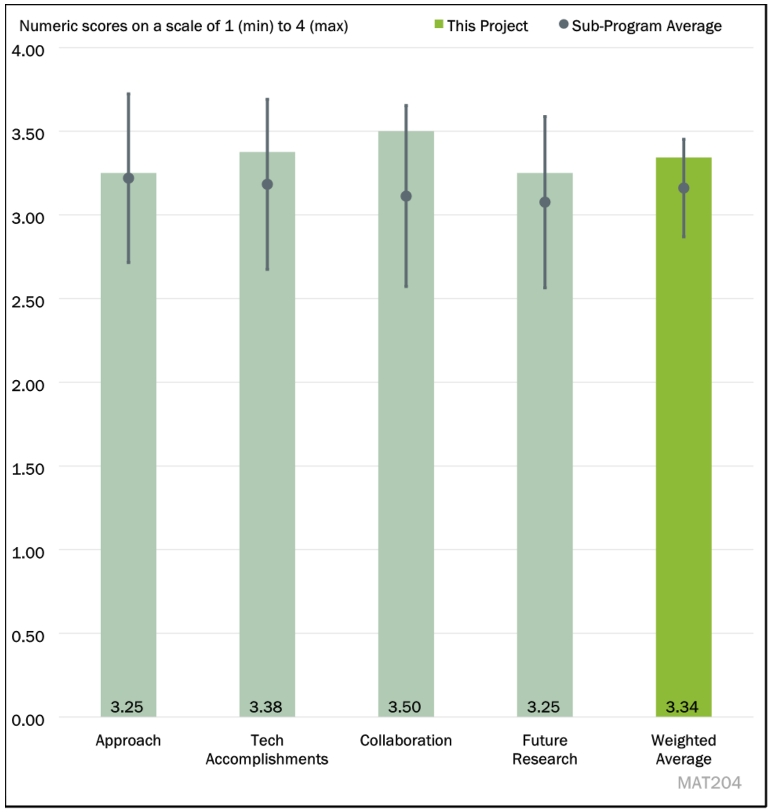

Figure 5-38 - Presentation Number: MAT204 Presentation Title: New Frontier in Polymer Matrix Composites via Tailored Vitrimer Chemistry Principal Investigator: Tomonori Saito (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer pointed out that this project deals with the following objectives: develop cost-effective new vitrimer resins for CF composites; develop the manufacturing process of CFRPs and improve the fiber-matrix interfacial adhesion; validate the manufacturing of fast-processable, recyclable and repairable vitrimer resins and CFRPs while maintaining their superior mechanical properties. The team has presented excellent progress in advancing these objectives, according to the reviewer. The resins being developed are very well aligned with DOE objectives of circularity and energy savings. The project has demonstrated achieving high tensile strength and processability for CFs. It has also shown a valuable process capable of thermostamping preforms with CF vitrimers, which is of high value to automotive and related applications. This also advances the work to high TRL levels. The process also demonstrates adding a dynamic covalent bond to commodity polymers, increasing their strength and durability. Interfacial adhesion with a fiber-matrix was demonstrated, which helps translate properties. All these successes point to advancing the objectives by the team.

Reviewer 2:

This reviewer commented that the work shows excellent results for initial property evaluation, including property retention during recycling but the reviewer complains of having yet to see in this or in any other presentation, long-term environmental durability and creep performance results. These test data will determine a use case for these novel materials.

Reviewer 3:

This reviewer shared that a tris-diol vitrimer was developed as a novel polymer matrix. The vitrimer exhibits decent mechanical properties at a high processing temperature. An iridium-based catalyst is needed for polymer functionalization (i.e., installing borate), which raises the cost. The reviewer is unclear on the ease/cost effectiveness of the synthesis and purification of tris-diol.

Reviewer 4:

This reviewer found that the project itself is well designed and interesting, because it investigates many vitrimer systems that might be of relevance to CFRCs. Excitingly, the work demonstrates the potential behind two different vitrimer systems: disulfides and boronic esters. A large weakness is that an analysis is not performed until the end of the project, so the reviewer found it hard to assess the viability of these specific chemical approaches. Boronic esters may be cost prohibitive for vehicle applications; the specialty monomers used in the disulfide approach may also prove to be cost prohibitive. TEA/LCA early in the project, instead of at the project milestone, could better drive resin development. Without analysis, specific alignment with VTO goals is hard to track. The reviewer also found it hard to understand why two different systems were explored. Benefits between the different approaches should be highlighted.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer refered back to comments provided in the previous question. The technical accomplishments are on target. The central premise of vitrimer recycling is being addressed at the basic science level without losing sight of higher TRL scale up. This is, indeed, commendable to the reviewer, who states that all the comments made above apply here.

Reviewer 2:

As the reviewer previously stated, the test results thus far are very encouraging, but much work has yet to be completed to support use of this technology as an engineering material system.

Reviewer 3:

The team has shown the re-processibility of the new vitrimer and its CFRCs to the satisfaction of the reviewer. Degradation of the CFRCs was also demonstrated, although the research has been focused on recovery of the CFs. Recovery of the monomers is also highly desired, which could very likely be achieved, but still needs to be demonstrated. Also, the CFRCs exhibit strains of over 10% or even 20%, which seem to the reviewer to be much higher than CFs can commonly reach.

Reviewer 4:

This reviewer described how the project team has shown the ability to make multiple resin formulations for re-use over multiple material lives and has shown similar performance across multiple material lives. The sizing of the fibers to participate with the dynamic chemistry is well done and shows enhanced properties. This will surely further help the development of recyclable composites. Overall, the project seems focused more on resin development then on composite development. This became evident in some of the answers to reviewer questions around composite performance. The reviewer suggests that the project team should examine the creep of their composite at service temperatures more in depth, as well as provide better explanations for the enhanced properties. Notably, the enhanced elongations at break of the composites is exceedingly high. This is an exciting result but defies the conventional wisdom around composite performance. Mode of failure should be further documented to understand this. The project team should explicitly state how their chemistry enables advanced performance, according to the reviewer.

Question 3: Please comment on the collaboration within the 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 reported that the project team has coordination with material suppliers.

Reviewer 2:

This reviewer approved that the team is fairly well coordinated. ORNL is teamed with the University of Tennessee and resin suppliers Hexcel, Krayton and Hexion. This is a logical team collaboration. It is surprising to the reviewer that the team does not have a tier one manufacturer or OEM on the team. With this excellent progress, which would be a natural outcome of the work.

Reviewer 3:

This reviewer found it very good to see collaboration with Hexcel, Huntsman, Hexion, who are leading suppliers that have knowledge and resources to commercialize the technology. Material cost, however, was not discussed and is an important factor for the reviewer.

Reviewer 4:

This reviewer commended that the team members have complementary expertise and contribute in different ways. As was mentioned in the presentation, if one more collaborator from automobile industry is on board, that would make the team even stronger.

Question 4: Please comment on the 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 tasks are clear enough for this reviewer, including repairability/recyclability study, obtaining cost-effective vitrimer-based CFRCs, and conducting a TEA. Given the current progress of this project, the team should be able to accomplish those tasks within the project timeline.

Reviewer 2:

This reviewer identified the team-proposed future work was to: (1) Further demonstrate repairability and recyclability but it was not clear to the reviewer how the team plans to do this, or how it differentiates from what has already been accomplished. Some quantification would help. (2) Prepare cost-effective vitrimer-based CFRPs and achieve a 700 MPa composite tensile strength. The target is good to have but raises the questions of how and what basis the target is to be achieved. (3) Conduct TEA and investigate the circular economy; some level of specificity is needed to qualify these generic terms.

Reviewer 3:

As previously noted, the reviewer believes that TEA and LCA should have been done earlier in the project, but its addition will greatly enhance this work. Demonstrating repairability is also a strong milestone.

Reviewer 4:

The future work looked fine to this reviewer, but data are needed on environmental durability, particularly creep near expected service temperature that would be just below the glass transition temperature (Tg).

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

For this reviewer, the project has relevance to multiple areas since circular economy is key to almost all the listed areas. The work is primarily in materials development.

Reviewer 2:

This reviewer confirmed that the project is very good for VTO Materials subprogram objectives in composites sustainability, and perhaps novel processing for cost reduction.

Reviewer 3:

According to this reviewer, given their light weight, high mechanical performance, and recyclability, the proposed vitrimers and CFRCs can be utilized in automobile manufacturing in future as sustainable materials and to enhance fuel economy.

Reviewer 4:

This reviewer restated that the approach of designing vitrimers is well conceived and aligns with VTO goals around recycling and reuse. Additionally, their recyclability is well documented. However, it is hard to understand alignment to project goals without analysis. Analysis should be conducted earlier in the project, or in future projects, to demonstrate and guide the approach. Currently, too many questions arise for the reviewer around cost of resin, cost of reprocessing, environmental impact, and manufacturing process to comment completely on alignment.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The funds appear to this reviewer to be sufficient; however, more effort should be dedicated to early TEA/LCA on future projects.

Reviewer 2:

This reviewer found that the team has adequate resources across the board in terms of processing, thermo-mechanical, thermal and related characterization, polymer formulations, composites preparation, etc. No additional resources would be needed in the reviewer’s opinion.

Reviewer 3:

This reviewer applauded the team as being very strong to move the technology forward.

Reviewer 4:

This reviewer considered that the team has sufficient resources to complete this project in a timely fashion.

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, Oak Ridge National Laboratory

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.

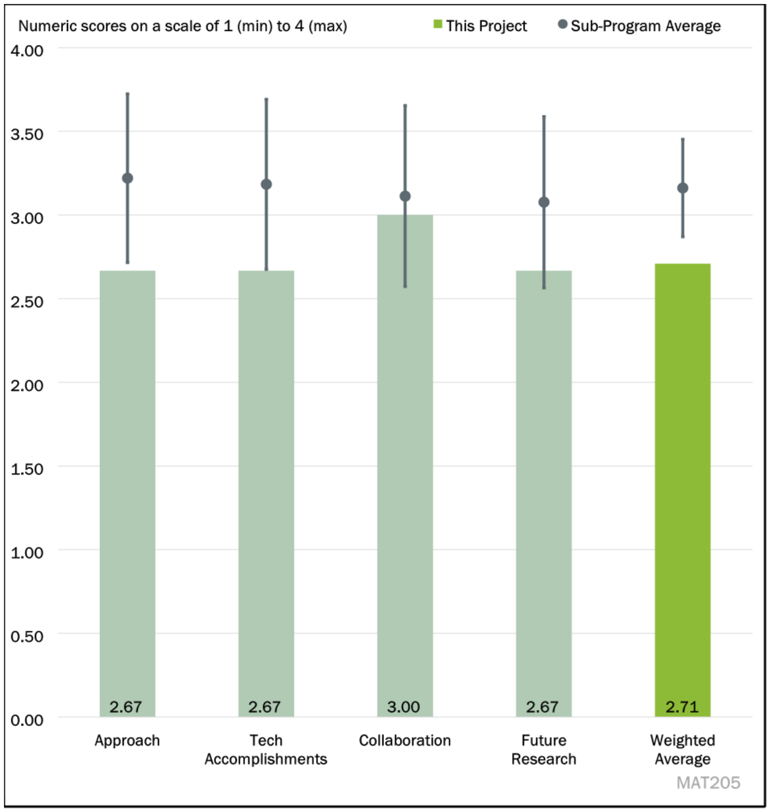

Figure 5-39 - Presentation Number: MAT205 Presentation Title: Adopting Heavy-Tow Carbon Fiber for Repairable, Stamp-Formed Composites Principal Investigator: Amit Naskar (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

One of the objectives appears to the reviewer to be the development of sizings for PP matrix materials; however, the reviewer did not see any work being performed on interfacial compatibility. The approach does not seem very ambitious.

Reviewer 2:

This reviewer summarized the project's stated objectives: (1) develop and commercialize high throughput manufacturing technologies with new interfacial engineering methods for efficient reinforcement of thermoplastic matrices using CFs; (2) translate the method for large tow CFs; (3) deliver repairable low-cost thermoplastic composites with multi-layered stamp formed structures with outstanding mechanical performance (0.8 1.4 GPa tensile strength, 50 100 GPa Young's modulus, and approximately 10% failure strain); and (4) develop processing technologies that enable 30%–50% cost reduction in composite parts. The reviewer found these objectives were generally good. The team's approach brings in thermoplastic resin films along with wide tow to produce what they call commingled stampable forms. The term commingled is somewhat loosely used here, in the reviewer's opinion, since the traditional commingled form has fiber reinforcement and resin also in the form of filaments (like fibers). The team has shown several basic level studies with the low-cost CF and some aspects of commingling. The work is generally in the right direction but still far away from the stated objectives. The team is developing an understanding of the thermal and process science of these materials. There is some effort to use the tow along with the resin to produce a sheet form. The reviewer observed that the slides were not numbered, making it more difficult to reference.

Reviewer 3:

This reviewer deduced that the project is only 50% complete ahead of the September 2023 end date which leaves only three months to complete the other 50%.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The presentation of continuous and chopped CF makes it difficult for this reviewer to sort out what data are being reported. For instance, it appears as if interlaminar shear strength is being reported for a chopped fiber composite where there would be no interlaminar region and, thus, the test results would not make sense. The reviewer was unclear about why the higher loading of CF leads to reduced strength with slower cooling.

Reviewer 2:

This reviewer found that the technical results are generally laid out logically. However, the key issue that the reviewer has with this brief presentation is the lack of a rationale/logic for why each study is being conducted. Also, the graphs/data are poorly labelled/annotated making is very difficult to understand what they are intended to say. As an example, for Slides 7-11 (assuming these numbers, since the slides are not numbered) characterization data are presented with conditions of freezing, quenching, etc. However, there is no accompanying information on what these are, why they are important in the context of the work, and what should the reader draw from them. All the reviewer understood was that the team has good characterization equipment and used it. The graphs are extremely hard to read and could use some professional editing. The stress-strain curves on Slide 12 are not even identified. They show five curves, but without identification. Also, the approach uses chopped fibers that were wet laid, but Slide 12 shows continuous wide tow. The reviewer is not clear on what intermediate form is being considered/characterized. If the plan is to use chopped fibers, then the data should be commensurate to that. The same lack of explanation/annotation could be said of Slide 13 and Slide 14. Overall, the technical work seems to take PP resin, along with the wide tow to produce wet laid mats and test them. It also seems that the wide tow is converted to chopped fibers and then used in the wet laid process. Hence, the true value of the wide tow may not be fully realized. The reviewer believes that the work is not yet fully aligned with the rather aggressive objectives.

Reviewer 3:

The ability of this project to achieve high throughput is not clear.

Question 3: Please comment on the collaboration within the 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 collaboration seems to be appropriate.

Reviewer 2:

This reviewer pointed out that the team comprises ORNL, University of Tennessee Bredesen Center, and Endeavor Composites. The collaboration is logical and seems to the reviewer to be functioning well. The team can carefully review their objectives and align the work better.

Reviewer 3:

This reviewer indicated that increased collaboration with an automotive OEM would be beneficial.

Question 4: Please comment on the 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 tasks to be reasonable though there seems to the reviewer to be quite a bit of work left to complete the project.

Reviewer 2:

This reviewer found very little detail was provided on the future research, which includes ambitious/unrealistic scale up plans.

Reviewer 3:

This reviewer offered the following comments: (1) Regarding ongoing work with Endeavor Composites likely being adopted for scaled up manufacturing, the reviewer commented: This is somewhat vague without knowing which form, volume fraction, and interface conditions would be pursued toward scale up. The reviewer is unclear about what "scale up" means in this context – size, asset base, commercialization (this word has been used in the first objective) – but the work does not point to any of that yet. (2) Regarding TEA and LCA of the products needing to be demonstrated, the reviewer commented: This is not entirely trivial and the reviewer wondered how this is possible for a project ending September 2023. (3) Regarding required development of high TRL R&D plan, the reviewer commented: This is a very vague statement and does not provide the reviewer anything to base what "high TRL R&D plan" means. (4) Regarding quantifying activation energies for forming chemisorbed matrices and identifying stabilized structures of polymer matrix attached to the CF surface, the reviewer found to be satisfactory. (5) Regarding conducting experiments at different temperatures to measure bound polymer fraction, the reviewer found this to be satisfactory. (6) Regarding demonstration of the CFRP stamping process for multi-layered structures, the reviewer commented: This needs some definition of how this would done, including a tool(s) plan, asset considerations, and process parameters to be developed. (7) Regarding the use of high throughput, low-cost large-tow CFs for stamped CFRPs, while making use of the developed interfacial chemistries that result in enhanced mechanical performance and crashworthiness, the reviewer questioned in what form his would be done and referred back to prior comment on the Slide 12 information. (8) Regarding remolding/restamping of structures, the reviewer was not sure what this means. (9) Regarding demonstrating the concept in small scale, the reviewer was not clear which concept, but accepted the comment. (10) Regarding building a cost model based on the current data and potential advantage of recyclability, the reviewer found this to be satisfactory but again not trivial. Overall, the reviewer found the work plan is good in terms of a layout, but shared that, based on years of experience, the reviewer would respectfully offer that completing all these efforts before September 2023 would require Herculean efforts.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer stated that composite materials are important to VTO.

Reviewer 2:

This reviewer believed that the work relates to materials, batteries, and energy efficiency.

Reviewer 3:

This reviewer commented that the effort is relevant assuming throughput and cost effectiveness are achieved.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found that the overall team complements in terms of resources and other resources are adequate.

Reviewer 2:

This reviewer accepted that the resources are appropriate.

Reviewer 3:

It appears to this reviewer that little work has been accomplished with the budgeted funds.

Presentation Number: MAT206
Presentation Title: Soft Smart Tools Using Additive Manufacturing
Principal Investigator: Jay Gaillard (Savannah River National Laboratory)

Presenter

Jay Gaillard, Savannah River 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.

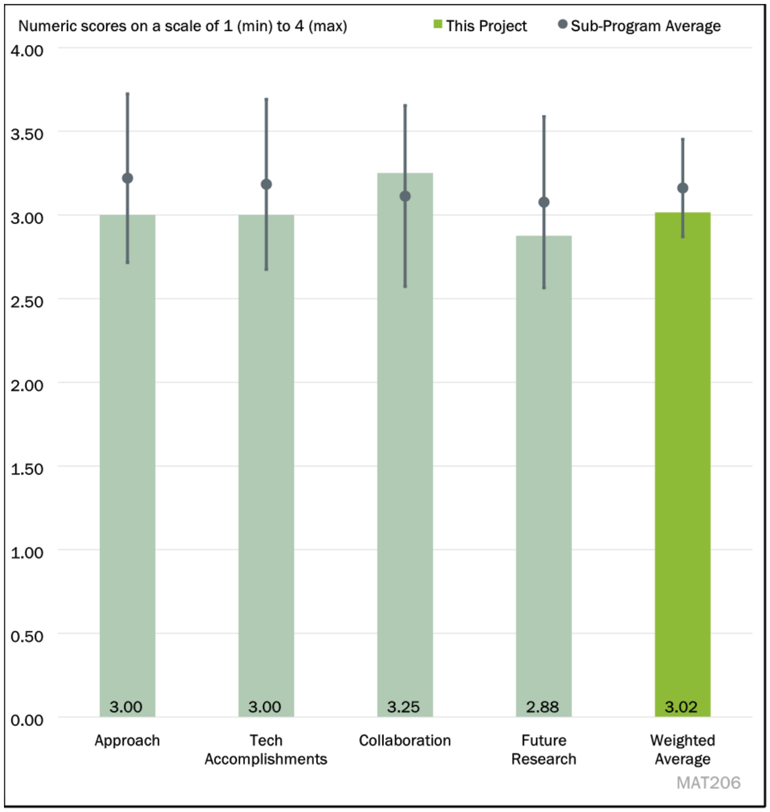

Figure 5-40 - Presentation Number: MAT206 Presentation Title: Soft Smart Tools Using Additive Manufacturing Principal Investigator: Jay Gaillard (Savannah River National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer commented that the project is well designed and well planned with a focus on the development of soft, smart composite tooling by AM. The technical barriers addressed are the extensive time spent engineering filament coating scale up and optimizing annealing parameters with carbon nanotubes (CNTs).

Reviewer 2:

This reviewer described how the objective of this project is to enhance the durability, life expectancy, strength, and conductivity of composite tooling using 3D printing, as demonstrated in the team's initial AMR slides from 2021. The team opted for CNTs as an electromagnetic susceptor for microwave heating, due to their superior heating performance compared to other alternatives. In year 2021, higher strength and modulus of 3D-printed samples with CNTs through microwave annealing has been observed as compared to non-annealed samples. In 2022, the team made CNT-coated continuous carbon fiber (CCF) prepreg tow and showed the increase in the heating performance. Building upon these accomplishments over the past 2 years, in Fiscal Year 2023, the team planned to scale up the manufacturing of CNT-coated CCF tow and intends to integrate sensor technology into the tooling. The overall direction and the design of the project appear adequate, and the proposed timeline is reasonable to the reviewer.

Reviewer 3:

This reviewer noted that the project team identified potential technical barriers for this project and the project aims to develop soft, smart composite tooling by additive manufacturing.

Reviewer 4:

This reviewer referred to polyaryletherketone (PAEK) concerns identified elsewhere in this review.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer found that the project team made significant progress relative to the project plan. The LCA and TEA data indicate significant improvement and cost reductions. CNT-coated CF samples showed very good properties after microwave annealing.

Reviewer 2:

This reviewer recorded that the team suggests overcoming the identified barriers of the manufacturing cost since the automotive tooling for making vehicle components by computer numerical control is energy and emission intensive. The team suggests that tooling production via 3D printing could lead to savings of about 50% in mold lead time, 40% in primary energy and GHG emissions as well as a 30% cost savings, assuming a 1-million-cycle lifetime. The team used CNT-coated CCF and introduced electromagnetic annealing to internally heat the composite. The team improved the mechanical/thermal properties of CCF at significantly lower energy. One question the reviewer poses is about the comparison data showing that the improvement is found only after the maximum force is applied, so the effectiveness in practical application is not clear (see figure on Slide 7). The team found that the CCF-reinforced 3D-printed thermoplastics have exhibited higher tensile properties and fiber volume fractions of up to 64%. However, the data are not presented well and the referenced papers [1-6] are not the about the team's work.

Reviewer 3:

This reviewer lauded that the team has shown great technical progress in a concerted manner. The reviewer is, however, concerned that the move to the PAEK thermoplastic will present more technical challenges than anticipated, suggesting that additional effort should have been spent on this earlier in the project.

Reviewer 4:

This reviewer noted that the team showcased several research outcomes this year. In terms of scaling up the manufacturing of CNT-coated CCF tow, improvement was achieved by increasing the production amount from a 300-ft long filament to a 3000-ft long filament, representing a 10x increase. Additionally, the team presented its findings from life cycle energy assessment and a TEA, demonstrating that the new technology being developed will lead to reduced energy consumption and lower manufacturing costs. Regarding the development of embedded sensors, the team presented its progress in two areas. Ink formulations were developed for direct ink writing and a technique was developed for printing a thermocouple on CCF. However, both ink development and thermocouple printing were already presented in a previous AMR meeting. The team claimed an increased performance by 20% in shear strength through microwave annealing. However, upon reviewing Slide 7, the force-displacement graph does not exhibit any noticeable increase in the maximum force to this reviewer. The team initially proposed sensor development for strain sensors and curing sensors as well as thermocouple sensors. However, the reviewer finds that this presentation lacks information about the strain sensors and curing sensors.

Question 3: Please comment on the collaboration within the 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 has good collaboration with Clemson University and Mainland Solutions.

Reviewer 2:

This reviewer noted that the team is led by Savannah River National Laboratory in partnering with Clemson International Center for Automotive Research, and Mainland Solutions, LLC. The team has individual roles: Savannah River National Laboratory is working on electromechanical susceptor design and continuous fiber and sensor 3D printing; Clemson University is working on mechanical testing; Mainland Solutions is working on the production of the CNT-coated 3D printing filaments and production of materials needed for the embedded sensors.

Reviewer 3:

The reviewer commented that an additional national laboratory partner would have further improved this score.

Reviewer 4:

This reviewer noted that the team is comprised of members from Clemson University and Mainland Solution, a material manufacturer. The inclusion of an OEM or a tier 1 company from the automotive industry would be immensely beneficial to the team because it would assist them in identifying the ideal target application.

Question 4: Please comment on the 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 pointed out that this is the last year of this project.

Reviewer 2:

This reviewer believed that the mechanical performance characterization is a part of this project and a way to prove the success of the project, but it is not complete enough to put into future work.

Reviewer 3:

This reviewer commended that the future work has a precise proposed scope. Large challenges, however, are foreseen by the reviewer in pivoting from nylon to PAEK, which the team did not fully address in the scope.

Reviewer 4:

The reviewer observed that the team proposed the following tasks: (1) investigating the use of PAEK as an alternative material for better durability and improved durability and quantifying its effects; (2) developing a multi-head printing technique for sensor integration; and (3) demonstrating market viability. Given that the project is scheduled to conclude in just a few months, accomplishing both Task#1 and Task#2 appears to be demanding in the reviewer’s view.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believed that the project nicely addressed the materials and manufacturing areas of the VTO missions.

Reviewer 2:

This reviewer affirmed that the scope of work is well aligned with the overall VTO Materials subprogram objectives.

Reviewer 3:

This reviewer offered that tooling is a large, sometimes hidden, cost of conventional manufacturing and this is an innovative approach to reducing tooling costs using AM, which the reviewer finds very commendable.

Reviewer 4:

The project, according to this reviewer, is highly relevant to VTO Materials subprogram objectives. Due to its high cost and long lead time, the development of tooling technology greatly affects the automotive industry. Upon successful completion, the proposed project will result not only in the reduced costs and short lead time, but also in parts with improved quality based on integrated sensor data.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said that the team has sufficient resources to finish the project's milestone.

Reviewer 2:

This reviewer determined that the team has sufficient resources to complete the planned tasks.

Reviewer 3:

The resources appear to this reviewer to be reasonable and sufficient for successful completion.

Reviewer 4:

This reviewer found the resources available to be sufficient to meet stated goals; however, the PAEK challenge may require a resource loading shift.

Presentation Number: MAT207
Presentation Title: Multi-Material, Functional Composites with Hierarchical Structures
Principal Investigator: Christopher Bowland (Oak Ridge National Laboratory)

Presenter

Christopher Bowland, Oak Ridge National Laboratory

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.

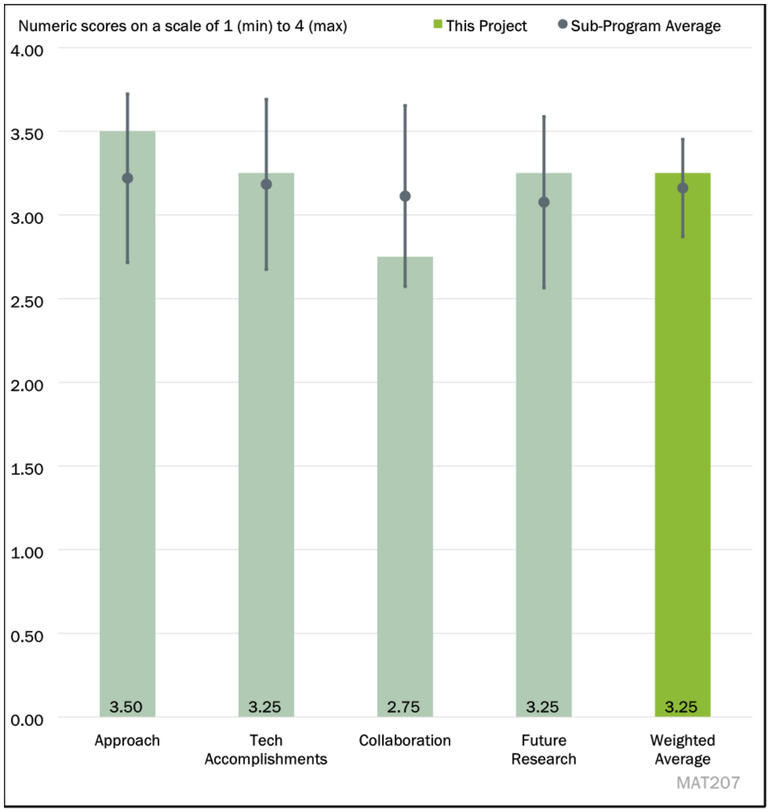

Figure 5-41 - Presentation Number: MAT207 Presentation Title: Multi-Material, Functional Composites with Hierarchical Structures Principal Investigator: Christopher Bowland (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer said that the project has clearly addressed the barriers and technical targets proposed for the project. The technical target to optimize the crash energy is very relevant, and the reviewer feels that it would be nice to have a few experiments demonstrating this capability with the developed material.

Reviewer 2:

The complex technical barriers were addressed well for this reviewer and demonstrated with project progress and all milestones completed at the time of the AMR. The project continued to take a methodical approach to the integration of *in situ* damage monitoring and enhanced mechanical properties in CF/ABS mixes and CF composite laminates. The reviewer considers this to be great progress.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer believed that there was significant accomplishment in achieving 60%–100% improvement in in-plane shear strength and energy release up to 250°C. All progress was commensurate with the plan as developed and technical challenges were met with success. Delay in fatigue testing and *in situ* measurements have put these tasks behind schedule, but they are underway with the collaborator.

Reviewer 2:

This reviewer considered that good progress has been achieved in validating the electromagnetic characterization with various amounts of $BaTiO_3$. This accomplishment appears to have been completed last year. However, the reviewer would find it useful to determine a threshold voltage that causes specific failure of the composite using this technology. A significant achievement is that the team has successfully developed a process to deposit PAN nano fibers on the CF. Additionally, determining the appropriate thermal treatment to maximize strength is excellent. The tensile results of the samples were tested for a layup of 45/-45 (Slide 12). However, this layup only provides the shear stiffness of the composite. The reviewer desired to see the tensile test results for those samples, which could provide a greater understanding of the various interfaces. On Slide 13, a significant improvement of 137% was found in transverse tensile strength with PAN nano fiber orientation. This improvement may be attributed to the use of a low-strength matrix material (2 MPa). The reviewer is unaware of whether this matrix material will be reasonable to use in practical applications.

Question 3: Please comment on the collaboration within the 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 the project involves Columbia University as a collaborator in evaluating the fatigue testing. The reviewer is unsure of the efforts by the other collaborating partner, Enfluxx Tech, LLC.

Reviewer 2:

To this reviewer, the collaboration appeared to be the weakest part of the project because of delays in providing funding to the collaborator to begin fatigue testing. The work has begun, but the project is nearly over. A successful license agreement was completed for the technology.

Question 4: Please comment on the 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 observed that the remaining challenges for the project are well-documented. However, higher priority should be given to scale-up demonstrations, according to the reviewer, who also suggests that cost modeling is another critical step that has the potential to uncover new research areas for reducing the overall cost.

Reviewer 2:

This reviewer believed that the project team has developed an effective series of technical and TEA tasks to complete, but there is no discussion of future implementation of the technology into vehicles and what parts the materials could best be used to reduce weight.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer found that the project is highly relevant to the automotive industry as it focuses on developing new multi-functional composite materials that can consolidate multiple components. The developed materials are lightweight compared to existing materials, thus improving the efficiency for the transportation industry.

Reviewer 2:

This reviewer described how the project is integrating sensor technology and enhancing composite strength that will allow for improved reliability and lower weight composites by reducing excessive design. This reduction is because of increased confidence levels and will further reduce the cost along with the weight reduction if the TEA analysis can show a minimal cost addition.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer was satisfied that the project has sufficient resources to execute the remaining tasks.

Reviewer 2:

This reviewer accepted that the resources are sufficient, as evident by the progress and accomplishments of the milestones which are on target.

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)

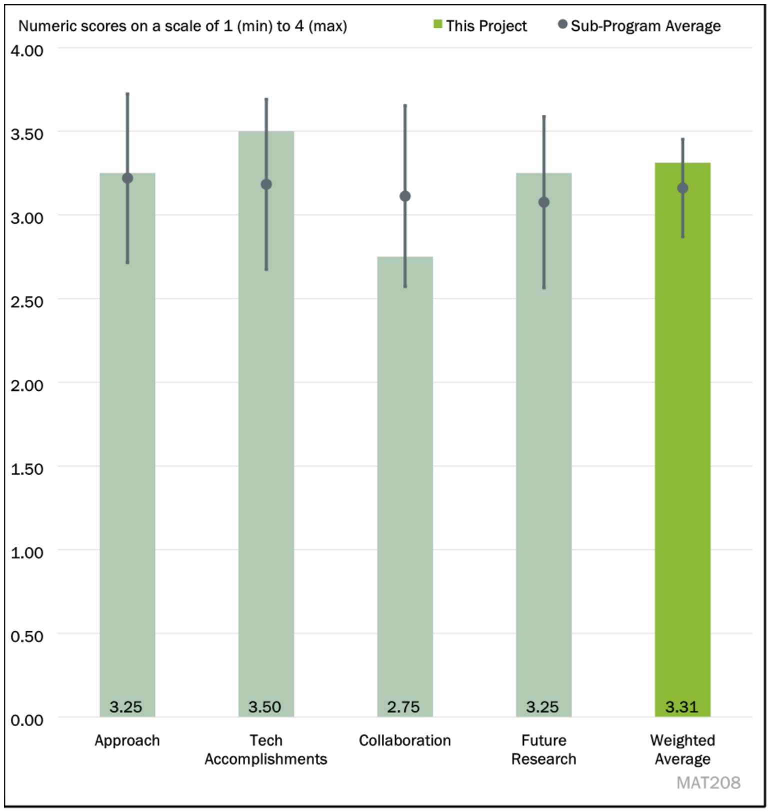

Figure 5-42 - Presentation Number: MAT208 Presentation Title: Efficient Synthesis of Kevlar and Other Fibers from Polyethylene Terephthalate (PET) Waste Principal Investigator: Daniel Merkel (Pacific Northwest National Laboratory)

Presenter

Daniel Merkel, Pacific Northwest National Laboratory

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.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer noted that the project aims to fabricate Kevlar fibers from polyethylene terephthalate (PET) waste. While the initial approach was good, the project ended up recovering terephthalic acid from PET and conducting the same chemistry and fiber spinning process as the current manufacturing of Kevlar. The reviewer agrees that it is worthwhile to gain the capability to de-polymerize PET, synthesize polyamide, and spin fiber to Kevlar. However, the concept of the current research will not have a significant impact. PET waste-based terephthalic acid may already be available from PET producers, rendering the depolymerization process of limited value. Thus, unless the project can have more added advantages, the strategy may not provide a significant practical advance to the industry.

Reviewer 2:

This reviewer believed that the team has a good approach to using a mixed PET waste stream to synthesize aramid fibers as a route to potentially lower their cost. Good characterization work has been performed on the synthesized material prior to fiber spinning, and it seems that the team has figured out the proper material synthesis approach to perform the spinning tasks. And the team showed good fiber spinning results.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer recounted how the initial approach of PET depolymerization did not provide satisfactory molecular weight and the team had to pivot the approach. Considering that setback and needing to figure out fiber spinning conditions, etc., the team made reasonable progress.

Reviewer 2:

This reviewer found great progress in overcoming some of the fiber spinning challenges that existed at the time of last year's AMR presentation. The team put together good quantifiable milestone targets to assess the success of the project. All milestones seem to have been successfully met and the project looks to be on schedule. Poly-paraphenylene terephthalamide has many challenges to characterize due to the solvents required to dissolve this material. Encouragingly, the team found a good alternative to performing traditional molecular weight characterization.

Question 3: Please comment on the collaboration within the 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 a good collaboration with Washington State University was established. Another collaboration may be needed to perform single fiber testing at different strain rates. If this research continues, single fiber tensile testing would be desirable.

Reviewer 2:

While Washington State University is listed as a partner, their role is not clear to this reviewer. There is no clear indication of active collaboration.

Question 4: Please comment on the 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 was reasonable to this reviewer. Performing TEA/LCA is good; however, the team needs to carefully think through what technological novelty this project provides. Unless PET can be depolymerized much more effectively than the current state of the art or a completely new process to produce Kevlar can be developed, this project has minimal novelty.

Reviewer 2:

The proposed future work was clearly defined for this reviewer, but some tasks may be very ambitious to perform by the end of the project. The fiber spinning optimization requires a lot of effort. Composite fabrication may be an ambitious target since so much material will be needed to fabricate a bulk-scale composite. The new spinning setup will definitely help with producing enough fiber for a composite, but it will still require significant spinning effort to produce enough highly consistent fibers. And, typically, aramid fibers are produced as woven fabrics, which is hard to perform at a laboratory scale. Composite fabrication is an appropriate goal to end the project. The results from the TEA at the end of the project to evaluate how this waste PET approach compares to existing aramid fiber costs could be interesting.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believes that the project is relevant, but the team needs to revise the strategy.

Reviewer 2:

According to this reviewer, the project is very relevant to the VTO Materials subprogram objectives by producing cheaper fibers for vehicle lightweighting using an approach that can utilize waste materials.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer commented that the team acquired various equipment and has had sufficient funding to conduct the research.

Reviewer 2:

This reviewer considers the resources sufficient to achieve the stated milestones in a timely fashion to end this project this year.

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)

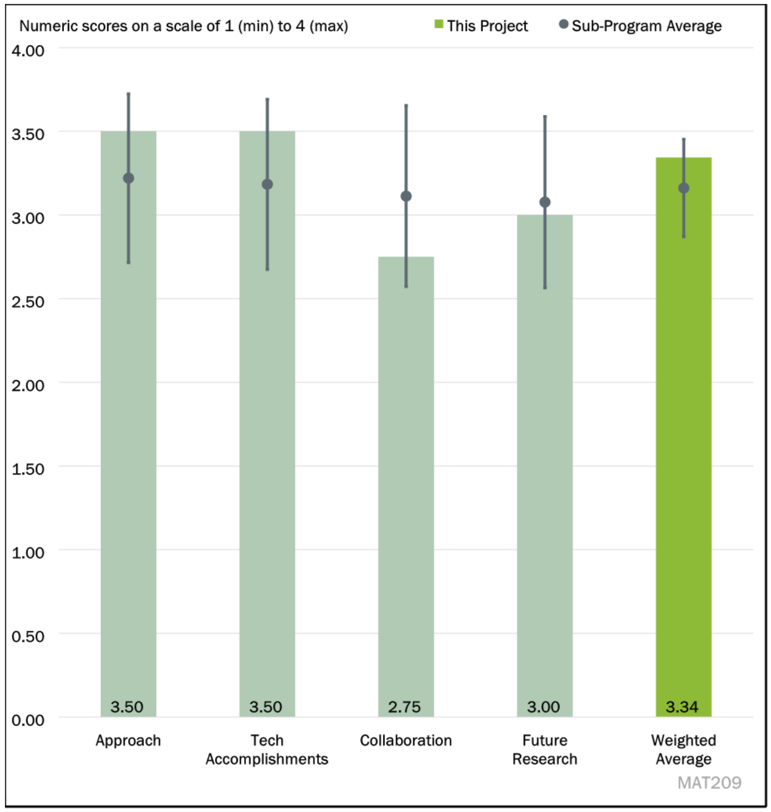

Figure 5-43 - Presentation Number: MAT209 Presentation Title: Bio-based, Inherently Recyclable Epoxy Resins to Enable Facile Carbon-Fiber Reinforced Composites Recycling Principal Investigator: Nicholas Rorrer (National Renewable Energy Laboratory)

Presenter

Nicholas Rorrer, National Renewable Energy Laboratory

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.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The project provides an approach that is interesting to this reviewer for the development of bio-derived composites that provide the additional benefits of being designed for chemical recycling. Beyond recovery of the polymer constituent, this approach also lends itself to recovery of the reinforcing fiber, which could represent significant added value, depending on the type of fiber used.

Reviewer 2:

This reviewer found the approach to create covalently adaptable networks and CFRPs from bio-based building blocks is good, especially for achieving low GHGs. Also, the LCA clearly shows recycling CF will significantly reduce GHG and energy input. The overall approach is good, although the team will probably need to readjust various aspects of the technology to make it commercially viable. For example, while the presenter mentioned that the target mechanical performance was to achieve equivalence to that of epoxy based CFRPs, it was not perfectly clear to the reviewer what exact target performance (values) this project is pursuing. Depending on the specific use and specific vehicle parts, the required mechanical properties will differ. Additionally, requirements for long term stability and hydrolytic stability are unclear. Once the team can evaluate various aspects and properties, this concept can go to a much higher TRL, according to the reviewer.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer observed that the data reported demonstrate significant progress towards the overall project objectives. Production of sample composite panels for testing was demonstrated in addition to recovery of the fiber preforms. These were used in subsequent trials to demonstrate repeated recycling loops and maintenance of mechanical properties. One potential drawback is the emphasis on resin infusion, which may not be well suited to a broad array of geometries encountered in automotive applications. However, this limitation may not exist in other industry sectors.

Reviewer 2:

This reviewer found that the team accomplished creation of thermoformed parts along with a detailed LCA/TEA. Overall progress and technical accomplishment are good. Especially, LCA results will be very helpful to be shared in the community to understand the impact of CF resins, as well as their recycling. There are potential concerns to this reviewer on the thermo-mechanical properties, which the team should consider addressing. The data showed Tg around 70^{o}C–80^{o} C, which is on the low side. While such low Tg helps processability, it raises concerns that the thermal stability could be too low for the resins to be used for some vehicle parts. From the dynamic mechanical analysis curve, the CFRP could start softening at 60^{o}C or so (depending on frequency). The team should consider raising Tg to 100^{o}C–120^{o}C range. Another potential issue is that the spider chart may be masking some of the properties. To demonstrate the CFRP to be usable for vehicles, the team needs to consider various tests to satisfy the safety requirements of OEMs.

Question 3: Please comment on the collaboration within the 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 NREL team showed extensive collaboration from academia, industry and the national laboratories.

Reviewer 2:

It seemed to this reviewer that there are internal collaborations with NREL's project Bio-Optimized Technologies to keep Thermoplastics out of Landfills and the Environment (BOTTLE) or other projects, but that there is limited collaboration outside of NREL.

Question 4: Please comment on the 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 development of the thermoforming approach has the promise to expand the range of applications beyond that of resin infusion and would provide more flexibility in material processing. Scale up of operations will also provide further data to determine the type and cost of capital infrastructure required for implementation in the field.

Reviewer 2:

This reviewer noted that the team will be able to meet the planned milestones. The reviewer believes, however, that it will be more beneficial to meet a very clear target of mechanical properties as well as stability to satisfy the stringent requirements for vehicle parts.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer found that the work reported is aligned with the VTO mission statement.

Reviewer 2:

This reviewer considered that the project scope (bio-based resins as well as covalently adaptable networks) is highly relevant. This is one of the best ways to transform CFRP technology toward low carbon and circular technology.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The team appears to this reviewer to have staffed the project sufficiently to complete all milestones and deliverables within the timeframe of the original project proposal.

Reviewer 2:

This reviewer opined that the team has good resources to conduct all the experiments, LCA and TEA, and will be able to execute all the planned activities.

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)

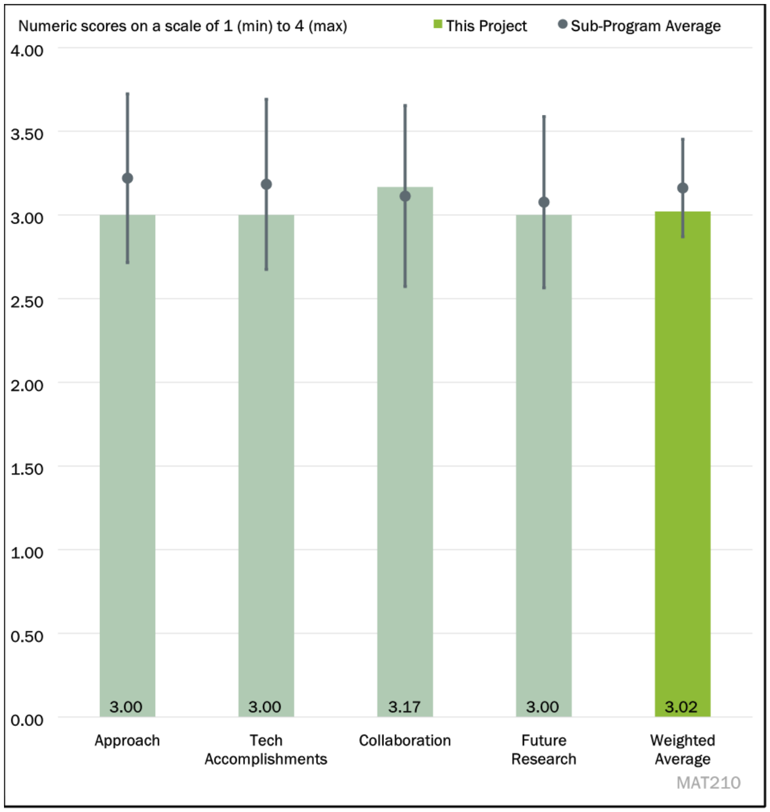

Figure 5-44 - Presentation Number: MAT210 Presentation Title: A Novel Manufacturing Process of Lightweight Automotive Seats - Integration of Additive Manufacturing and Reinforced Polymer Composite Principal Investigator: Patrick Blanchard (Ford Motor Company)

Presenter

Patrick Blanchard, Ford Motor Company

Reviewer Sample Size

A total of 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.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

According to this reviewer, the proposed approach is very good and the integration with Ford is outstanding. The reviewer states a personal view that AM is not compatible with automotive manufacturing rates and believes that this work has shown that to be true.

Reviewer 2:

This reviewer found the work plan to be appropriately scoped and well executed, taking advantage of Ford baseline experience and ORNL expertise in AM to effectively craft a nice demonstration project integrating modeling and some materials evaluation along with demonstrating manufacturing processes. The reviewer is unclear as to whether the project had defined quantitative goals to measure against. Although in-line sensor integration and smart systems work were identified in the objectives of the project, there was no discussion of that work being performed during the currently completed project – just mention of these items for future work.

Reviewer 3:

This reviewer considered the approach to develop composite structures integrated with AM is good. The project attempted to address the technical barriers as listed. However, the reviewer is unclear as to whether the technology demonstration was purely virtual or involved tangible demonstrations at the component/seat back level. The control of fiber orientation in making the AM preform was mentioned, but no details were provided regarding how the orientation information was determined. The reviewer believes that the AM material was co-molded with CF material. The reviewer raises the question about any concerns regarding corrosion.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer pointed out that, although delayed by COVID, efforts coalesced well to demonstrate a route to increasing stiffness while reducing weight in the demonstration article. (It might have been even more impressive for the reviewer if the demonstration article had been tested as planned.) This reviewer appreciated hearing the candid assessment of status of the technology readiness vis-à-vis near-term production insertion, notwithstanding the showing of an enhanced structure using the novel approach.

Reviewer 2:

The reviewer commented that the team has made good progress although the development has shown the cost savings per pound are very high.

Reviewer 3:

This reviewer reported that the average stiffness determined from the samples is around 9.1 GPa (Slide 6), and the strength is 76.4 MPa (Slide 7). These values are very low compared to a commercially-available sheet molding compound, which would perform better and be cheaper. The reviewer asks, therefore, why this material was chosen to integrate with AM materials for the seat back. The stiffness of the composite seat back with a fully filled interior space and metal insert is around 930 N/mm (Slide 10). These values are lower than the metallic design (1100 N/mm), raising doubts for the reviewer as to whether this composite design has met the requirements. Overall, the reviewer believes that reducing the weight by 1.7 kg is good; however, the price increase per kilogram saved of $90.5/kg is very high and the reviewer asks whether there are any plans to reduce this price increase.

Question 3: Please comment on the collaboration within the 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:

Although the reviewer felt that interfaces and interactions were not fully defined in the presentation, the reviewer believes that the collaboration went well regardless of the severe COVID-related perturbations. The reviewer considers this work to be a good example of effectively introducing laboratory R&D into a real-world application for assessment of technology capabilities versus readiness.

Reviewer 2:

The team is very strong, according to this reviewer.

Reviewer 3:

This reviewer offered praise for good collaboration between Ford and ORNL.

Question 4: Please comment on the 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 pointed out that the project is complete so the future research description would require follow-on funding to be proposed later. The items identified are considered by the reviewer to be definitely worthwhile but are more directed to providing longer-term research data than pointing towards addressing roadblocks in implementing the demonstrated approach into production.

Reviewer 2:

This reviewer noted that the project has been completed.

Reviewer 3:

This reviewer observed that no future work was proposed as the project was completed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believed that the project provides good insight into possibilities for enhancing performance and reducing vehicle weight along with assessment of the TRL for implementing this approach into production.

Reviewer 2:

Lightweighting is believed by this reviewer to be critical for future vehicles.

Reviewer 3:

This reviewer stated that the project is very relevant in developing new materials for lightweighting and increasing the efficiency of the transportation sector.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer noted that an effective technology demonstration has been completed. Perhaps with more funding, the demonstration article could have been tested, but it is not clear that data would have changed future work in this area.

Reviewer 2:

This reviewer found that the project was completed with the resources provided.

Reviewer 3:

This reviewer concluded that the project had sufficient resources for executing this project.

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 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.

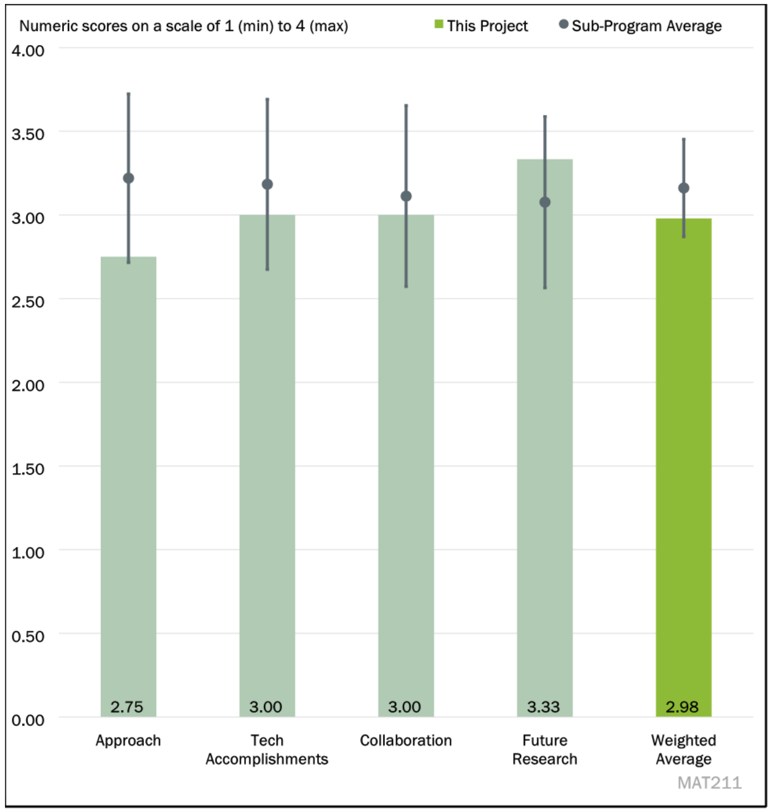

Figure 5-45 - Presentation Number: MAT211 Presentation Title: Sustainable Lightweight Intelligent Composites (SLIC) for Next-Generation Vehicles Principal Investigator: Masato Mizuta (Newport Sensors, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The technology for damage detection appeared to this reviewer to require wide coverage or integration of sensors across a large area to be effective. For this to be practical, the researchers need to address the potential cost ramifications. In addition, the reviewer holds that, while use of a natural fiber core may offer some mass savings, there is no way of knowing the robustness of these materials in hostile service environments. Trimmed parts would need some form of edge protection in order to mitigate moisture ingress.

Reviewer 2:

This reviewer described how, in this project, a sensor is developed with natural fiber core and CF-hybridized strain monitoring sensor skins. The team has demonstrated the sensitivity of the sensor for tensile, flexure, and impact loading. The work aims to develop sustainable solutions. Overall, the studies have focused on static loading conditions. The work is largely conducted at a coupon level. The pathway for adoption by OEMs is not clear to the reviewer although the presenter mentioned that an OEM may be interested.

Reviewer 3:

The technical barriers and challenges were clearly outlined and addressed for this reviewer. However, the reviewer did not see much novelty in the use of a surface-adhered PVDF sensor integrated with a strain sensor on the surface of a CF composite with a natural fiber core. PVDF sensors have been previously demonstrated as sensing elements that can be adhered to the surface of composites. Additionally, this type of sensor adds weight to the composite without contributing any mechanical benefits, so they do not necessarily contribute to the lightweighting effort for vehicles.

Reviewer 4:

This reviewer pointed out that the project uses two types of sensors (static and dynamic). However, the reviewer was unclear as to why both are needed. In other words, the necessity of using two sensors within a single part was unclear to the reviewer. The response of both sensors was limited to the applied location, and therefore to observe the health of the whole structure, the whole structure or multiples of these sensors would be required. A cost analysis is required.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer pointed out that the robustness of using natural fibers for a bumper application will need to account for weather exposure and any potential failure modes. Furthermore, the team did not present any methodology for making rapid connection to the embedded sensing. This will be a requirement for any type of final implementation.

Reviewer 2:

The team accomplished all milestones in a timely manner, according to this reviewer. However, the reviewer believes that more sensor data could have been presented to show the effectiveness of the sensors. More data are needed to prove that the sensors will work in real-world scenarios.

Reviewer 3:

This reviewer referred back to some of the points mentioned above as applying to progress made. The team calls the sandwich construction natural fiber core and carbon/sensor skins as the novel sustainable lightweight intelligent composites technology and claims enhanced crashworthiness. Overall, the scientific approach of the work is very good and systematic. The challenge, according to the reviewer, will be implementation on a large scale. As an example, the water ingression, long-term durability, adhesion to the substrates, the form that the sensor will deliver for a structure (number, size, placement), measurement control unit (location, placement), and cost are unknowns at this point. The value of the work will be truly realized when all these questions get addressed. Presently there are many sensors on the market, and the utility of this technology (besides having a natural fiber core) was not fully clear to the reviewer.

Reviewer 4:

This reviewer found that the project successfully demonstrated that both types of sensors could be applied to composite structures for structural health monitoring, and preliminary data supports the hypothesis of early damage detection.

Question 3: Please comment on the collaboration within the 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 stated that the team has reported adequate collaboration across the team. However, moving forwards, the team should seek guidance from potential Tier 1 and OEM partners regarding a more comprehensive set of requirements.

Reviewer 2:

The team established a good collaboration with the University of North Texas to the satisfaction of this reviewer and the reviewer believed that a lot of work was performed at the university. The collaborative effort can be improved if the team had a tier-one supplier or OEM involved to demonstrate commercialization.

Reviewer 3:

The collaboration identified by this reviewer is between Newport Sensors and the University of North Texas. The testing/characterization is largely conducted by the university and the sensor development is by the company. The reviewer believes this is good, but the identification of the tier 1/OEM's statements are rather vague, so this remains a weakness in this project.

Reviewer 4:

This reviewer found that there is additional scope to improve collaboration and work with some leading OEMs. On Slide 14, the presenter mentions that the team has reached out to multiple OEMs and Tier 1 suppliers. The reviewer would be interested in seeing how these interactions could be turned into tangible collaborations in the near future.

Question 4: Please comment on the 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 indicated that the work to date does not address any concerns related to cost. Therefore, a detailed understanding of the TEA will be essential to validate commercial feasibility of any proposed application.

Reviewer 2:

This reviewer thought that the remaining challenges and barriers were clearly discussed. The team plans on fabricating a small-scale bumper beam for demonstration purposes was good. As proposed, the manufacturability and TEA are crucial to understand the commercialization feasibility for this technology.

Reviewer 3:

This reviewer noted that the project is ending in August 2023. The team indicated that some of the compression molding trials will take place through a future Small Business Innovation Research (SBIR) grant. Hence, the reviewer considers the future work question to be not appliable.

Reviewer 4:

The reviewer stated that the project aims to demonstrate the technology to more significant automotive parts (e.g., bumper beams). Applying these sensors to curved surfaces or more complex geometries than flat surfaces will be great because most damage initiation occurs from the highly stress-concentrated regions.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

According to this reviewer, maintaining the structural integrity and health monitoring of composite structures is essential to create confidence in the composite systems for load-bearing applications.

Reviewer 2:

The project provides an approach to strain monitoring and impact detection, according to the reviewer. However, the total cost of implementation is unclear to the reviewer and a broad array of sensors may be needed to detect localized damage to components. This could render the technology too expensive for automotive applications due to on-going cost constraints.

Reviewer 3:

This research is relevant for tracking damage within a composite, but it adds weight to the system, which goes against the VTO's objective of lightweighting. Using a natural fiber core can serve the lightweighting objective, but the focus of this work seemed to be on the sensing aspect, which adds weight to the system.

Reviewer 4:

This reviewer said that, while the work applies to materials, electrification, and energy savings in general, the development is actually more on the sensing side.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer confirmed that sufficient resources have been deployed to progress the project towards the final milestones and deliverables.

Reviewer 2:

The team has had sufficient resources to conduct this project, according to this reviewer.

Reviewer 3:

This reviewer considered that the project has sufficient resources to achieve the proposed goals.

Reviewer 4:

This reviewer found that the resources are sufficient to achieve the milestones of the project. The reviewer observed that the funds are almost excessive to achieve the milestones.

Presentation Number: MAT212
Presentation Title: Integrated Self-Sufficient Structurally Integrated Multifunctional Sensors for Autonomous Vehicles
Principal Investigator: Amrita Kumar (Acellent Technologies, Inc.)

Presenter

Amrita Kumar, Acellent Technologies, Inc.

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.

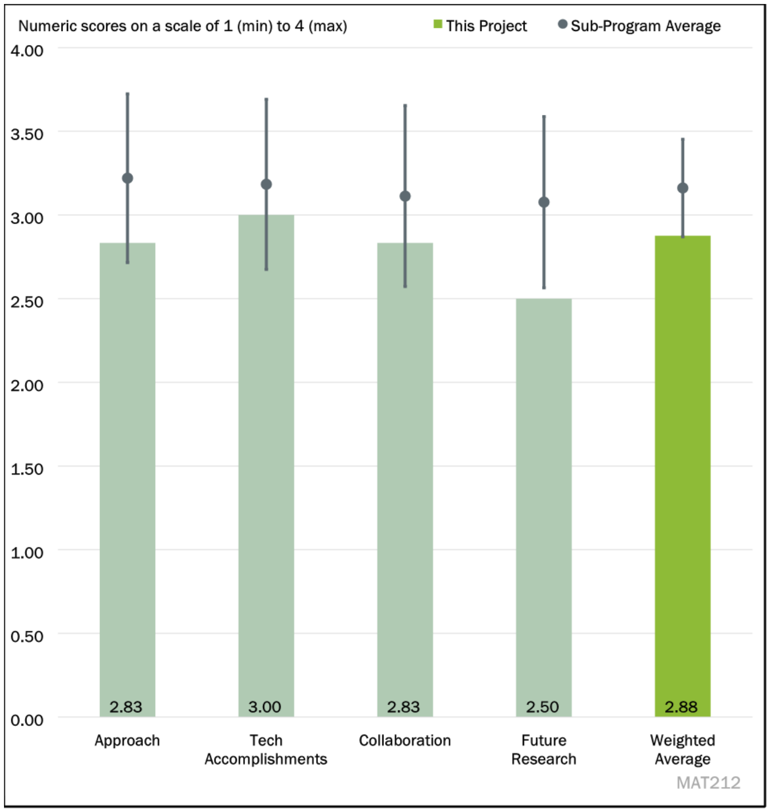

Figure 5-46 - Presentation Number: MAT212 Presentation Title: Integrated Self-sufficient Structurally Integrated Multifunctional Sensors for Autonomous Vehicles Principal Investigator: Amrita Kumar (Acellent Technologies, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found that the team took an innovative approach to instrument a plastic bumper with accelerometers and then train the control system to identify a unique signal as part of the pedestrian protection system. There remains a concern by this reviewer that false positive recognitions (such as an animal strike) or false negative recognitions could endanger passengers or pedestrians. Additional sensor information (including low-cost vision systems) integrated with the novel accelerometer data could improve the overall effectiveness of such a device. The team could have done a better job comparing the advantage of the battery state-of-health monitoring system vis-à-vis traditional fault monitoring using conventional voltage/amperage monitoring circuits. A clearer picture of methods used to determine the state of health would be useful to the reviewer.

Reviewer 2:

This reviewer determined that some progress has been made in the project in overcoming the barriers and meeting the proposed technical targets. The development of multifunctionality in composite materials is critical for reducing the overall cost at the system level, and this project attempted to achieve that by developing a pedestrian crash sensing system to detect impacts occurring on the front bumper.

Reviewer 3:

The reviewer pointed out that the project relies on contact-based detection. This form of detection is believed by the reviewer to be already too late to deploy in any current passenger protection system. For example, the vehicle's speed and the size and weight of the object (human) that gets hit will have a different response. Not everything that will get hit with the bumper will fall on the bonnet. Therefore, this project has many assumptions, and practical success is highly limited to some scenarios of crash/pedestrian protection system and would have been more impactful to have non-touch-based system.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The research team appears to this reviewer to have accomplished the tasks identified in its project proposal. Further test data collected for the proposed battery monitoring system is anticipated and should provide a better picture of the utility of the state-of-health monitoring and relate to battery performance and state of charge.

Reviewer 2:

This reviewer described how preliminary data suggest that the sensor can detect the difference in single peak frequency of pedestrian and non-pedestrian objects. Therefore, the technology has the potential to detect the pedestrian in certain experimental conditions. More experimental variables need to be studied to build a credibility of the current technology.

Reviewer 3:

The reviewer was unclear as to whether pedestrian and non-pedestrian impacts are determined based on the peak frequency measured at the piezo sensor, and, if so, whether this is true for all the sensors located on the bumper, as well as what characterizes the low peak frequency for non-pedestrian objects. On Slide 13, the presenter mentioned that novel energy methods were developed to classify pedestrian and small animal objects. The reviewer considers that providing more details would be helpful. Regarding battery monitoring, the presenter did not explain how the signal envelope becomes smaller when the state of charge is lower or at what frequency these guided waves need to be used. It is also unclear whether the piezoelectric sensors are located on the pouch cells and, if so, whether they are bonded to the pouch cells. The multi-functional energy storage composite skateboard shown on Slide 18 is a combination of composite and battery. The reviewer was unclear as to what was demonstrated on this slide regarding the multifunctional ability of composites. On Slide 19, the reviewer is not clear what $\alpha 1$ and $\alpha 2$ represent. Overall, the progress was expected by the reviewer to be more significant.

Question 3: Please comment on the collaboration within the 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 applauded good collaboration between Acellent, Ford, and Stanford University.

Reviewer 2:

This reviewer noted that although project partner, Ford Motor Company, is named and the bumper instrumented appears to the reviewer to have been sourced from Ford, there is little information provided in the reporting that suggests significant interaction between the two organizations. Similarly, there seems to the reviewer to be no relationship between the reporting team and Ford related to the battery monitoring system, which integrated a relatively small storage system consisting of ten cells used to power a skateboard. No specific scaling to an automotive or analogous battery system is referenced. This could impact the ability to commercialize the technology to full-scale automotive systems, according to the reviewer.

Reviewer 3:

The contribution of the other partner was not clear to this reviewer, who also feels that a better explanation of the work scope of each partner is needed. Stanford is working under a different funding program. The link between this work and Stanford's work is not clear to the reviewer.

Question 4: Please comment on the 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 was not clearly provided in the AMR report. The reviewer believes that the functionalities of state-of-charge and state-of-health will be studied, but how this will be accomplished is not mentioned.

Reviewer 2:

This reviewer pointed out that there was no slide on future work, possibly because the project is on the verge of completion.

Reviewer 3:

This reviewer recounted how the team reported that 80% of the work on this project is complete (in June 2023) and the end date of August 23, 2023, is identified for completion. There was no proposed future work identified in this review or any gaps identified that need to be addressed in future work. This, the reviewer considers to be a shortcoming of the project whether the remaining 20% level of effort to be completed is addressed or (more importantly) suggestions for effort needed to commercialize in a potential Phase III technology commercialization phase.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believed that the proposed project supports the overall VTO objectives of developing multi-functional capabilities of materials to increase efficiency in the transportation industry.

Reviewer 2:

This reviewer indicated that the relevance is modest, but creating and demonstrating integrated sensor technology is important for future automotive materials, where incorporating functionality in the form of embedded systems will enable extended capability and bring greater value to these advanced materials.

Reviewer 3:

This reviewer pointed out that the project aimed to develop a battery monitoring system for EV cars. The innovative battery management system will provide information on the state-of-charge and state-of-health of batteries with high precision. As far as the reviewer understands, the pedestrian protection system is not directly related to VTO objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer affirmed that the project has adequate resources in executing the project.

Reviewer 2:

This reviewer determined that the project has sufficient resources to achieve the proposed goals.

Reviewer 3:

Based upon the accomplishments reported by the principal investigator, this reviewer understands that funding/resources were sufficient to complete the objectives of the program. Additional funds might have allowed for a more realistic (at scale) build of a higher capacity batter system for the state-of-health monitoring, but the reviewer opines that this first step to demonstrate the system capability was likely a prudent approach.

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, Oak Ridge National Laboratory

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.

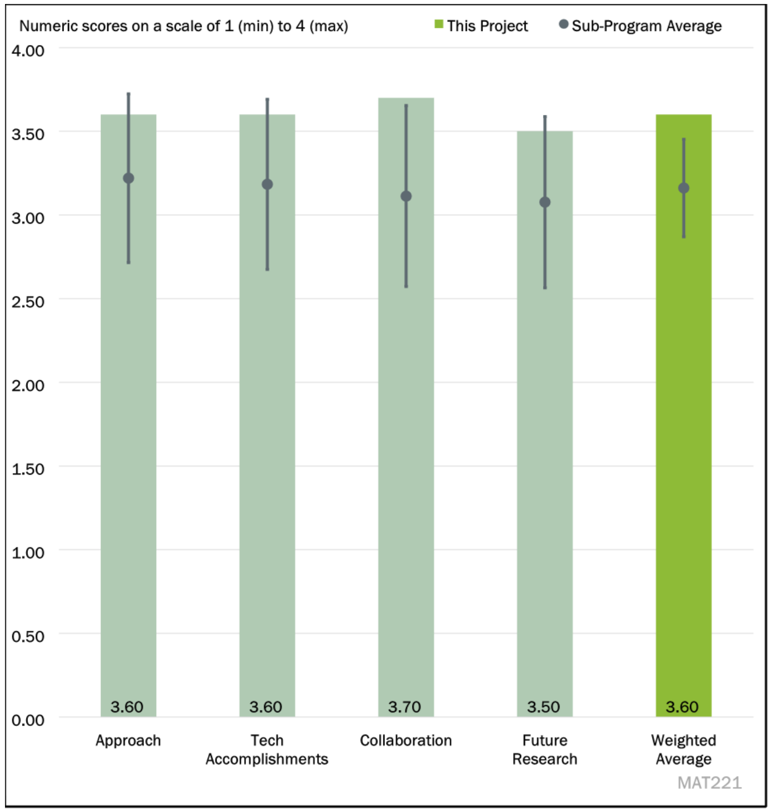

Figure 5-5 - Presentation Number: MAT221 Presentation Title: Lightweight and Highly-Efficient Engines Through Al and Si Alloying of Martensitic Materials Principal Investigator: Dean Pierce (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer considered that the key target for the project was optimization of the strength, thermal conductivity, and oxidation resistance of engine alloys. The project included use of computational modeling and experiments to develop new compositions. Finally, the technology performance was demonstrated on engine prototypes. According to the reviewer, the progress and deliverables for the project have been quite impressive.

Reviewer 2:

This reviewer pointed out that the project is addressing the heavy-duty vehicle sector to improve the state-of-the-art diesel engines to enable efficient use of lower carbon fuels. This is needed since the heavy-duty vehicle sector is difficult to electrify, with significant trade-offs occurring between battery weight, payload weight, and vehicle range. As such, the work being done by the ORNL lead team is needed to help with the introduction of low carbon fuels in over-the-road trucks. Using alloys can increase strength and provide oxidation benefits but results in a decrease in thermal conductivity, which raises piston temperature. The project is attempting to identify and optimize the properties of piston crown steels, which are machinable and weldable and are at an acceptable price point. With peak cylinder pressures and temperatures in the piston exceeding 500°C (the performance limit of 4140 alloy) to obtain higher efficiencies with low carbon fuels, new piston materials are needed to operate in these more severe engine conditions. A two-phased approach to take laboratory developed material to industrial scaleup is being used by the ORNL-led team. Leveraging the integrated computation materials engineering (ICME), laboratory scientists designed approximately 35 alloys that could withstand the conditions encountered in these higher temperature engines. The best candidate alloy was identified (G3-5M). The 4-year structure to bring the materials from start of the research to a commercially ready product can be used as a roadmap for other material development projects.

Reviewer 3:

This reviewer said that the project is very well designed to allow development and engine testing of piston prototypes. The first 2 years focused on laboratory scale research and the last 2 years are focused on industrial scale up.

Reviewer 4:

This reviewer appreciated the clear approach presented, starting from computational exploration to creation of industrially sized heats and experimental evaluation.

Reviewer 5:

This reviewer, noting that a 500-hour soak at 600°C revealed a reduced margin of improvement over 4140 when compared to an “as-fabricated” state, questioned whether long-term stability might be a concern. Heavy duty diesel engines would be expected to operate at high temperatures for an order (and possible multiple orders) of magnitude longer than 500 hours. The computational design component (prior to the down-selection of G3-5M) was not at all clear to the reviewer, who questions what iterations were being examined, what were the specific characteristics and cut-offs for these properties, and what methods facilitated this analysis.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer praised the project as again showing the value of the ICME and the ability to develop new materials needed for higher efficiency operations in both combustion and electrical systems. G3-5M was tested to document the key material properties needed for higher piston temperatures. An 85% increase in strength was demonstrated over 4140 steel at 600°C, along with a 28% increase in strength over H11 (5Cr tool steel) despite much lower alloy content. According to the reviewer, high cycle fatigue is more important than high tensile strength for the piston application. G3-5M showed 107% increase versus 4140 and 30% increase versus H11 in fatigue strength at 600°C after aging at 600°C for 500 hours. G3-5M extends the oxidation resistance at 600°C and demonstrated modest increases in thermal conductivity over H11. Sulfur was added to G3-5M to improve machinability. The challenge remains to replicate these results on scale-up.

Reviewer 2:

This reviewer described how prototype pistons have been manufactured and engine testing with full scale pistons made of the new alloy has been completed. New G3-5M alloy exhibits significant increases in strength (85%), extends the oxidation resistance over 4140 and has modest increase in thermal conductivity over H11 alloys. The G3-5M piston survived a modified peak power output test with enhanced severity in a Cummins X15 X600 production engine.

Reviewer 3:

This reviewer pointed to great laboratory-scale work and microstructural characterization and found that utilizing the split test for direct comparison is extremely compelling.

Reviewer 4:

This reviewer noted that the team had designed and tested a promising alloy that seems to provide improvement over baseline materials.

Reviewer 5:

This reviewer noted that the project successfully achieved the project milestones. The properties achieved for the new alloy composition have been very impressive. The piston prototypes survived the aggressive engine testing. The results from engine oxidation tests, however, were not presented.

Question 3: Please comment on the collaboration within the 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 lauded that the alignment of the project team with a national laboratory lead, ORNL, enables it to leverage unique capabilities from experience with other related projects under Thrust 4 to maximize the investment made by DOE. ORNL is also setting in place the mechanisms needed to commercialize this technology as it develops cooperative R&D agreements (CRADAs) with industry partners. These arrangements are critical to bring this technology to the commercial marketplace. The CRADAs between Cummins and ORNL and the partnership established with Mahle (both industry leaders) sets the groundwork for the transition to commercialization.

Reviewer 2:

This reviewer praised how the strong ORNL team is highly complemented by the addition of a Tier 1 (Mahle) manufacturer and a Tier 1 company that has many of the characteristics of an engine manufacturer OEM (Cummins).

Reviewer 3:

This reviewer noted that the project is being carried out through a CRADA between ORNL and Cummins with piston manufacturing partner Mahle.

Reviewer 4:

This reviewer pointed out that the main gap identified by the researchers was in finding a prospective steel mill for larger production volumes.

Question 4: Please comment on the 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 future work is clearly presented, suggesting, however, that it would be natural for the commercial partners to support the suggested activities. The reviewer was interested to know if there had been any interest from the OEMs/suppliers for investing in it and commercializing/licensing the technology.

Reviewer 2:

This reviewer listed tests to be completed on fatigue, wear, and laboratory scale oxidation. The team will fine tune the chemistry if needed to address any required systems performance improvements in components that are needed during low compression fuel combustion.

Reviewer 3:

This reviewer found that the proposed future research plan is well laid out and seems very feasible, given that the project is in its 4th and last year. Remaining tasks include characterization of engine tested pistons in addition to fatigue, wear, and oxidation testing, as well as developing a detailed final report.

Reviewer 4:

This reviewer identified the future research as mostly composed of closing out planned testing. Exploration of expansion into other applications seems good to pursue if commercialization is possible.

Reviewer 5:

This reviewer was not convinced on the wear testing needs disagrees with the utility of thermal fatigue (past reviewer comment) on heavy-duty pistons for diesel applications. The reviewer concluded that the path seems appropriate.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirmed that the project is in line with VTO Materials subprogram objectives and is an industry CRADA with Cummins.

Reviewer 2:

This reviewer believes that the project is directly relevant to the VTO Materials subprogram objectives.

Reviewer 3:

This reviewer characterized the work as a classic performance problem being solved through materials R&D.

Reviewer 4:

This reviewer stated that the project identifies and addresses a near term gap in energy efficiency for heavy duty vehicles, which will likely remain dependent on fossil fuels.

Reviewer 5:

This reviewer opined that the project is relevant and important to the VTO, especially with regards to GHGs by operating the heavy-duty vehicle engines at higher temperatures and more efficiently. This is particularly important since electrification of heavy-duty vehicles with large payloads is still uncertain.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer noted that the budget includes only a $150,000 DOE contribution with $350,000 cost share from Cummins via the CRADA for a project with significant technical achievements.

Reviewer 2:

This reviewer believes that the project again illustrates the unique value of the ICME. This project has overcome material challenges encountered during high efficiency combustion. The performance characteristics of this alloy permit engine builders to adapt their engines to use low carbon fuels. The use of CRADAs should continue to be encouraged to allow industry to invest in this promising research. DOE should also identify other possible applications for this alloy and its unique performance characteristics.

Reviewer 3:

This reviewer thinks that the resources seem adequate, noting that not a lot of time remains if extensive fatigue testing is planned.

Reviewer 4:

This reviewer commented that there are no limits to the successful completion based on resources identified.

Reviewer 5:

This reviewer said that the project funding for the laboratory seems to be fine.

Presentation Number: MAT222
Presentation Title: Extending Ultrasonic Welding Techniques to New Material Pairs
Principal Investigator: Jian Chen (Oak Ridge National Laboratory)

Presenter

Jian Chen, Oak Ridge National Laboratory

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.

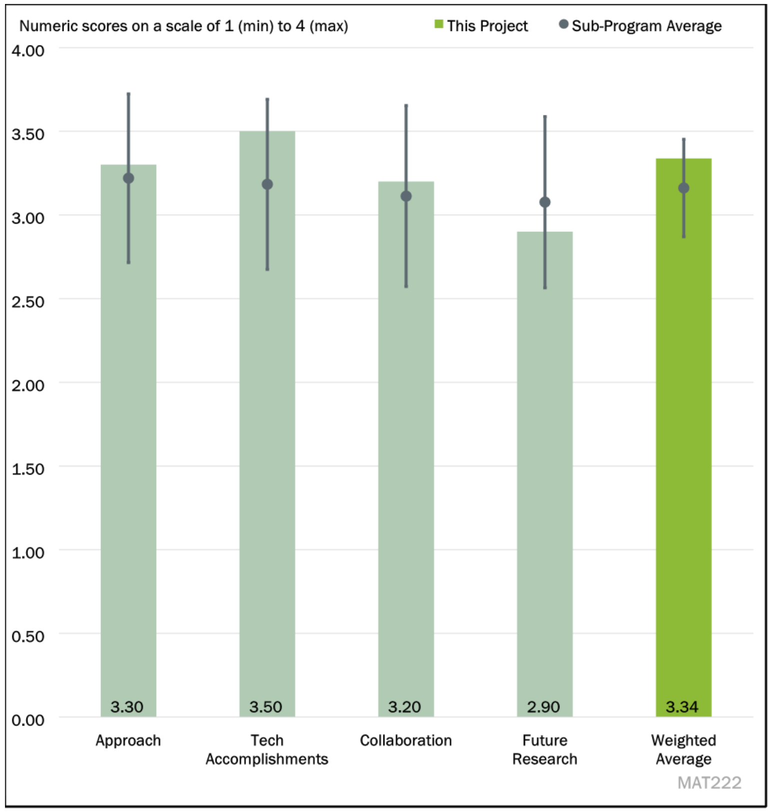

Figure 5-6 - Presentation Number: MAT222 Presentation Title: Extending Ultrasonic Welding Techniques to New Material Pairs Principal Investigator: Jian Chen (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found the project approach, which includes a model-based engineering strategy to guide the development of a novel ultrasonic welding (USW) process using *in situ* measurements, post-weld characterizations and modeling to be a good one.

Reviewer 2:

This reviewer commented that substantial effort has been placed on evaluating the process of USW. This includes finding relationships between process parameters and mechanical performance and developing creative *in situ* measurement techniques. One important barrier of translating parameters determined on single joints to multiple joints has been addressed.

Reviewer 3:

This reviewer shared that the project does a nice job of surveying various techniques using USW to address the problem of multi-material joining. The results for all materials combinations appear promising. Since the last review, the researchers have established a close-looped processing parameter set to make multiple joints in a row, based on thermal characteristics that align with button size. The demonstration showed that this technique can work on different material stack-ups for a line of welds. Given the use of thermal characteristics, a demonstration of using the USW control approach using different thicknesses of sheet material would have been useful to see. The ultrasonic rivet joining (URJ) approach was an important addition to extending this technique to CF reinforced polymers (CFRP) joined to Al. The selected materials were appropriate for the study and the results look promising.

Reviewer 4:

This reviewer noted that the original objective was to extend USW from coupons to multi-weld components. In the first year, a directional effect (longitudinal vs transverse) was noted but neither the underlying physics nor how it could be taken advantage of was investigated. This seems to the reviewer to be a missed opportunity, especially when considering the constraints imposed on multi-joint structures. In year 3 an *in situ* characterization technique was developed which the reviewer finds very interesting. In fact, the reviewer sees an opportunity to apply that to further investigate this directionality issue. The project, however, focused on expanding to multi-material combinations, which corresponds to a quite specific objective stated in year one vs a more general objective stated for years two and three. The corrosion aspect is a good opportunity for collaboration, but since it was not originally planned for and was included in the reports, the reviewer is concerned that the budget which could have further advanced the stated project objective was spent on that. The expansion to CFRP/Al joints was included in the original planning but because this project did not include a clear manufacturing readiness level (MRL) as part of the objective, the reviewer finds it is not possible to make a comment on planning to this effect. For example, an issue of the horn design was highlighted but it was not made clear what the fundamental issue was leading to this problem. Regardless, the reviewer believes that the interaction of horn design and quality should be further investigated.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer noted that significant accomplishments in the least year include *in situ* interface characterization of USW, joining immiscible Mg to bare steel, a predictive tool to correlate temperature with joint strength, new model-based approach to determining process parameters for welding large coupons, and a patented URJ approach to join metal/polymer.

Reviewer 2:

This reviewer stated that the technical progress is aligned with project plan.

Reviewer 3:

This reviewer pointed out that the team has accomplished quite a bit, particularly in the USW control study.

Reviewer 4:

This reviewer found that most targets have been achieved or are on track but does not see, however, a close interaction with the industry.

Reviewer 5:

This reviewer commented that the project has covered a significant amount of ground and made significant progress towards overcoming the issue of extrapolating the USW process from a single coupon to a multi-weld joint. For example, the team states that it has developed a very different and innovative approach to monitoring and controlling the USW process to ensure consistent joint strength and quality under different pitching distances and locations of multiple spot welds at the part/component level. Unfortunately, the presenter does not provide a clear explanation of what that process is. For example, the presenter states that the process consistently monitors process signals and gives a diagram with a “sensor” on the sonotrode. Yet, the presenter then goes on to state that the predictive tool correlates temperature with joint strength. However, it is not explained how temperature is derived from the continuously monitored process signals. Despite this, the work on developing correlations of process and strength and defining good/bad welds based on threshold values is of great importance.

Question 3: Please comment on the collaboration within the 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 saw appropriate collaboration among partners by ORNL, the project lead, leveraging PNNL advanced electron microscopes and Argonne National Laboratory (ANL) advanced X-ray synchrotron source. The team also mentioned proactively engaging with the industry partners to further mature the process.

Reviewer 2:

This reviewer noted that contributions appear to be made and collaboration carried out by the partners.

Reviewer 3:

This reviewer commented that the partners seem well coordinated in the experimental work and the simulation work.

Reviewer 4:

This reviewer opined that the coordination is good between projects, giving as an example that this work is feeding the corrosion project which was a separate project in itself. However, it is unclear to the reviewer whether this diverted significant resources from this project’s stated goal. As a side note, since adhesive does provide an inhibiting role in corrosion, further work on the impact of wet adhesive at the faying interface on the USW process is necessary.

Reviewer 5:

This reviewer believes that closer contact and collaboration between the laboratories and also some collaboration with academia would be desirable. ORNL seems to perform most of the activities.

Question 4: Please comment on the 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 identified future research to be appropriate, considering that project completion in Fiscal Year 2023 includes refining URJ process conditions with the new rivet and sonotrode design, as well as extending it to join large structures and achieve an average joint strength at least 80% of the reference strength obtained on single-joint coupons.

Reviewer 2:

This reviewer was concerned that a detailed plan for future work does not seem to have materialized. A look at different materials and a new sonotrode design are mentioned but details are not planned. Additional tasks may be to look at corrosion in detail and to develop at least one real-life application that would be undertaken with the industry.

Reviewer 3:

This reviewer finds that the focus on extending the URJ approach is great but thinks that there is a lot more work that can be done on the USW controls side in terms of stack-ups and extending the process to something more industrially capable.

Reviewer 4:

This reviewer stated that the project is nearly complete. The project did have clear go/no-go decision points outlined in the project plan. Because this project covered a significant amount of work, the reviewer recommends that the final project report detail the various technology questions identified and investigated and assign MRLs as well as what remains to be addressed to move the technology to the next level. This would strongly support off-shoots of additional projects and help industry understand the technology and potential opportunities.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirmed that the project supports the VTO materials subprogram objectives as it is investigating multi-material joints with two variants of ultrasonic welding to achieve vehicle lightweighting for improved energy efficiency.

Reviewer 2:

This reviewer believes that solutions to vehicle construction involve multi-material systems; joining dissimilar metals especially solid-state joining is very important.

Reviewer 3:

This reviewer said that development of a joining technology for multi-joint assemblies composed of lightweight materials addresses one issue for moving this technology towards industrial applications, whereupon its implementation would support mass reductions and thus reduction of GHG emissions in addition to increasing the range for EVs from those mass reductions.

Reviewer 4:

This reviewer found that the project is aligned with the Materials subprogram.

Reviewer 5:

This reviewer pointed out that multi-material joining is a key enabler for lightweighting technologies. This project uses extensive experimental work to provide a closed-loop way to change parameters quickly without advanced planning to address the weld button in a line of joints. It would be useful to see an industrial partner that could evaluate this technology for applications.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believes that nearly $1 million in Fiscal Year 2023 funding seems appropriate for scope and accomplishments of this project which is ending in Fiscal Year 2023.

Reviewer 2:

This reviewer said that the resources seem to be sufficient; some work related to modeling of multi- joints and Al-composite multi-joints remain to be completed.

Reviewer 3:

This reviewer says that the project seems to have sufficient resources to deliver its objectives.

Reviewer 4:

This reviewer answered this question by stating that the year 1 presentation did not include a clear set of timing and deliverables, which would be reasonable for a low MRL project. However, if the MRL were higher, there would be an expectation that the resources were spread too thin and that more resources should have been provided and been more narrowly focused. Year 2 review clearly includes a Gantt chart of deliverables and timing, and the resources appear to be aligned with this plan given the body of work presented over the 3 years. Furthermore, this question cannot be answered without making some reference to the imposition of

COVID upon the original project plan and the ability to move the project forward while the team members were working remotely. To that point, the reviewer feels the team did an excellent job.

Presentation Number: MAT223
Presentation Title: Extending High Rate Riveting to New Material Pairs
Principal Investigator: Kevin Simmons (Pacific Northwest National Laboratory)

Presenter

Kevin Simmons, Pacific Northwest National Laboratory

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.

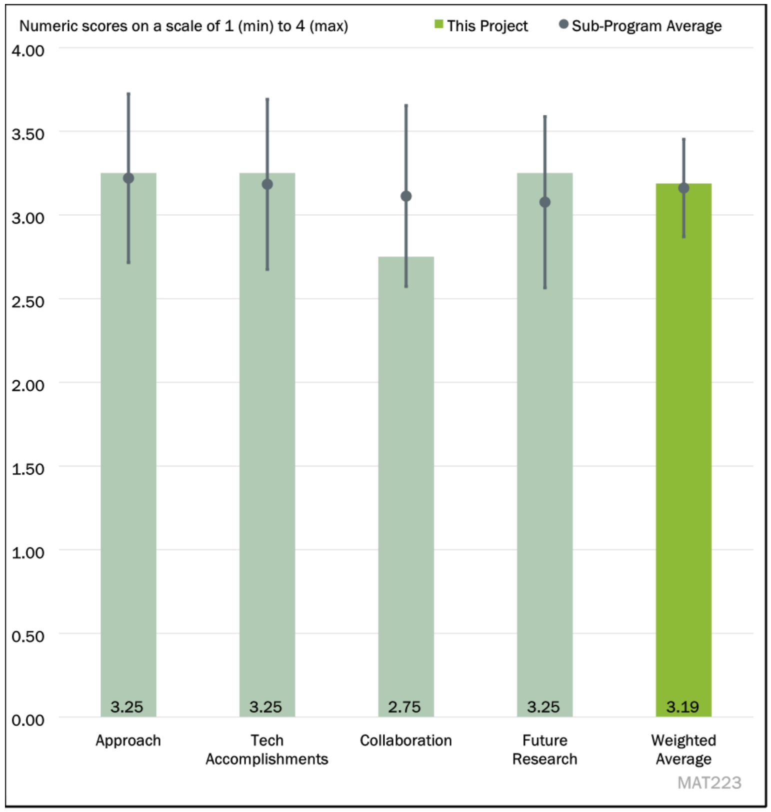

Figure 5-7 - Presentation Number: MAT223 Presentation Title: Extending High Rate Riveting to New Material Pairs Principal Investigator: Kevin Simmons (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer acknowledged a good overall approach that includes surface modification, joining, and corrosion performance to correlate the effect of processing on joint microstructure and bond strength for high-velocity and high-rate friction rivets.

Reviewer 2:

This reviewer noted that the project is developing high-rate riveting processes (high-velocity riveting [HVR] and high-rate friction riveting), in some cases combined with adhesive bonding, to produce multi-material joints for lightweight metals and composites. One of the stated barriers is that “no high-fidelity models exist to aid engineers in joint and process design” which seems like a possible understatement of prior work. Perhaps a more accurate description of the barriers addressed by this project would relate to insufficient reliability/load carrying capacity in multi-material joints, where the project team seems to be making good progress.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer identified significant accomplishments in the last year that include determining chemical bonding at adhesive/substrate interfaces and plasma enhanced mode I fracture energy (330% increase) and lap sheer (200% increase) of CFRP joints. Progress was also made in laser texturing CFRP, resulting in a 7%

increase in lap shear. The team completed more than 150 tests, resulting in surface modified Al optimized for lap shear adhesion with HVR.

Reviewer 2:

This reviewer found that good progress is being made. Some of the noteworthy accomplishments include (1) the development of a sustainable lignin adhesive with 90% of the strength of the comparable thermoset adhesive and (2) demonstration of dissimilar Al-to-steel rivet joints with high load carrying capacities where the team is showing some substantial improvements.

Question 3: Please comment on the collaboration within the 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 good collaboration among PNNL, ORNL and ANL to develop scalable and cost-effective processing methods to improve the properties of the joints in multi-material systems.

Reviewer 2:

This reviewer believes that most work seems to be happening at PNNL. ORNL's development of the lignin-based adhesive was reported in two other project presentations (MAT 223 and MAT 225) and the reviewer was not entirely clear on where the funding came from to complete that aspect of the project. The industrial partners are engaged in relatively small roles as material advisors. Enhanced connections (perhaps present but not emphasized) could tie together the various aspects of the project more strongly.

Question 4: Please comment on the 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 determined the proposed future research to be appropriate, given that project completion in Fiscal Year 2023 includes additional mechanical tests and detailed microstructural characterization to understand the joint behavior and continued collaboration with the modeling team to simulate process development for stronger joint performance.

Reviewer 2:

This reviewer pointed out that the 3-year project is planned to end in September 2023 (3 months after the peer review). Milestones are weighted towards the project end. Two of six milestones have been completed, meaning that there are still 4 milestones outstanding, suggesting a possibly challenging schedule. The Future Work slide focuses on high-rate friction riveting, leading the reviewer to question whether any work is still being done on the other joining methods including HVR.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirmed that the project supports VTO materials subprogram objectives as it is investigating multi-material joints with high-speed joining techniques to achieve vehicle lightweighting for improved energy efficiency.

Reviewer 2:

This reviewer determined the project is well aligned with DOE objectives in multi-material joining.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer opined that just under $700,000 per year funding over 3 years seems appropriate for the scope and accomplishments of this project, which is ending in Fiscal Year 2023.

Reviewer 2:

This reviewer assented that the resources are sufficient.

Presentation Number: MAT224
Presentation Title: Solid State Joining of Multi-Material Autobody Parts Toward Industry Readiness
Principal Investigator: Piyush Upadhyay (Oak Ridge National Laboratory/Pacific Northwest National Laboratory)

Presenter

Piyush Upadhyay, Oak Ridge National Laboratory/Pacific Northwest National Laboratory

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.

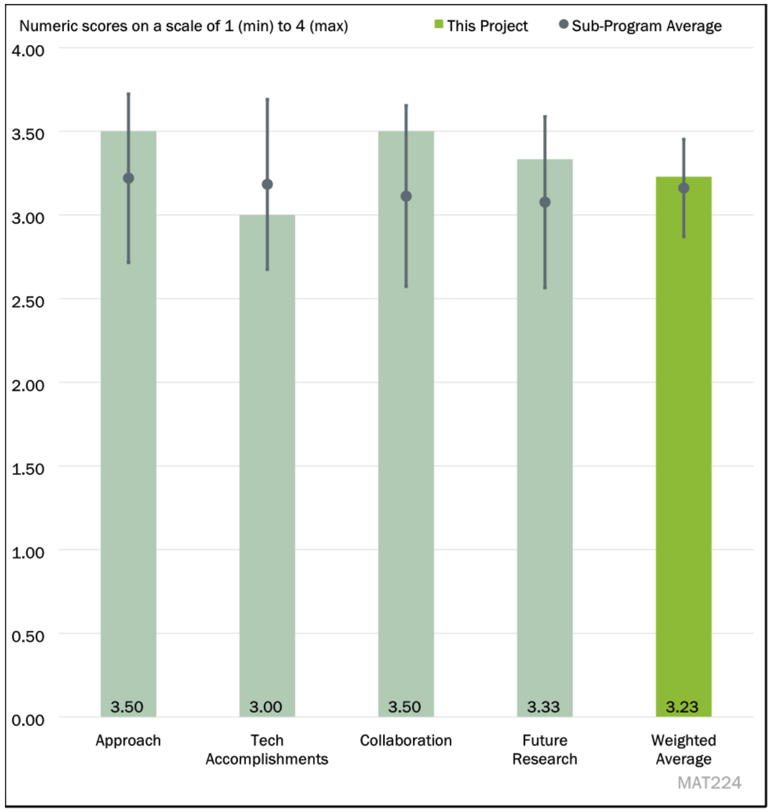

Figure 5-8 - Presentation Number: MAT224 Presentation Title: Solid State Joining of Multi-Material Autobody Parts Toward Industry Readiness Principal Investigator: Piyush Upadhyay (Oak Ridge National Laboratory/Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found that the project is mostly on track, and, with a few exceptions, milestones are being met.

Reviewer 2:

This reviewer said that the project approach of evaluating two solid-state joining (friction stir welding and friction self-piercing rivet methods for multi-material components, including dissimilar Al-Al, Al-ultra-high strength steel, and Al-CFRP, and demonstrating viability and repeatability on a robotic platform is a sound one. The approach could be slightly improved by including Al-Mg, but, according to the reviewer, overall, this is a sound approach that seems to be well targeted for commercial application.

Reviewer 3:

This reviewer noted that the project is deploying friction stir welding for solid-state linear and spot joining of multi-material components to support lightweighting. The large-scale robotic platform implementation being pursued here is an important advance for scale-up of this method from coupon/lab scale to an automotive product application. The investigators have succeeded in this platform transition and are effectively handling scale-up challenges such as low bonding at the exit hole. The optimization approach for parameters such as dwell and plunge time is methodical and sound with steady improvements being made.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

Noting that the project deals with solving manufacturing related challenges and improving efficiency of joining processes, the reviewer points out that these are difficult to accomplish in laboratory settings. Nonetheless, PIs from two laboratories are co-operating and making reasonable progress.

Reviewer 2:

This reviewer found that the project has achieved good joining performance results with friction stir welding and friction self-piercing riveting. Furthermore, development of pilot hole and plunge-in parameters, as well as weld bonding performance evaluations, have resulted in further improvements. However, the tool life assessment, demonstrated predictability, process repeatability, weld fixture and fixture schemes, and the component fabrication and joining process demonstration and evaluation are all back loaded or delayed into the final six months of a 3-year project. This timing plan may be significantly underestimating the expected challenges in this phase, and it seems to the reviewer unlikely that this project will be completed on time. In fact, two and one-half years into a 3-year project, only two milestones have been achieved.

Reviewer 3:

This reviewer said that the technical achievements to date are very good, though there are some delayed milestones compared to the project plan.

Question 3: Please comment on the collaboration within the 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 found excellent collaboration between national laboratories and industry teams.

Reviewer 2:

This reviewer held that the project effectively utilizes resources from two national laboratories along with automotive industry participation from Honda (providing material guidance and stack-ups as well as design and process requirements), Arconic (providing Al sheet materials), and Magna (providing Al stampings for the project demonstration phase).

Reviewer 3:

This reviewer was pleased that the collaboration between the two laboratories seems to be well coordinated and the industry partnerships, including with Honda, are valuable for the full-scale body-in-white/stamping studies.

Question 4: Please comment on the 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 future research plans were satisfactorily presented.

Reviewer 2:

This reviewer considers that the proposed future research is appropriate and well defined to further improve on the work already completed and further support potential high-volume commercial application.

Reviewer 3:

This reviewer pointed out that the project is nearly complete (ends September 2023) and some milestones were delayed so it may be challenging to complete all of the outstanding milestones prior to project end. Some milestones are still noted as “future” rather than in progress, suggesting that work on these has not yet begun.

According to the reviewer, the purpose and value of the future work is clear. The work with stampings that include curvature will be important for demonstration of the range of capabilities of this weld technique, so hopefully this can be completed despite the challenges with other lead times noted.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believes that joining is a critical technology for the lightweighting mission of the Materials program. The project supports this technology.

Reviewer 2:

This reviewer determined that the project supports the overall VTO materials subprogram objectives by focusing on development of cost-effective, fast, and reliable dissimilar metal joining technologies to enable improved integration of high-volume lightweight mixed material automotive sub systems.

Reviewer 3:

This reviewer affirmed that the project is well aligned with DOE objectives in multi-material joining.

Question 6: Please provide comments on the resources of the project. 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.

Reviewer 2:

This reviewer considers that the funding for the project is substantial. However, the project objectives are substantial as well. The collaboration of two national laboratory teams along with three industry partners should result in a successful project, although there is some risk of going beyond the planned completion date.

Reviewer 3:

This reviewer said that the resources are sufficient.

Presentation Number: MAT225
Presentation Title: Surface Modifications for Improved Joining and Corrosion Resistance
Principal Investigator: Vineet Joshi (Oak Ridge National Laboratory/ Pacific Northwest National Laboratory)

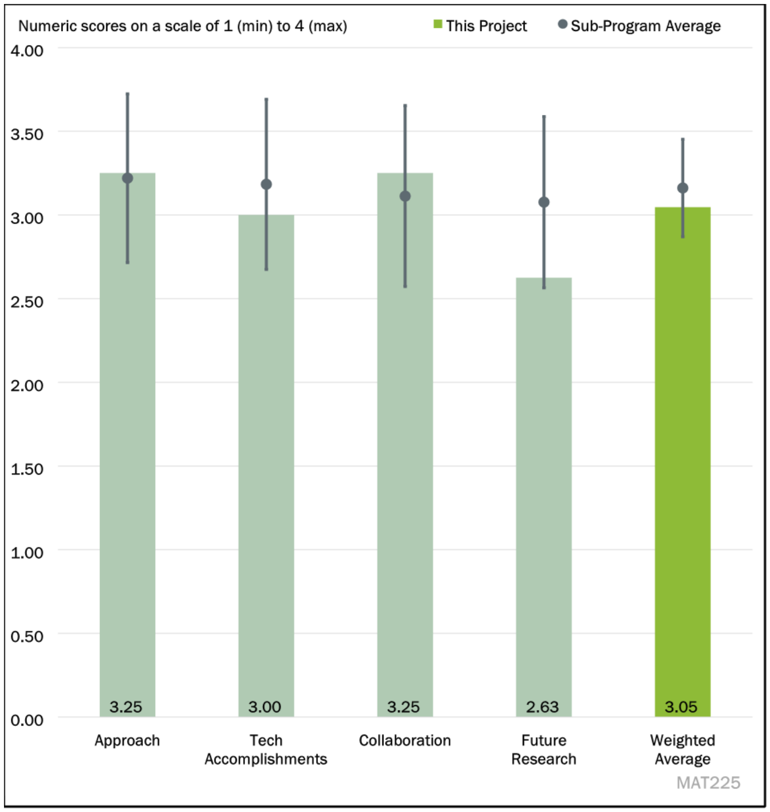

Figure 5-9 - Presentation Number: MAT225 Presentation Title: Surface Modifications for Improved Joining and Corrosion Resistance Principal Investigator: Vineet Joshi (Oak Ridge National Laboratory/Pacific Northwest National Laboratory)

Presenter

Vineet Joshi, (Oak Ridge National Laboratory/ Pacific Northwest 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. 50% of reviewers felt that the resources were sufficient, 0% 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.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

According to this reviewer, the project has addressed technical barriers on corrosion resistance and joint strength using open air plasma-treatment, electric insulation on steel rivet to mitigate galvanic corrosion of dissimilar joints, and laser ablation treatment, along with introduction of an adhesive between joint plates to improve bond strength. All the adopted methods demonstrated a clear trend of improvement on the identified technical barriers. The team has designed all the testing plans reasonably to evaluate the effectiveness of proposed technical approaches.

Reviewer 2:

This reviewer points out that the project addresses barriers related to joining and corrosion resistance of multi-material combinations prone to galvanic corrosion and includes some impressive progress. However, the efforts seem to the reviewer to be a bit scattered in some areas and don’t seem quite as coordinated as they could be. For example, the addition of high velocity clinching was not discussed at all early in the project and there is no description as to what is different between high velocity clinching and conventional clinching to make it a more desirable joining alternative. It is not clear to the reviewer whether this process is better for less ductile materials. Furthermore, coach peel or cross-tension tests would be very valuable in fully understanding joint performance before and after corrosion testing since the failure mechanisms and behavior can be dramatically different than those for lap shear and/or double cantilever beam.

Reviewer 3:

This reviewer was concerned that the project appears to be driven more by the dissimilar material joining work of other projects than by deep diving the fundamentals of any corrosion inhibiting technology. However, this is in line with the objective to achieve three times greater joining life than for a given technology and, as such, addresses the technical barriers. Unfortunately, the advantages of the various corrosion inhibiting technologies may be distorted because of the experimental nature of the joining processes these were applied to. The reviewer feels that inclusion of a baseline commercial joining technology such as SPRs would have provided a substantial basis of comparison.

Reviewer 4:

This reviewer characterized the project as developing surface treatment methods to improve adhesion and reduce electrical conductivity to improve galvanic corrosion performance. Work includes experimental and COMSOL modeling. The reviewer is glad to see that the team has integrated saltwater exposure corrosion tests this year and is now also conducting experiments with an industry standard pulsed laser. The reviewer would find it helpful to see more quantification of saltwater corrosion performance improvements from surface modification.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer noted that the original objective is to produce high-quality, corrosion resistant joints with three times longer lifetime. Different levels of enhancement were achieved in different tasks. For instance, it was reported the resistance was improved by more than two times compared to untreated materials. It is unclear to the reviewer how much further enhancement can be achieved. Scale up of opener plasma treatment was achieved through introduction into a robotic system. Tasks originally planned to complete in March and June are all marked in progress. The reviewer suggests that an explanation on reasons for delay would be helpful.

Reviewer 2:

This reviewer is impressed by the technical accomplishments, especially with respect to the open air plasma work and the alumina-forming alloy steel rivets. However, it is not clear how the alumina-forming alloy rivet performance would compare to zinc-plated rivet performance, and the value of the results are ultimately limited by the weaknesses inherent in the dispersed project approach, according to the reviewer.

Reviewer 3:

This reviewer described how the project has developed analytical techniques to investigate surface interactions (such as chemical bonding) which can be exploited not only for this project but any related projects investigating surface processing for improved performance under environmental exposure. For example, the types of adhesives were extremely limited and not necessarily those which are heavily used in structural automotive applications. Furthermore, a novel oxide coating for rivets was developed, which exhibits significant promise. However, it would be advantageous to compare the performance of zinc-coated rivets which is a commercial standard as a baseline.

Reviewer 4:

This reviewer related how most milestones are completed or on track for completion. The milestones are primarily process-related deliverables. While these tasks are being completed more or less on schedule, the reviewer would have liked to see more quantitative specificity on the performance improvement targets embedded in more of the milestones of this project (e.g., reduce X by Y% rather than simply "demonstrate the minimization of long-term corrosion … by utilizing optimized surface treatment methods"). Especially for a project of this size, SMART milestones would make the tangible technical progress clearer, according to the reviewer.

Question 3: Please comment on the collaboration within the 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 believes that collaboration between the three laboratories and industry is well organized and utilizes strengths from each partner reasonably.

Reviewer 2:

This reviewer found that the group of participants (including three national laboratories, one automotive OEM, and one automotive adhesives supplier) seem to be well coordinated and focused on complementary tasks, so that the work of each informs the others and does not duplicate efforts.

Reviewer 3:

This reviewer determined that there is significant collaboration between the joining process projects and this project since this project is focused on application of surface modification techniques on these aforementioned joining technologies. The issue the reviewer sees is that the objective is a three times greater life over the baseline and since these joining technologies are currently undergoing development, it is difficult for the reader to understand what the baseline is.

Reviewer 4:

This reviewer believes that collaboration between the three laboratories is well coordinated, with monthly meetings and shared material batching for consistency. The involvement of industry is good; the scale and specifics of the General Motors (GM) partnership, however, are not totally clear to the reviewer, who feels that, without strong industry involvement, it could be difficult to get this technology scaled and out of the laboratory.

Question 4: Please comment on the 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 clarification would be helpful to understand to what extent adhesion bonding and corrosion resistance are expected in future work.

Reviewer 2:

This reviewer said that the proposed future research seems to be well planned to address the stated remaining challenges in the program, although they do not address some of the shortcomings related to joint strength testing.

Reviewer 3:

This reviewer ranked the proposed future research as fair based on the amount of funding remaining and the breadth of topics that the project team is proposing to investigate. The proposed future research topics are of significant technical importance. For example, the team proposes to refine the process for laser and atmospheric plasma modification of AA7075 and cast Al. The remaining budget is listed as 20% and process development for these two alloys and processes would seem to require a significantly greater level of engagement. It may be more prudent to identify a key question or hypothesis and then investigate that as an attempt to deep dive a singular topic which could help to achieve the three times life improvement.

Reviewer 4:

This reviewer pointed out that the project is nearly complete (ending 3 months after the AMR, in September 2023) and future work plans include process refinement, further evaluation of additional surface treatment methods, and more characterization and modeling. This is a wide range of activities for the short time remaining and the tangible benefits that will be gained from each activity are not completely clear to the reviewer, who would like to have seen more specificity here (targets) as well as further justification for the expected benefit from each of the planned experimental/characterization/modeling activities. The reviewer questions what will be learned from the planned testing, and how will this learning inform strategies to address the critical barriers. In the reviewer's view, the most valuable future work for the three months remaining would focus on developing clear, repeatable and benchmarked datasets quantifying the improvement gains from the most promising surface modification techniques developed in the project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirmed that the project supports the subprogram objective on Materials by improving the strength and galvanic corrosion resistance of multi-martial systems in vehicles.

Reviewer 2:

This reviewer said that the project is relevant to the VTO Materials subprogram objectives as it is focused on developing surface modification techniques to optimize corrosion performance of dissimilar multi-material joints.

Reviewer 3:

According to this reviewer, corrosion of dissimilar material joints is a significant technical barrier to the industrialization of advanced joining technologies for just joints. Because of this, mass saving multi-material joints are not commonplace in the automotive sector and mass savings opportunities are missed. Mass savings is one path to a society having fewer GHG emissions.

Reviewer 4:

This reviewer confirmed that the project is well aligned with DOE objectives in multi-material joining and corrosion mitigation.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer noted that the whole project team is performing testing on the same batches of materials. Sufficient materials are planned for future tests and software licenses are available to the team for simulation tasks.

Reviewer 2:

This reviewer believes that the milestones of the project have been assessed as the team has defined them based on the available resources within this project as well as the opportunities for leveraging the experimental work of other projects. In that regard, the reviewer says that the team has done a good job in distributing the available resources to a broad scope of work. It is hoped by the reviewer that, at the end of the project, the final report contains not only a summary of what the project team has accomplished, but, more importantly, a roadmap for developing the surface modification technologies of interest to higher MRLs. For example, extrusions typically have a higher level of reflection of a laser beam than a cast surface. The reviewer would like to know how that might affect the refinement of laser surface modification and how might the distribution of alloying content within a casting affect the oxidation product. This project scratches the surface with the available resources so the reviewer would hope that the goal is to identify those specific technology roadblocks, i.e., technical questions which need to be answered in future work.

Reviewer 3:

Considering that this is a reasonably large project, the milestones, most of which are process-based and qualitative rather than performance-based and quantitative, don’t seem to this reviewer to be as ambitious or sharply focused as they could be for the resources available (funding level) for this project.

Reviewer 4:

While the project has achieved some impressive results, according to the reviewer, the scope of work does not seem to justify the substantial funding allocation provided for this project.

Presentation Number: MAT226
Presentation Title: Machine Learning for Joint Quality and Control
Principal Investigator: Keerti Kappagantula (Oak Ridge National Laboratory/Pacific Northwest National Laboratory)

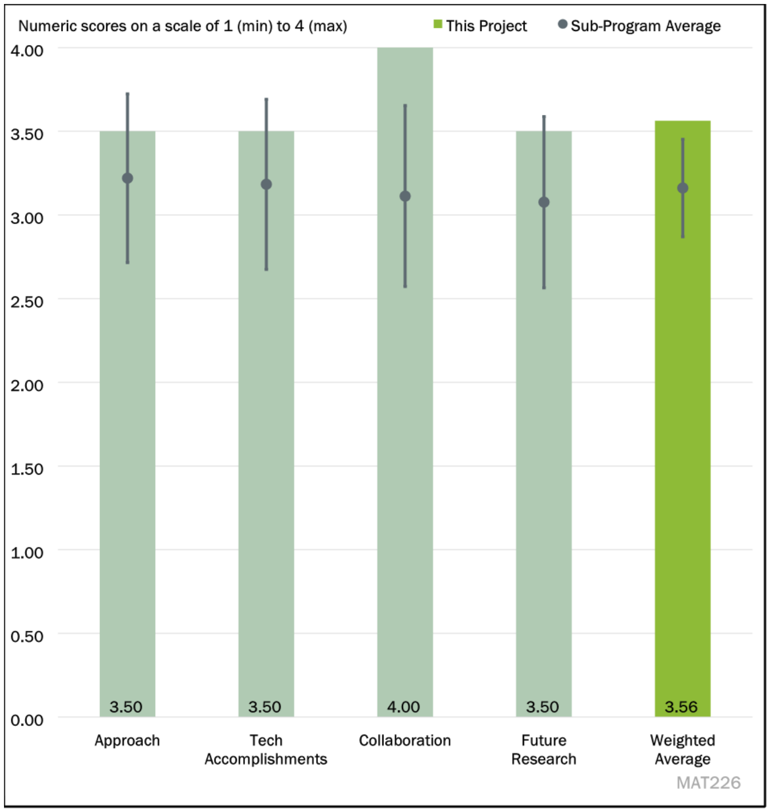

Figure 5-10 - Presentation Number: MAT226 Presentation Title: Machine Learning for Joint Quality and Control Principal Investigator: Keerti Kappagantula (Oak Ridge National Laboratory/Pacific Northwest National Laboratory)

Presenter

Keerti Kappagantula, Oak Ridge National Laboratory/Pacific Northwest National Laboratory

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.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer noted that the project leverages more than 30 gigabytes of spot-welding data (images and test data) from industry partner GM to develop machine-learning models that can be used for decision support and process optimization. The project is well planned and executed, according to the reviewer.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer points out that the project has about a year remaining in its period of performance and is generally on track or ahead of schedule. One milestone due June 30, 2022 (1 year ago) is listed as “on track” rather than complete or delayed. The reviewer is not sure whether this may be a typo and perhaps should have been listed as June 30, 2023. The reviewer appreciates that the team has also been responsive to reviewer feedback, and during Fiscal Year 2023 the project team has been working to assess the extensibility of the machine learning (ML) framework to new joining and manufacturing processes. That work should be valuable.

Question 3: Please comment on the collaboration within the 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 praised the collaboration between PNNL, ORNL, and GM as excellent and said that the strong connections between the partners are contributing to the successes of this project. The team is doing a great job of fully leveraging a valuable dataset provided by GM.

Question 4: Please comment on the 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 found the future work is well planned and purposeful. One planned activity of note calls for the development of resistance spot welding process designs based on predictive ML modeling, which will be transferred to the industry partner. This will be valuable to GM and will also demonstrate the commercial relevance of this framework for improved multi-material joining.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirmed that the project is well aligned with DOE objectives in multi-material joining.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found that the resources are sufficient.

Presentation Number: MAT229
Presentation Title: Development of a Novel Magnesium Alloy for Thixomolding of Automotive Components
Principal Investigator: Govindarajan Muralidharan (Oak Ridge National Laboratory/Fiat Chrysler Automobiles LLC)

Presenter

Govindarajan Muralidharan, Oak Ridge National Laboratory/Fiat Chrysler Automobiles LLC

Reviewer Sample Size

A total of four reviewers evaluated this project.

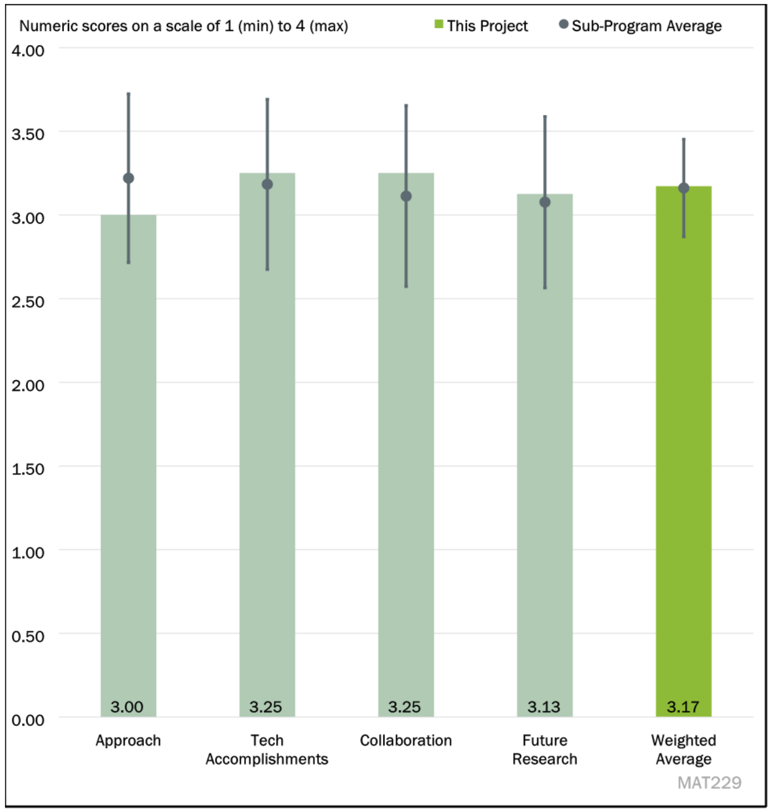

Figure 5-11 - Presentation Number: MAT229 Presentation Title: Development of a Novel Magnesium Alloy for Thixomolding of Automotive Components Principal Investigator: Govindarajan Muralidharan (Oak Ridge National Laboratory/Fiat Chrysler Automobiles LLC)

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.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer praised the approach taken by the principal investigators as thorough and systematic.

Reviewer 2:

This reviewer pointed out that this a LightMat project in which a national laboratory collaborates with an industry partner to address a technology issue. In this project, ORNL worked with Fiat Chrysler Automobiles (FCA), Leggera Technologies, and Magnesium USA, to develop a methodology for easy thixomolding processing of Mg alloys. Using the low-cost thixomolding approach, Mg alloys, which are generally quite brittle, can be shaped. The goal of the project is to develop design and processing of new alloys with improved ductility over the baseline and eventually demonstrate it by fabricating a vehicle component. A successful development from this project could help with introducing Mg alloys as light weighting materials in vehicles.

Reviewer 3:

This reviewer notes that the barriers to Mg castings are the melting point and material properties. The team down-selected two alloys with similar melting points of AZ91D with higher ductility and yield strength. The project has progressed to die casting a spare wheel carrier, but the reviewer noticed that the milestones have a gap of over a year that doesn't show progress on the project. Only Mar. 2022, June 2023, and Sept. 2023 is on track for a component level materials evaluation from the cast component.

Reviewer 4:

This reviewer did not believe it was clear why a new alloy for thixomolding is needed. An existing, more ductile alloy such as AM20 or AM50 in die casting conditions should meet the required high elongation (15%-18%), in the reviewer's assessment.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

According to this reviewer, the project yielded new alloy compositions that can be thixomolded and demonstrated improved ductility and strength. Further, using this process, a vehicle component was manufactured. The project progress was, for the most part, in accordance with the plan. However, the corrosion test results were not available, and testing is being conducted and is expected to be completed by end of the fiscal year.

Reviewer 2:

The accomplishments of the team are commended by the reviewer. The team has been able to derive an alloy which has outperformed their reference alloy, AM60B. There are, however, some issues that remain to be resolved, including: (1) The elongation and other targets of Alloy #1 were met in the laboratory scale batch production. However, the elongation target was not met in the production run. The team took great pains during the presentation to explain why this occurred. The question is whether they would have the time and funds to demonstrate that they can rectify this issue by project's end in the way they explained it during the presentation; (2) A cost analyses to confirm that money was saved by their methodology and new alloy is missing. The analyses should include the cost of weight saving per unit. This figure should be compared with VTO's targets; (3) It is not immediately apparent in the bar charts presented (e.g., Slide 13 and Slide 14) whether the data presented were from single data points or from average values. An indication as to whether these are single values or averages, as well as the inclusion, or an indication, of error bars/error levels would be both prudent and helpful; (4) The reviewer is aware that not all of the latest results were presented at the meeting. The end of the project is about 3.5 months away. The reviewer questions whether the remaining tasks will be finished by the new deadline for completion of Sept. 2023.

Reviewer 3:

This reviewer believes that a successful process window was achieved for the component casting with Alloy #1, but Alloy #6 needs addition trials. Progress was made with Alloy #1 demonstrating the fine microstructure achieved that shows good strength and ductility. Alloy #1 shows increased strength and elongation over the standard AM60B, as indicated by the 25% finer grain size, which improves the property performance. The progress also showed the improved strain rate performance of the standard AM60B alloy.

Reviewer 4:

This reviewer found that Alloy #1 only achieved 10% elongation which is not better than die cast AM60B alloy.

Question 3: Please comment on the collaboration within the 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 lauded outstanding collaboration among the members. The reviewer did not find a clear breakdown of cost share among the team members but said that it appears that Leggera Technologies contributed the most.

Reviewer 2:

This reviewer found that the synergies amongst the collaborators are clearly laid out on Slide 18, which is a good response to concerns express in a previous review. The reviewer commended the team for this.

Reviewer 3:

This reviewer stated that there had been good collaboration among the three organizations on this project.

Reviewer 4:

This reviewer found it difficult to understand from the presentation who contributed what work. The slide indicates the breakdown of activities, but it would be easier to understand the workflow collaboration if the slides had the collaborators' symbols and any coordination activities between collaborators had been indicated.

Question 4: Please comment on the 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 approved that the future plan includes corrosion testing on the commercially fabricated thixomolded parts. Additionally, mechanical testing on the commercial parts will be important.

Reviewer 2:

This reviewer references the reviewer's previous comments in Section 4 about the elongation of Alloy #1 in the production run, and about the cost analyses of the part to demonstrate not just weight savings, but the cost of the weight saving per unit mass.

Reviewer 3:

This reviewer found the future work to include a good list of items that includes corrosion, more high strain-rate for impact damage, and electrochemical work on Alloy #1. There appears to be no discussion of Alloy #6 for completion, raising the question to the reviewer of whether the team might not see a path forward for future work with that alloy.

Reviewer 4:

This reviewer hoped that the final casting trials and testing can provide better properties. Otherwise, no significant improvement has been achieved in this project (unfortunately).

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirmed that the work contributes directly to weight savings and improvement of fuel efficiency in vehicles.

Reviewer 2:

This reviewer found the project relevant to lightweighting.

Reviewer 3:

This reviewer assented that vehicle lightweighting by using Mg alloys that can be fabricated at somewhat lower temperatures could benefit the environment.

Reviewer 4:

This reviewer said that the project supports the VTO program via weight reduction and high-speed processing. The alloy development improves the performance with would allow for even further weight reduction with a redesigned component.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said that the resources and the cost share are commensurate with the project tasks.

Reviewer 2:

This reviewer believes that the project is in line with resources for the progress that was made against the stated milestones and are on track for completion.

Reviewer 3:

According to this reviewer, it is difficult to assess whether the team has sufficient funds to complete the work. Vital information to make that assessment is missing.

Presentation Number: MAT231
Presentation Title: Light Metals Core Program Introduction
Principal Investigator: Glenn Grant (Pacific Northwest National Laboratory)

Presenter

Glenn Grant, Pacific Northwest National Laboratory

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. 50% of reviewers felt that the resources were sufficient, 50% 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.

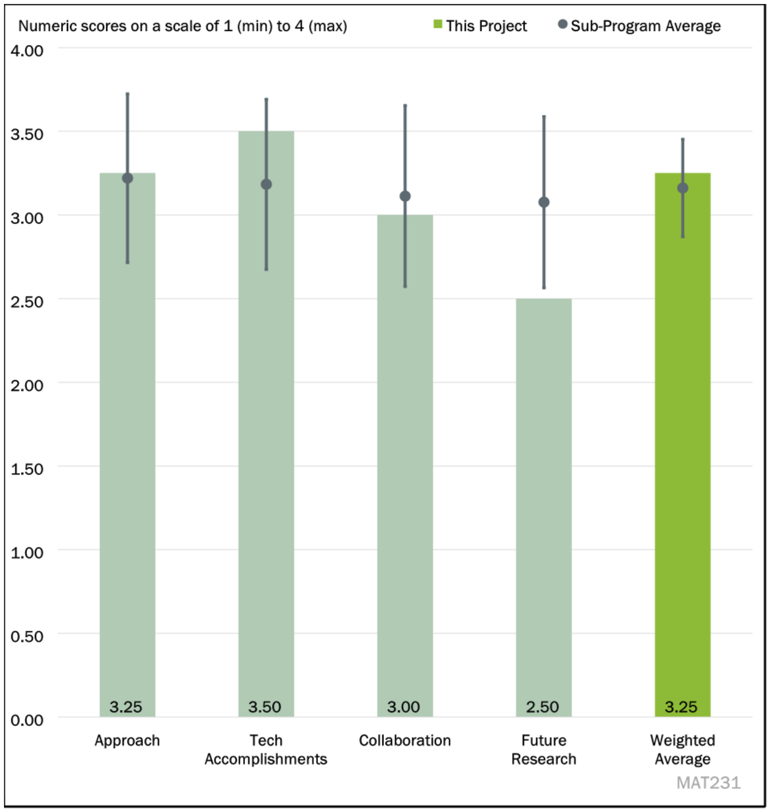

Figure 5-12 - Presentation Number: MAT231 Presentation Title: Light Metals Core Program Introduction Principal Investigator: Glenn Grant (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found that the program focuses on critical technical issues associated with light metals.

Reviewer 2:

This reviewer believes that this project is the flagship program for the laboratories to work with industry focusing on light metals; the projects are well thought out and contribution from industry is significant. Wrought and cast light metals (Al and Mg) are studied with focus on property improvements. The data from the projects are being used to develop predictive models, which the reviewer considers a good idea. The selective strengthening may be a good idea but models in predicting the performance may be delayed. The reviewer suggested that the project needs more discussion with end users to facilitate the uptake of these ideas.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer finds that most of the projects show good progress. But some projects (such as simulation projects) are still at early stage of development. The reviewer sees a need to work closely with automotive OEMs to implement some of the technologies.

Reviewer 2:

The reviewer says that the project team has had significant interaction with industry partners and many publications have been issued. However, more efforts are needed in modeling and in predicting the performance of local property variations.

Question 3: Please comment on the collaboration within the 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 OEM and Tier 1 suppliers are involved and that the projects are interactive with useful in-kind contributions from industry in the form of materials/products.

Reviewer 2:

This reviewer found the collaboration to be generally good, but not always have the best teams been used to address specific technical issues. Although the program is to support national laboratories, the reviewer suggests that top experts in universities should be invited as consultants to some of the projects to fill expertise gaps in some cases.

Question 4: Please comment on the 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 only that the program is coming to an end by the end of Fiscal Year 2023.

Reviewer 2:

This reviewer found not much future work presented and suggests running more focused efforts in the future and building the best teams beyond just the two national laboratories.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer found the work to be highly relevant to vehicle lightweighting.

Reviewer 2:

This reviewer predicted that light metals will be used in more quantity in vehicles to achieve light weighting, energy efficiency, and cost reduction and pointed out that this research is focused on modifying, enhancing local properties to enable better performance.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believes that the program is well funded but suggests that in future the projects can be planned with go/no-go points to close ones with less benefits and start new ones.

Reviewer 2:

This reviewer believes that more resources are needed to overcome key challenges in sustainability and modeling development.

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, Pacific Northwest National Laboratory

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.

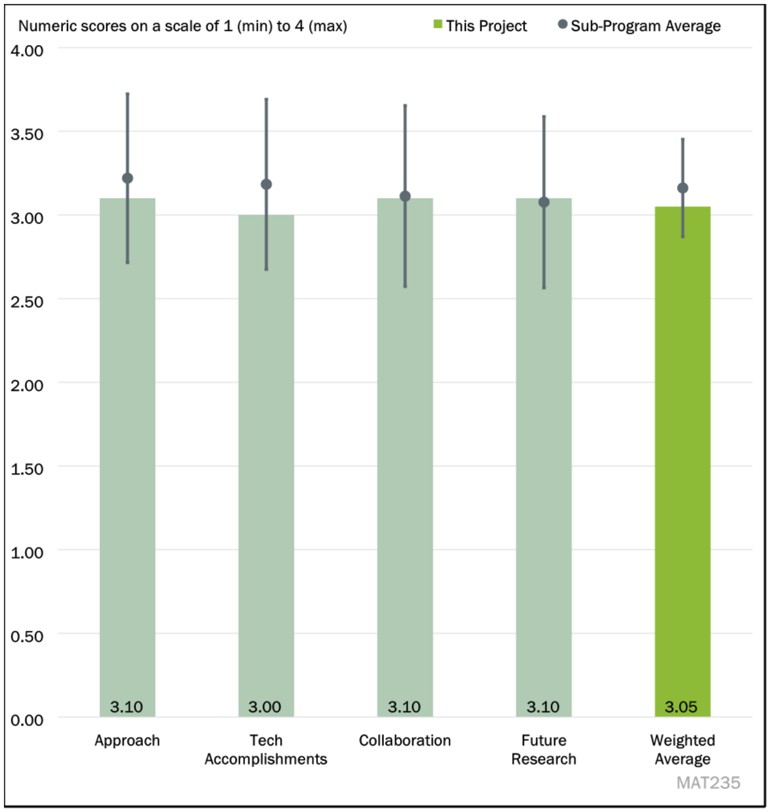

Figure 5-13 - Presentation Number: MAT235 Presentation Title: Light Metals Core Program - Thrust 4 - Residual Stress Effects Principal Investigator: Ayoub Soulami (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer finds the project to be a good one that is focus on residual stress measurement and modeling in the Lightweight Metals Core Program (LMCP).

Reviewer 2:

This reviewer pointed out that the technical target of this project focuses on developing an integrated suite of computational models to accelerate product development cycle time by understanding the residual stress distribution as a function of process conditions and maintain part dimensional stability. In this review period, the project developed two different modeling tools for simulation purpose such as residual stress only or residual stress along with distortion predictions for friction stir processing and bending processes demonstrated on Al and Mg materials. The reviewer notes that the team is currently in progress for Milestone 2.0 with a due date of Sept. 2022 and questions what caused the delay or whether it was a misprint and should be 2023 instead of 2022. If the team targets to improve the model by end of Sept. 2023, it is a reasonably planned timeline, according to the reviewer.

Reviewer 3:

This reviewer believes that the project correctly identified the problem of distortion due to residual stresses.

Reviewer 4:

This reviewer notes that the project is very much focused on modeling and predictions with simulations. The experimental validation, however, seems to have commenced has not advanced sufficiently to address the model validation with respect to residual stresses aspect sufficiently.

Reviewer 5:

This reviewer feels that the project is well designed, and the timeline is reasonable.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer says that the accomplishments are generally effective.

Reviewer 2:

This reviewer praises the technical progress as excellent but. records a slight concern that the project is at the mercy of the overall program projects and focused solely on PNNL projects.

Reviewer 3:

This reviewer considers the developed modeling methods to have delivered good agreement in residual stress distribution outside of friction stir zone, which effectively assists the process path design for component strength and dimensional stability. However, the current simulation methods developed do not incorporate material property changes with precipitation evolution in the stir zone and, therefore, generate a discrepancy in predicted stress profiles within the stir zone. The reviewer would find it helpful if more details could be provided to explain how the model will be further improved to address this discrepancy.

Reviewer 4:

This reviewer confirmed that the project predicts residual stresses with some level of validation, but is concerned that it did not predict distortions, which are real challenges in industrial applications, according to the reviewer.

Reviewer 5:

This reviewer believes that the model development in this project is very good but that. residual stress measurements still need more work. The methodology was shown as an appendix but not explained in the presentation so that the effort could be evaluated. The source of residual stresses was expressed as being related to differences in the microstructures but there is not much analysis of these microstructures, according to the reviewer.

Question 3: Please comment on the collaboration within the 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 believes that the laboratories have good division of effort and seem to be collaborating substantially.

Reviewer 2:

This reviewer considers that collaboration is well coordinated with the partners.

Reviewer 3:

This reviewer found good coordination with PNNL activities but believes that it would be good to coordinate with the ORNL activities as well.

Reviewer 4:

According to this reviewer, it would be helpful to clarify what tools will be used to measure the micro and macro residual stresses at PNNL and ORNL, respectively, and how efforts on modeling of residual stress at the two sites will be coordinated. It is unclear to this reviewer what the role of ANL is in future research.

Reviewer 5:

This reviewer suggests working closely with the computer aided engineering (CAE) community in the automotive industry to predict distortion in real parts.

Question 4: Please comment on the 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 there is good focus on residual stress measurements in future work planned and looks forward to seeing these results at the end of the project.

Reviewer 2:

This reviewer said that the proposed future research is adequate.

Reviewer 3:

This reviewer said that the proposed future research is reasonable to overcome barriers.

Reviewer 4:

According to this reviewer, it is unclear how model prediction accuracy can be further improved within the stir zone, especially for Al alloys with precipitation evolution. The reviewer is concerned regarding a lack of details on whether a comprehensive material property database will be established to address this technical barrier.

Reviewer 5:

This reviewer suggests implementing the residual stress and distortion models in commercial software used by industry to have real impact.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer noted that the project supports LMCP which directly addresses the glider weight reduction mission pertaining to lightweighting.

Reviewer 2:

This reviewer pointed out that the project aims to predict part performance made of Al or Mg alloys with localized microstructures, residual stress and distortion introduced by friction stir and bending processes and assist to optimize process parameters for residual stress and distortion control. However, it is unclear to the reviewer how the models developed currently would be able to assist in developing stress relief procedure since it requires a creep database, especially for Al alloys with precipitation mechanisms.

Reviewer 3:

This reviewer finds the project to be relevant to lightweighting.

Reviewer 4:

This reviewer holds that the residual stress prediction is important in vehicle construction; the models will be very much material specific, and it would be good if models can be made more generic.

Reviewer 5:

This reviewer believes that the project supports overall the VTO materials subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer affirmed that the resources are sufficient.

Reviewer 2:

This reviewer said that the resources seem sufficient.

Reviewer 3:

According to this reviewer, sufficient resources are being applied to deliver milestones.

Reviewer 4:

This reviewer noted that $250,000 seem to be remaining for residual stress measurements. It was not clear to the reviewer, however, how these funds were to be used but the reviewer considered them to be sufficient.

Reviewer 5:

This reviewer pointed out that the team consists of three national laboratories with advanced measurement and simulation tools. The reviewer, however, suggested that it would be more helpful if the team can clarify what are the exact tools to be used at each partnering site.

Presentation Number: MAT236
Presentation Title: Advanced Characterization and Computational Methods
Principal Investigator: Thomas Watkins (Oak Ridge National Laboratory)

Presenter

Thomas Watkins, Oak Ridge National Laboratory

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.

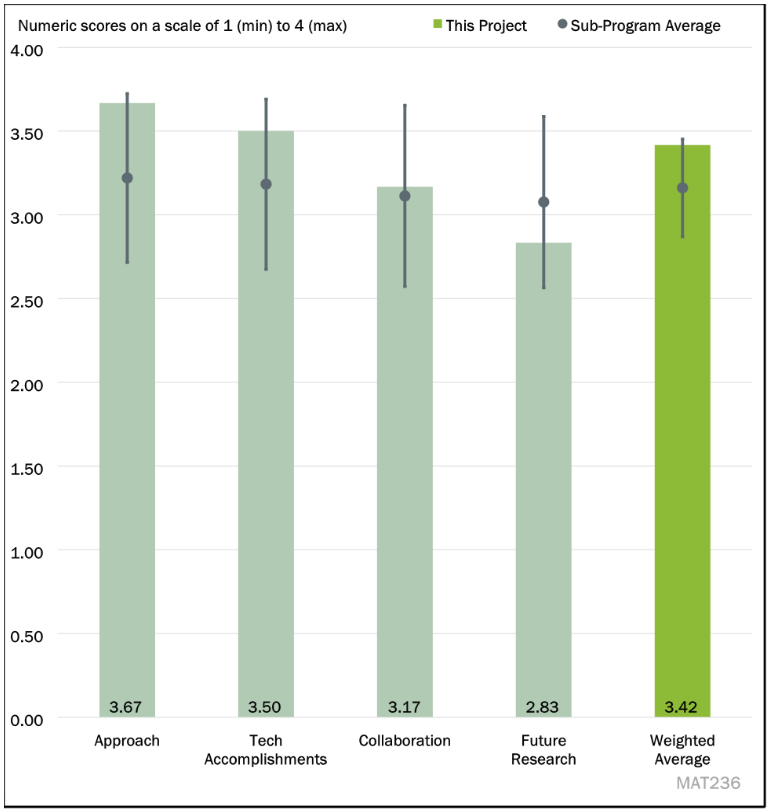

Figure 5-14 - Presentation Number: MAT236 Presentation Title: Advanced Characterization and Computational Methods Principal Investigator: Thomas Watkins (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer opined that new propulsion materials are needed to address current technology gaps for electric powertrains in light-duty and heavy-duty vehicles. The team of national laboratories is applying advanced materials characterization and computational tools to accelerate the development of the next generation of powertrain materials with superior combinations of properties, manufacturability, and cost to enable the design of future advanced electric vehicles. This database of material properties is permitting the accelerated development of materials needed to support the improvements needed to successfully deploy EVs. The process to select these projects includes a review of the proposed project by the laboratory leaders, then either rejection, suggested revisions, or acceptance. This appears to the reviewer to be a fair way to get tasks integrated into the project, as these laboratory leaders are the most knowledgeable about the status of the database and where new capabilities are needed.

Reviewer 2:

The word “accelerate” is emphasized heavily in the Thrust 4 goals, but the actual level of acceleration is unclear (unlike, for instance, the Materials Genome goals of “2x faster,” etc.…). A more thorough understanding of materials behavior/responses is most certainly being elicited, and overall, the work of the groups within this area is commendable.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer noted that multiple activities are being performed under this project. These efforts are expanding the database of material characteristics needed to support the development of more efficient electric propulsion systems. Tasks underway include: (1) ultra-conductor development for enhanced EV performance (2) Al-Ni alloys for improved electrical properties (3) Al-Ni alloys microstructure evolution on electrical and thermal conductivities, (4) electrical and magnetic properties characterization, (5) thermal properties in lightweight alloys for EV propulsion, and (6) carbon nanotube coating as a thermal interface material. Most work is being performed to understand and improve the electrical and thermal properties of materials. The materials with the most promise appear to be Al-Ni alloys and carbon nano-tube coatings. The national laboratories leveraged their impressive capabilities to perform the testing needed to understand these materials. Success is difficult to assess for these types of projects; however, the impact factor assessment appears to be a good way to assess. Sixty-six percent (8 of 15) of the journal publications and 63% (5 of 8) of the articles with significant Thrust 4 (Advanced Characterization and Computation) were assessed as having an Impact Factor of 5.

Reviewer 2:

This reviewer would like to see the capabilities of the teams extended a bit more than what was summarized. According to the reviewer, the effect of cooling rate on the refinement of a microstructure is certainly interesting but hardly cutting edge within the current research.

Question 3: Please comment on the collaboration within the 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 the three national laboratories participating as program partners, ORNL (Program Lead), PNNL, and ANL, are working together and effectively using their unique tools to support the development of next generation EV powertrain materials. The National Renewable Energy Laboratory (NREL) is also involved by offering access to the High Performance Computer User Facilities. This arrangement appears to be an effective way to perform the work using facilities that are best suited to complete the proposed subtask activities.

Reviewer 2:

This reviewer noted that the work is being spread across three national laboratories that are extensively familiar with one another based on collaboration across a vast number of programs.

Question 4: Please comment on the 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 pointed out that the researchers will continue to expand on the research to improve electrical and magnetic measurements for EV materials. In the eyes of the reviewer, these are critically important material properties for electric vehicles. Additional work is planned on developing/understanding ultra conductors using the ShAPE process. Researchers will continue to implement the eutectic growth cellular automata model in open foam for high performance computing. All three activities are needed to cost-effectively help improve the materials being used in EVs.

Reviewer 2:

According to this reviewer, future research for the five-year program seems to be “continuing doing what we are doing.” While the reviewer finds this appropriate, the reviewer notes that long term programs can ideally leverage discoveries to branch in new directions, even within the stated focus area.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer states that the project is directly relevant to the VTO Materials subprogram objectives.

Reviewer 2:

This reviewer confirms that the areas being addressed meet the VTO objectives.

Reviewer 3:

This reviewer finds the project is aligned with the Materials subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believes that these subprojects complement the activities being performed outside of this project. This appears to the reviewer to be a cost-effective approach to keep the ICME database and modeling tools updated and accurate.

Reviewer 2:

According to this reviewer, a considerable amount of funding is being provided, but the impressive publications list provides strong evidence that this is project money well spent.

Reviewer 3:

This reviewer finds that the resources are sufficient.

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, 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. 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.

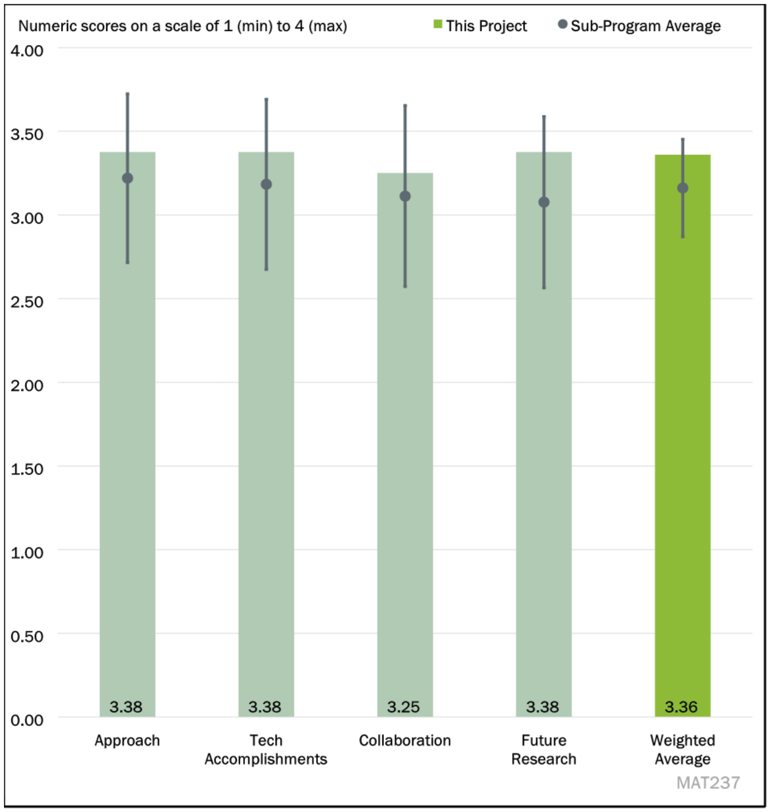

Figure 5-15 - Presentation Number: MAT237 Presentation Title: Materials, Lubricants, and Cooling for Heavy Duty Electric Vehicles Principal Investigator: Jun Qu (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer characterizes the project as leveraging CNTs due to their exceptional thermal conductivity and self-lubricating capabilities and adding them to EV fluids for improved heat transfer and lubricating efficiency. The project is using chemical vapor deposition to create a CNT coating for EV thermal and friction management.

Reviewer 2:

This reviewer finds the project to be very exciting research that is approaching real world applications. The team has a well-developed research plan to successfully demonstrate both super-lubricity and heat transfer efficiency. By integrating CNTs, this work provides a pathway for both characteristics. Through the research, a process to organically modify the CNTs has been established and a pathway established for using polar CNTs and non-polar CNTs in lubricating oil with little impact on viscosity. CNTs were assessed as an approach to improve thermal impedance reduction through the use of a CNT coating on a part of a thermal interface material. Leveraging the existing knowledge from the ICME database was a cost-effective approach to address issues encountered with EVs in regard to cooling and parasitic friction challenges.

Reviewer 3:

This reviewer calls the project an interesting approach to re-visiting the extraordinary properties of CNTs.

Reviewer 4:

This reviewer said that the primary challenge of how to use CNTs as an additive or a coating was described and addressed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer identified as notable accomplishments in the least year: success in CNT's oil suspension and organic modifications to mitigate the oil viscosity rise due to addition of CNTs. Minimal addition of modified CNT's (0.1%) increases oil's thermal conductivity by 10-12% and volumetric heat capacity by 10-16%. CNT coatings were formed with low-cost chemical vapor deposition process and provide super lubricity which demonstrated 40-60% reduced thermal impedance.

Reviewer 2:

This reviewer recounted how a chemical vapor deposition process was used to form a CNT coating growth on stainless steel and Al alloy. This coating provided super lubricity in a macro-scale for over 500,000 cycles in a laboratory test. This also provides an emergency coating to ensure that, if lube oil is lost, low friction operation can continue for an extended period of time. The CNT coating could also provide 40%–60% reduction in thermal impedance, when combined in an interface in a non-friction environment.

Reviewer 3:

This reviewer said that progress seems good with the inclusion of considerable work in the friction reduction category. Some baselining of the characteristics would have been helpful to the reviewer. The reviewer poses a question of how the wear compares to a diamond like carbon coating and to a hard coating or surface treatment with standard lubrication.

Reviewer 4:

This reviewer notes that the focus, thus far, has largely been in developing a method to suspend CNTs or to coat other materials with CNTs. While good progress has been made in these efforts, it still seems to the reviewer that the practical challenge of use of CNTs has yet to be addressed.

Question 3: Please comment on the collaboration within the 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 observed that there is a CRADA with Valvoline regarding existing lubricants and a CRADA with Rocky Mountain Research Institute regarding coatings is in the process.

Reviewer 2:

According to the reviewer, the alignment of the project team with a national laboratory lead, ORNL, enables it to leverage its unique capabilities from other related projects under Thrust 4 to maximize the investment made by DOE. ORNL is also setting in place the mechanisms needed to commercialize this technology as it develops CRADAs with industry partners. These arrangements are critical to bringing this technology to the commercial marketplace. Typically, university participation is requested to be included as part of these projects. However, the reviewer is of the opinion that, since this project is much closer to commercialization, university participation would not provide significant value as CRADAs have been/are being executed with industry participants.

Reviewer 3:

This reviewer thinks that Valvoline is certainly an ideal partner.

Reviewer 4:

This reviewer said that, although the presentation addressed who was collaborating, how they were working together and what roles each group was taking on was not as well addressed.

Question 4: Please comment on the 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 material characterization and systematic thermophysical and tribological evaluations are appropriate future research activities based on the project end date at the end of Fiscal Year 2023.

Reviewer 2:

In the estimation of this reviewer, several steps are still needed to develop a commercial product with this technology. On the lubricant side, work still needs to be done on stable CNT oil suspensions at elevated temperatures, optimization of size and concentration of CNTs in oil, impacts on electrical, thermophysical and tribological properties of the oil, and determination of what is required to meet EV fluid requirements. On the coatings work, work needs to continue with higher contact pressures and temperatures, assessments of impact of CNT size and number, determination of system thermophysical and tribological impacts, and development of commercial EV components using this technology.

Reviewer 3:

This reviewer offered that good follow-on work was identified. Despite the positive results being shown, there is a lot of work to do in this area before the adoption of CNTs.

Reviewer 4:

Though noting that it is likely outside of the current timeline, the reviewer suggests that doing some prototype testing inside engines or engine components may be a good check. The reviewer has a suspicion that the CNTs may behave in unexpected ways that may not be the same as what is optimal in a laboratory setting. The reviewer also suggests looking into the cost/scalability questions with using CNTs.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer finds that the project contributes to VTO's materials program goals to accelerate development of advanced materials for EVs. Specifically, the project focuses on propulsion materials and lubricants for heavy-duty EVs to improve cooling efficiency and reduce parasitic friction in electric motors and electric vehicle axle gearboxes.

Reviewer 2:

The reviewer confirms that the project is directly relevant to the VTO Materials subprogram objectives.

Reviewer 3:

This reviewer characterizes the project as a rather advanced approach on potential improvements to lubricants.

Reviewer 4:

This reviewer says that the project addresses frictional losses that are common to all vehicles.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer offers that just under $500,000 per year funding seems appropriate for the project scope and accomplishments.

Reviewer 2:

This reviewer believes that the project’s innovative approach to lubrication and cooling has significant commercial applicability in the EV space and throughout industry. The use of CRADAs should be encouraged to allow industry to invest in this promising research. DOE should also identify other possible applications of this exciting and cutting-edge research.

Reviewer 3:

According to this reviewer, the completion level identified indicates that some fast-paced work will have to occur at the finish.

Reviewer 4:

This reviewer suggests more interaction with the heavy vehicle industry as end users. Perhaps the interaction would be more about getting the industrial perspective, but it also seems to the reviewer that it might help with earlier adoption of these discoveries. Additional resources may also assist in evaluating cost and scalability, according to the reviewer.

Presentation Number: MAT241
Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion
Principal Investigator: Beth Armstrong (Oak Ridge National Laboratory)

Presenter

Beth Armstrong, Oak Ridge National Laboratory

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.

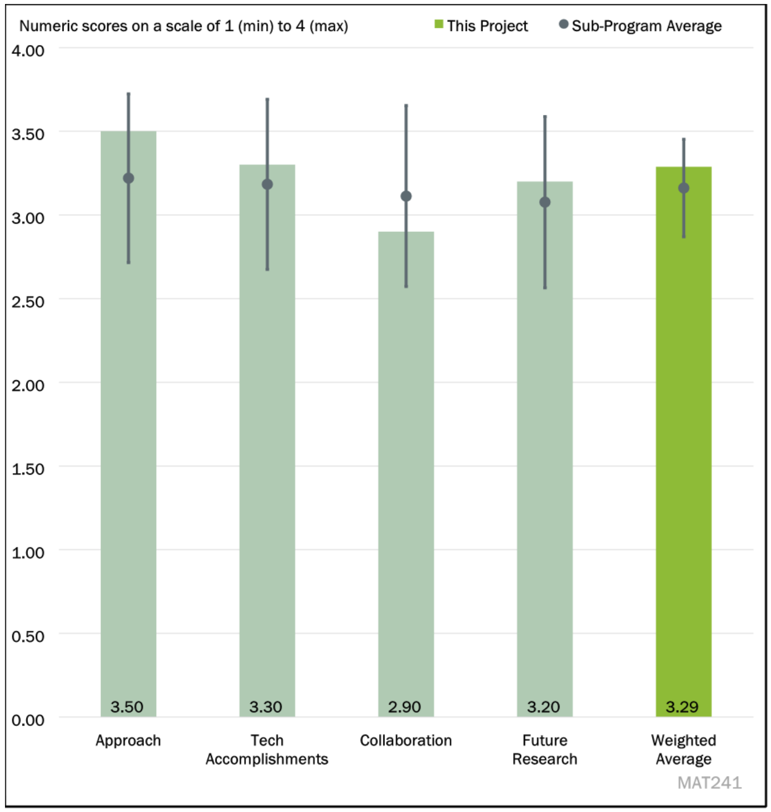

Figure 5-16 - Presentation Number: MAT241 Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion Principal Investigator: Beth Armstrong (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer considers that the project's approach to developing tunable and lighter weight advanced ceramic materials and developing new processing methods for fabrication of wireless charging systems for EV applications is a good one, as not much information on this topic exists in the literature.

Reviewer 2:

This reviewer notes that this activity falls under Thrust 3 of the VTO PMCP, Advanced and Additive Manufacturing for EVs. New lightweight cost-effective ceramic materials are needed for wireless charging. Recycled ferritic powders currently dominate the resource supply chain and the impact of recycled powders is unknown. Since ferrites in use today were developed over fifty years ago, new characterizations and tailored compositions, the reviewer concludes that use novel architectures and processing techniques are needed. The ORNL team is developing tunable and lighter weight advanced ceramic materials. They are also developing new processing methods for fabrication of wireless charging systems for EV applications. They are completing this by using a 6-stage process: determine properties of interest; benchmark existing materials; develop new materials; optimize ferrite fabrication methods; and fabricate lightweight architectures using advanced processing techniques.

Reviewer 3:

This reviewer sees the work as approaching the topic of materials development from both the performance and manufacturing sides. This approach of optimizing the Ni dopant concentration for Curie temperature and permeability and also the dispersant concentration for stability in a slurry is useful for determining the candidate materials. The approach could be improved by adding a modeling component but with limited literature, which could be difficult. Overall, the project is well organized.

Reviewer 4:

This reviewer commends the project for making good use of computational thermodynamics approaches to supplement physical characterization. The ceramic vs metallic choice seems overly simplistic, according to the reviewer, who believes that ceramics often (or always) add a layer of complexity due to reduced yields from stochastic defects.

Reviewer 5:

This reviewer finds the research space here to be very broad and aspirational. As such, the reviewer finds it hard to determine which technical barriers are most relevant and how the planned approach addresses them.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer identified notable accomplishments in the least year to include baselining commercial materials, developing new materials by dopant chemistry, determining a need for a new processing method, and determining that the use of dispersants improves stability of ferrite powders.

Reviewer 2:

This reviewer found that the team has successfully completed a baselining of common commercial materials, making possible an assessment of composite and porous architectures. According to the reviewer, nonmagnetic cementitious space leads to the applicability of lighter weight porous structures. Dopant nickel ferrite ($NiFe_2O_4$) materials meet the Curie temperature requirements to permit induced magnetism. Sinterability is critical to control microstructure and strength of material. The reviewer believes that more fundamental understanding of Ni dopant materials is needed since large grains are needed for optimum magnetic behavior. A processing method to achieve larger grains is needed since sintered microstructure is highly dependent on the starting particle size. Sinterability and mechanical properties balance are critical. Researchers investigated the Zeta potential, finding that high Zeta indicated indicates a more dispersible powder. Slurry stability is needed to control the material architecture. Slurry stability improved with increasing Ni dopant concentration and increasing dispersant concentration. Doping creates complex spinel solid solutions and researchers have investigated the detailed defect chemistries of doped ferrites with computational thermodynamics.

Reviewer 3:

This reviewer believes that the project's progress is good, including the identification not only of areas of progress, but areas where improvement is needed, which is a strong component of the direction of this research.

Reviewer 4:

This reviewer is concerned that the research, thus far, seems focused on a fairly-narrow composition range. It is not clear to the reviewer whether these are the best materials for the application or if additional alloy development would be beneficial.

Reviewer 5:

This reviewer saw good progress on identifying candidates. but finds it somewhat unclear how the last objective is going to be achieved in the time remaining.

Question 3: Please comment on the collaboration within the 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 the partners seem well equipped to perform analysis.

Reviewer 2:

This reviewer said that several ORNL facilities including the National Transportation Research Center and the Manufacturing Demonstration Facility are contributing to the project as is a commercial power vendor, Steward Advanced Materials.

Reviewer 3:

This reviewer commented that the project team led by ORNL is able to leverage its extensive in-house capabilities that are required to advance the material development work. Using the National Transportation Research Center and the Manufacturing Demonstration Facility, along with Raman microscopy and electron probe microanalysis, these facilities and tools provide the needed capabilities to assess the development of these materials. The addition of industry partner Steward Advanced Materials, (a commercial powder vendor), provides the team a new capability to assess actions needed to bring macro scale material production to the commercial marketplace. The reviewer believes that leveraging other national laboratory capabilities should be considered along with, when the time is right, the execution of a CRADA with an industry partner that would be interested in commercializing the material into a wireless charging solution.

Reviewer 4:

This reviewer noted that various reviewers have already pointed out the lack of partnerships outside of the laboratory, which is unfortunate because the work is applicable to extremely relevant current technology needs. The reviewer suggests that the team, perhaps take a closer look at startups or small companies that can join as in-kind contributors.

Reviewer 5:

According to this reviewer, the project seems to be mainly an in-house effort so far.

Question 4: Please comment on the 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 future research is appropriate, considering that project completion in Fiscal Year 2023 includes continued optimization of processing techniques and modeling, as well as development of magnetic property testing techniques.

Reviewer 2:

This reviewer noted that ORNL is proposing to continue efforts to optimize colloidal processing techniques for casting and additive manufacturing fabrication. They also plans to continue modeling efforts to guide the development of future ferrite material compositions and to develop a model to guide design of novel architecture structures, which is to lead to the development of intermediate and large-scale magnetic property testing techniques. This approach appears to incorporate the right steps that are needed to develop a material for wireless charging systems.

Reviewer 3:

The reviewer commented that the proposed research into both processing techniques and modeling components is reflective of the level of understanding on the topic that the team has gained over the course of this program. The testing technique development presents a challenge.

Reviewer 4:

This reviewer pointed out that the principal investigator has identified a large margin for improvement of efficiency, even among benchmark materials. However, the reviewer suggests looking at slightly higher technology readiness levels (TRLs) with research directions such as scale models or similar tools so that environmental factors (water, concrete, salt, etc.) can be evaluated. Also, instead of the dynamic charging, charging while parked might be an easier near-term target that would also address some of the concerns about connectors in EVs, according to the reviewer.

Reviewer 5:

This reviewer lauds the project as certainly promising and a great jumping off point for future work and would like to see more specifics around each of the bullet points. For example, for the continued optimization of the colloidal processing techniques, the reviewer asks whether this research has indicated more promise in one technique over the other (extrusion vs. casting), whether the intermediate and large-scale testing techniques would be used (for production and/or for down selecting a large number of compositions, etc.).

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirms that the project supports the VTO materials subprogram objectives, as it is part of the PMCP's advanced and additive manufacturing for EVs thrust and is developing new, lightweight and cost-effective ceramic materials for wireless charging.

Reviewer 2:

This reviewer said that the project is directly relevant to the VTO Materials subprogram objectives.

Reviewer 3:

This reviewer believes that there is no question on this program's applicability to EV infrastructure development.

Reviewer 4:

This reviewer noted that the project links to materials and electrification challenges while expressing curiosity as to whether links to the batteries program have been explored since this style of charging would change the target cycle lifetimes and discharge rates.

Reviewer 5:

This reviewer held that wireless charging is an important advancement to improve adoption of electric vehicles and that better/cheaper solutions are needed.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believes that the just under $300,000 per year funding seems appropriate for the scope and accomplishments of this project, which is ending in Fiscal Year 2023.

Reviewer 2:

This reviewer said that the resources appear to be sufficient to achieve the stated goals of the project.

Reviewer 3:

This reviewer questioned the project's being 75% complete with 3 months left.

Reviewer 4:

This reviewer found the resource question hard to gauge, as this seems to the reviewer to be a high risk/high reward project and commented that additional resources or collaborations for integration into road or other applications seem likely to be useful here.

Reviewer 5:

This reviewer noted that this project is very much a research project, so resources are fine.

Presentation Number: MAT242
Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion, Advanced Ceramics and Processing for Wireless Charging Systems, Novel Ultra High Conductivity Composites for EVs
Principal Investigator: Tolga Aytug (Oak Ridge National Laboratory)

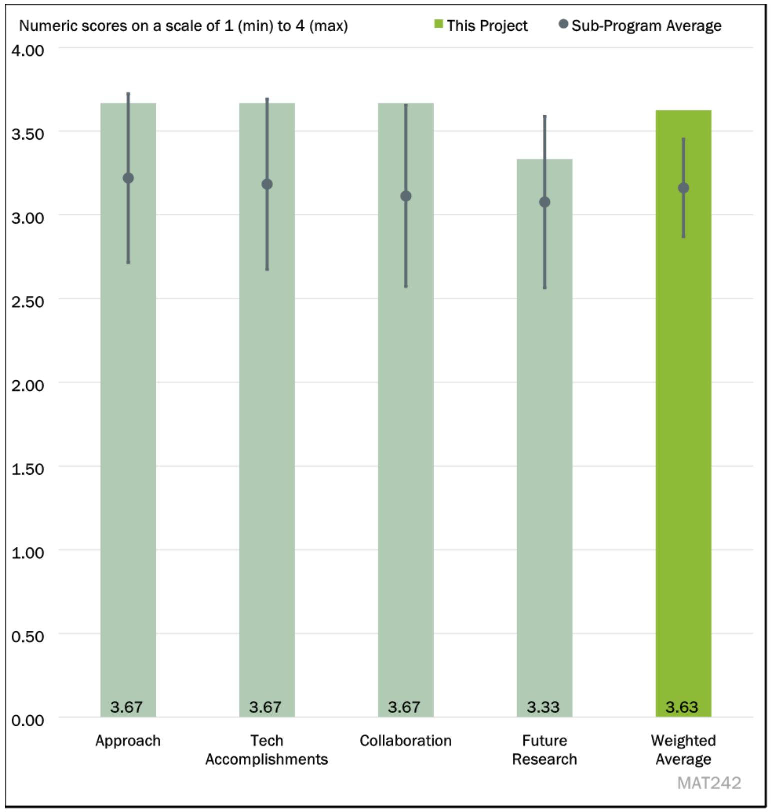

Figure 5-17 - Presentation Number: MAT242 Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion, Advanced Ceramics and Processing for Wireless Charging Systems, Novel Ultra High Conductivity Composites for EVs Principal Investigator: Tolga Aytug (Oak Ridge National Laboratory)

Presenter

Toiga Aytug, Oak Ridge National Laboratory

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, 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.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer pointed out that the project involves research on novel, ultra-high conductivity materials for EVs to enable the project aims to develop the materials to meet DOE 2025 power density and size performance targets and reliability goals. Reductions in EV components’ volume/weight and improvements in efficiency are currently limited by the copper windings used for electrical conductivity. Research is being performed to improve the efficiency and lower the weight of electrical conductivity materials as compared to copper windings.

Reviewer 2:

This reviewer commended the project as a good mix of characterization and process evaluation to determine if the copper-CNT material is feasible and scalable.

Reviewer 3:

This reviewer found the project to be a well-designed study that answers several questions and shows improvement in conductivity with the addition of graphene. The team appears to have a good start on scaling up the production, according to the reviewer.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer described how ultra-high conductive materials are needed since the market for copper is growing significantly. A target for improved conductivity over copper has been set at 10%. Ultra conductive copper (UCC) with CNTs embedded in a copper matrix material is being explored. The project work has transitioned to demonstrating a double layer matrix from a single layer which provides validation that more layers can be added. Excellent interfacial adhesion was achieved between the copper and CNT layers. Copper has successfully infiltrated the CNT layer, which is very important for improved conductivity. Improved resistivity (from single layer at 4.5%–8.0% increasing with a double layer to 8.6%–11.2%) and increased ampacity (from single layer at 7.2%–8.4% to double layer at 14.0%–15.0%) have been demonstrated with the double CNT layer material. It was found that improvements in resistivity do not scale linearly with additional layers. These results were validated by a third-party test performed by Southwire, which performed ASTM resistivity tests for both volume and weight. Modeling through advanced computations indicates that increased electrical conductivity is predicted when a combination of nitrogen and electronic doping is used to increase the charge carrier density of the CNTs by an order of magnitude. CNTs are also shown to improve the mechanical strength (tensile and modulus) of the UCC matrix. However, the material does become less ductile than pure copper. A scaled-up production of the UCC copper matrix with copper sputter system that was modified for reel-to-reel operation was also modeled.

Reviewer 2:

This reviewer noted that the team built several prototype Cu-CNT composites and evaluated the electrical and mechanical responses, which showed improvement over the benchmark material. The team also fabricated material in a form more relevant for industrial use.

Reviewer 3:

This reviewer stated approvingly that the project has progressed well. The team demonstrated an incremental improvement on the parameters that they were assessing and verified the conductivity through third party testing. The progress appears to be on track to complete the project with fabrication equipment that can support the next steps.

Question 3: Please comment on the collaboration within the 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 commented that the alignment of the project team with a national laboratory lead, ORNL, enables it to leverage its unique capabilities from other related projects under Thrust 4 to maximize the investment made by DOE. ORNL is using the Oak Ridge Leadership Computing Facility, specifically the Compute and Data Environment for Science data analytics research facility, and the Summit supercomputer. ORNL is also preparing to move this project from laboratory research to commercial production. ORNL has partners with leading organizations, including Southwire, Chasm Advanced Materials, and General Graphene. With GM now showing interest in this project, a formal arrangement with the partners and GM in the form of a CRADA should be considered.

Reviewer 2:

This reviewer found the list of collaborators and how they are integrated into the project to be good.

Reviewer 3:

This reviewer believes that the team has coordinated well and is glad to see industrial involvement.

Question 4: Please comment on the 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 ORNL is proposing to continue efforts to optimize parameter space to establish the highest possible performance. Activities to assemble and evaluate the influence of multilayer UCC composites with additional copper/CNT stacks are also proposed. A scale up to an all-continuous reel-to-reel process and establishing key processing parameters for long- length (more than 50 cm) CNT deposition are also proposed. The team also wants to explore H_2O based CNT dispersion formulations combined with scalable CNT coating approaches. In addition to these activities, a comparison between recycled copper versus virgin copper should be completed to determine whether there are any differences in UCC performance.

Reviewer 2:

This reviewer did not see any finite element analysis or similar optimization approaches discussed by the principal investigator. It seems to the reviewer that determining the optimal mix of layer thickness and distance between layers could be investigated computationally, as could failure mechanisms.

Reviewer 3:

This reviewer thinks that the proposed future work is definitely on the right track in focusing on further scaling. The only thing the reviewer would add is that there needs to be an assessment of robustness and repeatability. This is especially important as more layers are added. This may also be incorporated into what the team is proposing, according to the reviewer, but the reviewer thinks that this does need to be addressed (even if only a preliminary study were to be done).

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer finds that the project is directly relevant to the VTO Materials subprogram objectives.

Reviewer 2:

This reviewer says that the project fits into the electrification and materials objectives.

Reviewer 3:

This reviewer affirms that the project is very timely and relevant.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found that the team appears to have sufficient resources to complete the project by September 2023.

Reviewer 2:

This reviewer considers the resources to be sufficient to achieve the stated goals of the project. However, additional resources could accelerate UCC material to the commercial market. This should be considered, as copper demand is significantly increasing, and alternative ultra-conducting material is needed.

Reviewer 3:

This reviewer remarked that the team noted being overloaded.

Presentation Number: MAT243
Presentation Title: Manufacturing Demonstration of a Large-scale
Principal Investigator: Srikanth Pilla (Clemson University)

Presenter

Srikanth Pilla, Clemson University

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.

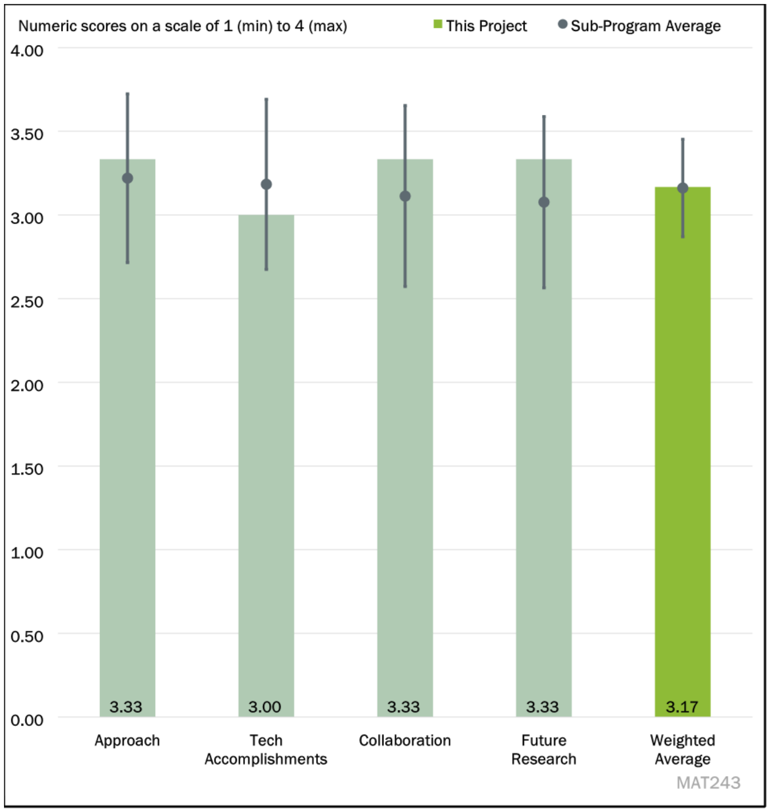

Figure 5-18 - Presentation Number: MAT243 Presentation Title: Manufacturing Demonstration of a Large-scale Principal Investigator: Srikanth Pilla (Clemson University)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer found that the team has focused on tasks including design and technology integration, multi-material joint modeling and experiments, cost assessment, cycle times and design optimization for full scale validation to sharply address the technical barriers identified.

Reviewer 2:

This reviewer considers the approach to be straightforward and reasonable.

Reviewer 3:

This reviewer pointed out that the overall approach of developing a new glider is essentially the same as any commercial OEM would take. However, the project team has identified opportunities for lightweight material integration into the body-in-white structure, which drives a number of new technologies. The project team has identified potential roadblocks and structured its project to address them. For example, development of a CF/metal joint is ongoing with process development and planned subsequent CAE card development. However, typically this requires validation of the material card on a drop tower hat section or the like which the reviewer does not see included in the work plan.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer determined that all tasks in Budget Period 1 were completed, and five tasks are in progress for Q3 2023–Q2 2024. In general, sufficient progress has been made for each planned target.

Reviewer 2:

This reviewer commented that, considering that the project is at a 30% completion level, the fact that the team has whittled down the selection to two concepts based on a set of criteria is appropriate. (The reviewer would have preferred for these criteria to have been identified and concepts weighted accordingly.) However, what is unclear to the reviewer is the method the team used to represent the various concepts under the loading conditions given that the CF/metal joint CAE card has not been developed at this point. Because representation of these CF/metal interfaces is the key to success for such an aggressive plan, this point requires greater elucidation within the project.

Reviewer 3:

This reviewer noted that, with the project being in its first year, it is rather difficult to evaluate the progress. The concept development appears to be good; however, it is rather attempting to be effective and qualitative, not quantitative. The numerically evaluated team's different concepts are based on a physics-based simulation; however, the fidelity of numerical simulations was not provided. Due to the limited presentation time, detailed explanations of the progress were not given.

Question 3: Please comment on the collaboration within the 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 considers the role of each partner in the project team to be clearly stated and good contributions are made from each partner from industry and universities. Involvement of nine companies from different aspects contributes significantly to the implement of the proposed work.

Reviewer 2:

This reviewer applauds the collaboration and coordination across the project team as being well-designed to create synergies.

Reviewer 3:

This reviewer commented that, although the project team includes a wide cast of members, this is not atypical for such a body-in-white development project. The weekly meetings and technical team discussions, which the reviewer assumes to be smaller, are very positive and, in fact, necessary, according to the reviewer. What is not clear to the reviewer is how and when the various specific deliverables (such as the CAE card for the CF/metal joint and determination of the feasibility of using recycled materials and the CAE card for such an optimized recycled content) are to be synced to the greater glider design project. A linear timing chart reminiscent of a typical week-by-week vehicle development plan highlighting the various data syncs, deliverables, etc., would help to show the greater picture of coordination across the project team.

Question 4: Please comment on the 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 tasks are clear for addressing the remaining challenges and barriers, although it would be helpful to the reviewer to have been provided more details on the technical approaches to be used to achieve each task/objective.

Reviewer 2:

This reviewer praises the proposed future research as very focused and detailed, with an overall step-by-step approach. One thing which the reviewer believes may be helpful is identification of the critical path for development of this multi-material glider. This would facilitate identifying whether resources were allocated in the best manner to mitigate risk for the overall project.

Reviewer 3:

The proposed future work looks reasonable to this reviewer.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirmed that the project will support the Materials subprogram to achieve cost effective sustainable lightweighting vehicle body-in-white sub-systems through comprehensive evaluation of multi-material systems, joining methods, industry-standard manufacturing processes and recycling technologies.

Reviewer 2:

This reviewer holds that development of a multi-material joining technology as well as recycled fiber composites of lightweight materials addresses the technology development needs towards industrial applications. Its implementation would support mass savings and thus reduction of GHG emissions in addition to increasing the range for EVs by such mass savings.

Reviewer 3:

The redesign and manufacture of a high-volume mid-size sport utility vehicles' body-in-white sub-system to achieve cost-effective and sustainable lightweighting through component consolidation, state-of-the-art optimization tools, multi-material joining methods, industry-standard manufacturing processes, and recycling technologies while meeting or exceeding baseline performance is very relevant to VTO's mission space.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found that the team collaborates with a very good list of industrial collaborators along with two universities to ensure achieving the stated milestones.

Reviewer 2:

This reviewer points out that this a large project with many participants. The project resources/budgets appear to be appropriate.

Reviewer 3:

This reviewer described how the project is a very complex integrated endeavor where there are critical technology development paths nestled within a conventional automotive glider development project. Unfortunately, there is no information regarding how the significant budget sum is allocated and broken down to address the critical technology roadblocks this project addresses, according to the reviewer. However, given that the key players (Honda, Ohio State University, Clemson) are all coming at this from their respective fields of experience, the reviewer feels that it is safe to assume an appropriate allocation of resources. This will be more evident after the second full year of completion.

Presentation Number: MAT244
Presentation Title: LMCP P1A - Sheet Materials with Local Property Variation
Principal Investigator: Scott Whalen (Pacific Northwest National Laboratory)

Presenter

Scott Whalen, Pacific Northwest National Laboratory

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.

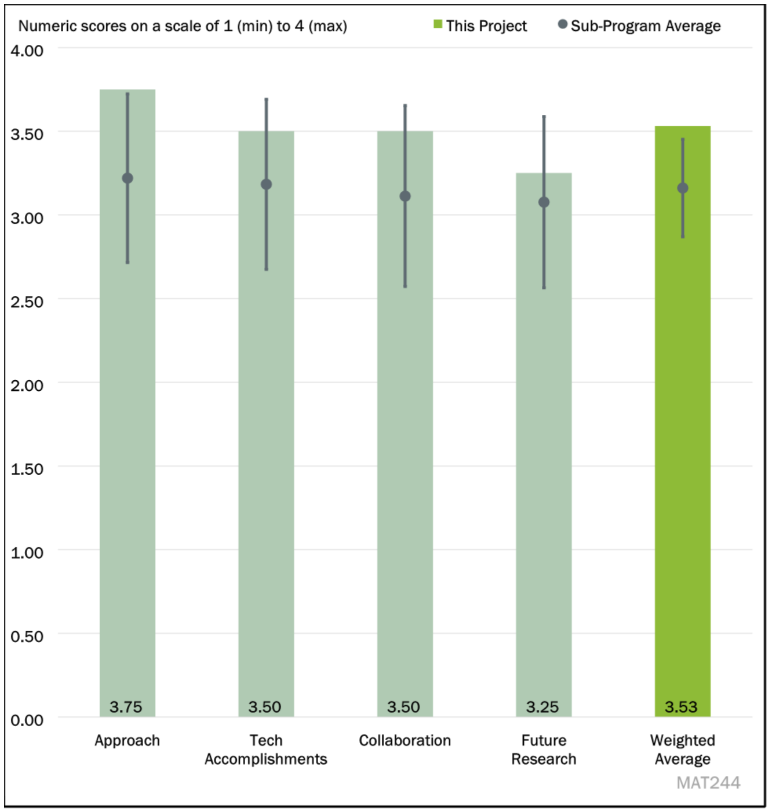

Figure 5-19 - Presentation Number: MAT244 Presentation Title: LMCP P1A - Sheet Materials with Local Property Variation Principal Investigator: Scott Whalen (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer stated that enhancing local properties can be beneficial to certain applications.

Reviewer 2:

This reviewer notes that the approach has been changed from previous years, in which it involved converting the extruded pipe to sheet. This year the work was concentrated on extrusions with varying wall thickness as the end product. The approach is good, and the team had some earlier success in obtaining tubes with variable wall thickness. The team has also identified possible applications in collaboration with industry partners.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer stated that the process demonstrated significant property improvements in certain parts.

Reviewer 2:

This reviewer notes that the team has developed a process to obtain variable wall thickness in pipes and also developed a technique for rapid cooling. Progress has been made on measuring the performance. More efforts are needed to model and prediction of performance of variable wall thickness.

Question 3: Please comment on the collaboration within the 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 good collaboration with industry.

Reviewer 2:

This reviewer said that the team has obtained advice from an OEM of the end use product that has raw material suppliers.

Question 4: Please comment on the 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 determined that the future work proposed on process improvement and use of recycled material is good.

Reviewer 2:

This reviewer would encourage using post-consumer scrap to maximize impact.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirms that the project is relevant to vehicle lightweighting.

Reviewer 2:

This reviewer points out that the project is trying to develop technology to produce components with targeted properties at target locations. The success on the process development needs to be supported by design, models, and testing.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer states that the resources seem sufficient.

Reviewer 2:

This reviewer expects that there will be enough funds for experimental work but that maybe in future more efforts will be needed on design and modeling.

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, Oak Ridge National Laboratory

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.

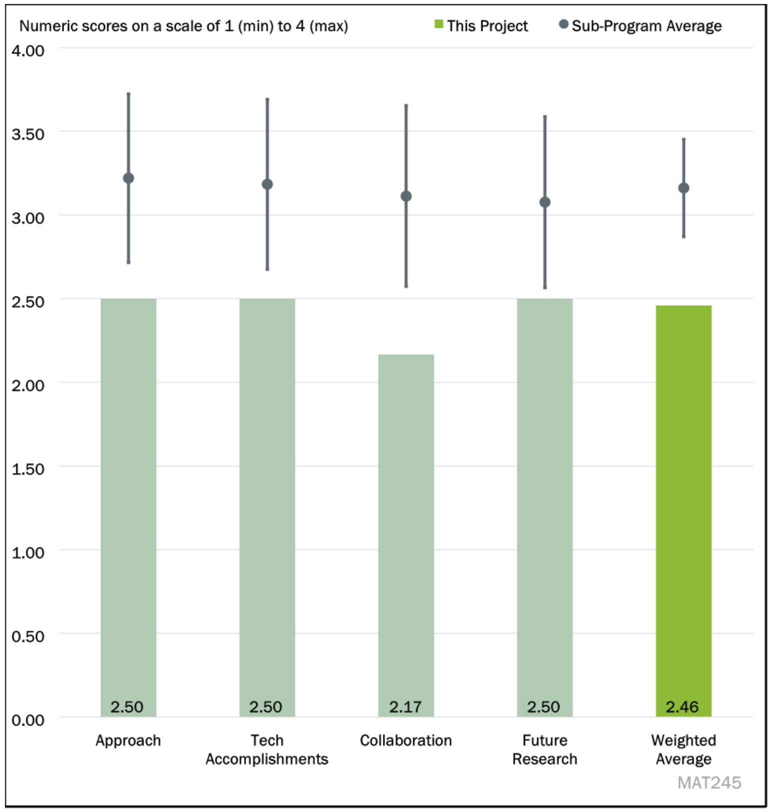

Figure 5-20 - Presentation Number: MAT245 Presentation Title: LMCP P1B - Form-and-Print - AM for Localized Property Enhancement of High-strength Al sheet Principal Investigator: Alex Plotkowski (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer commented that the approach is to modify or build surfaces on sheet material to change the local properties. While the added material can enhance the performance (strength, corrosion or fatigue) the change in structure of the underlying material can also influence the performance in a bad way. However, according to the reviewer, these properties cannot be determined without conducting some experiments and this project is conducting such experiments.

Reviewer 2:

To this reviewer, research on improving the ability to recycle alloys seems to be missing.

Reviewer 3:

This reviewer found that the approach identified adding a stiffening bead using wire additive and plug welding a predrilled hole. The problem for the reviewer is that the testing was done on a lap joint.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

It is somewhat concerning to this reviewer that Fiscal Year 2023 milestones are only half complete at end of the third quarter.

Reviewer 2:

This reviewer comments that the team has developed processes and evaluated multiple materials. While some improvements have been observed, the reviewer feels that the validity and usefulness of the process still needs to be proven.

Reviewer 3:

This reviewer described how 4047 filler wire used to plug weld a 6016 sheet through a pre-machined hole resulted in cracks at the interface and porosity in the infill. The increased stiffness achieved by adding beads to a flat sheet resulted in cracks, which is not acceptable. The results indicate that there is no benefit associated with using wire feed laser-assisted processing and no plan to address the situation. The feasibility of adding a stiffener to a 90-degree bend was not investigated, and not scheduled. The reviewer believes, but is uncertain, that the feasibility of plug welding using Al4047 wire through a machined hole in a 304 stainless steel to attach a 6061-Al bottom sheet is pending investigation in year 3.

Question 3: Please comment on the collaboration within the 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 believes that the team has good working relationships with partners. An OEM and suppliers are involved.

Reviewer 2:

This reviewer asserts that collaborations with Ford Motor Company, Mazak, Lincoln Electric and CompuTherm were noted but only collaboration with Mazak (procurement) was actually described.

Reviewer 3:

This reviewer sees no evidence associated with collaboration within the project team.

Question 4: Please comment on the 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 is satisfied that end of the program is near, and progress is good with not much being planned before the end of the project in Fiscal Year 2023.

Reviewer 2:

This reviewer merely notes that proposed future research includes evaluating 4043 and 5356 wire to increase ductility and toughness of the beads.

Reviewer 3:

This reviewer refers to a listing of ideas having been provided with purposes defined and, in a few cases, given qualitative descriptions but considers it difficult to determine their likelihood of success.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirms that the project supports the VTO materials subprogram.

Reviewer 2:

This reviewer believes that the project supports the VTO subprogram objectives and is relevant to the materials joining program but feels that it has been poorly executed. The reviewer understands that the project objective is to investigate the feasibility of adding a stiffener rib to a formed sheet vertical wall or join dissimilar materials by plug welding through a predrilled hole using a TruLaser wire-fed 5-axis weld system. The project objective was not accomplished in the eyes of the reviewer.

Reviewer 3:

This reviewer affirms that improving the performance of sheet products can make them more viable for automotive applications.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said that the number of milestones and the accomplishments appear appropriate for the level of funding.

Reviewer 2:

This reviewer believes that the project has been provided enough resources and the team has many different units of equipment available for the work.

Reviewer 3:

This reviewer asserted that the results presented do not appear to include any significant effort from the cross-functional team members.

Presentation Number: MAT246
Presentation Title: LMCP P1C - Local Thermomechanical Processing to Address Challenges to Implementing High Strength Al Sheet
Principal Investigator: Mert Efe (Pacific Northwest National Laboratory/Oak Ridge National Laboratory)

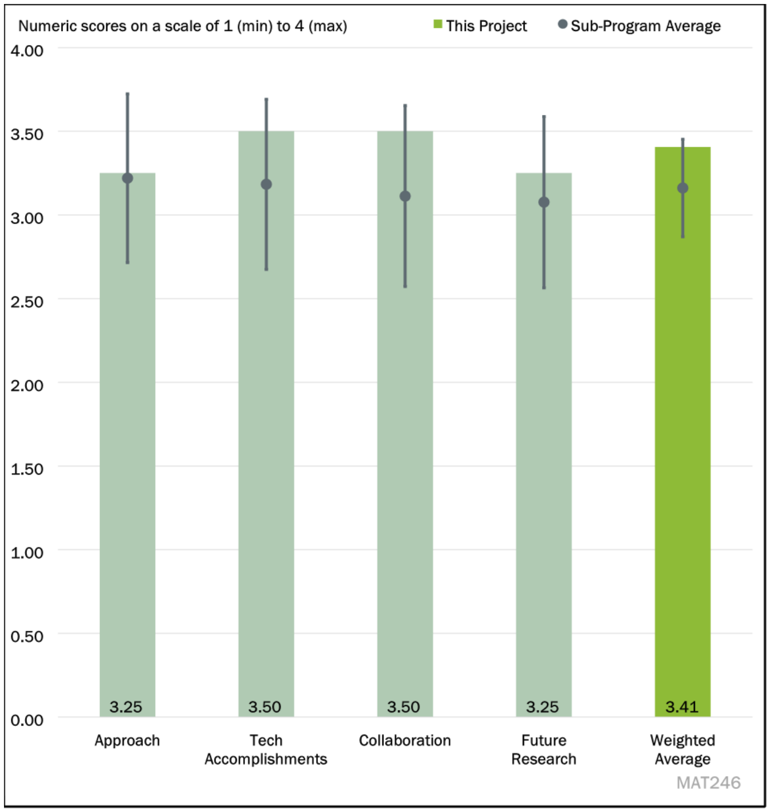

Figure 5-21 - Presentation Number: MAT246 Presentation Title: LMCP P1C - Local Thermomechanical Processing to Address Challenges to Implementing High Strength Al Sheet Principal Investigator: Mert Efe (Pacific Northwest National Laboratory/Oak Ridge National Laboratory)

Presenter

Mert Efe, Pacific Northwest National Laboratory/Oak Ridge National Laboratory

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.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found that the project approach of evaluating four known unique thermo/mechanical processes that can be readily integrated into the manufacturing line to address local formability challenges with high strength heat treated Al alloys only in areas where improved formability is needed while maintaining high strength performance in areas where high formability is not needed is a novel approach that could provide some benefits when aimed at strength critical applications. However, at this point, it is not clear that any of the processes evaluated will be sufficiently cost effective to influence high volume production component applications.

Reviewer 2:

This reviewer complained that there was no discussion of the fact that making it more recyclable (T4 instead of T6) appears to reduce performance nor discussion of how to mitigate this.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The project seems to this reviewer to be on track: at end of the third quarter, ¾ of the milestones are complete.

Reviewer 2:

This reviewer commended that the project displayed good technical progress to date, achieving T4-level formability with some processes and close to T4-level with all processes evaluated. Laser processing formability improvements must still be evaluated, along with completion of modeling and characterization work, and work towards increasing process speeds. The project team should be able to complete these tasks in the time remaining.

Question 3: Please comment on the collaboration within the 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 lauded the team's robust collaboration with ORNL and said that evidence was provided of collaboration with industry, including Ford, GM, Honda, and Tier 1 suppliers.

Reviewer 2:

This reviewer approved of the level of collaboration and coordination between participants, noting that there seems to be very good cooperation between partners and the tasks of each being complementary to the others. Additionally, the desires of the automotive OEMs seem to have been incorporated in the project work.

Question 4: Please comment on the 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 proposed future research is well suited to addressing the remaining project barriers. Laser processing formability improvements must still be evaluated, as well as completion of modeling and characterization work, and increasing process speeds. The project team should be able to complete these tasks in the time remaining.

Reviewer 2:

This reviewer pointed to a listing of ideas provided with purposes defined, and in some cases, given qualitative description, but without sufficient information, making it difficult to determine likelihood of success.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirmed that the project work supports the VTO materials subprogram.

Reviewer 2:

This reviewer pointed out that the project focuses on local formability improvements to allow for increased use of higher strength Al alloys with T6 and T76 heat treatments to enable weight reduction in strength critical applications where high strength Al materials might not normally be practical due to formability limitations.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found that the number of milestones and the accomplishments appear appropriate for the level of funding.

Reviewer 2:

This reviewer stated that the sufficiency of resources has been demonstrated as the project is approximately 85% complete and the work accomplishments seem to closely mirror that.

Presentation Number: MAT247
Presentation Title: LMCP P2A - Solid Phase Processing of Aluminum Castings
Principal Investigator: Saumyadeep Jana (Pacific Northwest National Laboratory/Oak Ridge National Laboratory)

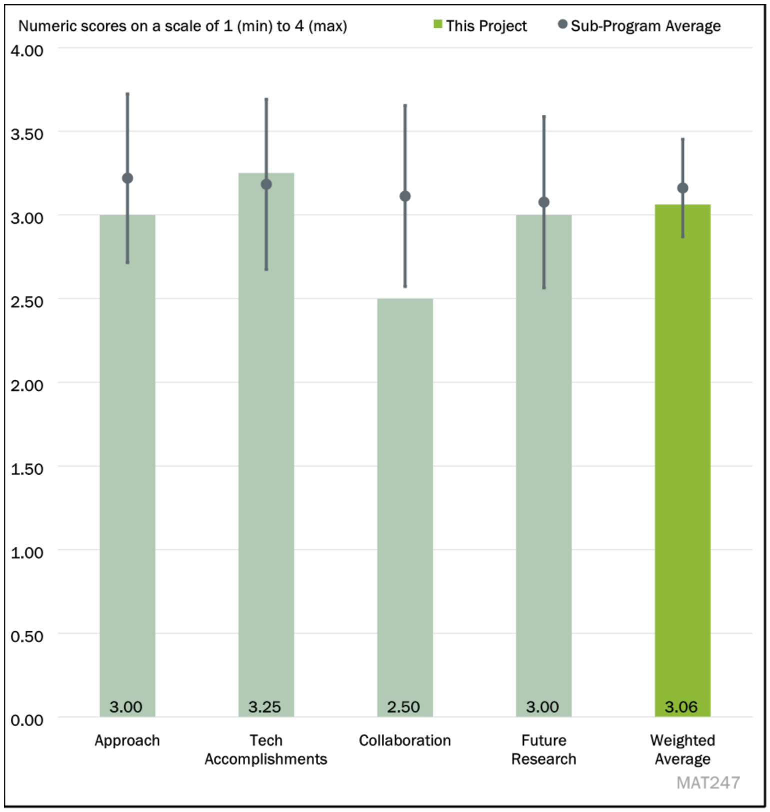

Figure 5-22 - Presentation Number: MAT247 Presentation Title: LMCP P2A - Solid Phase Processing of Aluminum Castings Principal Investigator: Saumyadeep Jana (Pacific Northwest National Laboratory/Oak Ridge National Laboratory)

Presenter

Saumyadeep Jana, Pacific Northwest National Laboratory/Oak Ridge National Laboratory

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.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

To this reviewer, the idea of modifying local structure to enhance properties of cast alloys is good. However, in die cast samples, the top surface is the best material and change may affect it adversely, suggesting that a non-intrusive technology would be useful.

Reviewer 2:

This reviewer finds the approach is appropriate in this project. The friction stir processing (FSP) particularly is making impressive progress.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer believes that friction sir welding as well as ultrasonic processing have improved fatigue resistance by modifying/closing sub-surface porosity. This is a good result but testing these processes on actual parts may be challenging due to complex geometries.

Reviewer 2:

According to this reviewer, the FSP track of the project is making good progress and has demonstrated significant improvements to the fatigue life of samples with a modest increase in hardness (strength) as well. The power ultrasonic-based surface processing (PUSP) is progressing more slowly, but it will be interesting to see what the team accomplishes in the future.

Question 3: Please comment on the collaboration within the 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 finds that, given the parallel tracks, the level of collaboration is satisfactory. Since the FSP process modifies the surface of a sample while improving bulk mechanical properties, and PUSP is being used for surface modification, it will be interesting to determine whether both can truly operate synergistically in the future.

Reviewer 2:

This reviewer points out that supply of material has been provided by the OEM but that no Tier 1 or 2 suppliers have been involved.

Question 4: Please comment on the 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 future work is relevant and believes that it will be particularly interesting to see the applicability of PUSP to complicated thin wall cast parts, and to see the application of FSP by a robotic platform on a prototype part.

Reviewer 2:

This reviewer anticipates completion of the project by end of Fiscal Year 2023 with no new proposed work. The reviewer also is concerned that there is no service provider for product testing.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer points out that the project is aiming to develop technologies to modify/enhance the properties of cast material. This can be an enabler for improved performance and reduced weight.

Reviewer 2:

This reviewer applauds both tracks of this project as directly relevant to the lightweight materials research area as the project is focused on improving properties of component materials, one on the bulk properties specifically, and one on the surface properties.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believes that the resources seem to be sufficient for the proposed work.

Presentation Number: MAT248
Presentation Title: LMCP P2B - High Intensity Thermal Treatment
Principal Investigator: Aashish Rohatgi (Pacific Northwest National Laboratory)

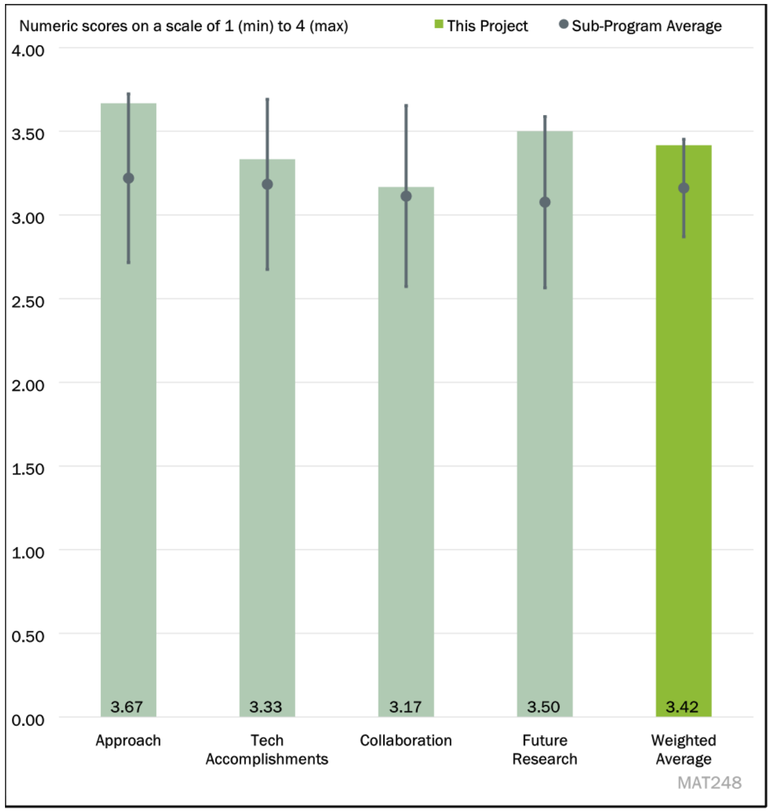

Figure 5-23 - Presentation Number: MAT248 Presentation Title: LMCP P2B - High Intensity Thermal Treatment Principal Investigator: Aashish Rohatgi (Pacific Northwest National Laboratory)

Presenter

Aashish Rohatgi, Pacific Northwest National Laboratory

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.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer considers the approach to be an impressive collection of work. The three tasks are well designed, and the appropriate work has been done to answer the relevant research questions that have arisen and move the tasks forward.

Reviewer 2:

This reviewer sees the approach as including far more testing related to the barrier of low-cost than to the barrier of recycling.

Reviewer 3:

This reviewer commends the approach of evaluating processes to improve properties during solidification, post-solidification, and post-heat treatment as a well thought out and generally comprehensive plan. However, it is not clear to the reviewer whether the improvements from ultrasonic intensification during permanent mold casting solidification will carry over to high pressure die casting processes.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer observes significant progress that has made since the previous year. The team has addressed the research questions that arose from its prior years' work and continues to make great progress and has completed or is on the trajectory to complete the previously proposed future work.

Reviewer 2:

This reviewer believes that the project team has made great progress and achieved impressive results with ultrasonic vibration during the permanent mold casting process and peening of finished castings. Heat treatment of prototype castings through Joule heating and fatigue testing of peened cast Al parts remain to be completed.

Reviewer 3:

This reviewer finds it somewhat concerning that Fiscal Year 2023 milestones are just over ½ complete at end of the third quarter of Fiscal Year 2023.

Question 3: Please comment on the collaboration within the 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 saw evidence of collaboration with ANL using its Advanced Photon Source and ORNL. Equipment from Eck Industries, Sugino Corp. and LSP Technologies was also noted as good by the reviewer.

Reviewer 2:

This reviewer believes that the researchers have effectively leveraged the experimental capabilities of the Advanced Photon Source at ANL and their industrial partners in obtaining large castings from Eck industries.

Reviewer 3:

According to this reviewer, the project team consists of a well-coordinated group of partners from industry and national laboratories working on complementary tasks. The reviewer suggests that the addition of at least one automotive OEM would be desirable to help enable potential commercialization of the technologies evaluated and developed through the project.

Question 4: Please comment on the 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 praised the proposed future research as well defined for addressing the remaining challenges and achieving the remaining project milestones by the prescribed end of the project.

Reviewer 2:

This reviewer considers the proposed future research to be sufficient. In-depth analysis of the *in situ* diffraction data will hopefully indicate details of the microstructural refinement mechanism, which is particularly important to this project. The reviewer is eager to see the results from the fatigue tests on the peened material.

Reviewer 3:

This reviewer found a listing of ideas provided with purposes defined in some cases and believes that those with quantitative descriptions appear likely to succeed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirms that the project supports the Materials subprogram.

Reviewer 2:

This reviewer pointed out that the project’s efforts are focused on reducing the cost of lightweight Al castings by using local property improvements to meet performance requirements with lower cost secondary Al.

Reviewer 3:

This reviewer said that the project is clearly relevant to the lightweight metals portion within the objectives of the Materials program. The team has been particularly successful with the microstructural refinement thrust. The local heat treatment thrust has identified the issue of blistering, and it will be interesting to the reviewer to see the effects of the local surface peening task on lifetimes.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found that the number of milestones and the accomplishments appear appropriate for the level of funding.

Reviewer 2:

This reviewer believes that the resources seem sufficient to achieve the stated milestones in the defined timeline and the project team reports that work is on track to achieve the final two milestones.

Reviewer 3:

This reviewer said that the researchers are continually meeting their objectives in a timely manner, such that the level of resources appears to be correct.

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, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

75% of reviewers felt that the project was relevant to current DOE objectives, 25% 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.

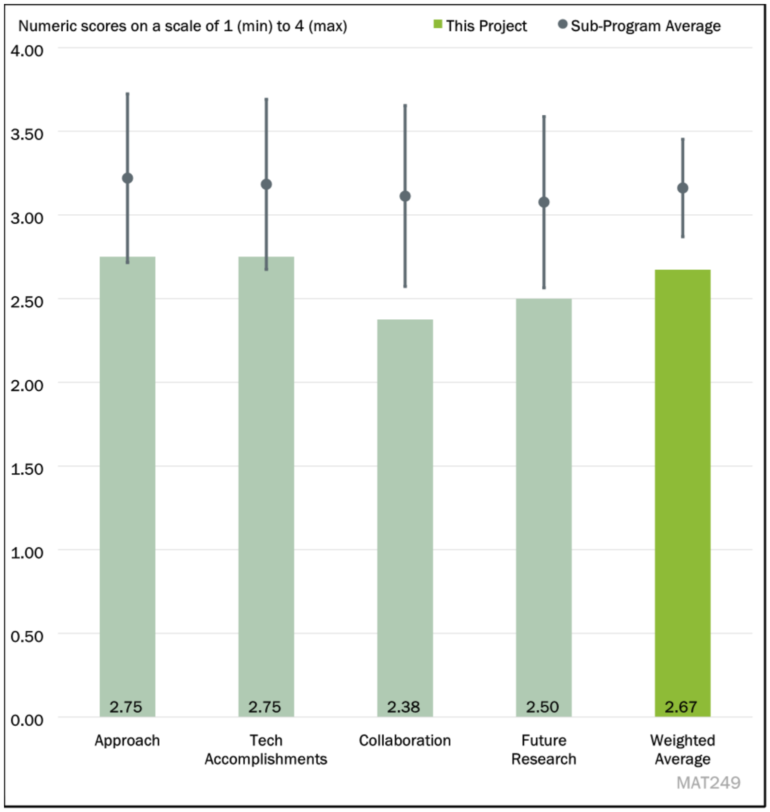

Figure 5-24 - Presentation Number: MAT249 Presentation Title: LMCP P2C - Cast-and-Print - AM for Localized Property Enhancement of Al castings Principal Investigator: Alex Plotkowski (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found that the approach taken by the principal investigators is sound and will lead to addressing the issues being investigated.

Reviewer 2:

This reviewer considers the project to be well designed. Significant technical barriers on printing on cast forms are being addressed at the laboratory scale.

Reviewer 3:

In the view of this reviewer, this is a particularly complicated capability the researchers are trying to develop, and there are still some issues that should be addressed. While work has been described, there is more work to be done to determine the problems that will arise from gas flow during additive manufacturing (AM) on complicated part geometries. Any change to a geometry will change the local flow, and potentially lead to unexpected results in the print. The reviewer thought that the team was going to study this in the previous year. This is in addition to the issues with porosity seen in the substrate in the rivet tabs.

Reviewer 4:

This reviewer asserts that the work performed does not address the project objective and barriers. According to the reviewer, the unstructured approach resulted in disarrayed results and an ineffective use of funds.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer lauded excellent technical accomplishments so far, noting that there are a few issues that the team should consider addressing: (1) Empirical and mathematical evaluations of the residual stresses (and strains) in the deposited material. Visual inspection, as the team has done, is a great first evaluation for the damaging effect of residual stresses, strains, and materials deformation. However, other methods need to be employed to fully evaluate and quantify these materials' conditions. According to the reviewer, any issues missed will likely show up during service. It is preferable to identify them at this stage of research to forestall unfavorable surprises that may appear in the field testing. (2) Cost analyses of the manufactured geometries, to confirm that cost was indeed reduced (as per the project objectives). The reviewer believes that analyses should also be presented to show that the other objectives of minimizing cycle time and reducing the impact of recycle streams were actually achieved.

Reviewer 2:

There is progress being made on what is a difficult task, according to the reviewer. While the geometry of the rivet tabs is quite simple, it would help to demonstrate some of the promise of this capability. The model validation for the AM Al 4047 and any weld consumable material foreseen as useful is important given the cooling rates in the AM process, many passes, etc. The reviewer would like to have some sort of deliverable described regarding this effort.

Reviewer 3:

This reviewer suggests that it would be good to see the interface performance against other joining approaches to establish the improvement provided by print-on-cast over joining two parts of the alloys of interest.

Reviewer 4:

This reviewer complained that the accomplishments were few and unsuccessful. The results indicate that the local properties cannot be modified using a wire additive which is previously known to be incorrect.

Question 3: Please comment on the collaboration within the 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 it promising that the team identified the rivet tab as a demonstration geometry, although it seems that the collaboration with industrial partners is minimal. It may be unavoidable given the TRL of the capability. However, if the model validation results for the precipitation kinetics are delivered, it will be particularly useful for future AM capabilities.

Reviewer 2:

This reviewer feels that, apart from listing the collaborators on Slide 14 and identifying that a Mazak machine is used in this work, not much else was mentioned about the contribution of each collaborator in this work. One assumes that the collaborations and synergies are deeper and more extensive than the presentation suggests.

Reviewer 3:

This reviewer desires that the team present more details regarding how the project interacts with the LMCP framework (for example Thrust 4) and the frequency of discussions with OEMs on the relevance of the process being developed.

Reviewer 4:

This reviewer sees minimal results overall and no results associated with collaboration outside of ORNL.

Question 4: Please comment on the 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 considers the researchers to have been successful, thus far, in identifying and addressing some of the issues that have arisen during the difficult process of performing AM on cast components. The proposed milestone for a feasibility assessment is maximally suitable. Clearly, this capability shows great promise, but needs a very large effort to become fully developed. AM leads to defects, microstructures, bulk, and surface features and properties that are unexpected, and depending on the alloy system, will continue to be far from a solved problem, in the view of the reviewer.

Reviewer 2:

This reviewer refers back to Question 1 for suggestions for future work that the team should consider.

Reviewer 3:

This reviewer opines that more details are needed on how computational tools will be used for process optimization. Current research details how computation was used for material modeling only.

Reviewer 4:

This reviewer said that future milestones were presented, but no details were provided to justify proceeding.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believes that, if successful, this work will contribute towards the lightweighting and performance improvement of Al castings for vehicles.

Reviewer 2:

This reviewer finds that the project fits directly with the goals of Materials technology subprogram and is directly applicable to lightweight (and other) materials systems. It will lead directly to new and improved manufacturing capabilities.

Reviewer 3:

This reviewer opines that the VTO Materials subprogram objective is to use wire additive to modify microstructure and geometry of formed Al sheet to enable advanced structural designs for lightweighting including local microstructure modification for improved properties and local chemistry modification to enable subsequent operations (e.g., joining). The VTO objectives are relevant. However, this project did not address the VTO Materials subprogram objectives to enable lightweighting, locally modify microstructure to improve properties, nor enable subsequent operations like joining.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

Project has sufficient resources in this reviewer's estimation.

Reviewer 2:

This reviewer confirms that the resources for the project are sufficient. However, in order to make AM a predictable, straightforward step in a manufacturing process, there is a significant amount of research and work to be done, far more than could be accomplished in a single project.

Reviewer 3:

This reviewer complained that vital information is missing for a proper evaluation of whether the funding in hand will suffice for the team to complete the work.

Reviewer 4:

This reviewer pointed out that there were ten ORNL persons listed on the title slide, but very little research efforts reported.

Presentation Number: MAT250
Presentation Title: LMCP P3A - Cast Magnesium Local Corrosion Mitigation
Principal Investigator: Vineet Joshi (Pacific Northwest National Laboratory/Oak Ridge National Laboratory)

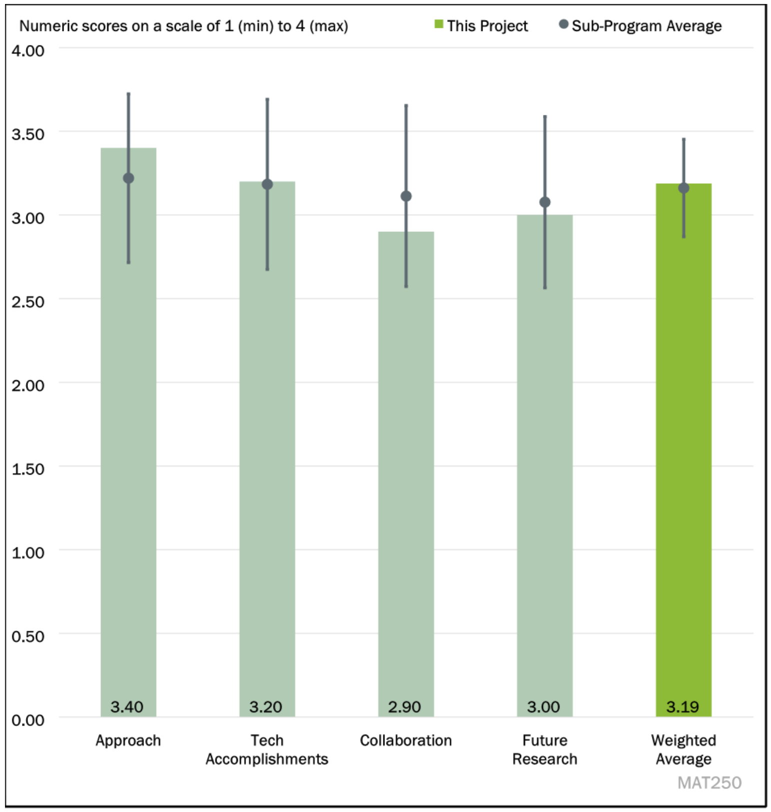

Figure 5-25 - Presentation Number: MAT250 Presentation Title: LMCP P3A - Cast Magnesium Local Corrosion Mitigation Principal Investigator: Vineet Joshi (Pacific Northwest National Laboratory/Oak Ridge National Laboratory)

Presenter

Vineet Joshi, Pacific Northwest National Laboratory/Oak Ridge National Laboratory

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.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer thinks that the approach of this project was well thought out because each of the various processes is being investigated by the laboratory process owner with the specific capabilities for its development. This is being accomplished while using the same experimental material which was fabricated via commercially-relevant processes. One point in particular which the reviewer found interesting in relation to feasibility was the amount of work accomplished, given the relatively low amount of funding over the life of the project. Given that the project is focusing solely on coupon level experiments, the reviewer found the electrochemical potential measurements to be a satisfactory means to evaluate the surface processing methods.

Reviewer 2:

This reviewer pointed out that the parallel projects have shown progress on their well-defined milestones. It remains to be seen how effective the coatings are when applied to components with realistic shapes, but the team is in the process of evaluating this.

Reviewer 3:

This reviewer believes that the approach contributes to overcoming barriers.

Reviewer 4:

This reviewer believes that the project is a good one; however, the reviewer thinks that the project could have merited more planning in the following areas: (1) The selection of the surface modification/coating technologies has not been well explained/justified. Silane coatings are already known to be effective. It is difficult to see how the reactive coating based on Li-salt has been selected among all coating/surface modification technologies developed. Cold spray can be very difficult for complex shapes. (2) The beginning of the project should have selected/identified applications for each technology and should have identified performance requirements for each coating used in the applications (galvanic corrosion, general corrosion, wear). These can be generic applications identified by the industry. For example, for galvanic couples, coatings may not be desirable on Mg since any defect would lead to accelerated galvanic corrosion. (3) Much time has been spent on coupon or single particle-level studies. The reviewer thinks that coupon level studies should be conducted by academia in close collaboration with the national laboratories. Academia can conduct in-depth materials analysis and train highly qualified personnel for the industry. The national laboratories can then devote more resources and time on the transfer of the technology to actual applications (industrial parts, complex and larger shapes) in close collaboration with the industry.

Reviewer 5:

This reviewer felt that some more general discussion of issues with the volatility of Mg might be helpful.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer noted that the monthly milestones appear to be on track.

Reviewer 2:

This reviewer observed that, at 75% completion, the amount of fundamental investigation and progress is commensurate with the available funding levels. This project is a very good example of what can be accomplished with a relatively low funding level yet coupled with a relatively narrow focus. The reviewer finds these types of focused, low MRL projects to be significantly more meaningful that those that attempt to cover a broader topic.

Reviewer 3:

This reviewer commented that both parallel projects have shown that surface corrosion and/or wear properties are enhanced with the different coatings. There is adequate and well-done characterization information collected to elucidate the properties of the coatings. The modeling of the cold spray will help with understanding the coating process and properties from the microstructure generated in the film.

Reviewer 4:

This reviewer found that the accomplishments are effective.

Reviewer 5:

This reviewer said that coupon level studies have achieved most of their goals, but corrosion evaluation needs to be completed. Zn coatings on curved automotive shape have been evaluated but scale up of other technologies and transfer to real components remain as challenges.

Question 3: Please comment on the collaboration within the 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 recounted that collaboration with ORNL, ANL, Applied Research Laboratory at Pennsylvania State University, Meridian Lightweight Technologies and PlasmaTreat Inc. had been noted and the topics assigned to each had been listed.

Reviewer 2:

This reviewer found an appropriate level collaboration between the researchers given the parallel track tasks of ORNL and PNNL. The laboratories have received components from industrial partners that they have sectioned and are now using for coating on more representative samples, so there is adequate collaboration with industrial partners as well.

Reviewer 3:

This reviewer lauded a good demonstration of collaboration and coordination.

Reviewer 4:

This reviewer found that the collaborations between laboratories is good but the collaborations with the academia and the industry can be further developed.

Reviewer 5:

According to this reviewer, aside from the common base material used by ORNL and PNNL, the unstructured added value of collaboration is not readily apparent in this project. However, the reviewer does not know that it is necessary for this project, thus, a lower rating for this question could be a bit unfair.

Question 4: Please comment on the 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 considers that the proposed future work is appropriate.

Reviewer 2:

This reviewer identified a listing of ideas provided with purposes defined and, in some cases, given qualitative description, but found it difficult to determine the likelihood of success.

Reviewer 3:

This reviewer believes that the proposed future research is significant and in line with what is necessary to develop these technologies to the next level of manufacturing readiness. However, they are not in line with the available funding based upon the reviewer’s experience in developing new processes. Regardless, the value of this work is apparent and the identified topics for future research may help to draw in external collaborators.

Reviewer 4:

This reviewer credits that the researchers are aware of many of the challenges that will arise during scale up but identifies one significant issue that the reviewer believes should be considered, which is galvanic corrosion.

Reviewer 5:

This reviewer believes that more emphasis can be placed on scale-up.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirmed that the project is relevant to the Materials subprogram.

Reviewer 2:

This reviewer notes that corrosion and wear mitigation are important challenges in lightweight vehicle construction.

Reviewer 3:

This reviewer points out that development of surface modification processes for lightweight materials such as Mg addresses one issue for moving this lightweighting material towards industrial applications, whereupon its implementation would support mass savings and, thus, reduction of GHG emissions, in addition to increasing the range for EVs by such mass savings.

Reviewer 4:

This reviewer believes that the project will lead to improved corrosion and wear properties, so it is relevant to the Material technology subprogram.

Reviewer 5:

This reviewer confirms that the work is relevant to the Materials subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer feels that the number of milestones and the accomplishments appear appropriate for the level of funding.

Reviewer 2:

This reviewer thinks that the resources seem to be sufficient or even excessive as only long-term corrosion and wear studies remain to be conducted.

Reviewer 3:

This reviewer believes that this project has accomplished a significant amount of value-added work with the relatively small budget allocated over the period of this project.

Reviewer 4:

According to this reviewer, the support for the project appears to be sufficient; the team was able to meet its milestones and also to leverage results from other projects.

Reviewer 5:

This reviewer stated that the resources applied are sufficient.

Presentation Number: MAT251
Presentation Title: LMCP P3B - Thermomechanical Property Modification of Mg Castings
Principal Investigator: Mageshwari Komarasamy (Pacific Northwest National Laboratory)

Presenter

Mageshwari Komarasamy, Pacific Northwest National Laboratory

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.

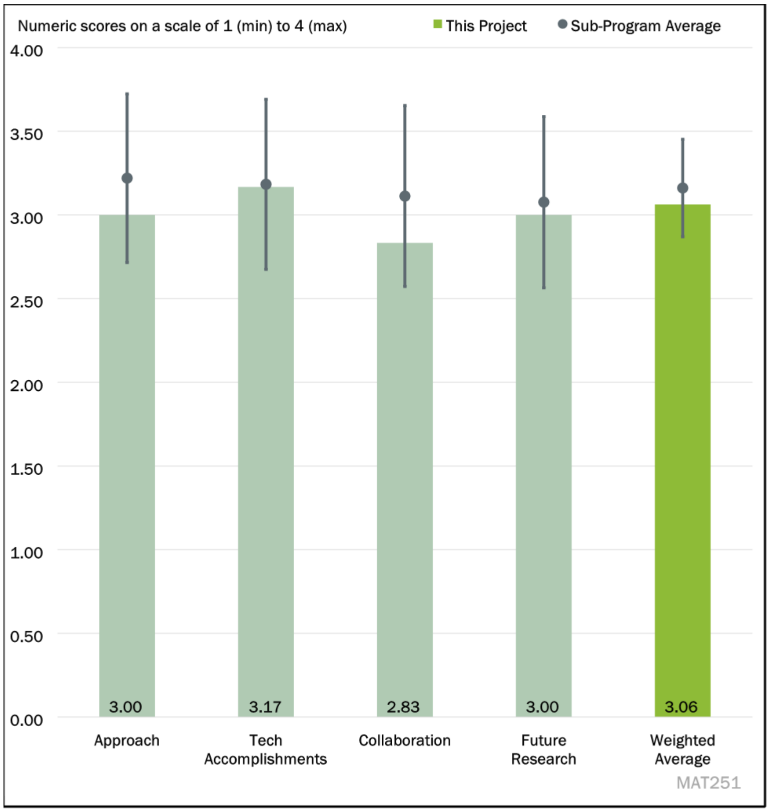

Figure 5-26 - Presentation Number: MAT251 Presentation Title: LMCP P3B - Thermomechanical Property Modification of Mg Castings Principal Investigator: Mageshwari Komarasamy (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer considers the project to be well designed to address technical barriers.

Reviewer 2:

This reviewer considers the primary barrier that remains is applying the FSP technique to realistically shaped components with large curvatures and small radii of curvature. While the team has been successful on 15^{o} parts, it would still be useful for the team to successfully apply FSP to complicated shapes. The team has proposed to apply FSP on 45/90^{o} coupons in future work, but it is still unclear if this will be successful or not.

Reviewer 3:

The reviewer finds that the Mg materials knowledge behind this project is limited and background in microstructural evolution in FSP is somewhat lacking. Microstructural evolution in the FSP and the affected zones needs to be evaluated and related to hardness. According to the reviewer, it cannot be assumed that FSP only mechanically refines the intermetallic phase; increase in temperature will lead to partial dissolution and even to reprecipitation. There may be recrystallization so electron backscatter diffraction analysis would also be desirable to the reviewer.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer praises the researchers for continuing to show impressive results. The increases in fatigue life in the FSP regions of the samples are extremely promising. The differences in properties between the FSP region, a heat affected zone (if there is one), and the surrounding material may lead to issues with real components, so this should be kept in mind for real geometries. Also, the researchers mentioned using different shapes of tooling. The team should be aware that the flow pattern in the weld nugget will change with different tooling and may lead to different properties, particularly fatigue properties. But, overall, the work shows great promise, according to the reviewer.

Reviewer 2:

This reviewer stated that progress has been made and the efforts have been effective.

Reviewer 3:

This reviewer noted that FSP has increased the fatigue performance of AM50 which is a major achievement. It seems that the calcium alloy did not provide additional improvement to fatigue performance.

Question 3: Please comment on the collaboration within the 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:

To this reviewer, the project partners appear to be working in collaboration.

Reviewer 2:

This reviewer commented that the collaboration between the laboratory partners, PNNL, ORNL, and ANL is good. It was unclear how closely they are communicating with industrial partners beyond receiving material from them. Hopefully, the proposed milestone for demonstration on a complex geometry without flaws can provide a demonstration that FSP can be applied to real components effectively.

Reviewer 3:

Collaboration exists but it is hard to evaluate since ORNL and ANL tasks are not presented.

Question 4: Please comment on the 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 work has shown to the satisfaction of this reviewer that fatigue life can be significantly improved through FSP. Demonstrating this on a real component would be an impressive milestone, and the proposed future work is the next step in achieving this goal. While not related to the current research thrust, the researchers should at least keep in mind that if they are depositing a different, stronger alloy, which they showed, they may need to consider the effects on corrosion properties, particularly galvanic corrosion, depending on the deposited alloy.

Reviewer 2:

This reviewer said that the proposed future work is appropriate.

Reviewer 3:

This reviewer was concerned that some aspects, such as corrosion evaluation, are not in the future plan. A scale-up to complex shapes is planned which is, of course, appropriate next step of the project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer finds that the technology contributes to the ability to use lightweight Mg in vehicle construction.

Reviewer 2:

The reviewer believes that the project is relevant to the Materials technology subprogram and is directly supporting the VTO subprogram objectives, as it is improving the mechanical properties of Mg significantly. The researchers have shown impressive improvements to the fatigue life of friction stir processed samples.

Reviewer 3:

This project supports the overall VTO materials sub-program.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer affirmed that the resources are sufficient to achieve milestones.

Reviewer 2:

According to this reviewer, though many details were not included in the presentation, there seems to be sufficient funds for scaling up to complex shapes.

Reviewer 3:

This reviewer believes that the next step in this project will likely be rather difficult to achieve, but the resources seem to be sufficient, as the team continues to make progress on its milestones.

Presentation Number: MAT252
Presentation Title: LMCP - Thrust 4 - Materials Lifecycle
Principal Investigator: Jeff Spangenberger (Argonne National Laboratory)

Presenter

Jeff Spangenberger, Argonne 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.

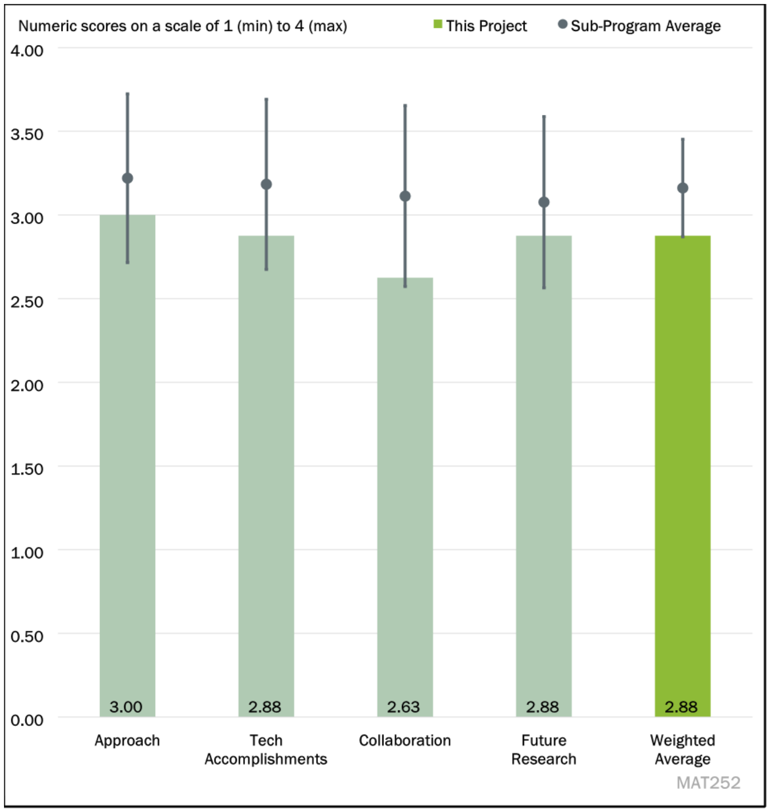

Figure 5-27 - Presentation Number: MAT252 Presentation Title: LMCP - Thrust 4 - Materials Lifecycle Principal Investigator: Jeff Spangenberger (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This project seemed to this reviewer to be more focused this year than at the time of the last review. Its modeling focus is attractive for including secondary alloys and understanding their impact on GHG emissions.

Reviewer 2:

This reviewer said that the technical barriers are being addressed.

Reviewer 3:

This reviewer believes that the project has a good approach.

Reviewer 4:

The technical barriers of the project were slightly unclear to this reviewer. There are, of course, many alloys and there will be more as new or modified alloys are developed by companies such as Tesla or Alcoa. The reviewer suggests that scrap generated perhaps can be recycled into master alloys that the alloy producers can use.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer considers that the project is on target to meet milestones.

Reviewer 2:

This reviewer approves of the life cycle analysis (LCA) tool that has been developed as an excellent start to the recycling of automotive scrap.

Reviewer 3:

This reviewer is satisfied that the project is making generally effective progress.

Reviewer 4:

This reviewer commented that the state of the art has been quantified but with few of the new technologies developed in LMCP being incorporated for comparison. It would have been beneficial to understand the basis for the modeling framework.

Question 3: Please comment on the collaboration within the 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 partners are collaborating effectively, in the view of this reviewer.

Reviewer 2:

The connection to the rest of ongoing LMCP work seemed somewhat tenuous to this reviewer.

Reviewer 3:

This reviewer believes that the project team seems to be meeting with collaborators regularly; however, the latest progress from other LMCP projects is not being incorporated regularly to assess its results over the state of the art.

Reviewer 4:

The reviewer assumes that the collaboration does exist; however, it was not explained in the presentation to the satisfaction of the reviewer.

Question 4: Please comment on the 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 anticipates that completion of the model will be useful when available to the community.

Reviewer 2:

This reviewer believes that the project is scoped to address future targets.

Reviewer 3:

This reviewer found the approach to develop the tool that helps easily see cost and environmental impacts related to recycling to be good.

Reviewer 4:

This reviewer is concerned that the future work seems to be constrained by the challenges related to obtaining data and information from the industry.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirms that the project work supports the lightweighting mission of the Materials subprogram.

Reviewer 2:

This reviewer points out that recycling automotive scrap is of high importance to enable the cost-effective use of light metal alloys in vehicle construction.

Reviewer 3:

This reviewer finds the project is aligned with the VTO Materials subprogram for materials.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

To this reviewer, for a modeling focused small effort, the resources are sufficient.

Reviewer 2:

Noting that the future work involves discussions with the collaborators and the industry and the completion of the LCA tool, the reviewer finds that the funds are sufficient.

Reviewer 3:

This reviewer believes that sufficient resources are employed to deliver the milestones.

Reviewer 4:

This reviewer finds that sufficient resources are available.

Presentation Number: MAT254
Presentation Title: Conductive Lightweight Hybrid Polymer Composites from Recycled Carbon Fibers
Principal Investigator: Yinghua Jin (RockyTech, Ltd.)

Presenter

Yinghua Jin, RockyTech, Ltd.

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.

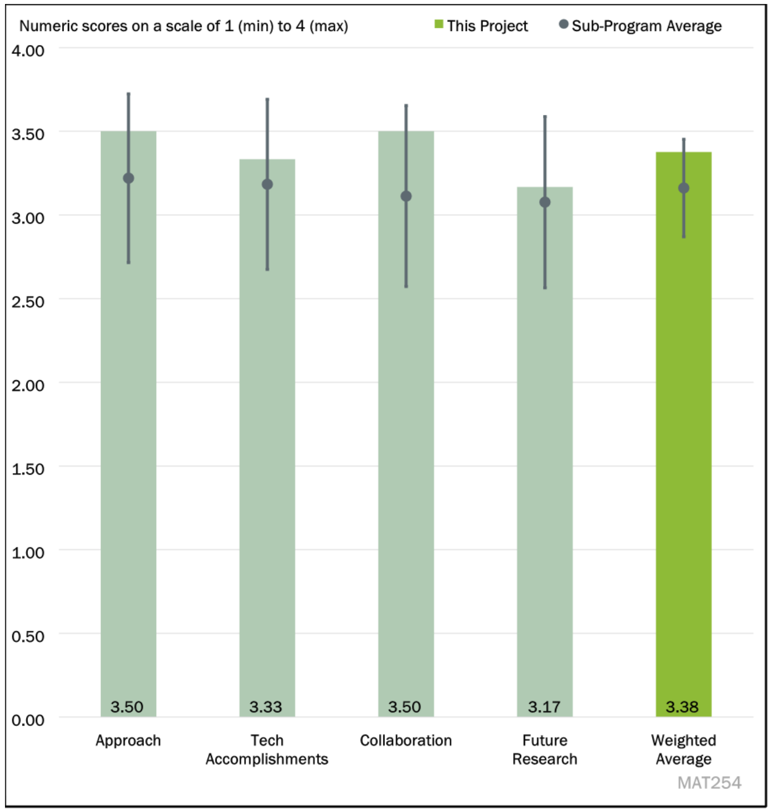

Figure 5-47 - Presentation Number: MAT254 Presentation Title: Conductive Lightweight Hybrid Polymer Composites from Recycled Carbon Fibers Principal Investigator: Yinghua Jin (RockyTech, Ltd.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer believed the project is well designed and well planned with a focus on the development of recyclable nano-and micro-filler reinforced vitrimer composites made from recycled milled carbon fibers (NMVC-R2) that have combined lightweight, high mechanical properties, and electrical conductivity. The claimed innovations are (1) the use of repressible and recyclable vitrimers with recycled milled carbon fibers lowers the overall production cost and (2) combined use of micro and carbon-based nanofillers to counterbalance the disadvantages of individual reinforcing fillers that synergistically improves mechanical strength and electrical conductivity of the materials.

Reviewer 2:

According to this reviewer, the project addressed a critical issue in the automotive industry by developing recyclable vitrimer composites made from recycled milled CFs that have combined lightweight, improved mechanical properties, and electrical conductivity. The approach and timeline are reasonable to the reviewer.

Reviewer 3:

This reviewer found that the approach provides a direct pathway for recovery and re-use of premium fiber reinforcement materials. However, the return on investment is not clear to the reviewer when considering composites reinforced with low-cost materials such as glass fiber. Therefore, the project team should verify the transactions cost analysis predictions recognizing that CF composites represent only a small fraction of polymer composite usage in automotive applications.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1: .

This reviewer noted that the team has developed NMVC-R2 composites through a solution-impregnation method or a solid-phase powder compression method. The team introduced combining nano- and micro-fillers leading to significant improvements in tensile modulus and electrical conductivity. The technical achievements of the team are that they (1) improved the interface adhesion between the fillers and polymer matrix through covalent surface modification of CF micro fillers with carbon-based nanofillers, (2) improved the conductivity of the NMVC-R2 composites through the formation interconnected network of conductive carbon-based nanofillers, and (3) enabled reprocessibility and recyclability of NMVC-R2 composites by using vitrimers in the polymer matrix. The tensile stress-strain curves show that the repaired sample exhibits a comparable modulus to that of the original sample; however, there was a considerable decrease in the tensile strength and elongation at break indicating the repair efficiency still needs to be improved.

Reviewer 2:

The project has completed all the milestones through June 2023 and the results are promising because they show improved mechanical and electrical properties with the addition of their nano-micro reinforcements in the recyclable matric. The reviewer does not have any concerns about the progress of the project.

Reviewer 3:

This reviewer considered that the results from the project show good progress against the objectives with demonstrations for repeated recovery and recycling of the CFs. Likewise, improvements in electrical conductivity were reported, albeit at levels that may not be suited to any practical application.

Question 3: Please comment on the collaboration within the 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:

According to this reviewer, the project team demonstrated good communication across the partners towards meeting the goals of the program.

Reviewer 2:

This reviewer shared that the team is led by RockyTech in partnering with the two teams at the University of Colorado - Boulder. Individual roles were described.

Reviewer 3:

This reviewer noted that the team worked with the University of Colorado - Boulder and the presenter clearly described which part of the project was done at the university.

Question 4: Please comment on the 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 saw the proposed work as being essential in determining suitability for the materials that need a V-0 flammability rating. The cost model should also make a comparison to glass reinforced composite materials as CF may not be an appropriate benchmark.

Reviewer 2:

This reviewer found the future work to be well described based on the teams' achievements including higher mechanical properties, scale-up process, feasibility in EMI shielding, study of the failure mechanism by tension, and three-point bending by experimental and computational modeling. The reviewer recommends having a reliability test with enhancing fewer defects or defect-free NMVC-R2 composites.

Reviewer 3:

This reviewer stated that, although the barriers and challenges were mentioned, no specific future task slide was provided.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirmed that the project goals are aligned with the VTO mission statement.

Reviewer 2:

The scope of work is well aligned with the overall VTO Materials subprogram objectives, according to this reviewer.

Reviewer 3:

This reviewer considered that the project is well aligned with the overall objectives of VTO.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer was satisfied that the team has made good progress with the resources currently deployed.

Reviewer 2:

This reviewer believed that the team has sufficient resources to carry out the planned tasks.

Reviewer 3:

The project is appropriately funded, according to the reviewer, who believes that the resources are sufficient to achieve project goals in the stipulated time.

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 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. 50% of reviewers felt that the resources were sufficient, 0% 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.

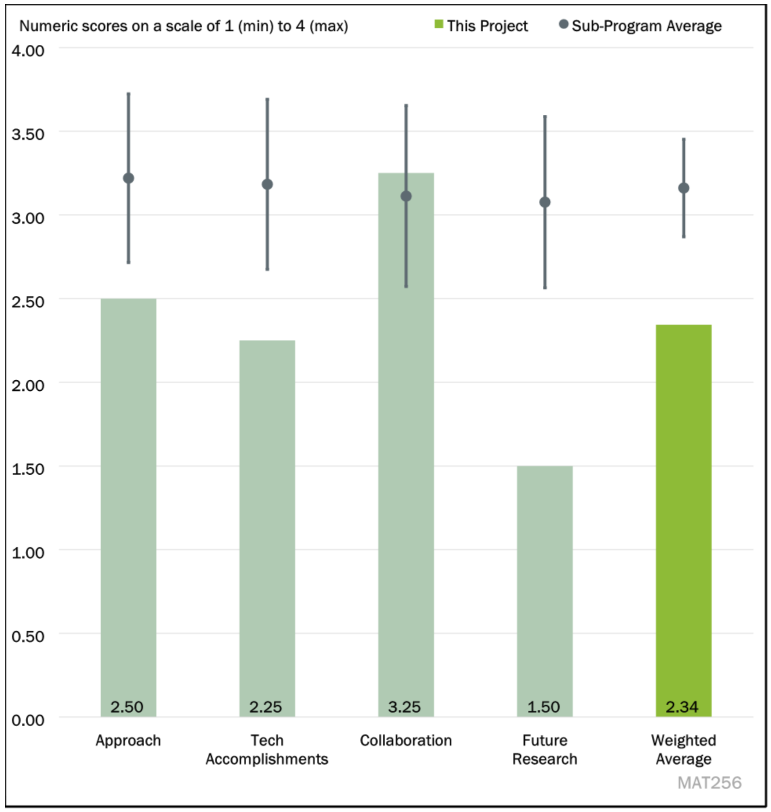

Figure 5-48 - Presentation Number: MAT256 Presentation Title: Game Changing Resin/Coating/Adhesive Technology for Lightweight Affordable Composites Principal Investigator: Scott Lewit (Structural Composites, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The approach is reasonably well designed to this reviewer although it appears to be a little more focused on marketing the concepts demonstrated in previously commercialized heavy vehicle applications to the automotive market rather than on technical investigation. The reviewer wrote that potential advantages to the approaches are identified whereas discussion of the barriers is sparse.

Reviewer 2:

This presentation had very little information on the actual work being performed according to the reviewer. The reviewer was unclear on what the team seeks to accomplish and what technical barriers exist.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer complained that several product forms with varying amounts of polyurethane have been identified by the team as being evaluated, but real data (other than announcing specific product forms) are pretty scarce, especially in judging cost versus performance. Adhesive performance of the gel coating approach does surpass paint by up to 25% in some of the product forms, as would be expected. Abrasion resistance is higher, but data presented only as total weight loss without testing reference data is hard to evaluate.

Reviewer 2:

This reviewer felt that the team has made little progress in the Phase I project and is unclear on whether any progress has been accomplished.

Question 3: Please comment on the collaboration within the 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 praised the teaming members as very strong.

Reviewer 2:

This reviewer commented that, while Structural Composites, Inc. is tapping into good resources in terms of materials and testing service suppliers, the reviewer is unclear about how much collaboration and feedback is actually being exchanged with Ford as a partner during execution of this Phase of the project. The reviewer would be interested in Ford's perspective on value/likelihood of replacing paint with gel coating in automotive applications. Out-of-paint-booth processing is touted in several places, but Ford's endorsement that this would be preferable to any new needs required for handling increased polyurethanes as a replacement would be encouraging.

Question 4: Please comment on the 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:

Discussions on barriers and plans for development and evaluation could be improved because they were not given much detail other than a very general listing of broad areas such as manufacturability, performance, damage tolerance, etc.

Reviewer 2:

The future work proposed is not clear.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

According to this reviewer, pathways for automotive utilization of some of the approaches identified can be seen, but it would have been useful to have more information on what is assessed as barriers and planned activities to address them.

Reviewer 2:

Lightweighting is important for future vehicles, in the opinion of this reviewer.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The resources appear to this reviewer to have been adequate to complete this Phase 1. The reviewer will be interested to see how this progresses in successive phases, if funded.

Reviewer 2:

It is unclear to this reviewer what the goals of this project are and what has been accomplished towards them.

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, LLC)

Presenter

Kurt Swogger, Molecular Rebar Design, 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.

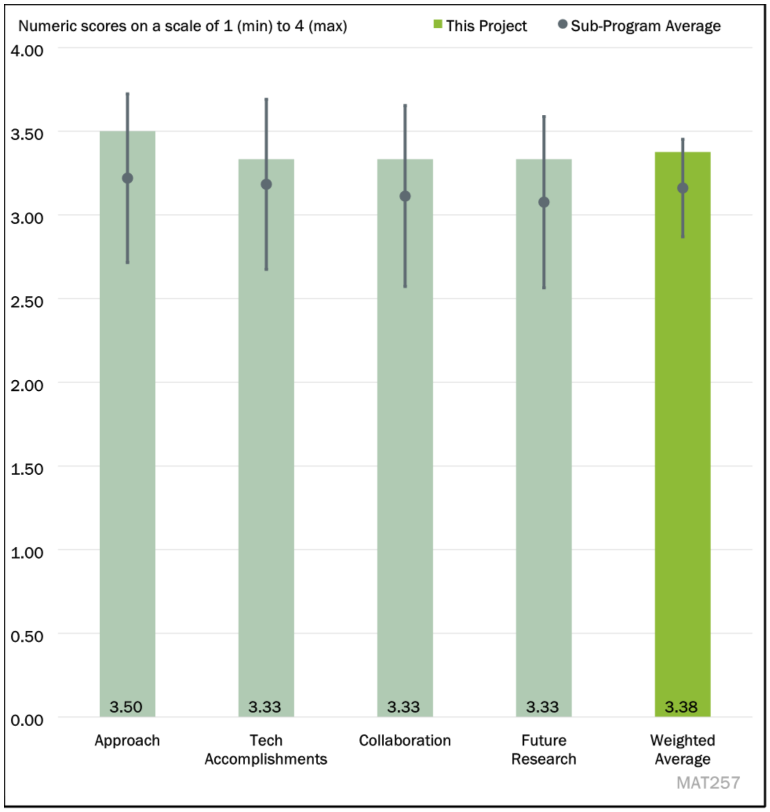

Figure 5-49 - Presentation Number: MAT257 Presentation Title: Changing the Design Rules of Rubber to Create Lighter Weight, More Fuel Efficient Tires Principal Investigator: Kurt Swogger (Molecular Rebar Design, LLC)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer applauded the project as well designed and well planned with a focus on the development of covalently bonded carbon nanotubes (Molecular Rebar® [MR]) for tire polymers with an improved lifetime of tread and rolling resistance of tread compound.

Reviewer 2:

This reviewer noted that the project aims to incorporate CNTs into tire materials to improve their performance, which the reviewer finds to be a novel approach. The goals are realistic but still very impactful if achieved. The levelized cost of energy and energy saving estimates are very impressive to the reviewer.

Reviewer 3:

Project has a good approach for using CNT-bonded rubber for improving tire durability.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer described how, in Phase 1, the team developed novel silane-functionalized and covalently-coupled molecular rebar CNTs for rubber and coupled silane moiety to OH/COOH groups of multi-walled CNTs. The team produced laboratory-scale silane MR in potential carrier agents and completed compound and test experimental silane-MR product and determined the most effective product form by optimizing dispersion, performance properties, and ease of manufacture process.

Reviewer 2:

This reviewer remarked how initial results showed novel silane functionalized and covalently coupled CNTs for rubber with improved lifetime and reduced composite density of 5%-7%. Initial results are found promising by the reviewer to support the project for a second phase.

Reviewer 3:

This reviewer observed that good technical results were presented. Knowing the ASTM/ISO standards used for testing material performance would have been helpful.

Question 3: Please comment on the collaboration within the 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 commended that the OEM and tier 1 suppliers are working together to commercialize the technology.

Reviewer 2:

This reviewer lauded an excellent team with great commercial partner engagement.

Reviewer 3:

The reviewer pointed out that the team is led by Molecular Rebar Design LLC, partnering with the Goodyear Tire and Rubber Co. and Arlanxeo. The reviewer is unclear about how these other companies contributed to the outcomes obtained in Phase 1.

Question 4: Please comment on the 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 described how, in the proposed future research in Phase 2, the team will develop "Guiding Principles" and develop and test prototype tires with Goodyear. The team will focus on (1) establishing optimum replacement ratios of silane-MR via masterbatch for incumbent silica fillers, (2) performing additional experimental formulations to determine the efficacy of alternative coupling agents and elastomers, and (3) continuing to provide silane-MR masterbatch for tire manufacturers' evaluations.

Reviewer 2:

Future tasks are seen by the reviewer as well aligned with the project objective, and, therefore, the reviewer believes that the project is progressing effectively.

Reviewer 3:

This reviewer found the approach for achieving Objective 2, especially assessing industrial adoption of the material choices, is not clearly defined.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer saw that the scope of work is well aligned with the overall VTO Materials subprogram objectives.

Reviewer 2:

The project, as described by the reviewer, aims to reduce rolling resistance and tire weight, leading to improved EV energy efficiency. The project is relevant for VTO due to its impact on reducing energy use per mile, reduced costs for electrified fleets, and global energy savings.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believed that the team has sufficient resources to carry out the planned tasks.

Reviewer 2:

The project has sufficient resources to achieve the proposed goals, according to this reviewer.

Presentation Number: MAT259
Presentation Title: Green Composites Fabricated from Bacteria Retted Bast Fiber and PLA for Light Weight Vehicle Components
Principal Investigator: Lee Smith (Z&S Tech, LLC)

Presenter

Lee Smith, Z&S Tech, 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.

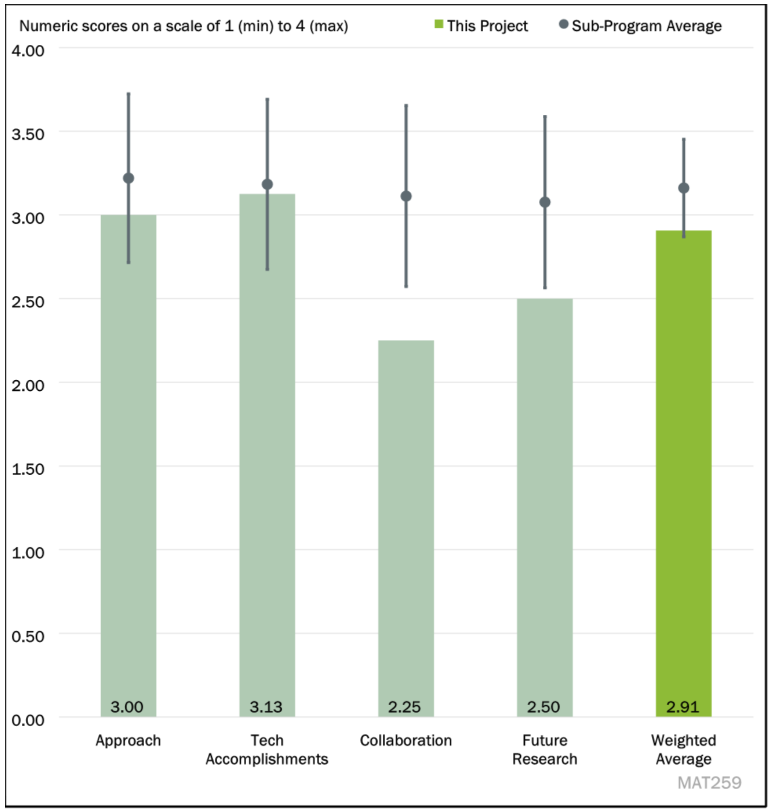

Figure 5-50 - Presentation Number: MAT259 Presentation Title: Green Composites Fabricated from Bacteria Retted Bast Fiber and PLA for Light Weight Vehicle Components Principal Investigator: Lee Smith (Z&S Tech, LLC)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer commended the work as uniquely focusing on VTO goals by attempting to better manufacture a different type of fiber mat and addressing the technical challenges. As such, the work is primarily focused on making enhanced fibers. The work has also incorporated a LCA early in the project to show its benefit, which the reviewer considers a strong approach. The work could benefit from baselining the composites' performance to other known materials and noting their performance benefits. Additionally, a clearer naming system or presentation of the mechanical data would be helpful to the reviewer.

Reviewer 2:

The approach is interesting to this reviewer; however, the reviewer professed to have little knowledge of this field and declined to comment on the potential impact.

Reviewer 3:

This reviewer described how the work featured self-cultured bacteria retted bast fiber material (BFM) with a view toward sustainable composite solutions. Apparently BFM is more environmentally friendly, lower in energy consumption to produce, and more economical and relevant to DOE metrics of lower embodied energy. The team used flax fiber to demonstrate the bacteria retting, produced fibers for composites, made composites, and tested them for different properties. The average fiber fraction was approximately 50% in the composites. The mechanical test data was compared within the variants and found marginally different. The team did not compare this data to available literature for benchmarking, which is a weakness of the study in the view of the researcher.

Reviewer 4:

This project is described by the reviewer as addressing sustainability needs for automotive composites by use of bacteria retted hemp fiber-reinforced polylactic acid (PLA) composites. However, it is not clear to the reviewer how the original hemp fibers were collected from hemp stalk. The initial processing would be a key factor for bacterial retting of those fibers, which essentially loosens the fiber bundles presented in the original feedstock, according to the reviewer. The reviewer is not convinced that the process will yield economic advantages because the process is very slow and will require 2-4 weeks. Also, the process will still need a lot of water processing. (The process may not necessarily require wastewater treatment, but the volume of water to be recycled is very high.) The preliminary LCA somehow shows advantages, but the composite properties show poor tensile strength, according to the reviewer.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This work was well designed in the judgment of this reviewer and showed advancement in biological retting, analysis, and material performance. As noted, baselines to vehicles parts to inform future research would be beneficial.

Reviewer 2:

This reviewer believed that the team has made significant progress in Phase I.

Reviewer 3:

This reviewer referred back to prior comments made above, saying that many of them apply. Also, the extended view of the work to engage an OEM/Tier 1 supplier would have provided a real value-proposition to the development of these materials. The studies are good from a scientific standpoint but their utility in practical applications is less clear. The comparisons are within their variants, but there is a need to compare these fibers to other fibers like hemp and other bast fibers and resins (through review of literature at a minimum), according to the reviewer.

Reviewer 4:

The initial work, as described by the reviewer, shows successful bacterial retting of hemp fibers and formation of bast fiber mat. The mat, however, when used for impregnation with a PLA matrix, showed composite properties that were not very appealing. The modulus of the composites is good, but the tensile strength is only as good as the resin’s strength, even after loading with 40%-50% fibers. This data suggest that the fibers are not flawless, are not fully retted, or have been loosened.

Question 3: Please comment on the collaboration within the 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 was not sure whether this work really fits for a Phase I SBIR because the work primarily was done by Z&S Tech.

Reviewer 2:

This reviewer found that the teaming arrangements are weak.

Reviewer 3:

This reviewer complained that the slides received by the reviewers had no collaborators listed. Only the lead company was listed as the performer of the work. The reviewer states that if this is a mistake, then the rating should be changed to N/A.

Reviewer 4:

This reviewer asserted that collaboration was not clearly presented, though. it was mentioned that the University of North Texas is involved in this work somehow.

Question 4: Please comment on the 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 no future work was presented and this is at the end of the Phase I.

Reviewer 2:

This reviewer said that future work was not discussed.

Reviewer 3:

This reviewer noted that the work showed an end date of April 2023, so the future work question appears to be irrelevant.

Reviewer 4:

This reviewer noted that any Phase 2 plan slide was missing in the presentation. Only during the Q/A session did the team mention some work to be done in the next phase.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believed the novel fiber approach to make fibers better and more efficiently is of extreme interest to the VTO Materials subprogram.

Reviewer 2:

Natural materials have the potential for sustainable automotive structures, according to this reviewer.

Reviewer 3:

This reviewer said the work applies to materials development.

Reviewer 4:

This reviewer commented that it is indeed a relevant topic, but the approach needs to be more convincing or appealing.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The resources are sufficient as seen by this reviewer.

Reviewer 2:

This reviewer reported that the team has completed the objectives with the funds supplied.

Reviewer 3:

To this reviewer, it looked as if the team had sufficient resources to conduct the work.

Reviewer 4:

Phase I resources are adequate, according to this reviewer.

Presentation Number: MAT260
Presentation Title: Green Composites from Carbonated Bio-based Oils and Recycled Nanofibers
Principal Investigator: Jesse Kelly (Luna Labs, USA)

Presenter

Jesse Kelly, Luna Labs, USA

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.

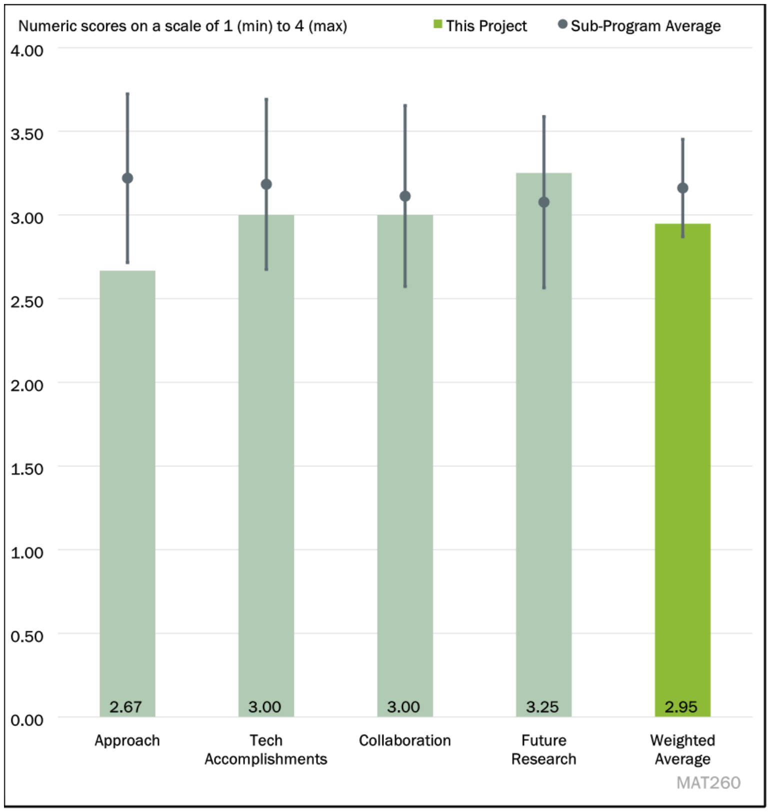

Figure 5-51 - Presentation Number: MAT260 Presentation Title: Green Composites from Carbonated Bio-based Oils and Recycled Nanofibers Principal Investigator: Jesse Kelly (Luna Labs, USA)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer referenced the VTO Materials goal to develop biobased polymer system that also consumes CO_2 and has useful properties. This material looks promising to the reviewer, as compared to ABS for example.

Reviewer 2:

This reviewer found the work (e.g., finding green replacements for today's materials) is strongly motivated; however, the reviewer sees a lot of claims made without significant results to back them up. Such claims include formulations to exceed current baseline properties, biodegradation, processing, and re-carbonization of the material. Importantly, the team should justify why a polyurethane is being used in composite applications and why PP, a cheap commodity plastic, is being used to baseline.

Reviewer 3:

This reviewer believed that the team is trying to do too much for a Phase 1 project. Instead of focusing on composite development, the team should have first focused on the resin development and addressed the Tg and heat deflection issues. Further, according to the reviewer, nanofillers and additives are not improving the strength and modulus that significantly. For use as composites, the material should have at least 10 GPa elastic modulus. The carbonation may not be a catalyst-free process. The reviewer is not sure how the team is expecting 15-30 ring weight percent in the caprolactone matrix because the building block linseed oil has only a few unsaturated moieties.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

Good technical progress was achieved at this phase, as seen by the reviewer, who believes that the approach shows enough progress and results to continue with Phase II.

Reviewer 2:

This reviewer found that the team has met all project goals. However, as noted above, it is difficult for the reviewer to ascertain why the team chose certain material baselines and whether this material will actually be a useful composite for lightweighting. PP and ABS are two materials the team uses as baselines but these materials would be difficult to substitute in current vehicles.

Reviewer 3: .

The caprolactone matrix exhibiting nearly 40 MPa and 1.5 GPa modulus was considered by this reviewer to be a very good result. However, the nanofibers are apparently not showing any significant reinforcement strength. The recyclability potential demonstration shows excellent progress.

Question 3: Please comment on the collaboration within the 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 seemed to this reviewer to have a strong connection with NREL who works well for producing resin and iterating on formulations.

Reviewer 2:

This reviewer found good collaboration between NREL and Clemson.

Reviewer 3:

According to this reviewer, Phase I did not really have a planned collaboration identified by the presenter; however, the reviewer finds that the Phase II collaboration plan is very clear.

Question 4: Please comment on the 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 Phase II formulation studies are appropriate for the material, according to this reviewer.

Reviewer 2:

The Phase II plan was clear to this reviewer. However, the reviewer recommends focusing on resin development first before moving toward composite formulation development.

Reviewer 3:

This reviewer noted that Phase I of the SBIR has ended.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This work did seem to this reviewer to align with the VTO Materials subprogram goals of low-cost fibers and de-carbonizing their manufacture; however, performance baselines are only to thermoplastics and unreinforced plastics requirements and should be better described, according to the reviewer.

Reviewer 2:

This reviewer considered the project to be highly relevant to the VTO goals for CO_2 reduction and sustainability.

Reviewer 3:

This reviewer offered that sustainable composites are highly desired, and the project is relevant to the need for vehicle lightweighting, and sustainability.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The resources seemed sufficient to this reviewer.

Reviewer 2:

This reviewer said that the resources were sufficient for a Phase 1 activity but there is still much work to be done to further develop and evaluate the material.

Reviewer 3:

Resources are adequate in the view of this reviewer.

Presentation Number: MAT261
Presentation Title: Multiscale Bioinspired Enhancement of Natural-Fiber Composites for Green Vehicles
Principal Investigator: Lorenzo Mencattelli (Helicoid Industries, Inc.)

Presenter

Lorenzo Mencattelli, Helicoid Industries, Inc.

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.

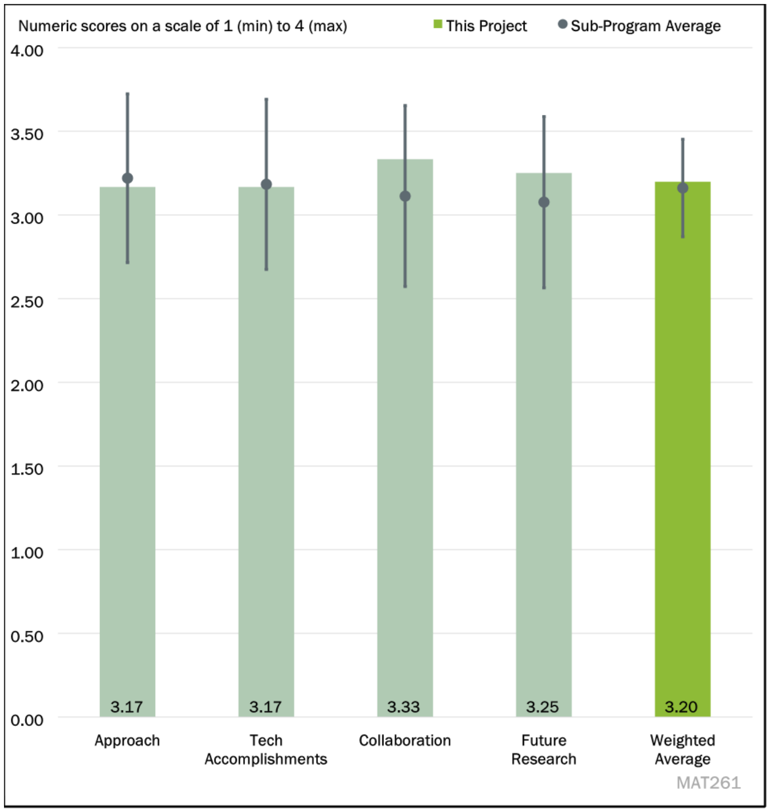

Figure 5-52 - Presentation Number: MAT261 Presentation Title: Multiscale Bioinspired Enhancement of Natural-Fiber Composites for Green Vehicles Principal Investigator: Lorenzo Mencattelli (Helicoid Industries, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The project was exciting to this reviewer since it involves flax fiber surface tailoring for improved composite performance with methyl acrylated PP, PLA, and epoxy matrices. The flax fiber surface tailoring approach involving nanoparticle deposition by simple deposition from liquid suspension of particles is basic and scalable. The composites showed excellent performance that is better than traditional glass fiber composites.

Reviewer 2:

This reviewer described how the work presents a method for enhancing the performance of composites through fiber orientation and additives. The bio-inspired approach of this work is not clear to the reviewer even with the bonus slide. More illustrative baseline experiments would be helpful. Overall, though, the project leads to impressive, enhanced performance of the composites relative to glass. Notably, glass is not overtly energy intense, so more analysis would be beneficial to this approach and narrative according to the reviewer.

Reviewer 3:

This reviewer noted that modification to the reference flax composite shows modest improvement using computer numerical control and conjunctive normal form. The glass baseline is not clear to the reviewer and whether chopped glass fiber or fabric was used. The properties look low suggesting chopped fiber was most likely compared to a continuous fiber fabric, which can be misleading, according to this reviewer.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer reported that the composites prepared in this project not only exhibit better mechanical properties but also excellent fatigue resistance. The surface tailoring approach along with helical layering of fibers is an excellent approach that likely caused enhanced performance, according to the reviewer. The team made significant progress and demonstrated more than 90% extended durability.

Reviewer 2:

The project team demonstrated to the satisfaction of this reviewer that its approach can lead to enhanced performance of a bio-composite. More details are necessary, though, to completely understand the approach in a more stepwise fashion.

Reviewer 3:

This reviewer confirmed that the approach shows a slight improvement over baseline flax fabric. The peak impact load looks better but the reviewer has concerns about the damage area.

Question 3: Please comment on the collaboration within the 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 has TPI Composites as a strong partner for the work, which could enable future parts manufacture. The team also clearly lists their collaboration between multiple project partners.

Reviewer 2:

To this reviewer, the project had good team collaboration.

Reviewer 3:

This reviewer indicated that the team has an excellent collaboration plan involving a university, a start-up and scaled-up parts manufacturing companies as members. The teamwork is apparent to the reviewer within the results presented.

Question 4: Please comment on the 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 praised the future research plan and Phase II goals with timelines as excellently presented.

Reviewer 2:

This reviewer did not see where the flax fabric has any commercial surface treatment or sizing. If not, the reviewer suggested that should be explored in addition to the nanoparticle approach. If toughness is of primary interest, the reviewer believed that would suggest braids over weaves.

Reviewer 3:

This reviewer stated that Phase I has ended.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believed that the project team demonstrated that this approach could lead to better performance than glass fibers. This work could help further enable low cost and decarbonized fibers.

Reviewer 2:

This reviewer said that the project is relevant to VTO goal for using bio derived materials.

Reviewer 3:

According to this reviewer, the team successfully demonstrated the possible expansion of natural fiber composites to structural and semi-structural applications. Sustainable composites with enhanced fatigue life and semi-structural performance address multiple R&D barriers towards sustainability goals with vehicle lightweighting.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The resources appear sufficient to this reviewer.

Reviewer 2:

The team seemed to this reviewer to have what was needed for the Phase 1 effort.

Reviewer 3:

The resources were sufficient according to this reviewer.

Presentation Number: MAT262
Presentation Title: Sustainable Automotive Composites Using Surface-Modified Cellulose Fibers
Principal Investigator: Girish Srinivas (TDA Research, Inc.)

Presenter

Girish Srinivas, TDA Research, Inc.

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.

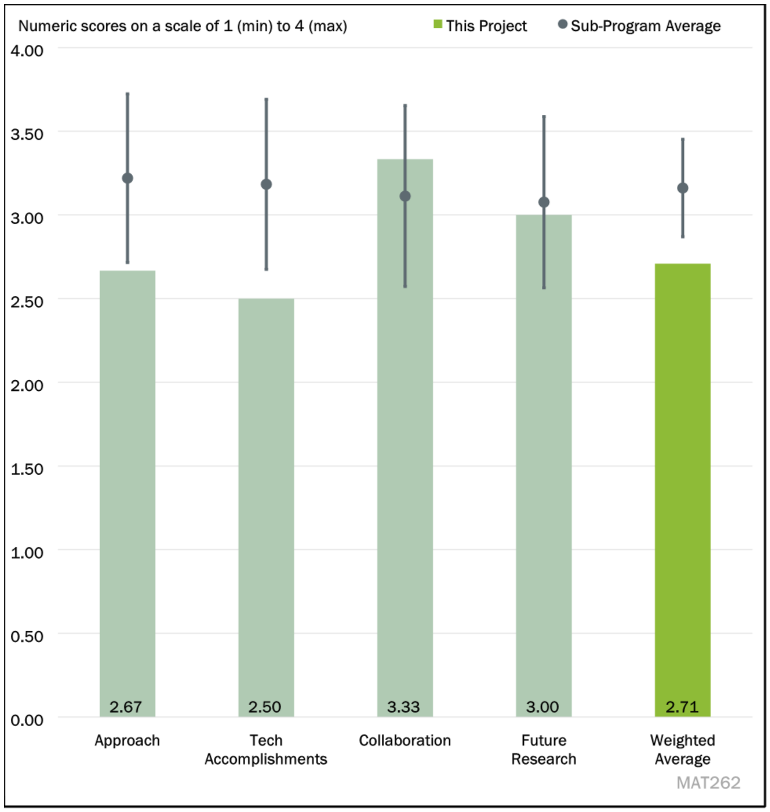

Figure 5-53 - Presentation Number: MAT262 Presentation Title: Sustainable Automotive Composites Using Surface-Modified Cellulose Fibers Principal Investigator: Girish Srinivas (TDA Research, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The team discussed the technical barriers to lightweight a car bumper using a bio-based nylon with surface-modified cellulose fiber filler clearly enough for this reviewer. The reviewer considers this to be a good approach to reducing the CO_2 footprint of the vehicle parts by replacing polycarbonate (PC)/ABS.

Reviewer 2:

This reviewer described how the project targets to replace PC/ABS by bio-based nylon-cellulose fiber composites. While the approach has potential, the details were unclear to the reviewer. The major advantage may be the use of bio-based nylon, but the reviewer raises doubts regarding the ownership of the IP. If a simple composite of commercially available bio-based nylon with cellulose fibers (or even with some modification) is the goal, then there does not seem to the reviewer to be much innovation. Also, the reviewer was not sure about the benefit of using composites to replace non-composite thermoplastic materials. That seemed to the reviewer to be hurting eventual circularity. In addition, the detailed properties were unclear to the reviewer since the team did not show any data (e.g., various mechanical data). The team showed its estimates on density—approximately 6% reduction, leading to the lighter weight composites and tensile modulus and yield stress increase—80% of the GHG reduction through the manufacturing process. The presenter further stated that “together with a biobased lightweight core, our composite offers 52% of a vehicle’s weight reduction while showing a modest (7%) cost increase.” While these estimates may be correct, the reviewer could not evaluate them without seeing the data.

Reviewer 3:

This reviewer complained that the presentation had no data, only claims.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer commented that the team successfully accomplished producing a composite using bio-based nylon and cellulose fibers that achieved better mechanical performance than neat bio-based nylon, and it had improvements compared to PC/ABS plastics. The reviewer would have preferred that the team quantify all the mechanical properties as opposed to just stating that the properties were improved. However, the reviewer does not necessarily understand the role of TDA Research Inc. in this project. Apparently, all materials are sourced from other companies and even the modeling is performed by another team. If this project continues to Phase II, then TDA Research Inc. needs to show what the company's role is in developing, testing, or modeling the material.

Reviewer 2:

The accomplishments were unclear to this reviewer. There may be an innovation for the modified cellulose fibers or bio-based nylon, but no details were provided, according to this reviewer. LCA indicates significant reduction in carbon footprint, which is good; however, the target is PC/ABS and the reviewer is not sure that industry will adopt such substitutes. The technology has to address cost, processability, throughput, etc. While cost estimates were mentioned, many other important parameters for industrial adoption were not discussed. Considering this is SBIR, the reviewer believes that the team needs to clearly define the performance/cost target to really make this a commercially viable product. Unfortunately, the presentation was too generic, and the reviewer did not find it possible to evaluate how good or how limited the value of this technology will be.

Reviewer 3:

This reviewer complained that the presentation has no data, only claims.

Question 3: Please comment on the collaboration within the 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:

TDA Research Inc. made good use of existing cellulose and bio-nylon.

Reviewer 2:

This reviewer applauded the team for assembling a great collaboration with many different entities, including a biobased nylon supplier, a core material supplier, a computational engineering company, University of Colorado at Denver for LCA, and the Larta Institute for a business model and marketing strategy. However, TDA Research Inc. needs to specify the tasks that they are performing within this project.

Reviewer 3:

This reviewer noted that the team listed the partners and some of collaborations. Their roles are satisfactory; however, it is unclear to the reviewer how this technology can be commercialized by strategic collaboration.

Question 4: Please comment on the 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 plan seemed satisfactory to this reviewer, but it was not clear to the reviewer why and how the future work will connect to commercially-viable products. As a research activity, the research made sense but it was unclear how viable the plan will be toward commercialization.

Reviewer 2:

This reviewer commented that the presenter stated that the project has ended.

Reviewer 3:

This reviewer believed that the proposed research is satisfactory but future test data should be included in a report.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirmed that the project is relevant. The approach is clearly addressing one of the paths for low-carbon and low-energy composites. But, as the reviewer commented previously, making composites to replace non-composites may not work for industry.

Reviewer 2:

The project is very relevant to the VTO Materials subprogram objectives of lightweighting a vehicle while also reducing CO_2 footprint of the materials, according to this reviewer.

Reviewer 3:

This reviewer said that material properties and CO_2 reduction claims support VTO goals.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer believed the team has the needed resources to conduct the research but the reviewer could not ascertain this with certainty because the detail was not provided, which made the resources needed unclear.

Reviewer 2:

While this reviewer said that the project has ended, the reviewer believed that the resources were sufficient to deliver on the targeted milestones.

Reviewer 3:

This reviewer found good project leverage using existing biomaterials.

Presentation Number: MAT263
Presentation Title: Green Polybenzoxazine/Natural Fiber Composites for Transportation
Principal Investigator: Christopher Scott (Material Answers, LLC)

Presenter

Christopher Scott, Material Answers, 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.

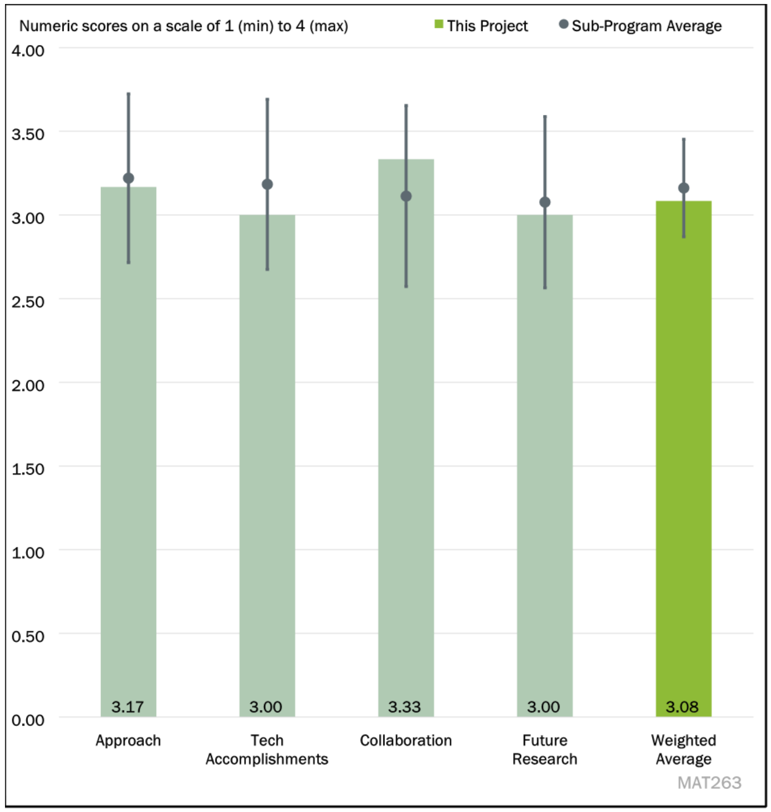

Figure 5-54 - Presentation Number: MAT263 Presentation Title: Green Polybenzoxazine/Natural Fiber Composites for Transportation Principal Investigator: Christopher Scott (Material Answers, LLC)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer praised the team for having a great approach to create benzoxazine resin using bio-based chemicals. The added vitrimer behavior adds to the novelty by enabling recycling of the composites. The composite had added natural flax fiber to make it even more environmentally friendly. The technical barriers were clearly addressed, and the challenges were met in a timely manner.

Reviewer 2:

This reviewer related that the proposed research plans to develop a flax fiber-reinforced sustainable polybenzoxazine resin composite. The team invented and characterized a novel bio-based benzoxazine resin, although resin characteristics and consistency in properties have not been presented. The composite exhibits recycling via transesterification. The energy demand for these composites are estimated to be lower than that of the Al, glass-fiber composites, or CFRCs. The properties of the resin system and feedstocks were not discussed (likely proprietary information), according to the reviewer.

Reviewer 3:

This reviewer commented that, while the approach to use bio-based polymer (polybenzoxazine), flax fibers, and addition of dynamic functional groups to make vitrimers is good, the reviewer is unclear as to the viability of the approach. The reviewer also questions who owns the IP, specifically if it is Case Western Reserve University. The major problem seems that the composite’s mechanical property (shown in the future work slide) seems too low to be viable. While polybenzoxazine provides an advantage of flame retardancy, the reviewer is unclear on how this specific bio-based polybenzoxazine with flax fibers can provide sufficient mechanical properties for target application.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer considered that the team accomplished all milestones that were mentioned. The team produced 450 g of the material, performed appropriate characterization, and fabricated composites within the timeframe of the project. The project showed the ability to reshape the composite as a recycling demonstration; however, the reviewer questions whether the resin and fibers can be recovered separately at the end of life. The reviewer would like to see that the fiber and resin can be fully recycled. Simply reshaping a composite does not necessarily solve the recycling issue. Also, a cost estimate would be good to have for this resin system to gauge the commercial feasibility.

Reviewer 2:

According to this reviewer, the project team, using Professor Ishida's laboratory, were certainly able to generate this specific polybenzoxazine/flax fiber composites so the plan may be accomplished; however, the achieved performance will not replace structural composites. The reviewer was unclear as to how the team will improve the mechanical property as shown in the future plan target. Making vitrimer is good to provide processability of thermoset property of polybenzoxazine; however, the team seems to use ester-based (catalyst) dynamic functional groups. The catalyst will provide malleability for manufacturing, but long-term stability may be a challenge. When there is need to repair or reprocess, this approach may not work well. Considering all of the potential hurdles, the team should have advanced much further during Phase I. If the material achieved much higher mechanical properties, then the remaining hurdle is lower. But that major hurdle is not addressed, which the reviewer doubted can be addressed quickly even in Phase II. The reviewer would have preferred to have seen more data. The reviewer admitted to possibly missing some of the potentials, but little discussion was given retarding the attributes and the mechanical performance, etc., if the claims are true.

Reviewer 3: .

This reviewer lamented that few data were presented, making it very difficult to estimate the progress. The dynamic mechanical analysis Tg was 116ºC but after two hours of curing, the Tg increased to 149ºC. The reviewer is not clear on how far below Tg the material would undergo transesterification reaction for the proposed recycling. Also, the slides presented to the reviewers showed a technical data sheet of the composite. The reviewer is unsure of why much of the characterization data and compositions are not mentioned. If the composite is already developed, then there should be a commercialization plan. Developmental R&D may not be needed, according to the reviewer.

Question 3: Please comment on the collaboration within the 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 applauded the collaboration with Case Western Reserve University (Professor Ishida) as excellent. For polybenzoxazine development, Professor Ishida's group is the group to work with. But the reviewer asks, who then owns the IP?

Reviewer 2:

This reviewer believed that there was an excellent collaboration with Professor Ishida at Case Western Reserve University, who is an expert in bio-based benzoxazine resin. To further improve the collaborations in the future, bringing in a tier 1 supplier or OEM would really benefit the project to prove its application feasibility.

Reviewer 3:

This reviewer pointed out that Case Western Reserve University has developed the resin. (The reviewer is not sure who owns the IP). But the reviewer noted that the collaboration lacks partnership with a tier 1 part manufacturer.

Question 4: Please comment on the 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 presenter stated that the project has ended. The proposed future research directions are clearly defined if this project gets funded for Phase II, according to the reviewer.

Reviewer 2:

This reviewer felt that, if satisfactory properties have already been achieved, the proposed future work is reasonable. However, the team aims to double or triple mechanical performance in future work, which is not realistic. If the TEA has a clear plan to meet the performance, it should have been described.

Reviewer 3:

This reviewer commented that the team has already developed a product (see product technical data sheets) that meets property needs for vehicle composites. The future research plan does not need resin and composite development tasks as those are already finalized. Phase II should focus on Thrust 3 and Thrust 4.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer found that the project supports the VTO Materials subprogram objective of vehicle lightweighting and reducing CO_2 footprint by utilizing bio-based materials.

Reviewer 2:

This reviewer noted that sustainable composites can help meet VTO Materials subprogram goals for sustainability along with vehicle component lightweighting.

Reviewer 3:

This reviewer confirmed that pursuing bio-based resins with natural fibers is a good direction for achieving low-carbon and low-embodied energy materials but the performance of these resins is not meeting the requirements of structural composites. If the team could identify a different target with marketable vehicle parts (by meeting cost/sustainability advantage etc.), the current performance may have a case to further pursue.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The project has ended, but it seemed to the reviewer that the resources were sufficient to deliver on the targeted milestones.

Reviewer 2:

This reviewer stated that the resources are sufficient.

Reviewer 3:

The resources seemed sufficient to this reviewer; especially, the participation by Case Western definitely helps to develop promising resins. Maybe a single goal to achieve the performance was too aggressive. Since this is a SBIR, the team should have accomplished reasonably high performance even before starting the SBIR project.

Presentation Number: MAT264
Presentation Title: Green Composites for Future Vehicles, Vitrimer Matrix + Natural and Recycled Fiber Composite Materials for High Performance, Repairable, Recyclable, and Bio-sourced Automotive Components
Principal Investigator: Philip Taynton (Mallinda, Inc.)

Presenter

Philip Taynton, Mallinda, Inc.

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.

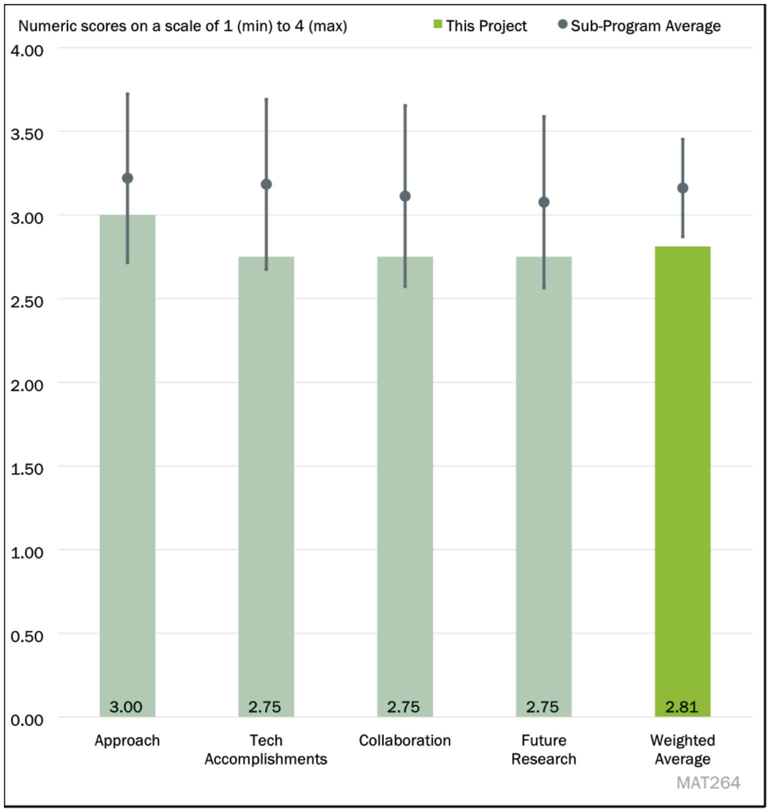

Figure 5-55 - Presentation Number: MAT264 Presentation Title: Green Composites for Future Vehicles, Vitrimer Matrix + Natural and Recycled Fiber Composite Materials for High Performance, Repairable, Recyclable, and Bio-sourced Automotive Components Principal Investigator: Philip Taynton (Mallinda, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer described how the project pursued flax fiber vitrimer composites. Considering the high GHG and energy input of CF production, exploring natural fiber-based composites is good. The team is utilizing its Vitrimax to produce the composites, in which the vitrimer matrix (Vitrimax) will provide malleability and recyclability with enhanced robustness due to its crosslinked network. Considering the team's success with Vitrimax, looking into flax fiber composites makes sense, although it was not perfectly clear to the reviewer what vehicle parts are suitable for this specific composites. The reviewer notes that the achieved mechanical performance is much lower than that of CFRPs.

Reviewer 2:

The approach did not appear to this reviewer to be compatible with automotive manufacturing rates since the vitrimer polymerization process is quite slow. The work should detail how this technology can be applied to high-rate manufacturing.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer related that the project successfully fabricated Vitrimax/flax fiber composites and showed the path for mechanical and chemical recycling. As the team indicated, there is a need to further tailor the various parameters such as viscosity, as well as chemical recycling details. As a Phase I effort, the project has accomplished what was needed, considering that the team already has a knowledge of vitrimer composites. Since the mechanical performance of this composite is much lower than those of CF and glass fiber composites, the team needs to clarify what application (e.g., specific vehicle parts) will be suitable for the use of this composite. If the mechanical properties, as well as cost performance, do not meet any of the vehicle parts, this project should simply end as having accomplished some exploratory research.

Reviewer 2:

This reviewer considered that the team has made progress towards its Phase I goals; however, the performance of the composites is quite poor and there was not a discussion into the methods to improve performance.

Question 3: Please comment on the collaboration within the 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 the team collaborated with the University of Southern California (USC) for various composite characterizations. USC has strong expertise on composite research, so this collaboration is mutually beneficial.

Reviewer 2:

This reviewer believes that the team would benefit from an OEM partner to show commercialization potential.

Question 4: Please comment on the 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 pointed out that the team proposed to pursue following tasks: (1) optimization of composite material, (2) development of room temperature infusion resin, (3) accelerated ageing and fatigue studies, recycling process optimization, and (4) prepreg optimization. In general, the plan is good, and the team seems to be aware of the technical challenges that need to be addressed. But, again, the team should clearly identify what kind of vehicle parts that the material intends to replace. If there is a large potential market, then this flax/Vitrimax composite research makes sense.

Reviewer 2:

The future plans are vague, according to this reviewer.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The project is highly relevant in this reviewer’s thinking. Vitrimers represents next generation resins for composites which can address various sustainability challenges. This project further expands to the use of bio-based fibers which could potentially address the challenges of high carbon and energy footprint by CFs or many other fibers.

Reviewer 2:

This reviewer believes that lightweighting is important for future vehicles.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer affirmed that both Mallinda and USC have enough resources to conduct the proposed research.

Reviewer 2:

This reviewer stated that the team completed its objectives.

Acronyms and Abbreviations – MAT

Abbreviation	Definition
3D	Three-dimensional
G3 5M	G3 5M steel alloy
A206	A206 composite matrix
AA7075	AA7075 aluminum alloy
ABS	Acrylonitrile butadiene styrene
ACMZ	Aluminum-copper-manganese-zirconium
AI	Artificial intelligence
Al	Aluminum
AM	Additive manufacturing
AM20	AM20 magnesium cast alloy
AM50	AM50 magnesium cast alloy
AM60B	AM60B magnesium cast alloy
AMR	Annual Merit Review
ANL	Argonne National Laboratory
ASTM	ASTM International, formerly known as American Society of Testing and Materials
AZ91D	AZ91D magnesium cast alloy
BAAM	Big area additive manufacturing
$BaTiO_3$	Barium titanate
BFM	Bast fiber material
BOTTLE	Bio-Optimized Technologies to keep Thermoplastics out of Landfills and the Environment
CAE	Computer aided engineering
CCF	Continuous carbon fiber
CF	Carbon fiber
CFRP	Carbon fiber reinforced polymer
CFTF	Carbon Fiber Technology Facility
CNG	Compressed natural gas
CNT	Carbon nanotube
CO_2	Carbon dioxide
COMSOL	COMSOL Multiphysics ® modeling software

Abbreviation	Definition
COOH	Carboxyl
COVID	Coronavirus disease (COVID-19), infectious disease caused by the SARS-CoV-2 virus
CRADA	Cooperative Research and Development Agreement
DLP	Digital light processing
DOE	U.S. Department of Energy
EERE	Energy Efficiency and Renewable Energy
EMI	Electromagnetic interference
EV	Electric vehicle
FCA	Fiat Chrysler Automobiles
FSP	Friction stir processing
GHG	Greenhouse gas
GM	General Motors
H11	H11 tool steel alloy
H_2O	Water
HPM	High-performance modeling
HTC	High temperature carbonization
HVR	High-velocity riveting
ICME	Integrated computation materials engineering
ID	Identification
IP	Intellectual property
ISO	International Standards Organization
L12	Phase of steel crystalline structure
LCA	Life cycle analysis
LLC	Limited liability corporation
LLNL	Lawrence Livermore National Laboratory
LMCP	Lightweight Metals Core Program
MAT	VTO Materials subprogram
Mg	Magnesium
ML	Machine learning
MMC	Metal matrix composites

Abbreviation	Definition
MoS_2	Molybdenum disulfide
MR	Molecular Rebar®
MRL	Manufacturing readiness level
$NiFe_2O_4$	Nickel ferrite
NMVC-R2	Nano- and micro-filler reinforced vitrimer composites using recycled milled carbon fibers
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer(s)
OH	Hydroxyl
ORNL	Oak Ridge National Laboratory
PAEK	Polyaryletherketone
PAN	Polyacrylonitrile
PC	Polycarbonate
PE	Polyethylene
PET	Polyethylene terephthalate
PLA	Polylactic acid
PMCP	Powertrain Materials Core Program
PNNL	Pacific Northwest National Laboratory
PP	Polypropylene
PUSP	Power ultrasonic-based surface processing
PVDF	Polyvinylidene fluoride
R&D	Research and development
RDD&D	Research, development, deployment and demonstration
SBIR	Small Business Innovation Research
SDF	Sudamericana de Fibras (company name)
ShAPE	Shear assisted processing and extrusion
SLIC	Sustainable Lightweight Intelligent Composites
T4	T4 level of steel temper
T6	T6 level of steel temper
T76	T76 level of steel temper
TEA	Techno-economic analysis

Abbreviation	Definition
Tg	Glass transition temperature
TiB_2	Titanium diboride
TRL	Technology readiness level
UCC	Ultra conductive copper
UHMWPE	Ultra-high molecular weight polyethylene
UNT	University of North Texas
URJ	Ultrasonic rivet joining
USA	United States of America
USC	University of Southern California
USW	Ultrasonic welding
VTO	Vehicle Technologies Office