7. Propulsion Materials

Advanced materials are essential for boosting the fuel economy of modern automobiles while maintaining safety and performance.

Propulsion materials enable higher efficiencies in propulsion systems of all types. For example, many combustion engine components require advanced propulsion materials so they can withstand the high pressures and temperatures of high-efficiency combustion regimes. Similarly, novel propulsion materials may be able to replace the current expensive materials in electric motors and drivetrain components, thus lowering the cost of electric-drive vehicles.

Using lightweight components and high-efficiency engines enabled by advanced materials in one quarter of the U.S. fleet could save more than 5 billion gallons of fuel annually by 2030.

The Vehicle Technologies Office (VTO) collaborates with industry to improve materials that will increase vehicle efficiency while meeting consumer and industry expectations. It does this through multiple approaches, including working closely with other VTO technology areas to identify and meet requirements for materials needed to develop cost-effective, highly efficient, and environmentally friendly next-generation heavy- and light-duty powertrains.

The major research and development (R&D) goal for Propulsion Materials is:

- Develop high performance, cost-effective materials that solve key challenges that currently limit the performance of propulsion systems (high-efficiency engines and electric drive, and compatibility with alternative fuels).

Subprogram Feedback

The U.S. Department of Energy (DOE) received feedback on the overall technical subprogram areas presented during the 2014 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE Vehicles Technologies Office (VTO) subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1: Was the program area, including overall strategy, adequately covered?

Question 2: Is there an appropriate balance between near- mid- and long-term research and development?

Question 3: Were important issues and challenges identified?

Question 4: Are plans identified for addressing issues and challenges?

Question 5: Was progress clearly benchmarked against the previous year?

Question 6: Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Question 7: Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Question 8: What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Question 9: Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Question 10: Has the program area engaged appropriate partners?

Question 11: Is the program area collaborating with them effectively?

Question 12: Are there any gaps in the portfolio for this technology area?

Question 13: Are there topics that are not being adequately addressed?

Question 14: Are there other areas that this program area should consider funding to meet overall programmatic goals?

Question 15: Can you recommend new ways to approach the barriers addressed by this program area?

Question 16: Are there any other suggestions to improve the effectiveness of this program area?

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc.

Subprogram Overview Comments: William Joost (U.S. Department of Energy) – lm000

Question 1: Was the program area, including overall strategy, adequately covered?

Reviewer 1:
The reviewer said yes. The reviewer commented that the overall program was easily understood and well presented. The business case and gaps were clearly articulated and logical in sequence.

Reviewer 2:
The reviewer said yes, and that the presentation showed a good strategy based on feedback from the industry.

Reviewer 3:
The reviewer said that the program covers the lightweighting and propulsion materials. The reviewer said that in the area of lightweighting, all the constituent materials, including aluminum (Al), magnesium (Mg), carbon fiber composites (CFCs), and steels, are well represented. The projects are addressing the identified barriers very well. The reviewer thought that similarly, the Propulsion Materials projects are developing solutions for light-duty and heavy-duty engines; the efforts on electric vehicles (EVs) is just beginning. It is expected that more material issues for EVs will be dealt with in the future as their use increases.

Reviewer 4:
The reviewer said that the Vehicle Technologies Office (VTO) program was clearly explained, the strategy was clear and consistent with the goals.

Question 2: Is there an appropriate balance between near- mid- and long-term research and development?

Reviewer 1:
The reviewer said yes, there is a good balance.

Reviewer 2:
The reviewer emphasized yes, there is a balance. The reviewer commented there is an appropriate balance between the mid-term and long-term development and research projects.

Reviewer 3:
This reviewer is impressed with that balance. Appropriately, the majority of projects and funding focus on near-term projects that are industry driven. The reviewer pointed out that there are also several basic technology development projects that may have longer term potential. For example, development of third-generation advanced high-strength steel (AHSS) appears to have a mid-/long-term potential, whereas much of the design and simulation tools have nearer term potential. The reviewer also pointed out the Graduate Automotive Technology Education (GATE) project, which focuses on education. This is clearly a longer term investment.

Reviewer 4:
The reviewer said that as more and more industry partners are involved, the projects may be moving from long-range to near- and mid-term, so a balance needs to be kept with some fundamental aspects of the materials in the portfolio.

Question 3: Were important issues and challenges identified?

Reviewer 1:
The reviewer said yes, the challenges were very well identified.

Reviewer 2:
The reviewer said that the issues/gap analysis as presented is very detailed by covering the various aspects as property requirement and performance enhancement are needed in medium- to long-term.

Reviewer 3:

The reviewer said generally speaking, yes. The propulsion materials presented gaps quantitatively with long term goals for each area. The reviewer noted that the lightweight materials (body) program identified focus areas, but did not set quantitative targets. The reviewer really liked the “When it Works" slide for the various materials. This slide summarized and brought into focus the prior slides, which explained the various considerations of lightweighting on commercial automotive.

Reviewer 4:

The reviewer commented that issues and challenges were mostly identified. The reviewer elaborated by stating that there are more broad societal issues that should be mentioned that set the framework for the technical goals and strategies. The reviewer believed that the issues of energy security and the challenges of light-duty vehicle customer expectations should have more of an airing. These help set policy and strategy.

Question 4: Are plans identified for addressing issues and challenges?

Reviewer 1:

The reviewer commented that the plans for addressing the technical issues were clearly identified.

Reviewer 2:

The reviewer said yes.

Reviewer 3:

The reviewer said yes, extensively. The reviewer commented that the currently funded programs were clearly and logically set up to tackle the stated priorities. For this reviewer, the only improvement might be building a longer term trajectory. For example, there is a shift in the composite area from low-cost carbon fiber (LCCF) funding to integrated computational materials engineering (ICME) and non-destructive evaluation (NDE) projects. According to the reviewer, this was great, but it might be a good idea to show what has been accomplished, what the current plans are intended to accomplish, and what is still to be done at some future time.

Question 5: Was progress clearly benchmarked against the previous year?

Reviewer 1:

The reviewer found that the presentations from various researchers have shown the year over year progress very clearly.

Reviewer 2:

The reviewer said yes, progress was clearly benchmarked against the previous year.

Reviewer 3:

The reviewer said that the progress highlights were presented clearly. The efforts were proceeding as expected.

Reviewer 4:

The reviewer said no, and elaborated that the accomplishments of the previous year were clearly presented. However, the reviewer observed that it was not shown how that translates into a trend or curve or measures relative to a benchmark. The reviewer noted that the accomplishments were impressive, and that the program is producing significant results.

Question 6: Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Reviewer 1:

The reviewer said yes. The reviewer commented that the major barriers industry is facing in the area of lightweighting are being addressed in an interesting mix of targeted technology development, such as LCCF and third-generation AHSS, and broader integrated efforts, such as the multi-material vehicle and magnesium intensive front end.

Reviewer 2:
The reviewer said yes.

Reviewer 3:
The reviewer commented that the projects address the multi-faceted issues and barriers surrounding lightweight materials and technologies.

Reviewer 4:
The reviewer observed that the energy efficiency of a vehicle is impacted by the weight and the efficiency of the powertrain. These aspects are being investigated by the subprograms on lightweighting and propulsion (internal combustion and electrification); while lightweighting is being supported very well, the support for the propulsion materials is marginally lower. The reviewer commented that lightweighting contributes to the short- and mid-term goals and the powertrain may contribute more towards long-term. The funding should reflect this aspect.

Question 7: Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Reviewer 1:
The reviewer said yes the program area appeared to be focused, well-managed, and effective in addressing VTO's needs.

Reviewer 2:
The reviewer found that the projects are selected to address the priority areas and are well managed.

Reviewer 3:
The reviewer concluded that the program is properly focused with efforts in many material and process systems, joining, corrosion and the computational tools that enable product and component design.

Reviewer 4:
The reviewer responded yes. The reviewer commented that the efforts are not a multitude of diluted efforts across a wide variety of potential performers, but rather focused, integrated efforts targeted at addressing a particular problem. This ensures sufficient resources are invested to address the problem and make significant progress towards a solution. The reviewer commented that it also allows course corrections in future years to address the new problems that are exposed based on the ongoing efforts.

Question 8: What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Reviewer 1:
The reviewer said that the projects are all good.

Reviewer 2:
The reviewer found key strengths to include integrated efforts across multiple performers to address significant issues (ICME of composites, multi-material vehicles [MMV], ICME of third-generation AHSS).

A key weakness is the project that is modeling weight impacts on crashes is not moving towards success. This reviewer's comments of that project have been submitted.

Reviewer 3:
The reviewer commented that there are few projects that are just evaluating existing materials; the data which are being generated needs to be correlated to metallurgical/manufacturing variables so that the data can be used in future. The reviewer cited lm073 and pm038.

The reviewer noted, on the other hand, projects such as lm054 and lm075 are very relevant to industry and have delivered good results. The new projects on ICME based research are having a good start and need to be watched.

Reviewer 4:

The reviewer detailed as strengths the diversity of the portfolio. This reviewer is particularly interested in the high strength aluminum efforts. The reviewer identified as weaknesses end-of-life recycling, especially for CFCs.

Question 9: Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Reviewer 1:

The reviewer responded yes.

Reviewer 2:

The reviewer commented that there is a healthy mix of evolutionary and revolutionary efforts to enhance the use of lightweight materials in automotive structures.

Reviewer 3:

The reviewer commented some yes, others no. The reviewer thinks in almost all cases the approach taken is appropriate and justified. The reviewer found that the approaches generally speaking do not have major holes, validate everything, and tackle a problem of significant importance.

Question 10: Has the program area engaged appropriate partners?

Reviewer 1:

The reviewer said yes.

Reviewer 2:

The reviewer commented that the program has successfully engaged OEMs, suppliers, universities, consultants and national laboratories, and concluded good collaboration.

Reviewer 3:

The reviewer commented that the primary partners appear to be the following: Oak Ridge National Laboratory (ORNL), with focuses on carbon fiber and propulsion simulation; Pacific Northwest National Laboratory (PNNL), with a focus on metals; USCAR/ original equipment manufacturers (OEMs), with focuses on integrated and validation projects; and some material suppliers. The advanced topics, such as breakthrough techniques in multi-material joining, are conducted by universities. The reviewer concluded that for transition purposes, these are all the right organizations. That said, the reviewer suggested it may be appropriate to look at what other technologies are being developed by other government laboratories beyond the U.S. Department of Defense (DOD) laboratories, including the National Aeronautics and Space Administration (NASA) (likely simulation), Forest Services labs (have developed a lightweight nano-fiber from wood), and DOD laboratories. The reviewer suggested that particularly in the area of composites, more coordination might be possible.

Reviewer 4:

The reviewer noted that the partnerships in the program, for both lightweight and propulsion materials, is made of many North America producers and Tier 1 suppliers; the presence of other international OEMs is not evident. The reviewer suggested that even though international OEMs may not be investing in R&D in North America, some efforts may be needed to bring them to the program.

Question 11: Is the program area collaborating with them effectively?

Reviewer 1:

The reviewer said yes.

Reviewer 2:

The reviewer said yes. The reviewer remarked that these laboratories have the specialized facilities, expertise, and industry relationships that make them natural partners for VTO.

Reviewer 3:

The reviewer said yes, and commented that there appeared to be good support, direction, monitoring, and interactions.

Reviewer 4:

The reviewer noted that while some of the industrial partners are contributing heavily through in-kind participation, the quantum of this is not consistent across all the partners/projects.

Question 12: Are there any gaps in the portfolio for this technology area?

Reviewer 1:

The reviewer said that the program needed more funding.

Reviewer 2:

The reviewer remarked that some of the barriers to adoption are not technical per se, but rather business and design process driven. The reviewer provided as an example qualifying composites has been cited as a barrier, and there have been numerous efforts across the government to address this issue. Yet, this issue still comes up, and it is not clear to this reviewer how it will be addressed in the automotive space. The reviewer asked is this not an issue for automotive, and if not, why not. If so, the reviewer would like to know what its impact is. The reviewer asked about the supply chain, and if there was adequate supply. The reviewer would like to know if the supply chain model is broken, or is industry able to handle this naturally. Technical gaps that came to mind for this reviewer are adhesives and corrosion. The MMV project should help identify the major issues that would prevent the adoption of some of the technologies that lead to a 30% weight reduction. The reviewer would like to know what areas could benefit the most from focused government investment to develop the technologies that would lead to a 50% lighter vehicle.

Reviewer 3:

The reviewer pointed out that sustainability, lifecycle assessment, and recycling needed to be integrated in the projects as new materials are being introduced. The reviewer noted that few existing projects have some of the issues covered but making it another task item will be useful.

Reviewer 4:

The reviewer commented that gaps include recycling of carbon fiber and many composite materials. The reviewer suggested that DOE can be the referee for more standardized composite material and process systems. Designers are still required to pick a raw material supplier, a sizing system, a resin system and then fabric form and part manufacturing all that influence the structural behavior of the finished part. The reviewer noted that designers need to have robust material properties, like DP600 steel or AA-6062-T4 extrusion whose material performance is rather independent of the supplier(s).

Question 13: Are there topics that are not being adequately addressed?

Reviewer 1:

The reviewer responded yes. The projects the reviewer evaluated appeared to address the topics adequately to achieve significant progress. The reviewer acknowledged that these projects will not likely solve all the problems. This is in part because it is often impossible to control for geometry and design architecture. The reviewer commented that further evaluations and projects will be necessary within the commercial community to understand the strengths and limits of the technologies. But, within the priorities and gaps outlined in the program, the topics are being adequately addressed.

Reviewer 2:

The reviewer commented low-cost composite manufacturing.

Reviewer 3:

The reviewer commented that there needs to be more attention to end of life and recycling especially for the composite areas.

Question 14: Are there other areas that this program area should consider funding to meet overall programmatic goals?

Reviewer 1:

The reviewer commented that the program is focused on supporting the needs of the existing high volume automotive industry. These companies have significant infrastructure to support and are, for the most part, tied to their particular vehicle architectures. The reviewer commented that smaller companies do not have these restrictions and could utilize alternative vehicle architectures. These new architectures might be superior in electric and fuel cell vehicles. The reviewer remarked that there appears to be no significant investment in exploring non-established vehicle architectures.

Reviewer 2:

The reviewer commented that CFCs need more funding.

Reviewer 3:

This reviewer referenced the response given in Question #2. Some fundamental aspects of materials research need to be supported; this should provide a long-term goal for the program.

Reviewer 4:

The reviewer recommended that there needs to be further efforts on end-of-life and recycling, reuse, reclamation of composites, especially CFCs.

Question 15: Can you recommend new ways to approach the barriers addressed by this program area?

Reviewer 1:

The reviewer commented that the current approach is good.

Reviewer 2:

This reviewer will have to think about this more before the reviewer can offer significant suggestions.

Reviewer 3:

The reviewer commented that the program must attack composite and CFC recycling and end-of-life. Additionally, DOE should increase efforts on manufacturing aspects, especially joining and corrosion.

Question 16: Are there any other suggestions to improve the effectiveness of this program area?

Reviewer 1:

The reviewer said that even though the scientific community is aware of past development in the area of their research, the industry/government team may not be aware of them. The reviewer commented that it will be helpful to have some experts provide state of the art/reviews. This can provide context to some of the new research themes. The reviewer provided as an example a presentation on the capability of internal combustion engines as evolved through the years will show the light for work on new high-temperature materials.

Reviewer 2:

The reviewer commented mostly good job here. This reviewer suggested focusing on fewer, larger value projects. Work on including all the aspects of a full vehicle performance, especially noise, vibration, and hardness (NVH) and heating, ventilation, and air conditioning (HVAC) requirements into the vehicle systems that are the subject of lightweight actions.

Reviewer 3:

The reviewer did not offer any suggestions to improve the materials technical area. However, this reviewer did offer a suggestion under the EV Everywhere umbrella. Similar to the way the use of EVs are tied to high-occupancy vehicle (HOV) lanes in California to encourage public purchase of EVs, linking EVs to parking benefits in Washington, DC, or other high density urban areas might have significant impact. The reviewer cited as an example that landlords who install charging stations would get some sort of tax or other financial benefit that would have to be partially shared with the tenant through reduced parking fees for some period of time [DOE Program Note: The reviewer's suggestion has been passed to the EV Everywhere team.].

Project Feedback

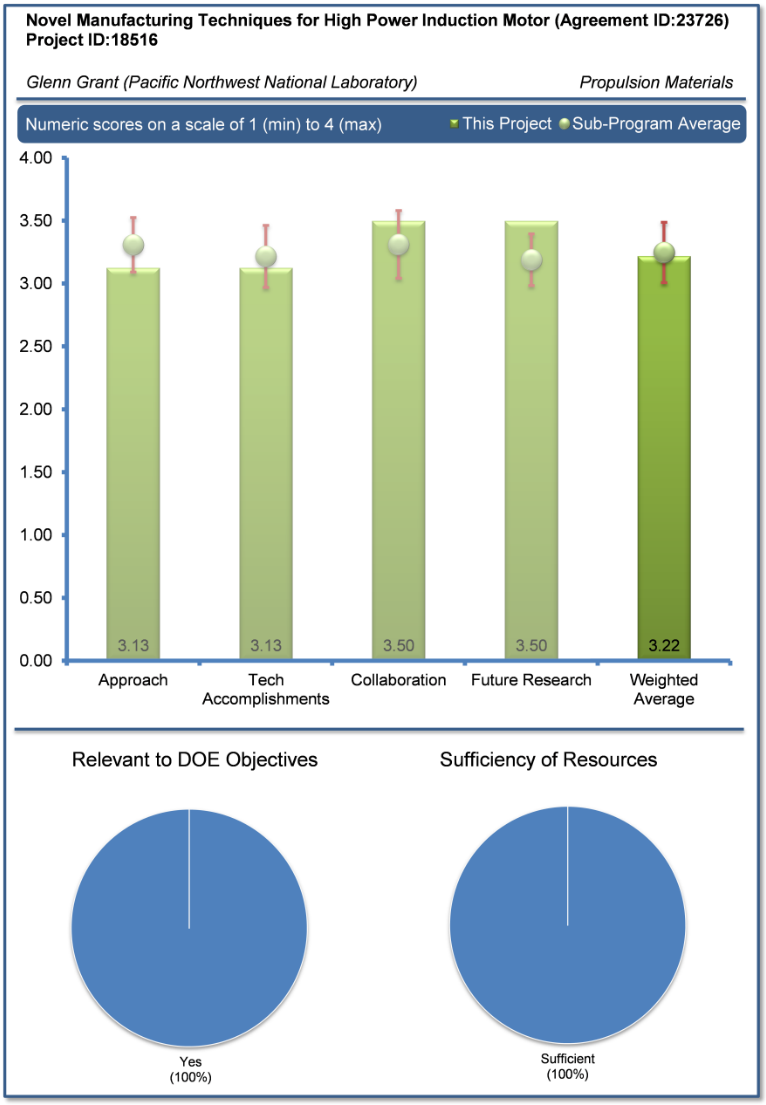
In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses *(on a scale of 1.0 to 4.0)*. In the pages that follow, the reviewer responses to each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

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Novel Manufacturing Techniques for High Power Induction Motor (Agreement ID:23726) Project ID:18516	Glenn Grant (Pacific Northwest National Laboratory)	7-12	3.13	3.13	3.50	3.50	3.22
Materials Issues Associated with EGR Systems (Agreement ID:18571) Project ID:18518	Michael Lance (Oak Ridge National Laboratory)	7-15	3.25	3.25	3.50	3.00	3.25
Durability of Diesel Particulate Filters (Agreement ID:10461) Project ID:18519	Thomas Watkins (Oak Ridge National Laboratory)	7-18	3.30	3.10	3.10	3.20	3.16
Materials for Advanced Turbocharger Designs (Agreement ID:17257) Project ID:18518	Phil Maziasz (Oak Ridge National Laboratory)	7-22	3.13	2.88	3.25	2.88	2.98
† High Temperature Aluminum Alloys (Agreement ID:24034) Project ID:18518	Stan Pitman (Pacific Northwest National Laboratory)	7-25	3.38	3.00	3.38	3.13	3.16
Tailored Materials for Improved Internal Combustion Engines (Agreement ID:23725) Project ID:18518	Glenn Grant (Pacific Northwest National Laboratory)	7-28	3.25	3.25	3.25	3.25	3.25
Catalyst Characterization (Agreement ID:9130) Project ID:18519	Thomas Watkins (Oak Ridge National Laboratory)	7-31	3.30	3.20	3.00	3.13	3.19
Mechanical Reliability of PS Actuators (Agreement ID:13329) Project ID:18518	Hong Wang (Oak Ridge National Laboratory)	7-34	2.70	2.70	3.00	2.75	2.74
Friction Reduction through Surface Modification (Agreement ID:23284) Project ID:18518	Peter Blau (Oak Ridge National Laboratory)	7-37	3.20	3.30	3.00	3.13	3.22
High Temperature Materials for High Efficiency Engines (Agreement ID:26190) Project ID:18518	Govindarajan Muralidharan (Oak Ridge National Laboratory)	7-40	3.20	3.10	2.70	3.20	3.09
Enabling Materials for High Temperature Power Electronics (Agreement ID:26461) Project ID:18516	Andrew Wereszczak (Oak Ridge National Laboratory)	7-44	3.38	3.50	3.63	3.13	3.44
Biofuel Impacts on Aftertreatment Devices (Agreement ID:26463) Project ID:18519	Michael Lance (Oak Ridge National Laboratory)	7-47	3.20	3.40	3.40	3.00	3.30
Characterization of Catalysts Microstructures (Agreement ID:9105) Project ID:18865	Larry Allard (Oak Ridge National Laboratory)	7-51	3.75	3.75	3.38	3.33	3.65
Applied ICME for New Propulsion Materials (Agreement ID:26391) Project ID:18865	David J. Singh (Oak Ridge National Laboratory)	7-54	3.10	2.90	3.10	3.00	2.99
† Alloy Development for High-Performance Cast Crankshafts	John Hryn (Argonne National Laboratory)	7-57	3.50	3.40	3.40	3.50	3.44

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
† CATERPILLAR Cast Alloy Development for Heavy Duty Engines: FOA 648 3b	Rich Huff (Caterpillar)	7-61	3.60	3.30	3.80	3.50	3.46
† Ford Motor Company Cast Alloy Development for Automotive Engines: FOA 648-3a	Mei Li (Ford Motor Company)	7-65	3.60	3.40	3.40	3.20	3.43
† General Motors Cast Alloy Development for Automotive Engines: FOA 648-3a	Mike Walker (General Motors LLC)	7-69	3.50	3.30	3.40	3.40	3.38
† ORNL: ICME Evaluations and Cast Alloy Development for Internal Combustion Engines 2012 FOA 648 Topic 3a	Amit Shyam (Oak Ridge National Laboratory)	7-73	3.38	2.88	3.38	3.13	3.09
† Lightweight Heavy Duty Engines (Agreement ID:23425) Project ID:18518	Govindarajan Muralidharan (Oak Ridge National Laboratory)	7-76	3.33	3.33	3.17	3.50	3.33
† International Energy Agency (IEA IA-AMT) Characterization Me (Agreement ID:26462) Project ID:18519	Hsin Wang (Oak Ridge National Laboratory)	7-79	3.33	3.50	3.83	3.17	3.46
Overall Average			**3.31**	**3.22**	**3.31**	**3.19**	**3.25**

† denotes poster presentations.

Novel Manufacturing Techniques for High Power Induction Motor (Agreement ID: 23726) Project ID: 18516: Glenn Grant (Pacific Northwest National Laboratory) - pm004



Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the project team had a creative approach to weld near edges with stationary shoulder tool. The reviewer added that the project is adjusting the exit hole approach to use other tip shapes.

Reviewer 2:

The reviewer acknowledged that the objectives are both well described and quantified. The project team's technical approach to reducing motor weight is through the application of friction stir welding (FSW) in the manufacturing process. The reviewer suggested that because the objectives are heavily focused on cost reduction, it would be good to describe in more detail the cost benefits of this approach compared to the current manufacturing process. Because the project team mentioned that casting is a possible approach but defects would not be predictable, the reviewer asked what defects are unpredictable. The reviewer queried whether overcasting the end caps would be a feasible alternative, and if a greater contact area could be achieved.

Reviewer 3:

The reviewer stated that the project is aimed at developing a process to join copper (Cu) end plates for motors and that the solid state joining process for doing this has been chosen. Even though this joining process has its advantages, the reviewer opined that the casting route needs to be explored further. The reviewer added that there are cast Cu rotors in production and encouraged the team to look into some other techniques and evaluate their efficiency, at least from literature review.

Reviewer 4:

The reviewer remarked that the focus of the project appeared to be in a key area of the development needed for induction motors to overcome barriers, and that the project is trying to overcome the disadvantages of current brazed and die cast rotor manufacturing processes by developing a solid state welding process. The reviewer added that the approach overall seems relatively straightforward, although the project delays may have exposed some issues, which indicate that the schedule contingencies may not have been adequately planned for.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer indicated that project team's problems were dealt with effectively, such as joining defects. The reviewer noted that the quality and conductivity issues have been addressed for similar metal joining, but suggested that the dissimilar metal joints need to be further evaluated.

Reviewer 2:

The reviewer stated that FSW of Cu has been used for Cu end plates and short bars, and that the project team's technical barriers have been successfully passed. The reviewer added that enough work has been completed and suggested that some preliminary cost estimates should be possible to estimate potential benefits.

Reviewer 3:

The reviewer acknowledged that the end cap weld appears to be a good approach to solve the problem, and that the solution to address temperature boundary control is innovative. The reviewer asked if there were other applications for the stationary shoulder. The reviewer added that the application of the project's technology can apply to other metals and products. The reviewer explained that issues still exist for solving exit holes and was unsure if it will be solved under this project. However, the reviewer noted that the exit ramp approach, although more expensive, can work.

Reviewer 4:

The reviewer commented that project team identified several challenges along the way, which impacted the project schedule. Tool selection, heat, and closing the exit hole were particular problems. The reviewer stated that the project appears to have now developed tool/process combinations that are delivering good welds, including several specialized tools. To address heat issues, the project developed a control algorithm based upon temperature and power requirements. The reviewer noted that the project also appears to have developed one method to address exit holes, though it is still struggling to develop a second method. The reviewer concluded that overall, the project team was finding some solutions, but addressing these challenge issues has impacted the project schedule.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that the project team had excellent collaboration with a Cooperative Research and Development Agreement (CRADA) developed for commercialization of the product, a strong purpose, and the right partners.

Reviewer 2:

The reviewer commented that one OEM who is willing to take the process to commercial production is more than enough for the success of this project.

Reviewer 3:

The reviewer stated that project involves a CRADA with General Motors (GM) who was clearly involved in key aspects of the project and who has weekly calls and meetings with PNNL. The reviewer also pointed out that from what was presented, GM appears committed to the project and is positioned to take the project results and implement them in commercial EV motors.

Reviewer 4:

The reviewer noted there is 50/50 cost share with GM and that target adopters are based on current GM motor platforms.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that the exit from the weld has been proven via the exit ramp approach. However, if a solution is proven for the exit hole via plug welds with taper plugs, a significant production cost savings can be achieved.

Reviewer 2:

The reviewer indicated that the project is nearly done right now, but there may be some applications for tools and processes to be developed in aluminum (Al) part manufacturing and that implementation would be under other projects. The reviewer noted that it appears the project has developed one solution for the exit hole issue, but is trying to succeed with a second solution, which is delaying completion of a milestone. The reviewer added that at some point, the project team will need to decide if one solution is sufficient because the Principal Investigator (PI) seems to think the project is close to succeeding with the second approach. The solution is based upon a commercial process for aluminum and steel, and has potential to be a cheaper process. The reviewer concluded that the project still needs to develop a cost analysis of the final processes selected.

Reviewer 3:

The reviewer remarked that the time for the evaluation of dissimilar joining process may not be enough if the project is planned to be closed by September 2014.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the project is relevant to VTO objectives where it is focused on reducing the cost of induction motors which do not have the materials issues of permanent magnet motors and may be a key component for cost-effective EVs.

Reviewer 2:

The reviewer pointed out that electrification is one of the ways to reduce the fuel consumption in vehicles. This person added that the electric motor is an integral part of the electrification, and ways to reduce the cost and increase the efficiency of motors will improve the probability of electrification.

Reviewer 3:

The reviewer reported that electric motors are becoming an increasing part of light-duty (LD) vehicles and that reducing the weight of the critical systems is important in achieving DOE goals.

Reviewer 4:

The reviewer commented that light and more efficient motors result in increased petroleum displacement.

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

Reviewer 1:

The reviewer remarked that the resources appear sufficient and the project is nearly complete.

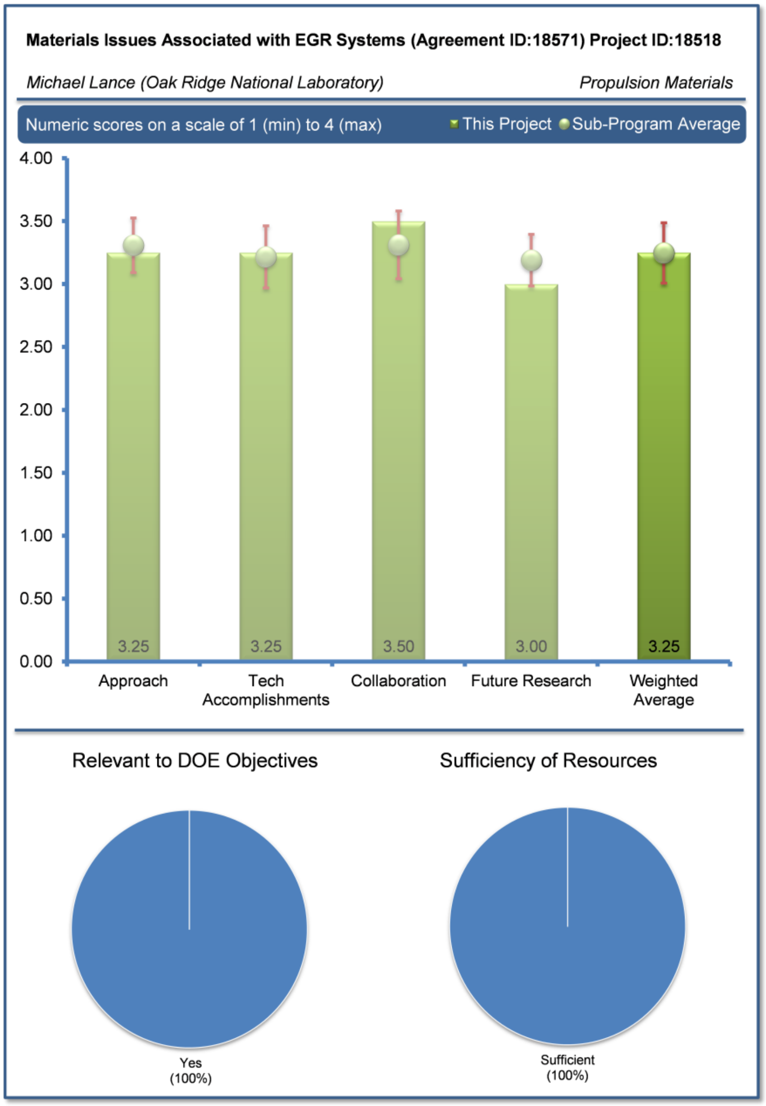
Reviewer 2:

The reviewer reported that the right amounts of Federal and industry resources were applied to this issue.

Reviewer 3:

The reviewer commented that significant work with technical challenges still remains and FSW exit appears to be most critical. The reviewer questioned if current proposed solutions are cost-effective when remaining funding is claimed to be sufficient. The presenter indicated the project end date needed to be extended, but it was not clear what the new proposed project schedule was.

Materials Issues Associated with EGR Systems (Agreement ID:18571) Project ID:18518: Michael Lance (Oak Ridge National Laboratory) - pm009



Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the approach of the project to develop experimental equipment for deposit formation and aging, obtain exhaust gas recirculation (EGR) coolers from industry, and to investigate active and passive controls was very good.

Reviewer 2:

The reviewer noted that the project team's approach seemed valuable for identifying the cause of EGR fouling. The team's suggestion to characterize the dew point is promising for improving the operation and identifying regeneration strategies.

Reviewer 3:

The reviewer commented that it was good that the project team's investigations started by listening to the field, but the selection of tools for research seemed a bit like trial-and-error, and stated that perhaps for such a very new problem, there was no other possible approach.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer remarked that technical accomplishments of using industry-provided coolers to determine the origin of plugging and lacquer-like deposits was excellent. In addition, information from the project has been put into the public domain through the publication of two Society of Automotive Engineers (SAE) papers in 2014.

Reviewer 2:

The reviewer pointed out that the technical accomplishment using neutron scattering seemed useful and that having a wide variety of fouled devices may improve the identification of buildup mechanisms as they interact with the geometry.

Reviewer 3:

The reviewer noted that most of the work focused on characterizing materials in fouled EGR systems, where there was little discussion on proposed material solutions that would reduce the EGR fouling. The reviewer questioned if other material could not be identified for side-by-side testing, which could have already started.

Reviewer 4:

The reviewer stated that the following two important mechanisms have been identified for EGRcooler fouling: very fluffy soot cake that contains much air and therefore has very high insulation value and, consequently, poor heat transfer; and the more dense lacquer deposits that do not block heat transfer but can result in clogged channels and, therefore, more pressure drop over the EGRcooler. The project team's explanation of the lacquer effect suggested that the nitrogen oxides (NO_x) level was also a factor, which would be beneficial if it was a relevant factor for typical NO_x levels seen in engines, or that the levels are anyhow enough to deliver the acid needed for the lacquer formation. The reviewer opined that it was a pity that the test with the neutron technique did not give the expected answers, and questioned if it was possible to give some guidance to when this new technology can or cannot be used.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that the project's collaboration was excellent because the work was coordinated with the entire diesel engine community.

Reviewer 2:

The reviewer explained that the project team indicated good collaboration because the project team obtained fouled devices and had ongoing discussions with the project partners.

Reviewer 3:

The reviewer stated that the collaboration was with all diesel engine manufacturers.

Reviewer 4:

The reviewer commented that OEMs were well incorporated in the investigation, but questioned why the supplier, Modine, was not mentioned anymore as it was in 2013, even though their logo was on one of the final sheets. The reviewer suggested that perhaps the optimal tools for this research could have been determined earlier if there was collaboration with another institute or university.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the project team proposed future work to better understand refreshment strategies, to characterize late-stage deposits, and to continue to address barriers.

Reviewer 2:

The reviewer explained that the project team's use of computational fluid dynamics (CFD) on deposit formation seemed difficult without a mechanism to distinguish the root cause of buildup.

Reviewer 3:

The reviewer acknowledged the contributing factors have been identified. Further, lube oil was not a contributor, but low exhaust gas temperature and unburned hydrocarbon (HC) coming out of the engine have influence. Up to this point in the project, no practical value for the amount of unburned HC, soot, or the ratio between them was provided, and perhaps knowing this value as function of exhaust gas temperature would avoid serious problems. The reviewer suggested the project team should continue to study cleaning mechanisms in order to provide the guidelines on how to avoid these kinds of problems.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer noted that the project's objective to mitigate EGR fouling was relevant to DOE's objectives of petroleum displacement, and that his work will reduce the impact of EGR cooler fouling on efficiency and emissions. The project will address the barrier of improved efficiency in advanced combustion engines that require EGR to operate over a wider range of speeds and loads.

Reviewer 2:
The reviewer explained that EGR helps to reduce NO_x emissions, and without it, the fuel consumption would have gone up considerably. Therefore, all EGR problems have to be resolved in order that this technology remains a stable and efficient NO_x reduction measure.

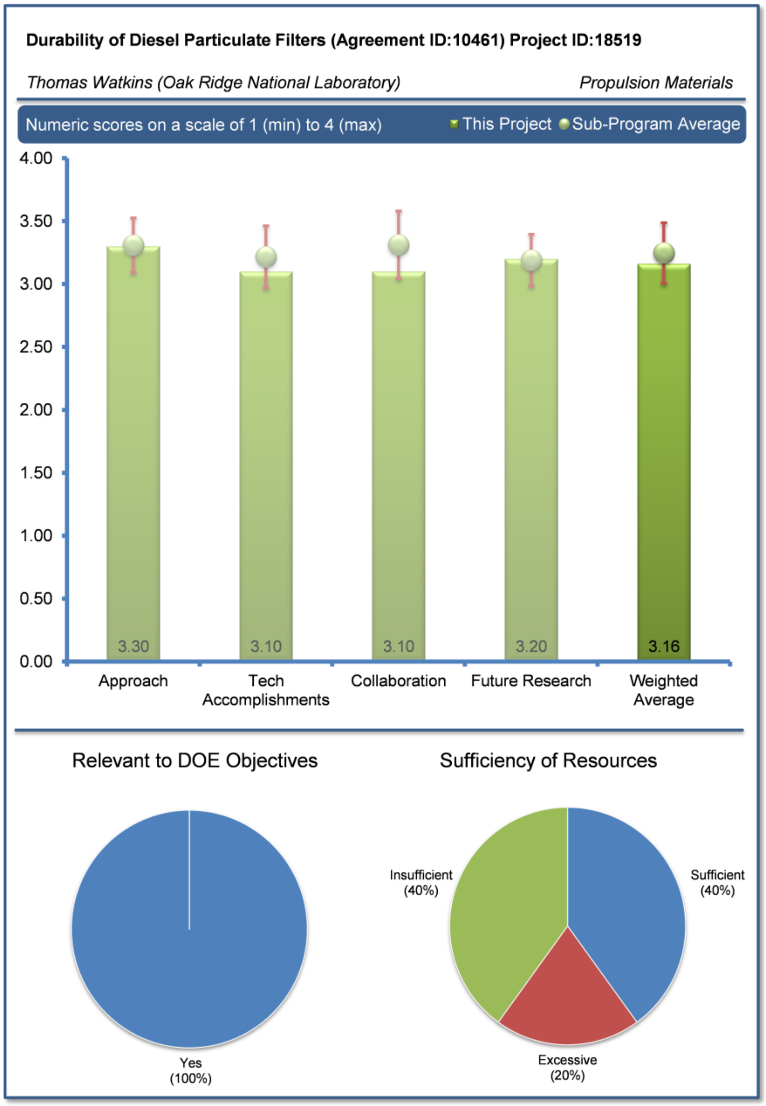
Reviewer 3:
The reviewer expressed that the project attempts to address the fuel efficiency penalty from EGR emission systems, but was not entirely clear what its impact was on fuel efficiency.

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

Reviewer 1:
The reviewer mentioned that project had a little more than two years before completion, which was about 25% of the project. Because approximately 30% of the funding remained, the resources should be sufficient to complete the project.

Reviewer 2:
The reviewer stated that more expensive testing will be needed to investigate the relation between EGR cooler fouling and various drive cycles.

Durability of Diesel Particulate Filters (Agreement ID:10461) Project ID:18519: Thomas Watkins (Oak Ridge National Laboratory) - pm010



Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the project team had an excellent approach, with Cummins providing the materials and performing the in-house testing, ORNL performing mechanical testing and microstructural analysis, and then the team providing these results to the diesel community for model development.

Reviewer 2:

The reviewer noted that the project's work was important to characterize failure mechanisms associated with in-use mechanical and thermal stresses. However, much of the work appeared routine and may not fit the charter of the national laboratories, and therefore, much should be done at the supplier level.

Reviewer 3:

The reviewer noted that the research team effectively implemented the mechanical test procedures to identify properties of an assorted set of filter materials. The project team tackled non-linear (cycle-dependent) properties in the materials and modeled thermal conditions that can help predict stress zones.

Reviewer 4:

The reviewer commented that the project team's approach of characterizing candidate materials was a usual approach in determining the performance of devices such as the diesel particulate filter (DPF) to various road conditions as experienced in diesel engine vehicles. The durability requirements are affected by whether the vehicle is classified as HD or LD. The reviewer noted that for cost reasons, placing a DPF material rated for HD 425,000 miles into a LDV requiring only approximately 100,000-mile durability did not make sense.

Reviewer 5:

The reviewer explained that the project did focus on material property characterization, but the duration seemed too long. The reviewer questioned why DPF manufacturers are not providing funding to accelerate this testing in order to better understand their products.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:
The reviewer mentioned that the project team's technical accomplishments have been good and have helped address the barriers. The measurement of elastic modulus was important because it affects the lifetime prediction of diesel particulate filters. The reviewer noted that if data has indicated that failure is controlled by strain, then aluminum titanate may be considered a good material for higher-performance DPF substrates.

Reviewer 2:
The reviewer expressed that this very long project had grown because of the large number of materials analyzed, including multiple materials, but had led to a material selection and therefore had met the objectives.

Reviewer 3:
The reviewer commented that the project team's progress on technical accomplishments was good, but questioned if the characterizing of porous materials truly represents the actual material or is it dominated by the pore size and distribution. In addition, if the data generated for porous materials does represent inherent material properties, the reviewer questioned how it will be affected when other material properties are measured, and suggested that some indication of the statistical reproducibility of the data should be provided.

Reviewer 4:
The reviewer explained that the failure mode modeling advances derived from this work will help the aftertreatment industry better understand the usage issues and the appropriate placement and use of these substrates. However, the project would have benefited from the inclusion of a supplier partner in the project to perform some of the more routine tasks and analyses. The reviewer indicated that there was only minor interaction cited with Corning.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that Cummins and ORNL were working very well together, not only in supplying materials but in carrying out burner tests and modelling.

Reviewer 2:
The reviewer concluded that the project team's coordination and collaboration with other institutions appeared to be more than adequate because Cummins is recognized as a world leader in diesel engine technology. However, the reviewer suggested that some indication of inclusion and collaboration with materials providers should be addressed, because Cummins would not likely supply the actual materials in its production DPFs being made for its engines.

Reviewer 3:
The reviewer stated that Cummins provided information to the diesel community so that it could be used to update their respective models, but there did not seem to be a great deal of collaboration with other diesel engine manufacturers.

Reviewer 4:
The reviewer acknowledged that the project team had a 50/50 CRADA with Cummins, but questioned why no DPF manufacturers were key partners, and should they not be providing funding to test and characterize their products, or if they were already doing that but considering it as internal intellectual property (IP).

Reviewer 5:
The reviewer commented that the use of substrate suppliers would have been useful for some of the project tasks and the team's insight.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
This reviewer explained that planning for future work in this project recognized that determining one property of a porous material constituted the first step to characterizing the full database of materials properties needed for the DPF models, and suggested that more detail should be provided to enable an evaluation of which properties should be prioritized.

Reviewer 2:
The reviewer emphasized that the project was a long-duration project that had achieved most of its objectives. However, new materials were needed to be characterized as potential alternatives to traditional cordierite or silicon carbide (SiC) substrates.

Reviewer 3:
The reviewer acknowledged the project team's focus on new zeolite materials which may lead to some improvements in the product technology.

Reviewer 4:
The reviewer noted that future work to continue investigating mechanical properties of zeolite-based substrates, and the initiation of new testing methodologies for evaluating highly porous materials, will help overcome the barriers.

Reviewer 5:
The reviewer explained that the project team would like to include the testing of zeolite material as well, and noted that including more materials in the system is valuable.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer explained that this project, by developing optimized regeneration strategies for DPFs, will increase the acceptance of clean diesel engines, resulting in reduction of petroleum consumption.

Reviewer 2:
The reviewer commented that DOE objectives are also environmental safety considerations, where diesel filtering and catalysis were critical to health and efficiency issues.

Reviewer 3:
The reviewer expressed that the project results were relevant but new information was limited for most of the materials.

Reviewer 4:
The reviewer commented that lowering the quantity of fuel required to chemically reducing the particulate and NO_x loading on DPFs, supports the overall DOE objective of petroleum displacement. The reviewer agreed that there were clean diesels actually capable of meeting emissions levels comparable, or even superior, to gasoline-powered vehicles, and that they would enable a 25-40% reduction in U.S. LD vehicle fuel consumption. Currently, clean diesel vehicles appear to have lower particulate emission levels than comparable gasoline vehicles.

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

Reviewer 1:
The reviewer noted that compared to the vast potential fuel economy benefits of transitioning a large percentage of LD vehicle fleets in the United States to clean diesel technology, the resources being expended for this project were miniscule. One only needed to look at the diesel vehicle penetration in Europe to understand the large fuel economy benefits such a transition would bring to the United States.

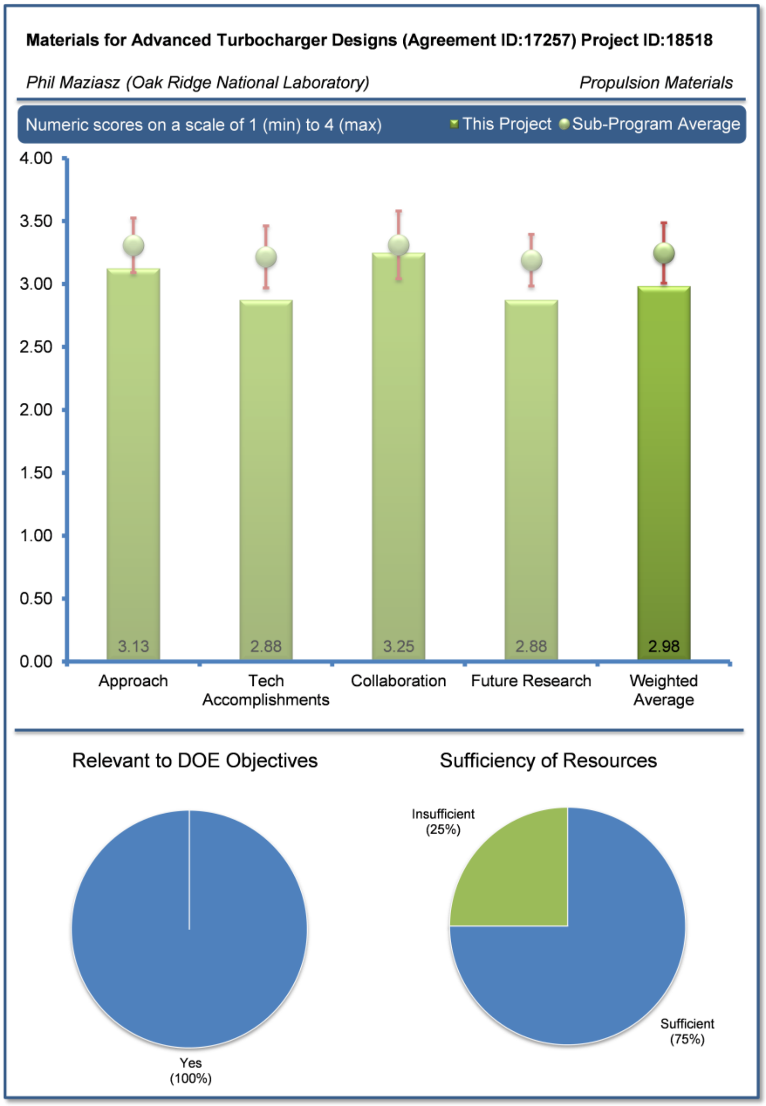
Reviewer 2:

The reviewer commented that the project’s resources were sufficient for completion in 2015.

Reviewer 3:

The reviewer pointed out that the project was lengthy and heavily funded, and considering the type of work being performed, it appeared to be somewhat over-funded.

Materials for Advanced Turbocharger Designs (Agreement ID:17257) Project ID:18518: Phil Maziasz (Oak Ridge National Laboratory) - pm038



Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the project was following the Honeywell turbo materials approach, and was well defined to assess materials for turbocharger material qualification.

Reviewer 2:

The reviewer pointed out that the project was evaluating one steel alloy, CF8C-Plus, for high-temperature performance including creep, fatigue and oxidation. The experiments were well designed to address the understanding of these behaviors necessary for the use of this material.

Reviewer 3:

The reviewer stated that the project had a reasonable goal to demonstrate the increased capability for a material to meet the higher-temperature properties and performance needed for turbocharger applications. However, it appeared that the approach was simply to evaluate an alloy developed ten years prior using routine testing and characterization activities.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that project team’s results for routine tests were showing good results in the target performance region for higher-temperature turbocharger applications.

Reviewer 2:

The reviewer reported that the project team’s progress was acceptable based on funding received, but the gap in funding delayed accomplishments.

Reviewer 3:

The reviewer remarked that the project did not receive funding during the fiscal year, but some progress had been reported on the testing. Even though the testing had been done to prove the superior performance of the alloy, the microstructure and metallurgical base for the improved performance was not presented. The reviewer suggested that the study of the metallurgical factors may help to fine tune the alloy for future uses.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer pointed out that the project having a CRADA with industry, or Honeywell, improved the potential for turbocharger material commercialization.

Reviewer 2:
The reviewer noted that the project team had a 50/50 CRADA with Honeywell.

Reviewer 3:
The reviewer commented that one end-user was part of the project and that commercialization was already underway. However, efforts to bring on a manufacturer were being hampered by the non-availability of foundries.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer indicated that completing the Honeywell test procedures would enable the use of CF8C-Plus material for more dynamic applications, such as turbochargers. Industry interest from Ford and Caterpillar, for Solar Turbines, will improve the likelihood for commercialization.

Reviewer 2:
The reviewer mentioned that future work primarily focused on CF8C-Plus, and questioned if there were any alternative Plan B to look at other materials, and also if CF8C-Plus can be further optimized for higher-temperature applications.

Reviewer 3:
The reviewer indicated that more testing of material was being proposed by the project team, but because the end-user is benefiting from the qualification of CF8C-Plus, their contribution to the project should be greater.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that increasing the operating temperature of the engines will improve fuel efficiency, but materials with improved performance would be needed.

Reviewer 2:
The reviewer pointed out that higher operating temperatures will enable more efficient engines.

Reviewer 3:
The reviewer commented that turbocharger temperatures would need to increase for use on higher-efficiency engines, where efficiency targets are clearly defined to increase by 20% over the 2009 baseline efficiency.

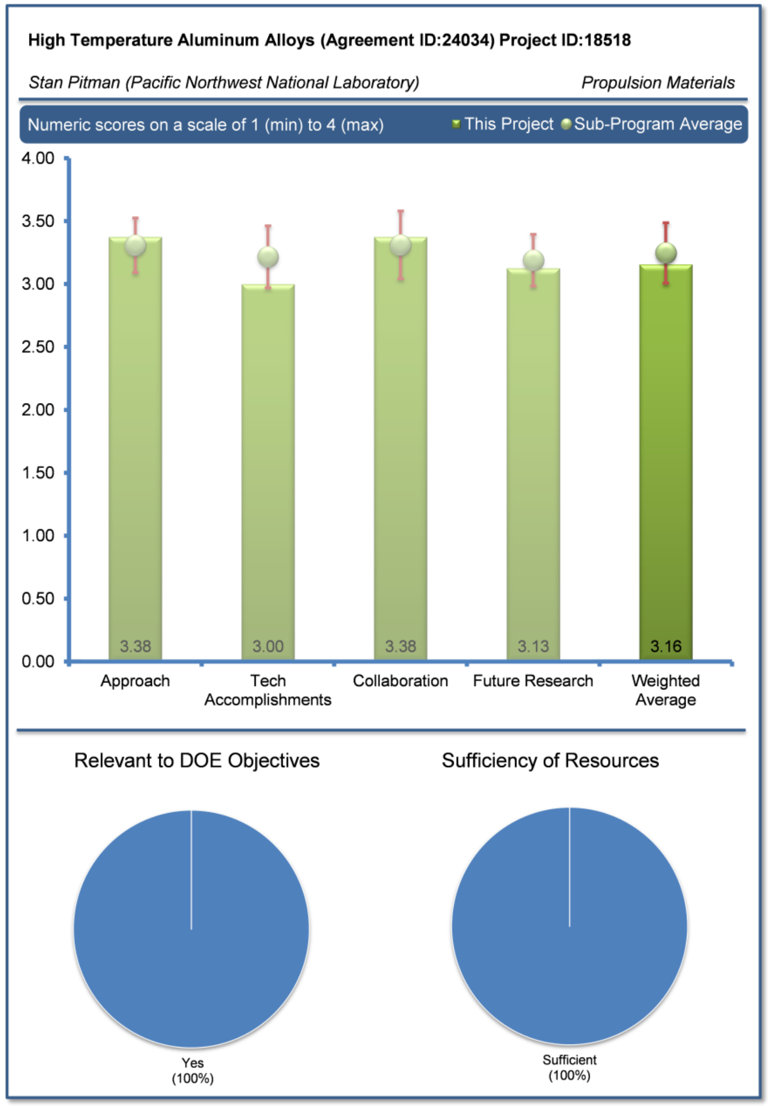
Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer observed that the funding decrease had impacted the completion date of the project, where increased funding would allow proper testing to be completed and the project to get back on track.

Reviewer 2:

The reviewer pointed out that project's total program budget was not specified. The project team mentioned funding cuts, but details were not specified, and the impact on program changes was also not described. Remaining testing, such as thermo-mechanical, were likely to be more expensive and time-consuming than the completed thermo-physical testing work. The reviewer emphasized that the program schedule needed to be extended for two more years, but questioned if this schedule could be accelerated when material is readily available from potential production foundries.

High Temperature Aluminum Alloys (Agreement ID:24034) Project ID:18518: Stan Pitman (Pacific Northwest National Laboratory) - pm044



Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer agreed that the project team's approach was logical for determining the potential for this project's rapid solidification method in creating high-strength, high-temperature aluminum alloys, and the critical aspects of cost and performance were addressed.

Reviewer 2:

The reviewer acknowledged that the project team's approach appeared logical and thorough, in that it called for evaluation of candidate formulations, production of candidate materials, and testing to determine properties. Once evaluated, one candidate will be selected for scaled-up production processes and a demonstration. The reviewer observed that a critical initial performance measure might have been set higher than was actually needed. The industry partner, Cummins, determined that tensile strength of 250 mega Pascals (MPa) was sufficient for the project team's needs, which was different than the project's initial objective of 300 MPa.

Reviewer 3:

The reviewer remarked that project team's approach to develop low-cost alloys was innovative and applicable to the targeted application of aluminum alloy based propulsion system components.

Reviewer 4:

The reviewer explained that the project team's approach was to use two methods that have solidification rates that differ by several orders of magnitude in both extremes, and suggested that a method that could provide a value in between could possibly have added more understanding to the project and helped to create a theory and models that were in combination with the material quality.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the project team had a process which was determined to produce better properties than the current material and that it could be used in mass production of product. Although the project did not meet the original targets completely, the results were attractive to the OEM.

Reviewer 2:

The reviewer explained that the team had worked to overcome problems associated with the consolidation of the aluminum flake, in order to continue exploring the properties of this alloy. It was important that the properties of the material at higher temperatures were still attractive to the industry, and Cummins, despite missing the 300 MPa target. The reviewer concluded that the project's work on this material with DOE funding could result in commercialization of the alloy.

Reviewer 3:

The reviewer stated that the project, overall, had made some interesting progress, in that it developed multiple candidate formulations and, ultimately, down-selected the one with the greatest promise for future scaled-up activities. There had been delays in the project, particularly involving a subcontractor, which extended the project past the original completion date. At this time, the reviewer was unclear as to when all the work would be completed, even though the cause of the delay was resolved. In addition, the reviewer opined that the project, at times, had a bit of good-news or bad-news elements. For example, several materials appeared to demonstrate such high-temperature strength that they exceeded the limits of the extrusion equipment, and thus, could not be extruded. The reviewer mentioned that this issue was resolved, and the mechanical testing was put back on track.

Reviewer 4:

The reviewer indicated that the mechanical properties of the alloy had not yet been verified, for the material supply delay may indicate difficulty of producing sufficient supply of material for commercial production.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project team had good collaboration, which included co-funding from Cummins and feedback on the usability of the resulting alloys. The inclusion of Transmet was also important because their experience in flake metal processing was directly applicable for this project. The reviewer added that, given the issues with the consolidation of the flake into extrusion billets, the input of Kaiser Aluminum was also valuable, and their input on how to use the flake in developing commercial alloy products, as described in the poster, was also useful.

Reviewer 2:

The reviewer commented that the project is working closely with Cummins under a CRADA. Cummins seemed to have been involved where needed, and had even indicated that the original objective, a tensile strength of 300 MPa, was actually higher than they required. The reviewer added that, ultimately, Cummins would be expected to move forward with using the material in its engines.

Reviewer 3:

The reviewer noted that the project team had a CRADA with Cummins and that the suppliers were in place. However, there was a delay in flake supply delivery.

Reviewer 4:

The reviewer noted that an OEM, an extrusion company, and melt spinning company were involved in the project. The reviewer said perhaps in a follow-up project addition of another research institute or university could be considered to build up the project theory.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that the project was almost finished with some outstanding tasks still remaining.

Reviewer 2:

The reviewer explained that proposed future work was not applicable, per se, because the project was slated for completion in May 2014.

Reviewer 3:

The reviewer stated that the project was nearing completion, and that material supply issues should be assessed.

Reviewer 4:

The reviewer expressed that the project was supposed to be nearly complete, but it appears that there are a number of tasks still required to be completed due to the delays of the subcontractor. Efforts appeared to be back on track, but it was unclear when the tasks would be completed. The reviewer explained that the remaining tasks, however, were important to the success of the project, as they involve the scaled-up activities for the selected candidate material, which appeared to also be in the phase of the project where greater involvement of the CRADA partner would take place. The PI indicated that Kaiser Aluminum was also involved, but indicated upon questioning that their role was primarily to observe the results of the project and to move forward if the project was successful. Kaiser Aluminum, however, did not actually appear to be involved in the project at all.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that the project involved the study of a lightweight material that could withstand higher temperatures and help to reduce the weight of internal combustion engines, and thus reduce fuel consumption by allowing more payload on HD vehicles and less empty weight for LD vehicles.

Reviewer 2:

The reviewer stated that lighter engine components lead to higher efficiency.

Reviewer 3:

The reviewer commented that the project was focused on improved lighter materials, which resulted in fuel efficiency improvements. In general, the PI indicated that the project's results might be most applicable to specialty applications, and not high-volume applications. The reviewer concluded that the results would be most useful for HD trucks and in military sectors.

Reviewer 4:

The reviewer expressed that the relevance of this project was generally good, in that it could provide lighter-weight HD engines and enable high-strength at higher temperatures, which would improve efficiency. The PI stated that a “diesel engine component” had been selected, but no details were provided, likely to protect proprietary information. The reviewer expressed that it was difficult to judge the relevance in more specific detail.

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

Reviewer 1:

The reviewer acknowledged that the resources appeared to be sufficient.

Reviewer 2:

The reviewer explained that with the cost share from the industrial partner, the funding appeared to be sufficient to complete the outlined work.

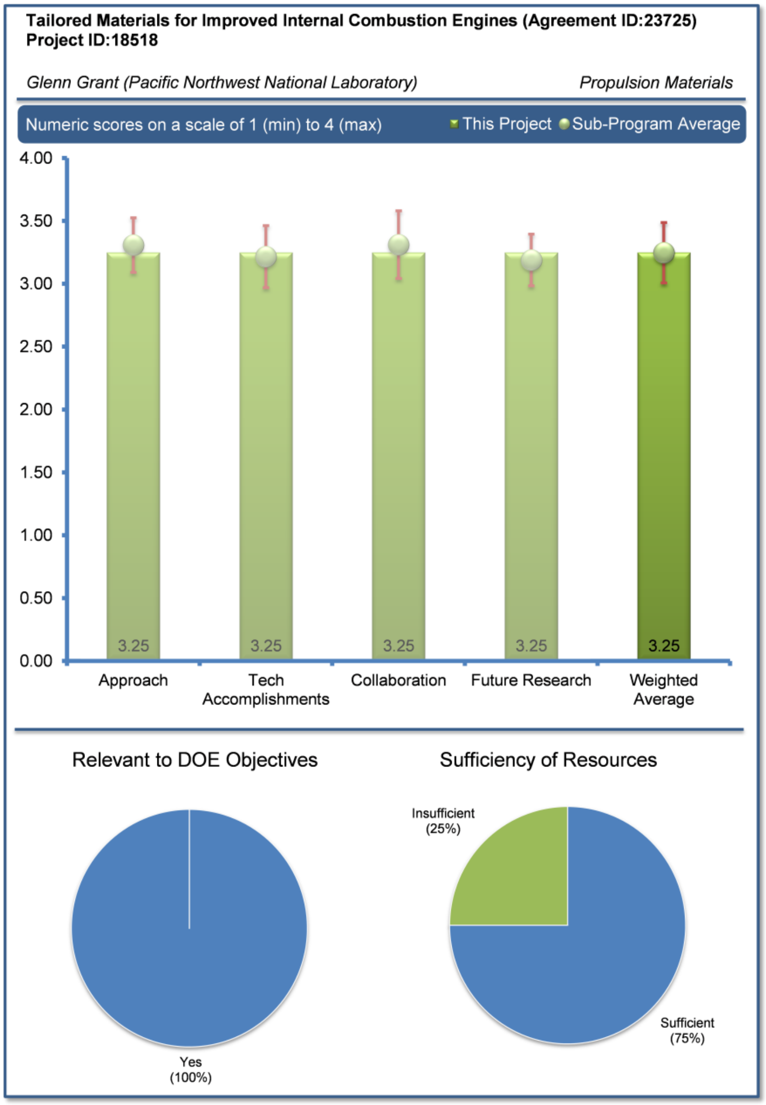
Reviewer 3:

The reviewer indicated that the resources appeared to be adequate.

Reviewer 4:

The reviewer remarked that more resources do not automatically result in better results.

Tailored Materials for Improved Internal Combustion Engines (Agreement ID:23725) Project ID:18518: Glenn Grant (Pacific Northwest National Laboratory) - pm048



Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that the project approach was very good as to understanding benefits of friction stir welding (FSW) on different engine materials and components.

Reviewer 2:

The reviewer suggested that it was a good idea to look at lower-cost alternatives to improve surface properties for advanced engines, instead of adopting more expensive materials, since cost would likely be a consideration for these new engines and any research to reduce costs would be helpful. Friction stir processing (FSP) had been successfully demonstrated and showed promise for increasing strength at room temperature. The reviewer explained that the approach to start with simple shapes to verify properties at high temperatures, and then moving to more complex real-part geometries, had merit. The reviewer added that it was important that the project team was thinking already about where to apply these surface treatments and how to accomplish this in volume production. The fatigue testing plan was comprehensive and covered the permutations of FSP and no FSP for fine and coarse microstructure cases.

Reviewer 3:

The reviewer commented that the project appeared to be well designed because it had a heuristic approach to improving material properties of vehicle engine components, and noted that a continuing problem with this kind of work was the lack of any baseline cost data. This reviewer understands the approach of seeking to modify the surface of engine components fabricated via casting so as to avoid higher-cost processing steps, but suggested that some data for improvement needed to be presented as soon as possible on actual test engine components with at least some indication as to the cost increment due to the FSW process.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer explained that the project results on higher-temperature testing looked very good, and that the team had identified the best material properties, coarse grain microstructure, to address strength and fatigue life issues. The team was addressing the issue of creep as an important issue at these temperatures, partly in response to previous Annual Merit Review (AMR) reviewer comments. The reviewer commented that the team would need to catch up somewhat on the cast crankshaft work.

Reviewer 2:

The reviewer stated that the project's accomplishments to date showed very promising results, especially on flat aluminum plates, but questioned if the progress will carry over to complex geometries with a stress distribution from complex loading. The reviewer opined that the project team should provide more on the processing costs, with at least some estimates for the targeted first adopters, and comparisons with the current material and process value stream. The reviewer observed that performance improvements could be made and could be significant, but was not clear if there would be a cost penalty. In the last year of the project, some cost modeling should be carried out. The reviewer suggested that some type of cost estimating should have been considered early in proposal and process selection.

Reviewer 3:

The reviewer remarked that the project's technical accomplishments were mostly on schedule but the most difficult tasks were yet to be done, for example, fatigue, creep and actual engine component testing. One item not explicitly addressed was the lack of concern for the depth of the FSW microstructure modification. The reviewer questioned if it was important to know how deep the surface microstructure needed to be in order for the improved performance in engine components to be realized in actual engine operation.

Reviewer 4:

The reviewer explained that application of the project's process on geometry other than coupons may prove to be difficult, and added that additional process variation due to the interface between processed and unprocessed areas may be of use.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the project team had had good collaboration with university and LD vehicle OEM partners, with fundamental work at the university and more practical commercial work at GM. The team was working together to prioritize the most important work first, which was to adjust milestones to address partner focus areas including oil holes.

Reviewer 2:

The reviewer noted that the project team was working closely with GM, who was providing 50/50 cost share and had provided full component samples.

Reviewer 3:

The reviewer stated that the project team's collaboration was satisfactory in that it had a national laboratory, a university, and an engine manufacturer, but noted that some additional benefit might be gained if a material supplier were involved to provide insight to potential material alloying components, which may greatly enhance the FSW improved baseline material.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the project team's future work plan was good, and noted that it would be more complex, time- consuming, and expensive than the current work to date on flat plates. The reviewer questioned if there were any technical hurdles anticipated in attempting the project's process on complex shapes and difficult-to-reach areas, and explained that crankshafts have high-stress regions that could be difficult to reach with FSP tooling.

Reviewer 2:

The reviewer stated that project team's proposed future work was a logical extension of the ongoing work, although its heuristic nature did not appear to add much to the overall theoretical understanding of the FSW process. The reviewer suggested that some small consideration of the thermodynamics and kinetics of alloy formation under FSW conditions could be included.

Reviewer 3:

The reviewer observed that there was quite a bit of work yet to be done despite the project nearing its completion at the end of the calendar year or fiscal year. The creep and fatigue test at 250°C should be very informative. The reviewer applauded the team's work on the feasibility of applying the project's process to more complex part shapes in order to address manufacturing issues.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer expressed that even though the project's work did support the overall DOE objective of petroleum displacement through potential engine efficiency improvement, it was more likely a cost reduction objective, a main driver of the industry partner.

Reviewer 2:

The reviewer explained that the project activity is relevant to DOE objectives of increasing efficiency through advanced combustion regimes because its method offers potential for lowering cost of these engines while maintaining the necessary material properties for reliability and durability. FSP did appear to be ideally suited to selectively improve material properties and thus would be needed in this application.

Reviewer 3:

The reviewer observed that the project team was focused on improved material properties to reduce component weight, and on improved engine performance, specifically, to study new, higher-efficiency combustion approaches using higher cylinder pressures which will put higher loads on the crankshaft. The team's project addressed improving the structural load capacity of the cylinder head and crankshaft.

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

Reviewer 1:

The reviewer stated that the project's resources appeared to be sufficient for the work to be performed, and noted that the project included an in-kind contribution of 50% from GM.

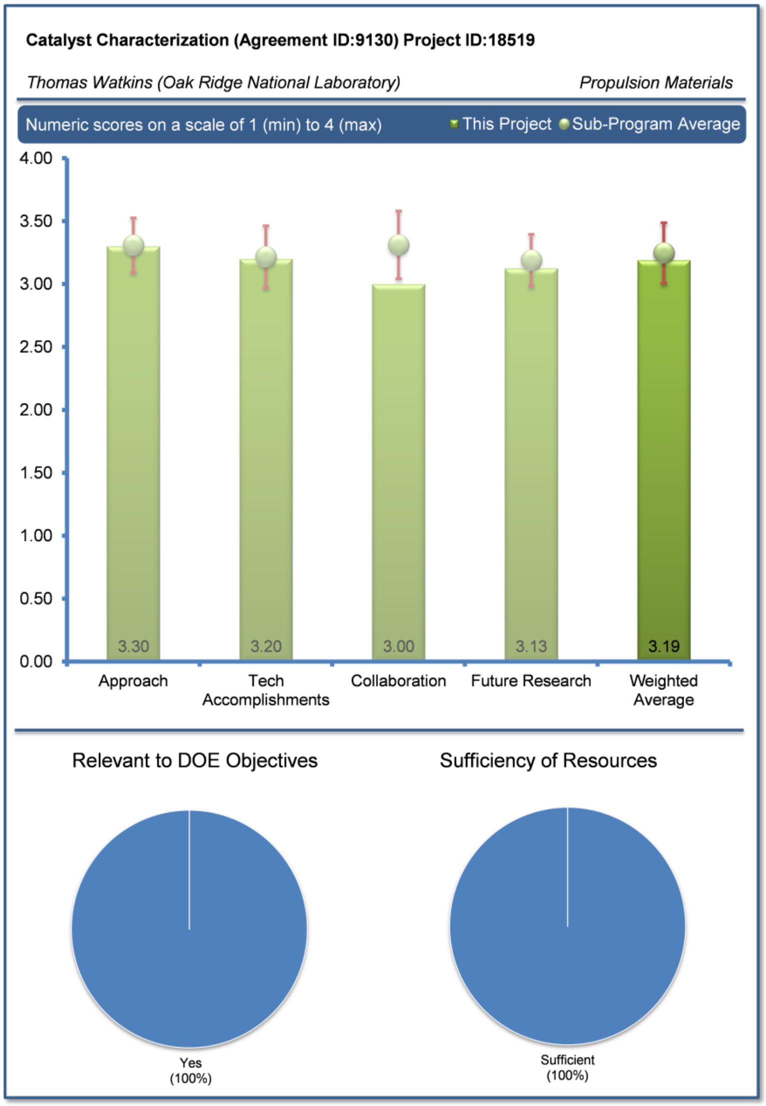
Reviewer 2:

The reviewer observed that the project spending appeared to be about 80% of budget. Most of the testing to date had been on flat plate coupons, where processing and testing would be much more expensive at the component level.

Reviewer 3:

The reviewer remarked that the resources for the project appeared to be sufficient to achieve the stated milestones in a timely fashion. There did not seem to be a strong timeline driver for the project's work to be completed; for example, there did not seem to be a rush to introduce the technology into actual engine components.

Catalyst Characterization (Agreement ID:9130) Project ID:18519: Thomas Watkins (Oak Ridge National Laboratory) - pm049



Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that investigators employed a very good approach that incorporated hydrothermal aging, which is a permanent effect. The reviewer said that it would be interesting to understand the transitory effects of sulfur poisoning. The reviewer added that the project had a good and novel use of spectroscopic tools used to characterize the reaction chemistry.

Reviewer 2:

The reviewer explained that the project's approach, with Cummins identifying critical studies needed, and providing samples to ORNL for their advanced characterization in order to understand performance and degradation mechanisms, has worked well.

Reviewer 3:

The reviewer stated that the project's approach to performing the work contributed to overcoming most barriers, given the required assumption of material homogeneity, which generally was not the case in real materials. Repetitive measurements of desired properties in various samples could provide some confidence in the reliability of the results.

Reviewer 4:

Although a lot of work had been done to look at what is seen and how the process can benefit, the reviewer did not see explanations of why it is happening. The reviewer agreed that measuring the behavior observed was useful and could be used to better the operation, but suggested that more of the approach should have been focused to explain the behavior.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the project produced valuable information related to the functioning of new selective catalytic reduction (SCR) materials as a function of thermal aging, but noted that incorporating the effects of sulfur on the product selectivity, including nitrogen (N_2) and nitrous oxide (N_2O), would have been helpful and also very relevant to LD vehicle applications where sulfur was still a component of the market fuels. However, the reviewer said that the project work provided very good insight into the operation of new SCR materials and ways to include ammonia slip catalysts (ASC) into the design of the SCR.

Reviewer 2:

The reviewer acknowledged that the project team's progress had been made in this project to complete the fiscal year (FY) 2013 milestone, which was the evaluation of degradation of commercial ASCs including a model catalyst as a function of operating conditions. In addition, progress had been shown toward completing FY 2014 milestones by the end of the project in September.

Reviewer 3:

The reviewer commented that the project team's progress on technical accomplishments had been good, as it would increase the database relevant to the properties needed to increase catalyst effectiveness. Some work on the indication of the long-term durability of catalyst effectiveness needed to be done and the results presented.

Reviewer 4:

The reviewer expressed that again, the temperature and desorption curves were valuable and the project team had completed many of them, but explanations or models of the curves would have created much more valuable information.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project team's coordination between Cummins and ORNL had been very good, and added that Cummins collaborated with academia and industry research institutions.

Reviewer 2:

The reviewer noted that the project team had one CRADA with one partner.

Reviewer 3:

The reviewer remarked that the project would have benefited from the inclusion of a catalyst supplier to provide additional catalyst copper (Cu) formulations. The Cu loading effects on the observed behavior would have been useful information as well; however, the overall characterization work from collaboration was very good.

Reviewer 4:

The reviewer commented that the project team's collaboration and coordination between Cummins and ORNL had been effective, but questioned whether the project could not be further improved if a catalyst and materials supplier were involved. The reviewer added that perhaps by doing so, the work could have been sped up and cost could have been reduced to each performer.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the work on this project was ending.

Reviewer 2:

The reviewer commented that since the project was ending in FY 2014, there was only some remaining work to finish investigations of the degradation mechanisms of catalyst materials, and to write a final report.

Reviewer 3:

The reviewer expressed that the investigators must also show the effects of sulfur on the activity of the catalyst in order to guide the operation of the catalyst as a function of time and aging and sulfur exposure.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that the project was very relevant for development of lean aftertreatment systems that would help reduce the cost and improve the efficiency needed to meet future standards for NO and N_2O.

Reviewer 2:

The reviewer explained that improving catalyst performance and durability, in anticipation of future emissions regulations standards, was a wise action to undertake if a company wished to remain ahead of the curve on stricter standards. The reviewer suggested that the project team might conduct the work, not only on different catalytic materials, but also determine if there are any effects on emissions caused by changes and variability of fuel composition.

Reviewer 3:

The reviewer stated that the project addressed barriers by providing information that is needed for future aftertreatment technologies and that resulted in fuel efficient aftertreatment technologies.

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

Reviewer 1:

The reviewer noted that the project would end in September 2014 and had 3% of funding remaining, and therefore there were adequate resources to complete the project.

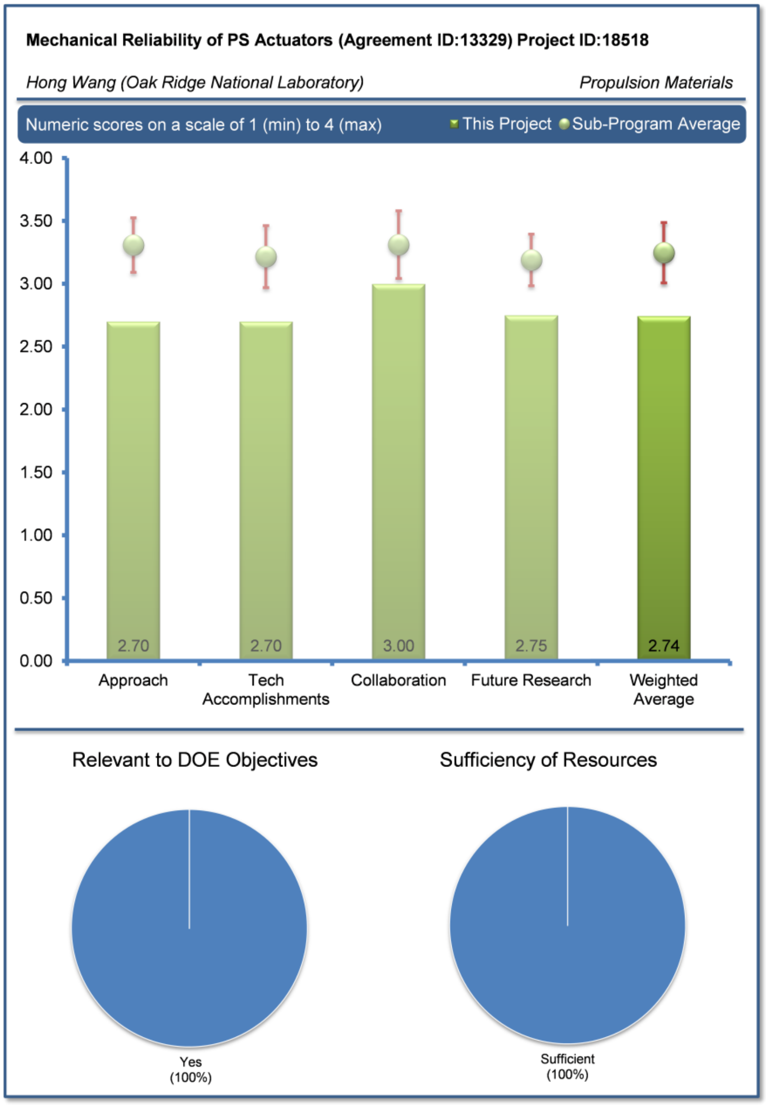
Reviewer 2:

The reviewer commented that the project was appropriately funded.

Reviewer 3:

The reviewer explained that the project resources had been sufficient to carry out the work and generate the results in a timely fashion. It remains to be seen if these data could be incorporated into products or devices to increase effectiveness and durability in diesel exhaust aftertreatment and contribute to future engine efficiency increases.

Mechanical Reliability of PS Actuators (Agreement ID:13329) Project ID:18518: Hong Wang (Oak Ridge National Laboratory) - pm051



Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer explained that the project approach was addressing the SuperTruck goal of 50% freight efficiency, which was important to consider given the prominence of the SuperTruck in current HD engine work. As noted in the relevant discussion, piezoelectric injectors can enable better control of fuel spray for improved efficiency and emissions. The reviewer added that the approach was addressing lead zirconate titanate (PZT) material response in realistic diesel engine fuel injector environments. Both mechanical strength and fatigue would be important in this application, and were being explored and addressed, and failure mechanisms were being explored to some extent. The reviewer recommended consulting with Cummins, the HD engine partner, on the areas of highest priority, for example, humidity issues.

Reviewer 2:

The reviewer expressed that the approach to performing the work was good but it was unclear why PZT and its properties were chosen as the ceramic material for the investigation. The project results to date indicated that some damage to specimens occurred during the test procedures. The reviewer expressed that the effects of the damaged PZT materials to piezoelectric activator performance should have been more clearly specified and, if possible, quantified. In addition, other relevant PZT properties should have been addressed to allow judgment as to the probability that use of PZT would enable piezoelectric actuators to be manufactured.

Reviewer 3:

The reviewer stated that the project objective and experimental plan seemed difficult to reconcile in the area of high cylinder pressure combustion. It appeared that the project team implied that the limitation was in the control of the injection cycle. However, the reviewer added that the project did not explore this aspect but evaluated the failure of the material using an accelerated test instead. A single design that evaluated these failure mechanisms in a device would clarify the relationship significantly. However, the reviewer explained that if the proposed accelerated failure mechanism was the same as those observed in practice, the resulting data would be helpful in the design and optimization of the project's devices.

Reviewer 4:

The reviewer noted that although many techniques were used to analyze the PZT material, there was very little, if any, analysis of the root cause. An example was the project team's observations of loss of capacitance without explanation of root cause. The team showed electrical burning failures in some of the devices in the stack, but no explanation of why for these specific cells.

Reviewer 5:

The reviewer commented that the project approach needed a better explanation of test conditions versus the actual conditions in the application.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer explained that based on the reported milestone chart, the project's activities were either completed or on schedule to be completed, so the project's progress appeared to be good. There was a good explanation of the significance of the electrical short failures and identification of failure modes, where this appeared to have a significant impact on the life of the injector, and thus, these findings appeared to be very useful. The reviewer added that the team was generating data on the performance of the material relative to the cycle life, and then used this data for computer modeling to revise the configuration of the injector, which became a valuable contribution for the national laboratories to make to support technology development. The data analysis was feeding the computer models, and could be used more broadly outside this project.

Reviewer 2:

The reviewer stated that the progress on the project team's technical accomplishments had been good and on schedule, but again, simply determining the effects of humidity on the PZT material did not ensure it would make a strong candidate for durable and cost-effective piezoelectric activators to be used in more fuel-efficient HD diesel engines. A stronger connection between PZT actuator performance and enhanced engine fuel efficiency needed to be made.

Reviewer 3:

The reviewer questioned how easy it was to change the number of layers of PZT in production, how the material was treated, and whether aging was the only treating of the material that was used.

Reviewer 4:

The reviewer said that because the project team has failed to identify root causes, and because the project is in its final year, the reviewer cannot see how the team will achieve their DOE goals. The reviewer cannot see how the project team will be able to optimize and design the system to reach their targets. The reviewer remarked that this project started in 2008, and it is unfortunate that these issues were not identified earlier and corrected.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the project team's collaboration and coordination with other institutions was excellent. The team included an engine company, a material supplier and a characterization laboratory, which were the three component sets of the expertise needed to carry out this work and generate reliable data to be a possible application to enhance HD diesel (HDD) engine fuel efficiency.

Reviewer 2:

The reviewer acknowledged that the project had a CRADA with Cummins who was providing a 50% cost share, which demonstrated a good collaboration. Successful collaboration was exemplified because Cummins would commercialize the piezo fuel injector technology, as stated in the presentation. The reviewer added that inclusion of a piezo material manufacturer, EPCOS, was also critical to advise the project team on material and electrical issues.

Reviewer 3:

The reviewer observed that although the collaborators did appear to be sufficient - including suppliers of materials and a final customer - the lack of observable progress appeared to indicate insufficient collaboration to achieve final goals.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer acknowledged that the project team's future work was logical in that it extended the currently ongoing activities, including a design optimization step with probabilistic design analysis, which should provide interesting results. The PI stated a need for additional research on stacks and the different performance characteristics of stacks relative to the base material, and therefore should be explored either by Cummins or the research team in order to extend the work's relevance.

Reviewer 2:
The reviewer pointed out that because the project team's work was being concluded this year, an outline of proposed future research had not been given. Future work, if PZT results from this work are encouraging, should include the determination of any other properties and cost estimates for manufacturing piezo activators incorporating the PZT.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer remarked that improved fuel injectors were an enabling technology for improved brake thermal efficiency (BTE) of diesel engines, where piezoelectric control could enable the more complex injection patterns needed by advanced compression ignition (CI) engines. The project's work on fuel injector improvements was relevant because it contributed to the goals of the Advanced Combustion Engines program and SuperTruck initiative.

Reviewer 2:
The reviewer remarked that if PZT should be confirmed to be an advantageous material to be used for HDD engine piezoelectric activators and if such usage could enable more fuel-efficient engine operation, this project would contribute strongly to the DOE overall objective of petroleum displacement. Failing that, the reviewer questioned if perhaps this material could have the possibility of being employed in natural gas HD engines by bringing other advantages to those engines.

Reviewer 3:
The reviewer explained that if PZTs were able to perform as fuel injectors as indicated by the project team, they could improve the efficiency of diesel and maybe gas engines that would help meet DOE objectives of petroleum displacement.

Reviewer 4:
The reviewer commented that high-performance fuel injector technologies are needed to achieve the required future combustion efficiency.

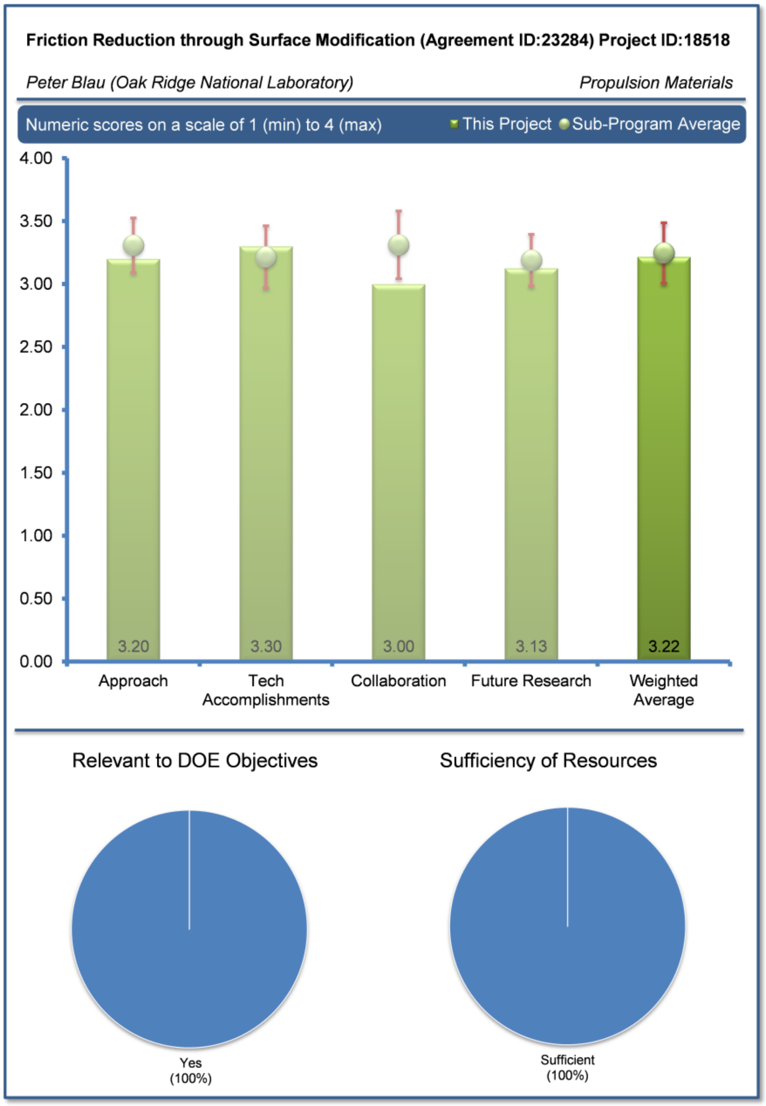
Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer commented that the project's resources appeared to be sufficient to complete the work described, and that there were no indications that the project was under-funded or over-funded.

Reviewer 2:
The reviewer explained that virtually all milestones for this project had been achieved in a timely manner and therefore, the project's resources appeared to have been sufficient.

Reviewer 3:
The reviewer pointed out that the project was an eight-year project with $1.54 million of funding, and that this should have been sufficient to achieve the milestones.

Friction Reduction through Surface Modification (Agreement ID:23284) Project ID:18518: Peter Blau (Oak Ridge National Laboratory) - pm052



Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer expressed that the project team worked effectively to identify potential opportunities to find areas where friction reduction could be achieved, and was also able to identify potential shortcomings to achieve efficiency targets. Furthermore, the team showed good inventiveness in identifying new means of creating friction reduction methods.

Reviewer 2:

The reviewer explained that the project approach was good and that the team had been targeting the most significant contributors to engine friction (http://www.dtic.mil/dtic/tr/fulltext/u2/a460134.pdf) in the piston rings and engine bearings. Although the valve train friction had been assessed through other analysis to be a lower contributor to friction than rings and bearings, it was still important to explore. The reviewer observed that the team appeared to be addressing the significant factors, which are multiple surface textures, multiple base materials, and debris trapping to avoid wear.

Reviewer 3:

The reviewer commented that the project's approach to performing the work was generally sound. However, as pointed out in the presentation slides, the bench test used to evaluate the performance of the surface-modified engine components could not reliably predict how the surface modification would perform in an actual engine. The reviewer added that there are atmospheres such as oil film, water, and combustion products that could invalidate or interfere with the results obtained in the laboratory test apparatus.

Reviewer 4:

The reviewer stated that the project approach of coating soft bronze bushings with a hard tile coating for friction reduction seemed ill-founded. The question that must be resolved is why bronze is used as a substrate in this case. The reviewer said that perhaps the reduction of friction through surface modification would suggest that other materials could be used in the same application. The reviewer added that it would appear that a parametric study of this system with modeling the expected reduction of friction would be desirable.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the project team had made good progress on technical accomplishments and the timing on achieving milestones seemed reasonable but again, it was unclear how applicable these techniques would be for use in diesel engines, since no actual tests had been run in engines.

Reviewer 2:

The reviewer stated that the project team's progress was systematic in creating potential friction reduction interfaces and with testing. However, the reviewer indicated that there was suspicion that the floating tile concept on bronze bushing would not achieve the desired outcome and may cause crankshaft wear. However, the project team may still produce valuable results.

Reviewer 3:

The reviewer stated that the project's progress appeared to be good overall, since all milestones were completed or in progress. The team was exploring multiple texturing processes to reduce friction, for this multiple pathway approach was important to reduce risk and demonstrate surface modification for several materials. The reviewer explained that notable friction reductions were achieved from piston rings last year, but the PI noted that this was in the boundary layer and not a major source of friction. It appeared that the team had currently moved on from the piston ring research. The reviewer pointed out that the team had seen more notable friction reduction from the fine mesh technique to bronze, which looked like an interesting and simple method for surface texturing, relative to some of the other methods explored. The downside of the shallow surface features being easily worn away was being explored. The reviewer observed that the use of lower-viscosity oils produced greater percent reductions in friction, but from a much higher friction baseline. The reviewer suggested that the team should qualitatively explore what the potentially broader implications were of using one oil viscosity over another because avoiding negative friction effects elsewhere in the engine would be desirable. A notable accomplishment for ORNL was the design of a new test machine to simulate real journal bearing conditions in the entire lubrication regime, or hydrodynamic to boundary layer. The reviewer concluded that test machine should help the team greatly in their research.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that the project team's collaboration with the national laboratory, a university, and Northeast Coating Technologies worked well. However, having a final customer that desired the technology would have been very valuable both to the assessment of the technology and to the barriers that need to be overcome to achieve success. The reviewer suggested that this could lead to additional testing regimes that may have been missed.

Reviewer 2:

The reviewer remarked that the team included collaboration with university and coating industry partners. It was unclear whether the team had yet reached out to any engine or vehicle OEM partners, but it may have been be too early in the research effort for this to be done.

Reviewer 3:

The reviewer stated that the project team's collaboration with other institutions had been satisfactory but could be improved greatly if there were an actual engine manufacturer involved. At this point, there was no indication that there was interest in the results of this work from the diesel engine community. The reviewer added that, given the long history of partnerships between ORNL and engine companies such as Cummins or Caterpillar, it was surprising that no interest from such companies was apparent.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that if funding is available from the Propulsion Materials program, some additional work on piston rings could be explored, as the project deals with a significant source of friction losses in the engine. The use of diamond-like-carbon in a "tile" configuration was intriguing, and it would be interesting to see if the wear coating worked successfully and retained the positive friction reduction aspects of the wire mesh texturing.

Reviewer 2:

The reviewer stated that the work was being brought to a conclusion; the next step would clearly be to proceed to actual engine tests to see if the modified surfaces hold up in an actual operation. This had been proposed and would be a critical step to obtain some interest on the part of a diesel engine partner.

Reviewer 3:

The reviewer noted that the project ends September 2014.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that 10% to 15% energy loss in powertrains was due to friction losses. The project was very good in that it directly linked friction reduction to fuel savings potential.

Reviewer 2:

The reviewer noted that the friction reduction would help achieve the DOE objectives and was a very relevant topic for both gasoline and diesel applications.

Reviewer 3:

The reviewer explained that the project was relevant to DOE and VTO goals for improving engine brake thermal efficiency, where it also contributed to 21st Century Truck Partnership goals for parasitic loss reduction through friction reduction.

Reviewer 4:

The reviewer commented that if this approach were successful in reducing friction in actual engines, it would indeed support the overall DOE objective of petroleum displacement because of the enhanced fuel economy of engines. However, at this stage in the work, it was a moot point; it remained to be seen if the approach would work in actual operating engines. The reviewer added that durability, of course, the hallmark of HD diesels, was also paramount for these engines.

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

Reviewer 1:

The reviewer commented that the project's resources appeared to be sufficient to accomplish the work outlined in the presentation, and that there were no indications that the resources were too much or too little to complete the project.

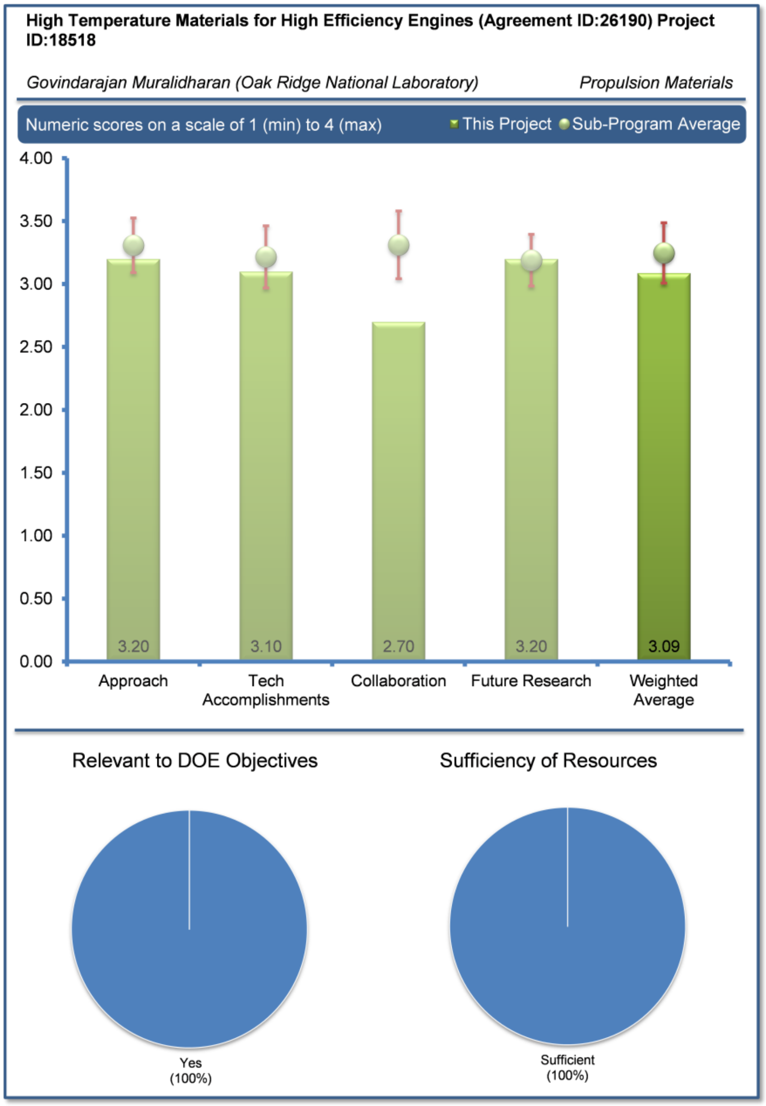
Reviewer 2:

The reviewer observed that the project's resources appeared to have been sufficient to achieve the stated milestones in a timely fashion. Were there a decision to proceed to actual engine tests, substantially larger funds would be required and at that time a diesel engine manufacturer would need to be involved.

Reviewer 3:

The reviewer questioned if all funding was from the DOE.

High Temperature Materials for High Efficiency Engines (Agreement ID:26190) Project ID:18518: Govindarajan Muralidharan (Oak Ridge National Laboratory) - pm053



Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer explained that the approach was reasonable and was addressing the major issues, fatigue life and strength, of high-temperature valve trains while keeping cost targets in mind. The computational approach to designing materials was a good application of national laboratory expertise and resources to bridge between fundamental and applied research.

Reviewer 2:

The reviewer reported that this was a new project, and that the technical barriers were well-defined with clear project objectives. The project was considering a tradeoff between strength and cost of new valve materials. The reviewer suggested a desire to see cost integrated into the project objectives, especially during the early part of the project.

Reviewer 3:

The reviewer stated that the project approach to performing the work was good, but only concentrating on reducing nickel (Ni) content may be limiting achieving the temperature performance level desired. It may have been necessary to add other, perhaps high-cost, elemental constituent to achieve the high-temperature oxidation resistance and creep resistance needed for an alloy to perform satisfactorily at 950°C. The reviewer expressed that the holy grail of high-temperature engine components had been thought of as being ceramic components; however, machining and other cost elements have made that difficult to achieve.

Reviewer 4:

The reviewer remarked that the project’s approach is good overall, and that using thermodynamic tools and expert knowledge would accelerate alloy development in the project area. The reviewer noted concerns over how results were measured and compared to previous research and what would be considered correct by the industry, but opined that a fortunate correction was possible. For example, if possible, the weight gain of oxygen or the weight loss by flaking could both be resolved by the weight of oxide and the removal of the oxide after each cycle.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the project was quite new, and to date, the progress was excellent. The identification of potential alloys and the testing at this early stage was excellent and furthermore, the identification of potential weaknesses of impurity levels and overcoming the problem showed that the project was well focused to achieve results.

Reviewer 2:

The reviewer remarked that this particular project was in its first year, so accomplishments are appropriate for this early in the process. This reviewer reported continued work on alloy development for optimizing key oxidation and strength characteristics. The reviewer recounted that the PI stated that the team was making use of traditional alloying processes in the lab, which was good because the findings could be extended to production processes.

Reviewer 3:

The reviewer stated that the project team's progress on technical accomplishments had been good but, to date, there did not seem to be any alloy composition in the series of alloys tried, which had achieved the properties needed for the 950°C performance goals. The reviewer questioned what other approaches to adding alloying elements might have led to the properties needed, and what the cost would have been.

Reviewer 4:

The reviewer indicated that initial alloy concepts were developed, and that modelling and simulation work were both in progress to study the composition effects on oxidation.

Reviewer 5:

The reviewer explained that the results of the initial analysis used both integrated computational materials engineering (ICME) tools to identify candidate alloys, and the anticipated performance using oxidation tests, seemed inconclusive. The reviewer questioned how the ICME had sped the decision of new alloy choices. The chosen materials did not seem to be an improvement on the base alloy choice. The reviewer also questioned if there was room in this system to allow for the higher rate of oxidation as compared to the 751 alloy; there seemed to be many basic questions that had not been addressed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said the project team's collaboration with the two partners, ORNL and Carpenter, appeared to be going well, but was concerned about the lack of an industrial partner that would be using the technology and could provide critical input on how the alloy should be properly evaluated. The researchers had identified the need and were trying to find this partner. The reviewer expressed that this would be critical to achieving the final goals for implementation of the technology.

Reviewer 2:

The reviewer noted that the collaboration with Carpenter, who had been a supplier of engine valve train materials for many years, was good. The team appeared to be doing the proper outreach and technical discussions with major engine OEMs and others who were unspecified at this point.

Reviewer 3:

The reviewer indicated that the project team's collaboration between ORNL and Carpenter Technologies currently appeared to be satisfactory, but was also encouraged to see that discussions had taken place with Cummins and Caterpillar in an attempt to gain their interest in the work. If the properties necessary for achieving the 950°C performance could be shown to have been achieved, it would be likely that these companies would want to enter into formal collaborations with ORNL.

Reviewer 4:

The reviewer stated that Caterpillar and Carpenter Materials Technology had been involved, but would like to see stronger a commitment to the project from an engine manufacturer, and questioned if the project was also applicable to LD engine manufacturers.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the project team's future work plan was good, as it was working toward alloy compositions necessary for meeting the high-temperature goals of 900°C, on the way, presumably, to the goal of 950°C.

Reviewer 2:

The reviewer explained that the researchers had developed a good plan to move to the development of new alloys. The project has identified procedures for evaluation which although they could be improved as mentioned above, were in the correct direction. Again the weakness going forward is the same as the weakness in the past, specifically the identification of a partner that can identify the test methods that will be necessary to evaluate the alloy before it would be accepted commercially.

Reviewer 3:

The reviewer stated that the project's proposed future work was logical and technically sound. However, it was not clear if other parameters in the alloy compositions would be further pursued, and questioned, for example, what other alloying constituents would make sense to try in order to reduce the Ni composition, and how such an approach would affect cost. Unfortunately, the addition of other trace elements usually seemed to add to the cost, rather than reduce it.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reported that the project addressed a materials need for improved engine efficiency, for, as the PI noted, high-efficiency engines would likely have higher exhaust temperatures which would be a limitation for LD engines in the future and may already be an issue for HD engines. Controlling the temperature of the valves through internal engine means would likely have some impact on efficiency, so avoiding the need for this with higher-temperature valve materials would be very important.

Reviewer 2:

The reviewer expressed that if the performance goals of these alloys were achieved, it would be likely that improvements in diesel engine efficiency could be achieved and the overall DOE objective of petroleum displacement supported. However, it is also possible that these alloys could improve the operating efficiency of natural gas HD engines, which would also support the goal of petroleum displacement.

Reviewer 3:

The reviewer noted that as engine temperatures and pressures increase to achieve performance goals, valve temperatures would increase and require higher-temperature-capable materials.

Reviewer 4:

The reviewer noted that valve materials were a key limiting factor for improved engine operating efficiency.

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

Reviewer 1:

The reviewer commented that the resources for the project presently appear to be sufficient to achieve the stated milestones in a timely fashion. Increased resources would be required if a breakthrough alloy composition were developed.

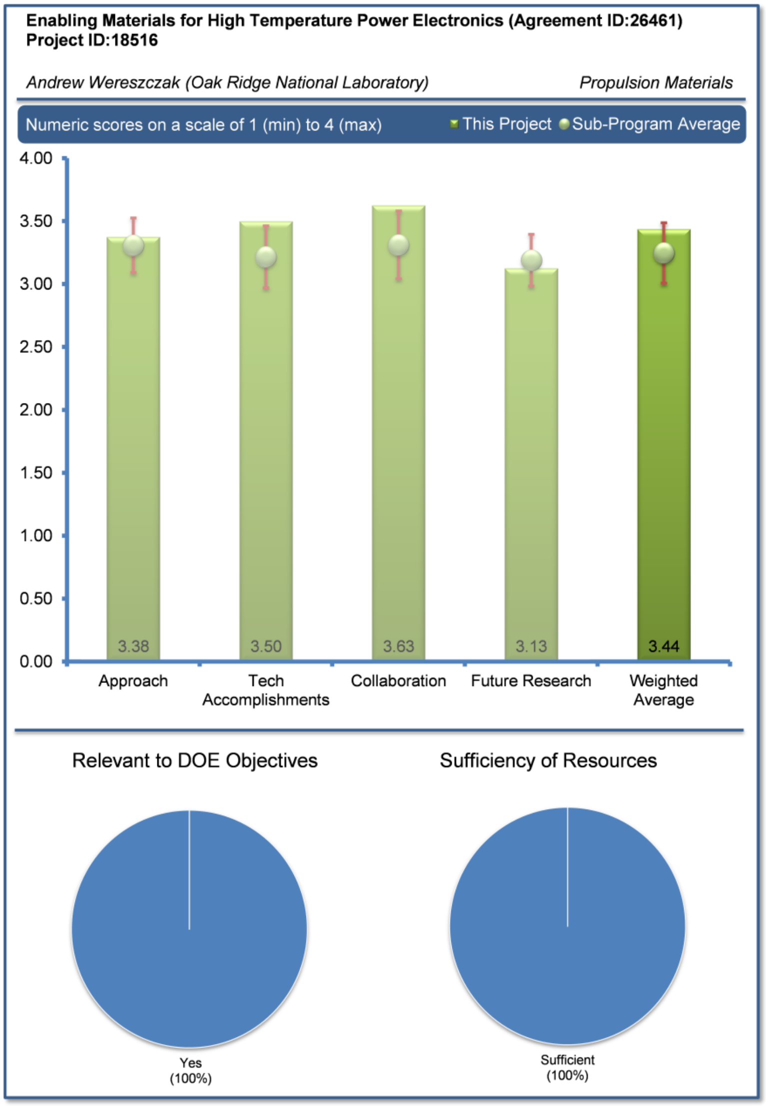
Reviewer 2:

The reviewer noted that the resources appeared to be sufficient for this project.

Reviewer 3:

The reviewer expressed that, unfortunately, the question could not be adequately evaluated because the actual funding was not spelled out in the presentation.

Enabling Materials for High-Temperature Power Electronics (Agreement ID:26461) Project ID:18516: Andrew Wereszczak (Oak Ridge National Laboratory) - pm054



Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the project team's approach was very focused, with two parallel initiatives being pursued (i.e., silver [Ag] sintering for interconnects, and organic dielectrics) with impressive industry partners. Both are needed to operate in the 200°C wide bandgap (WBG) operating environment, which was a much more efficient temperature.

Reviewer 2:

The reviewer commented that the project team's discussion of the barriers and the ability of the current project to overcome them was well presented. However, the quantum leap of this project - an undertaking to increase the temperature from 105°C to 200°C - was not well explained.

Reviewer 3:

The reviewer stated that cost was the first barrier identified but it was never addressed in the presentation, which seemed like the approach was hitting all other metrics. Cost may have been competitive in a life-cycle approach or performance benefit, but it was never addressed in the presentation.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer indicated that the project team had made impressive accomplishments to date with limited funding. Other. lower-cost sintering options were not considered but the reviewer understood that this was because of the limited funding received.

Reviewer 2:

The reviewer commented that in a relatively short time since startup, the technical accomplishments were progressing well in multiple task areas.

Reviewer 3:

The reviewer noted that the presentation focused mainly on the work in progress and that there were not many accomplishments, as this was a new project. For a newly started project, the team made great progress on getting work started.

Reviewer 4:

The reviewer explained that the project's design of experiments and their execution was good, with two efforts on interconnects and dielectric material. The interconnect part was progressing well, but accomplishments on the dielectric material were not well presented. Whether the pattern filing was related to this project, or the result of an earlier one, also needed to be clarified.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project team was working with other national laboratories such as the National Renewable Energy Laboratory (NREL) and industry partners, which would improve the opportunity for project success.

Reviewer 2:

The reviewer observed that the team's collaboration with multiple materials providers, process suppliers including Plater, and laboratory partner, the National Energy Technology Laboratory, seemed engaged and involved participation.

Reviewer 3:

The reviewer pointed out that project team included the necessary players to make commercialization possible with major suppliers on the team.

Reviewer 4:

The reviewer noted that the project team was working with several suppliers, although the extent of their involvement was not completely described.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the project's plan was good and that there were no gaps identified.

Reviewer 2:

The reviewer stated that the project's experimental and testing plan seemed to be addressing the critical process parameters, or environmental services issues.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer explained that higher power electronic operating temperatures could provide the opportunity to increase efficiency.

Reviewer 2:

The reviewer observed that the project was seeking to evaluate the feasibility of pushing the electronics operating temperature to 200°C, which would extend the performance window for EV applications.

Reviewer 3:

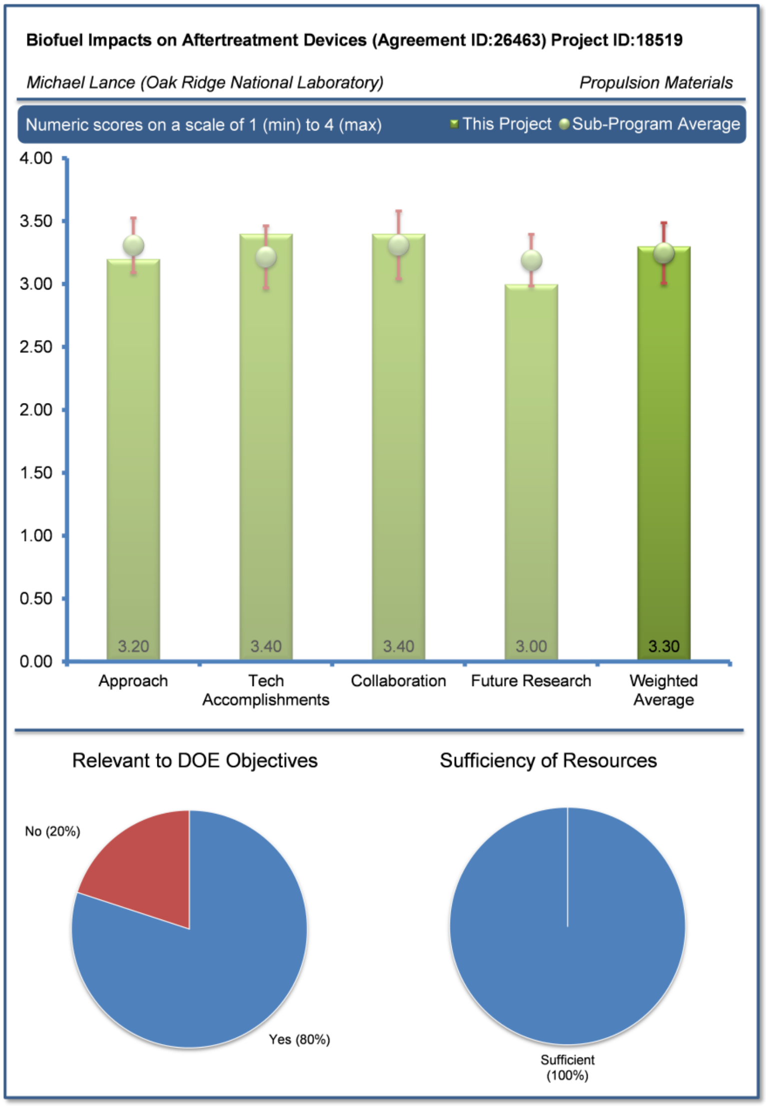
The reviewer expressed that since the electronics were playing more and more of a role on controls in the automotive industry, the efficiency of these components was critical for efficient operation. Improving the temperature capability would improve the reliability of the component.

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

Reviewer 1:

The reviewer stated that if more funding were available, more could be accomplished. However, funding received to date had been sufficient.

Biofuel Impacts on Aftertreatment Devices (Agreement ID:26463) Project ID:18519: Michael Lance (Oak Ridge National Laboratory) - pm055



Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer explained that the project team's approach to performing the work was excellent, very straightforward, and likely to quantify the effects of various residual concentrations of potassium (K) or sodium (Na) catalysts used to make the biodiesel fuel.

Reviewer 2:

The reviewer commented that the project team's approach to accelerate test with evaluation was excellent, where identifying the maximum potassium amount that represented a valid test was also very good. The reviewer expressed some concern that the focus was only on potassium and not on other elements or a combination of elements. The reviewer questioned if the other elements would be included later in the project.

Reviewer 3:

The reviewer stated that biofuels were definitely a way to become less dependent on imports of crude oil, but since the ingredients were not exactly the same as fuel derived from crude oil, the impact of those differences needed to be understood. The project research could give answers to some of these questions.

Reviewer 4:

The reviewer noted that this was a new project with clearly defined objectives.

Reviewer 5:

The reviewer opined that this project may not be focused on the correct catalyst poisons related to current biodiesel fuel production. Potassium and sodium fuel contaminants are associated with homogeneous fuel production. The industry is moving toward heterogeneous processes in order to more efficiently produce increased quantities of biodiesel fuel. The fuel-borne contaminants or poisons associated with those fuel production processes would not be the same. Therefore, downstream catalyst contamination issues might be different.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:
The reviewer indicated that because the approach was so straightforward, progress on technical accomplishments had also been excellent. No roadblocks to achieving the proposed technical objectives were apparent.

Reviewer 2:
The reviewer noted that there was good progress on the new project.

Reviewer 3:
The reviewer explained that even though the project was less than a year old, progress was excellent, for in one year the project team had carried out many tests and identified the optimum cycle. However, it cannot be certain, but should be determined, that the same behavior would hold for the other elements.

Reviewer 4:
The reviewer commented that the project had very interesting first results, and was surprised to see that the concentration of potassium did not increase on the catalyst front face very much. It seemed that there was a mechanism that absorbed, but also released potassium, but higher concentrations apparently did not work anymore. The reviewer added that it was also interesting that the concentration at the front of the second substrate was higher than at the end of the first substrate. Perhaps during the next week, these mechanisms could be further explored. The reviewer expressed that although the investigators had not and do not need to do emissions testing as precise as required for certification, the noise should have been reduced. It currently seemed that the NO_x emission was lower with 14 parts per million (ppm) potassium, but these differences were very likely due to noise in the measurements.

Reviewer 5:
The reviewer stated that the project team’s technical accomplishments were both consistent with the scope of the proposed project and appropriate. The team demonstrated good use of the facilities, analytical tools, and national laboratory resources.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that project team’s collaboration partners were very appropriate for the scope of project work.

Reviewer 2:
The reviewer noted that the project’s selected partners seemed very relevant for the proposed research.

Reviewer 3:
The reviewer stated that due to the high interest in the use of non-petroleum diesel fuels such as biodiesel, the collaboration and coordination with other institutions, such as engine companies Ford and Cummins and the National Biodiesel Board, had been excellent and unlikely to be improved upon.

Reviewer 4:
The reviewer expressed uncertainty about whether the project team’s collaboration with all partners may be good. However, the interactions between ORNL and NREL appeared to be working well. The reviewer added that it was not apparent what Ford was doing beyond providing a truck or engine.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer commented that the project team had a good approach to the next series of testing with calcium (Ca) instead of potassium, which would be interesting to see if the accelerated aging will fail at a similar high concentration.

Reviewer 2:
The reviewer mentioned that there is good future research being proposed for Cummins, but indicated a concern that element and element combinations were not being addressed, including calcium, magnesium (Mg), and sodium, and questioned if there was certainty that none of these elements were of concern based on potassium.

Reviewer 3:
The reviewer stated that the proposed future research was logical and appeared sufficient to achieve all the objectives laid out in the proposed statement of work for the project.

Reviewer 4:
The reviewer suggested that to represent anticipated failure mechanisms in the field, other fuel poisons should have been considered for biodiesel related projects. The reviewer did not believe that poisons studied in this work were the most relevant for future renewable fuel production. The lead investigators should have surveyed current biofuel processing facilities to determine if other poisons should have been considered before going forward. The reviewer added that biofuels could be derived from many different feedstocks, including waste oil associated with service industries.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer explained that the project supported the DOE objective of petroleum displacement because biodiesel is a fuel made from non-petroleum sources.

Reviewer 2:
The reviewer commented that biofuel can be a one-to-one replacement for imported oil.

Reviewer 3:
The reviewer pointed out the impact of biofuels on the project's catalyst and filtering systems were critical if biofuels were intended to be used.

Reviewer 4:
The reviewer emphasized that there was limited relevance for going forward and referred to related comments in the Future Work section.

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

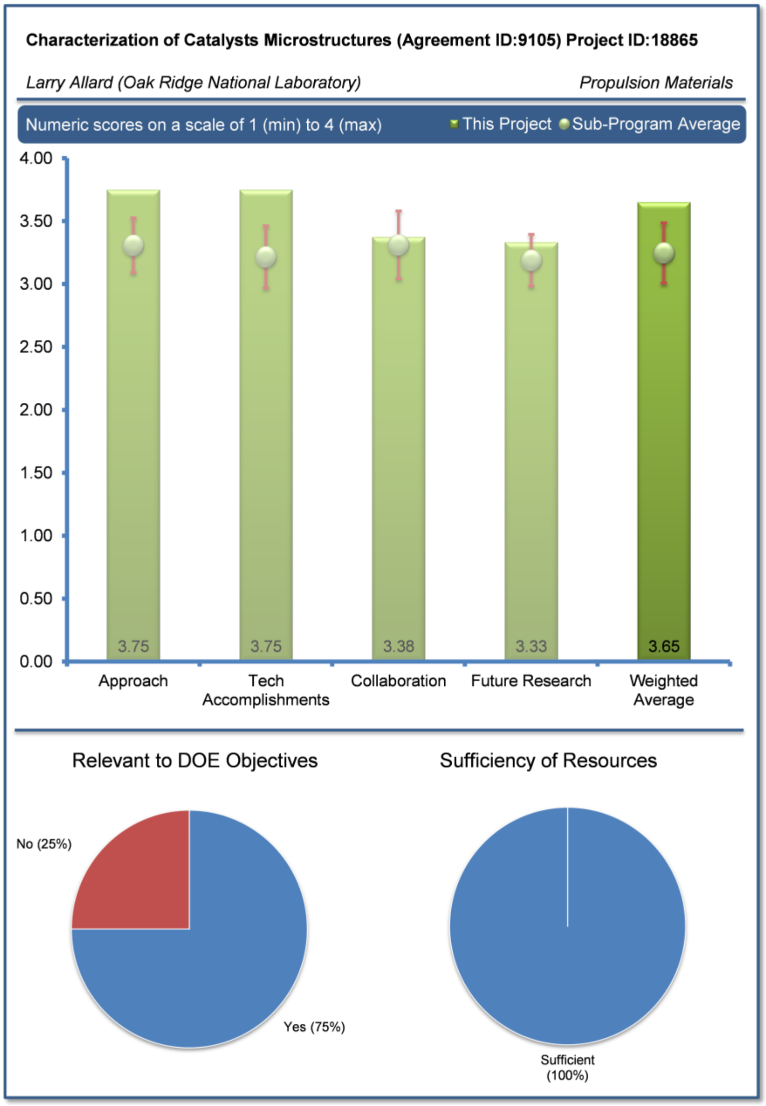
Reviewer 1:
The reviewer stated that the resources for the project appeared to be adequate to achieve the stated milestones in a timely fashion.

Reviewer 2:
The reviewer stated that the project's funding and resource levels were appropriate.

Reviewer 3:

The reviewer expressed that more resources do not automatically produce better results, for the results obtained so far needed to be analyzed and understood. With additional resources, perhaps an expensive test could be carried out that did not have limited added value.

Characterization of Catalysts Microstructures (Agreement ID:9105) Project ID:18865: Larry Allard (Oak Ridge National Laboratory) - pm056



Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that the project work continued to produce outstanding and world-class research at ORNL, to push electron microscopy to the limits of its capabilities, and to understand catalytic reactions at the atomic level. The approach was innovative in that it developed a microscope cell capable of containing gaseous reactants and catalytic materials.

Reviewer 2:

The reviewer observed excellent work. The researchers had created a new device to measure catalysis *in situ* in a microscope. The project team had also identified an early weakness of the first-generation device and corrected it, and also added an automated *ex-situ* to the system.

Reviewer 3:

The reviewer stated that the approach had a novel method for characterizing the structure of catalytic materials under reaction conditions. The information obtained from this work, as well as the development of the technique, would help elucidate the behavior of materials *in situ*.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer indicated that the project had made all technical accomplishments and also great technical progress.

Reviewer 2:

The reviewer mentioned that the progress toward achieving technical accomplishments had been excellent, but there remained barriers to overcome, some that were only listed in the Reviewer slide at the end of the presentation.

Reviewer 3:

The reviewer explained that the development of the project's technique could be widely used to further characterize materials and add important knowledge to how materials behave under reaction conditions.

Reviewer 4:
The reviewer noted that the testing was in real-world conditions.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer expressed that the project team had excellent collaboration between ORNL and Protochips on the device manufacturing, testing, and other aspects of the equipment manufacturing. The PI also published papers in highly regarded journals with high numbers of citations.

Reviewer 2:
The reviewer stated that the project team's collaboration and coordination with other institutions, such as universities, electron microscopy companies and others had been excellent and that continuing and expanding collaboration with other institutions as proposed is to be encouraged.

Reviewer 3:
The reviewer commented that the project's university and research collaboration appeared to be well thought out.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer explained that the proposed future research was good in that it proposed to address the barriers to having a fully functioning cell which could be placed in the electron microscope in order to investigate gaseous reactions.

Reviewer 2:
The reviewer said that further refinement and application of the project's technique were required to fully demonstrate the usefulness of the project's approach.

Reviewer 3:
The reviewer noted that the blank project ends September 2014.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that the project's work and instrument would provide additional characterization capabilities to the catalyst community.

Reviewer 2:
The reviewer suggested that developing methods to analyze catalysis reactions at the atomic level would help speed up critical knowledge for advancing catalysis development.

Reviewer 3:
The reviewer expressed that while it is very important to be able to investigate reactions *in situ* under the electron microscope, such investigations are one step away from actually supporting the DOE objective of petroleum displacement. This work came under the rubric of enabling technology, which could contribute to other projects that directly supported petroleum displacement.

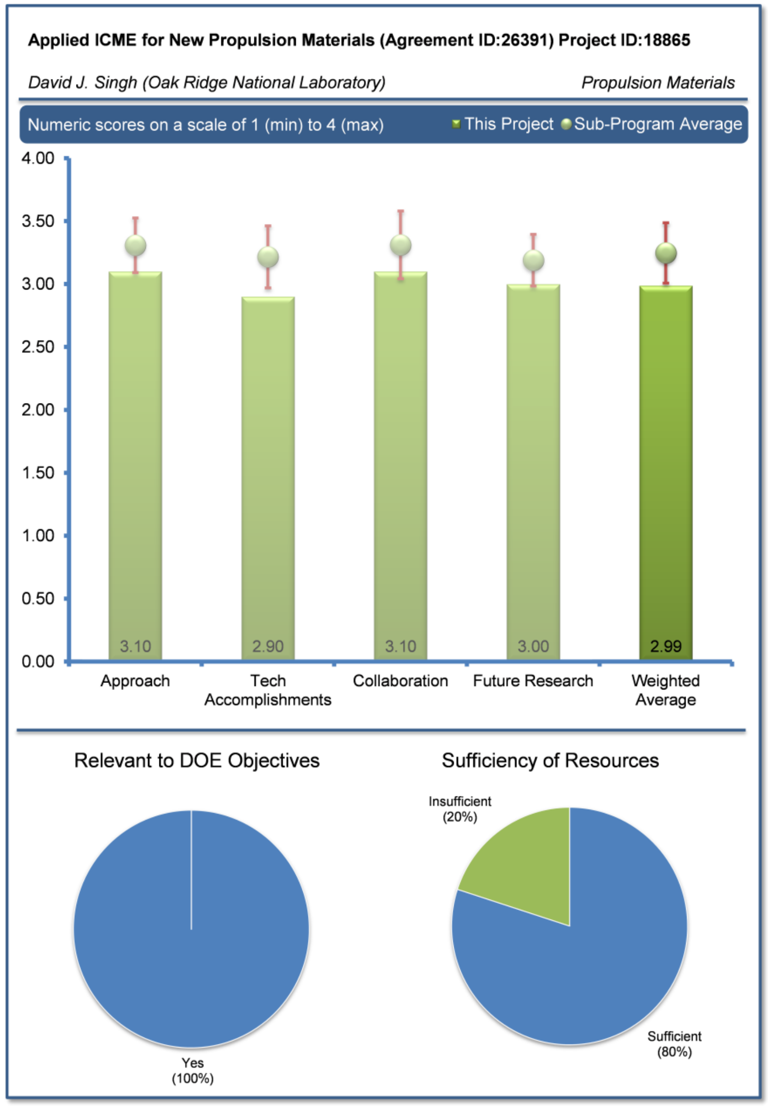
Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer noted that the project's resources were appropriate.

Reviewer 2:
The reviewer commented that the resources for this project appeared to be sufficient to achieve the stated milestones in a timely fashion.

Reviewer 3:
The reviewer noted that based on outcomes, the project funding appeared to be sufficient.

Applied ICME for New Propulsion Materials (Agreement ID:26391) Project ID:18865: David J. Singh (Oak Ridge National Laboratory) - pm057



Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that proving that ICME could be used to develop specific materials would provide a proven pathway to develop materials with specific properties in a much faster, lower-cost manner. The potential of using this approach to develop the four types of materials investigated was significant. The reviewer added that consolidating these four materials under a single project will ensure consistency in the approach to utilize ICME to develop these materials.

Reviewer 2:

The reviewer commented that the project's approach brings together a number of disparate projects under the banner of ICME. The approaches for the individual projects show different strategies for ICME use, which is a good way to show the capabilities of ICME; for example, modifying an existing material, seeking a completely new material, and examining a material's durability over time. This seemed a reasonable approach to achieving the goal of making material development faster, cheaper, and lower-risk. The reviewer added that the approach combined modeling and experiment.

Reviewer 3:

The reviewer stated that the project approach, being taken into the sub-tasks, appeared to be modeling with experimental or process validation, either by reference or actual demonstration. The model-validate loop was a reasonable technical approach to a modeling activity, but the reviewer opined that it did not constitute an ICME approach that was seen by those who envisioned the idea.

Reviewer 4:

The reviewer indicated the need to understand how gaps in ICME technology were going to be addressed and filled as the project continues, and questioned what could be linked from the smaller length scales to processing simulation.

Reviewer 5:

The reviewer explained that the project appeared to be a combination of four previously supported projects bundled together under a new banner called ICME. By bundling the four projects, this project appeared to now be a model of applying ICME concepts rather than addressing issues and barriers associated with each separate topic. The reviewer added that a more cynical reviewer might have concluded that the ICME banner was attached to these four original projects solely to extend their lifetime, for they were coming to closure. Little or no information was provided on the models employed, what properties they were modeling, and how these properties affected performance, for example, what properties were critical for commercial permanent magnets, such as size, weight, magnetic field, and Curie temperature. The reviewer questioned what critical variables the project team used to control these properties, what the models suggested was optimum, and how the project team validated the results.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that there were several notable accomplishments from this group of related projects. In all cases, new materials or material additions had been identified for further study. The reviewer explained that the non-rare earth magnet materials work should be of particular interest because of the need for such magnet materials to expand electric motor deployment. The confirmation steps shown in the slide were very important, as they illustrated the benefits of the ICME approach and provided confidence in the results.

Reviewer 2:

The reviewer acknowledged that the project team's accomplishments were good, and that it was a continuation of prior projects, for which the project team had a good grasp of the critical parameters that would impact performance, and their publications and IP records reflected that progress is occurring. With each of the four application area projects standing on its own, the project team seemed to be making good progress, but bundling them together under ICME overlooked their individual advances and successes. The reviewer said that it was not apparent how the project team could combine the modeling for the four separate applications into one ICME project, for the models for each application were different and hard to combine into a coherent story.

Reviewer 3:

The reviewer pointed out that the project had some accomplishments to date, starting with the integrated approach for the four materials and research areas.

Reviewer 4:

The reviewer explained that in the individual tasks, progress was being made to predict certain properties for processing-generated property modification. This work seemed to have been consolidated from other project areas and then pulled together into a single project, so much of what was reasonably reported as accomplishments dated to predecessor projects.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the project had a very good and diverse group of partners consisting of industry, a university, a materials consortium, and other Federal laboratories that provided the infrastructure with a long-term commercial success.

Reviewer 2:

The reviewer stated that a number of collaborators had been identified for this work from both industry and academia.

Reviewer 3:

The reviewer commented that the project team's collaboration appeared to be excellent, although the roles of the collaborators in the overall project were not stated with sufficient clarity to understand what their contributions were.

Reviewer 4:

The reviewer remarked that other than the stated names of numerous collaborative partners, no description was provided of what the partners were actually doing or providing to the project. As stated, the partners provided $0 cost share to the project.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer explained that future research could provide a new approach for developing materials with specific characteristics. The plan appeared to be able to achieve the targeted end goals of developing an integrated approach to cost-effective and timely material property development.

Reviewer 2:
The reviewer noted that the future work described in the presentation appeared to be logical and should achieve the goals set forth by the program.

Reviewer 3:
The reviewer explained that with the future activities laid out for each of the four application areas, it was difficult to see how the ICME concept was being brought in on the future activities. The future activities were presented as four discrete research topics, but the ICME activity did not encompasses all four areas.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that the project materials would enable higher-efficiency engines, providing the opportunity to decrease petroleum consumption.

Reviewer 2:
The reviewer indicated that PZTs were needed for advanced fuel injection and control systems to improve timing of injection events, and advanced catalysts would benefit the development of improved aftrertreatment devices needed to reduce emissions. The high-performance permanent magnets were needed for compact electric motors, and the thermoelectrics offer potential benefits to recoup waste heat.

Reviewer 3:
The reviewer commented that the project was relevant to the DOE goals of energy efficiency by creating and refining tools for new materials development. If successful, the project could reduce the time required and cost of developing new materials.

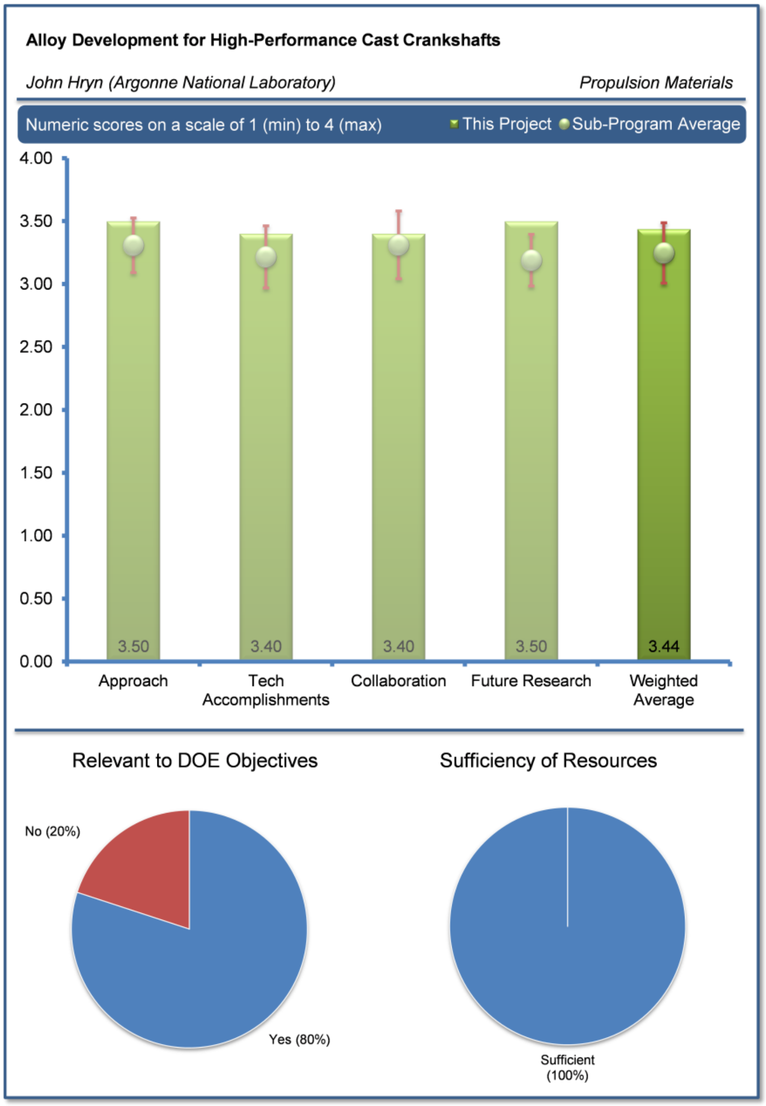
Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer stated that the project funding appeared about right for this effort.

Reviewer 2:
The reviewer noted that the project's resources appeared sufficient to achieve the goals set forth by the program.

Reviewer 3:
The reviewer expressed that the project had bitten off too many applications for ICME and should pull back the scope and just focus on one or two areas. The reviewer suggested catalysts and PMs.

Alloy Development for High-Performance Cast Crankshafts: John Hryn (Argonne National Laboratory) - pm058



Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer described a very solid approach and recounted the following steps that were mentioned: tomographic study of casting quality and structure; design and develop high temperature apparatus for *in-situ* phase evolution study; evaluation of laboratory sample castings; optimization and characteristics of the high potential alloy; and process concepts used in order to be able to correlate microstructure to processing and mechanical properties to optimize cast alloy for crankshafts.

Reviewer 2:

The reviewer indicated that the project appeared logically laid out, and built upon other projects conducted and tools developed at Argonne National Laboratory (ANL). The results and tools were now being applied to developing more cost-effective, lighter-weight, and higher-performance cast crankshafts. The reviewer added that this project was focused on developing some new systems required for this specific application, such as heating systems and others.

Reviewer 3:

The reviewer stated that the project approach of using ANL's advanced photon source (APS) as a resource for analyzing material microstructures and DOE's national laboratory resources was good.

Reviewer 4:

The reviewer observed that the casting appeared to be a better and lower-cost approach to develop lighter materials for engine crankshafts and other applications. Utilizing the ICME approach would permit faster and lower-cost materials development.

Reviewer 5:

The reviewer noted that the researchers seemed unaware of the development in a sister project and were not refocusing their plans accordingly.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:
The reviewer explained that the project results from the X-ray studies of microstructures were very useful. The ability to study microstructure during loading and to see changes was quite interesting, as was the work to study the alloy solidification process. The project work would help in validating and improving ICME models that were being used by a number of teams in this portfolio.

Reviewer 2:
The reviewer commented that the project just started in March 2014, and therefore there was not much at this point to report as far as accomplishments. The identified milestones and approach appeared sufficient, and the project progress was expected to be measured against the appropriate metrics.

Reviewer 3:
The reviewer commented that no mark had been given in order not to downgrade the project. The project just started, so the reviewer noted that accomplishments are naturally minimal.

Reviewer 4:
The reviewer noted that it is still very early in project and that assessment of the accomplishments was based on only 5% of the work.

Reviewer 5:
The reviewer expressed that the progress was difficult to judge since the project was just started with only 5% of the budget spent so far.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer expressed that the partners aligned well with other propulsion materials projects, having strong industry and academic partners.

Reviewer 2:
The reviewer commented that the project was working closely with Caterpillar, GM, Northwestern University, and the University of Iowa, and that the team seemed well developed and defined, with two industry partners sufficiently interested in the results to take project successes and incorporate them into commercial products. It was a bit early to judge the performance of the collaboration or coordination, but the project seemed to be planned to accomplish those elements successfully.

Reviewer 3:
The reviewer stated that the project team's collaboration was being conducted with both LD and HD OEMs, as well as universities.

Reviewer 4:
The reviewer noted that the project would be carried out with partners from all relevant disciplines.

Reviewer 5:
The reviewer observed that the project team's coordination was with Caterpillar but there was little knowledge of what other participants were doing.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer reported that the future research plans would be exploring several interesting areas, including precipitate and void formation as a function of the cooling temperature. The team would continue with the alloy development processes, the reviewer said, and the goal of correlating microstructures to optimal properties was good.

Reviewer 2:
The reviewer stated that project team had a good approach.

Reviewer 3:
The reviewer stated that the project team had a good work plan.

Reviewer 4:
The reviewer noted that leveraging relationships, which could lead to commercial development of results, was the key to success of the project.

Reviewer 5:
The reviewer acknowledged that the planned approach for future research appeared to be logically planned, and relied upon previous projects and tool development. Time will tell whether the desired outcomes would be achieved, and thus whether the planned activities actually would make sense.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer observed that the project was targeted at producing cost-effective, lighter-weight, high-performance components for engines in order to increase overall engine efficiency.

Reviewer 2:
The reviewer stated that the project’s team was an important part of a larger effort.

Reviewer 3:
The reviewer commented that lighter engine components led to more efficient vehicles.

Reviewer 4:
The reviewer indicated that the cast steel crankshafts could reduce the weight relative to current materials and potentially reduce the cost by eliminating machining steps. In this regard, the project was relevant to the DOE’s objectives.

Reviewer 5:
The reviewer stated that project did not directly support the overall DOE objectives, and pointed out that the project was more a (very interesting) cost/price reduction investigation.

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

Reviewer 1:
The reviewer commented that the project’s resources appeared to be sufficient to complete the work as described in the project.

Reviewer 2:
The reviewer stated that the resources appeared to be sufficient at this time.

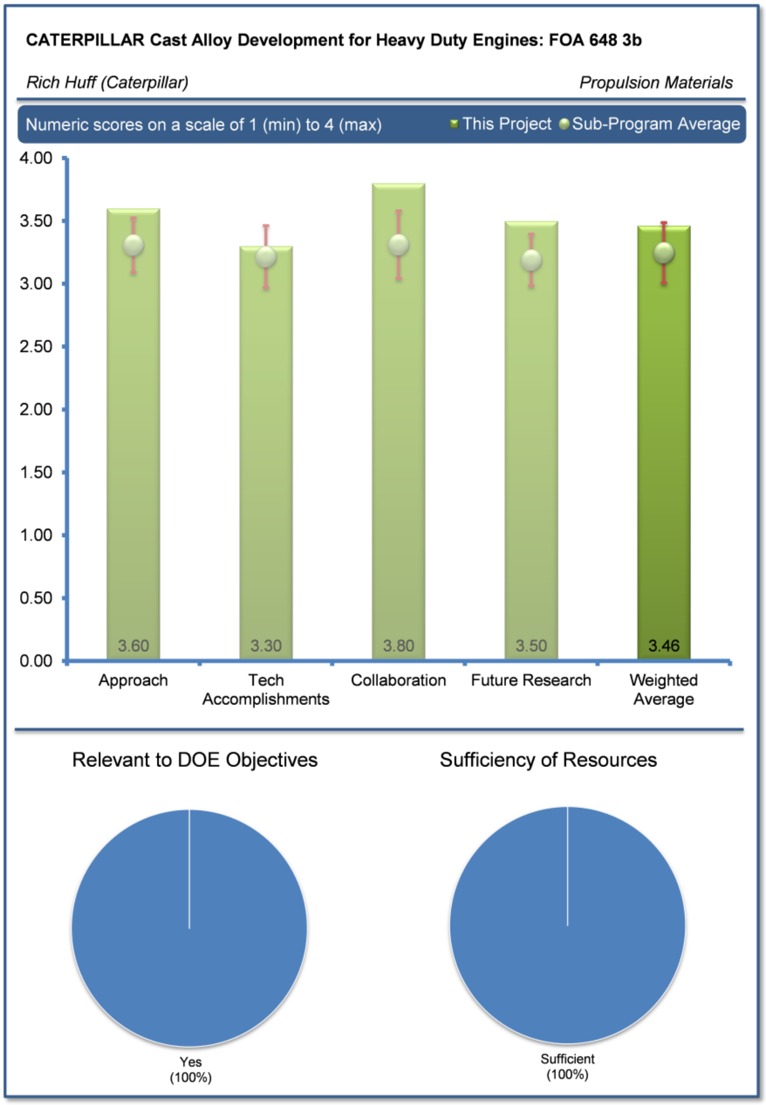
Reviewer 3:

The reviewer noted that the project funding appeared to be adequate.

Reviewer 4:

The reviewer noted that more resources do not automatically lead to better results.

CATERPILLAR Cast Alloy Development for Heavy-Duty Engines: FOA 648 3b: Rich Huff (Caterpillar) - pm059



Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the project approach was very complete, with all factors mentioned in the overview, where some had criteria and others had to be judged in combination with other criteria. Machinability was also taken into account. The reviewer added that a new element in the approach was to create a three-dimensional (3D) image and with that new ways can be found for enhanced materials, or ways to avoid problems in existing materials.

Reviewer 2:

The reviewer explained that the project's study of cast iron for HD was a good complement to the LD aluminum work. A unique aspect of this work was using DOE laboratory resources, the ANL APS, to identify the 3D graphite structure material properties. The reviewer added that this was a very interesting approach that took advantage of the unique laboratory capabilities, where initial casting trials were showing good improvements in tensile strength. The project approach seemed logical in general.

Reviewer 3:

The reviewer observed that it was a well-coordinated project that addressed critical goals.

Reviewer 4:

The reviewer commented that the project team's approach appeared logical and demonstrated strong knowledge of the specific barriers needing to be addressed. The project relied heavily upon tools and facilities previously developed and in-place, particularly at ANL and the University of Alabama at Birmingham (UAB). The reviewer noted, in particular, that the industry was leading this project, and had worked to set many of the technical objectives.

Reviewer 5:

The reviewer noted that the project approach was a mix of ICME techniques and APS assessments used to identify candidate materials for specific applications.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:
The reviewer stated that good accomplishments were demonstrated in the project's presentation, where the work focused on microstructure development during iron solidification. Use of the ANL APS to identify nucleates in the graphite network was important and had been used to guide follow-on microstructure work. The reviewer added that the modeling work, for example, the solidification of eutectic alloys, was also adding to the body of knowledge.

Reviewer 2:
The reviewer commented that it appeared that the Caterpillar team had successfully established a baseline to identify and model critical mechanisms that impacted the microstructure formations during cast iron solidification, and that the project remained on target.

Reviewer 3:
The reviewer reported that the project had a few delays, but the causes appeared to have been resolved, and the project was now moving forward, albeit a bit behind in overall schedule. This delay was particularly true for the machinability baseline work, which now appeared to be scheduled for completion this summer rather than the end of calendar year 2013, and delays along the way resulted in scheduling issues for the specific equipment needed to complete the step. The reviewer noted that otherwise, the project appeared to be accomplishing what it set out to technically, and with its work particularly in the area of graphic core chemical analysis, might be poised for what could be some groundbreaking results.

Reviewer 4:
The reviewer noted that the project's progress was good but still in the early stages. The project team was finding cause-and-effect relationships but lacked an understanding of why.

Reviewer 5:
The reviewer commented that inoculant variant showed finer grain in all different thicknesses, which was a desired property. The tensile strength was also higher, but the relation with the grain, as seen as a function of the thickness and the strength, was not very clear. The reviewer also noted that the lower of the inoculant was not clear.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer indicated that Caterpillar, the project lead, appeared to be working closely with ANL and UAB in particular, while relying upon QuesTek where needed. The project also associated with key experts at Northwestern University and Bradley University to supplement specific technical areas. The reviewer noted that in particular, the project team's coordination and collaboration was allowing the project to make full use , not only of the required expertise, but of the unique tools and facilities the collective team brought.

Reviewer 2:
The reviewer commented that the project had an excellent team.

Reviewer 3:
The reviewer observed that the team included a good balance of OEM, supplier, and university participants, including a modeling specialist.

Reviewer 4:
The reviewer noted that the project team had a close collaboration with ANL.

Reviewer 5:
The reviewer stated that the project was carried out with partners from all relevant disciplines.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer affirmed that it was a very good project.

Reviewer 2:
The reviewer commented that the future work for this project seemed to be reasonable and continued with the path identified by current work. Additional, the APS work would be useful for the project.

Reviewer 3:
The reviewer mentioned that the project's future plans appeared to be logically laid out and focused on addressing the remaining areas necessary for completion of the project. The reviewer expressed only one concern, namely that most of the modeling and analysis work was still to be completed, and given delays to date, it was currently unclear if all would be completed on time.

Reviewer 4:
The reviewer commented that the proposed future work appeared appropriate, to stay on plan and assess materials through casting trials, and assess the potential for the new materials performance.

Reviewer 5:
The reviewer stated that it was mentioned that the ICME tool was not very usable, but it would make this project stronger if data that could be used to enhance the ICME tool could be generated.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer pointed out that the project was focused on higher-performance and lighter-weight materials for engines. Not only would this result in efficiency increases for the engine due to its reduced weight, but it also would allow for offsetting vehicle weight increases elsewhere due to environmental, safety, and other systems.

Reviewer 2:
The reviewer commented that if the project's aim for weight savings and weight reduction enabled future lightweight vehicles, and/or vehicles with more cargo load capacity, it would therefore be beneficial to fuel consumption reduction, which would lead to reduction of oil imports.

Reviewer 3:
The reviewer noted that the project involved competitive cost and lightweight engine block material, which was an alternative to cast iron.

Reviewer 4:
The reviewer indicated that this project was relevant to the DOE goals of engine efficiency because increased efficiency would likely mean increases in peak cylinder pressure that would have to be addressed with similar material enabling technologies.

Reviewer 5:
The reviewer indicated that engine efficiency could be improved through both lightweighting and allowing operation at higher pressures.

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

Reviewer 1:
The reviewer stated that the resources appeared to be sufficient at this time.

Reviewer 2:

The reviewer noted that project's resources appeared sufficient to complete the work as described.

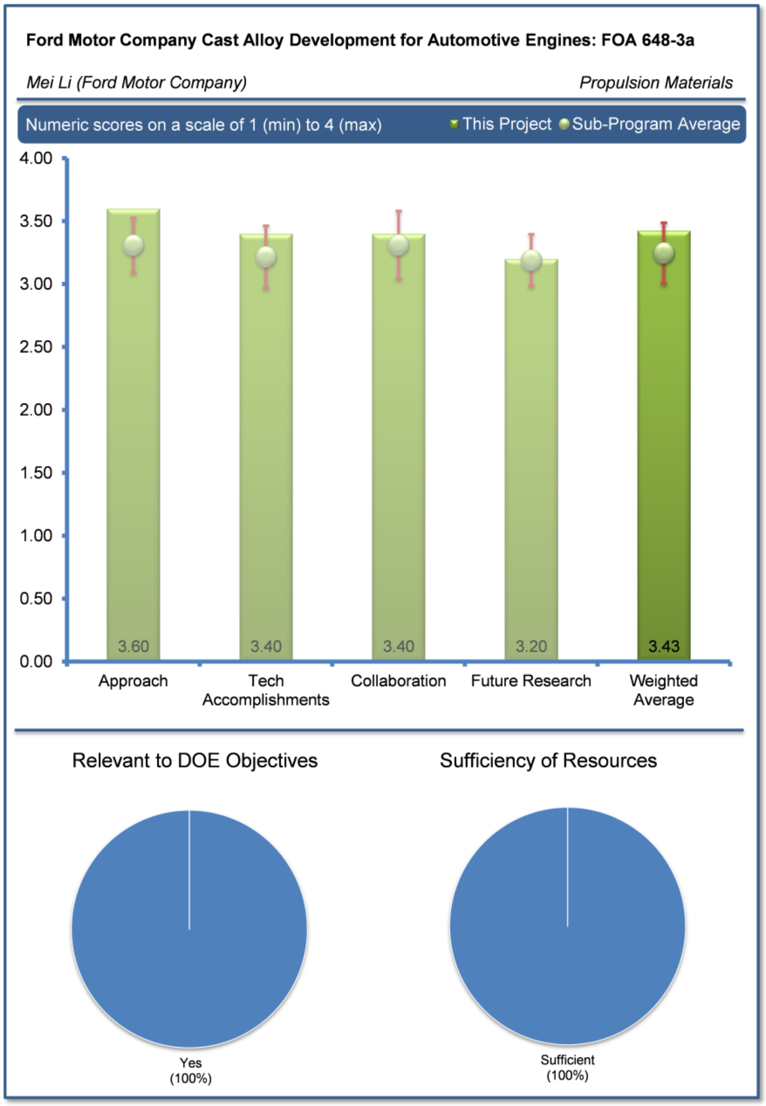
Reviewer 3:

The reviewer described that it appears that the resources were sufficient for this project.

Reviewer 4:

The reviewer commented that more resources do not automatically produce better results.

Ford Motor Company Cast Alloy Development for Automotive Engines: FOA 648-3a: Mei Li (Ford Motor Company) - pm060



Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the project had a very logical approach dealing with combination of material properties and cost considerations. Making use of ICME connected this project with others in the portfolio, which is interesting to compare the final results across the different projects.

Reviewer 2:

The reviewer indicated that the project had a thorough approach with all cost aspects included by using the "Technical Cost Model - Sand Casting Process Flow Diagram Assumption."

Reviewer 3:

The reviewer stated that the project appeared logically laid-out and focused upon addressing the identified materials barriers, and included not only development and testing of potentially higher-strength materials, but also resolving gaps in modeling tools. The reviewer added that the project appeared to build appropriately upon previously developed material formulations, and to be targeted for addressing specific engine design applications.

Reviewer 4:

The reviewer stated that the project had all pieces in place to develop aluminum alloy for high-performance engines. ICME modeling, cost model assessment, and tech transfer and commercialization were all needed to improve the likelihood of the project's success. The reviewer added that the coordination with GM and Chrysler with ORNL, if possible, should be encouraged, as there might be an opportunity to leverage the work being performed under projects pm061 and pm062.

Reviewer 5:

The reviewer noted that the project's alloy design was lacking.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer explained that a comprehensive cost model had been developed for the casting process. A number of alloy compositions had already been created for the project, and good material properties were already being shown. The reviewer added that the accomplishments were good given that the project was only 30% complete.

Reviewer 2:

The reviewer noted that 13 potential alloys were identified and tested, which had given an indication of a better baseline composition.

Reviewer 3:

The reviewer commented that the project had created 13 alloys to establish a baseline for further research, and with the first promising results produced, the next step can be made.

Reviewer 4:

The reviewer articulated that the project appeared to be largely on schedule, where efforts to date had shown seven alloys meeting DOE yield strength criteria, and the project had already identified several key reasons for these results that were focused on the specific elemental composition of the alloys.

Reviewer 5:

The reviewer expressed that a clear pathway to a marketable alloy is lacking. Many were being evaluated but the information to design a new one was lacking.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer explained that the project team was led by an industry member - Ford, and included Alcoa, Nemak, MAGMA Foundry, and the University of Michigan. The project lead appeared to be utilizing the partners where needed, although efforts to date, possibly due to phase of the project, appeared to have focused primarily upon the team lead's activities. The reviewer added that it was expected that there might be more cooperative activities as this project moves along.

Reviewer 2:

The reviewer commented that Ford appeared to be collaborating with a good set of partners, including a partner (Nemak) with expertise in casting of aluminum cylinder heads which are the specific components to be addressed, and a partner (MAGMA) that has casting simulation software. A separate slide on partners with their roles would be helpful to include in future presentations.

Reviewer 3:

The reviewer remarked that, in fact, there were three more-or-less competing projects, like SuperTruck, which meant that there were consortiums formed around every OEM and that it would be difficult for a research institute to collaborate with another institute that was involved in the competing project. All projects had involved a research institute, an OEM with machining expertise, a foundry, a university, and other experts.

Reviewer 4:

The reviewer commented that adding a national laboratory partner would help strengthen team.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer noted that Slide 24 of the presentation showed that the proposed steps were very logical.

Reviewer 2:
The reviewer concluded that the project's future work plan would accomplish the goals of the project, where it was important to develop the cost models to ensure that these alloys would be considered for use in production engines. ICME gap analysis results might assist other projects in using this modeling process.

Reviewer 3:
The reviewer explained that the project's future activities seemed to be clearly focused on completing project objectives. In particular, these efforts should result in optimized alloys, addressing gaps in capabilities of existing technical models, and establishing a cost model.

Reviewer 4:
The reviewer stated that project team was continuing to assess and refine Al-Cu-Mg-silicon-vanadium-zirconium-Ni- titanium-based alloys for strength characteristics. The cost targets of 110% of incumbent alloys costs, appeared to be difficult to achieve using the proposed materials. The reviewer suggested the project team attempt to optimize a new alloy for both strength and cost.

Reviewer 5:
The reviewer noted that a cause-and-effect relationship was being developed between different alloy additions, but it was not a clear if a mechanistic understanding was being developed.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer noted that lighter materials led to lighter, more efficient vehicles.

Reviewer 2:
The reviewer indicated that project was focused upon higher-performance, lighter-weight materials for engines, which would result in fuel efficiency improvements. These improvements would be two-fold, including higher-efficiency operation of engines and lighter engines which would result in lighter vehicles.

Reviewer 3:
The reviewer stated that this project was relevant to DOE goals for advanced engine efficiency because materials such as these will be necessary to enable higher-temperature operation and ensure durability while reducing weight.

Reviewer 4:
The reviewer explained that lightweight materials that can withstand higher temperatures can help to reduce the weight of internal combustion engines, and therefore reduce fuel consumption by allowing more payload for HD vehicles, or less empty weight for LD vehicles.

Reviewer 5:
The reviewer stated that this project was relevant to DOE goals for advanced engine efficiency because materials such as these will be necessary to enable higher-temperature operation and ensure durability while reducing weight.

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

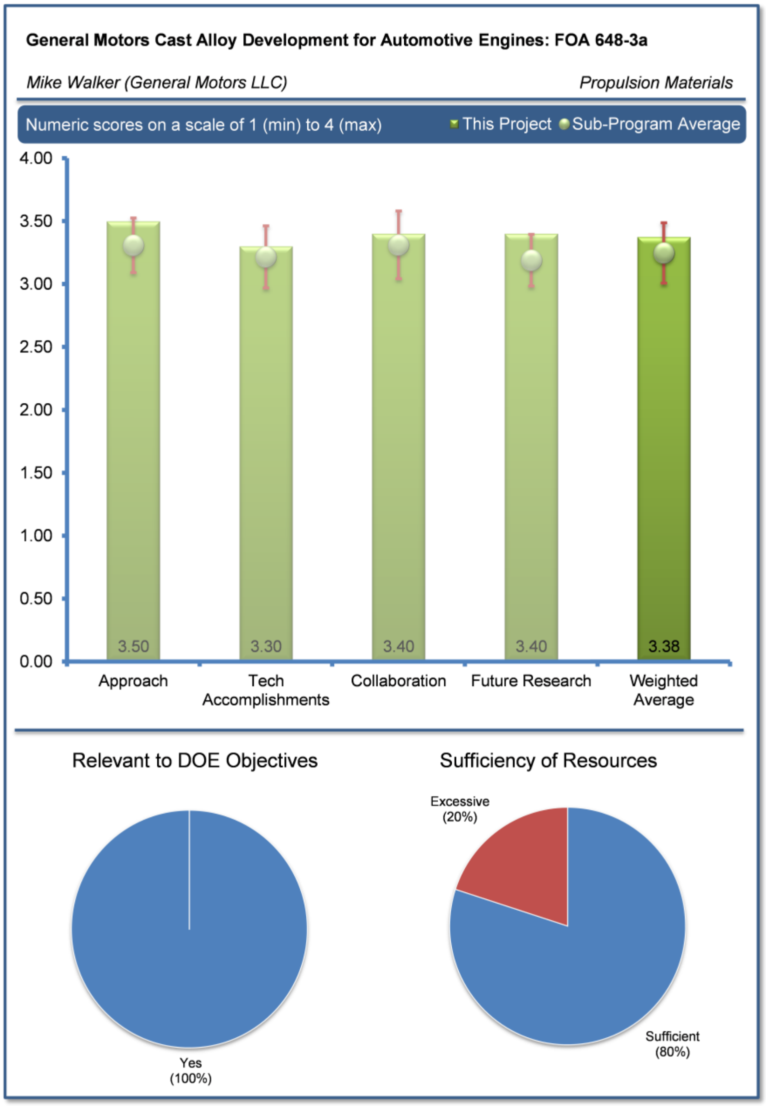
Reviewer 1:
The reviewer concluded that the project funding appeared to be sufficient to accomplish the tasks and was in line with other, similar projects in the Propulsion Materials portfolio.

Reviewer 2:
The reviewer reported that the project funding appeared to be sufficient.

Reviewer 3:
The reviewer commented that the project resources appeared sufficient at this time.

Reviewer 4:
The reviewer remarked that developing and validating a new material was a very costly and time-consuming process, but more resources do not automatically produce better results.

General Motors Cast Alloy Development for Automotive Engines: FOA 648-3a: Mike Walker (General Motors LLC) - pm061



Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that the project team's approach seems very logical and methodical in determining and ranking the most critical physical and thermal properties to meet requirements, then using experts to create alloys to achieve these requirements. The inclusion of cost models was very important, since if these alloys are too costly, they will not be used in large-scale production.

Reviewer 2:

The reviewer commented that the approach for the project appeared to be logically developed and focused on overcoming identified barriers. The project focused on evaluating candidate alloy formulations, developing test materials, evaluating the materials produced, and eventually, scaling up best candidate or candidates. The reviewer added that an additional element of the project was comparing the testing and modeling results, and evaluating existing models for analysis in order to address gaps. The performance objectives for the materials developed came from specific engine applications.

Reviewer 3:

The reviewer stated that the project team had a good approach with Design for Six Sigma tools. The reviewer said that it would have been interesting to know which tool was used in the selection process. In all three projects concerning cast alloys, there was discussion about the requirements that apparently were created by the DOE as outcome of a workshop and were the top ten of the requirements list. The reviewer expressed the need to know if these alloys could also be used for other sand cast Al parts that face high temperature and where current alloys have their limitations. Cast iron is currently being used in certain extreme applications, such as, turbo compressor housings for HD engines, where for LD, they are often die cast, and for boost pipe or additional coolers which have to specified in order to keep temperatures below the critical level.

Reviewer 4:

The reviewer explained that the project had a comprehensive approach for development of alloys, and well-defined performance metrics which allow a clear go or no-go decision. Coordination with Ford and Chrysler with ORNL, if possible, should be encouraged, as there might be an opportunity to leverage the work being performed under projects pm060 and pm062.

Reviewer 5:

The reviewer explained that the focus was on barriers but the approach was an evaluation of what was available and not really the development of new alloys.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that this project had some good accomplishments in its first year, including completion of the material requirement matrix, development of initial alloy concepts, casting of sample alloys, and initial properties testing. The priorities, which were very appropriate in the material requirement matrix, were clearly focused on production-capable materials.

Reviewer 2:

The reviewer reported that the project appeared to be on schedule and had prepared a detailed material requirement matrix, including ranking over 20 properties, identifying seven alloys for study, and conducting some of the analysis and measurements to identify properties. In addition, the PI indicated that the project team learned that it took more effort to identify more candidate materials than initially anticipated, and expressed that it was potentially due to the increased importance of thermal conductivity, which he saw as of greater importance, more than many other researchers had indicated.

Reviewer 3:

The reviewer noted that the project's progress to date was according to plan, which was detailed and well thought out.

Reviewer 4:

The reviewer indicated that seven alloys had been created, of which four had been modelled in a thermodynamic framework, and three had been identified by Density Functional Theory.

Reviewer 5:

The reviewer explained that the evaluation of the current alloys and analysis of the needs was good, but the progress or pathway to a new alloy was lacking.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that the project team had a good list of partners included in the work, including several academic institutions and the American Foundry Society, an interesting addition as a technical advisor. The project team had well-defined roles as was outlined in the presentation.

Reviewer 2:

The reviewer stated that the project was led by an industry member, GM, who was positioned to take the results of this project and move forward. The team also included three industrial sub-partners and two university sub-partners; all chosen to provide specific or unique capabilities to the project. The reviewer added that given the stage of the project- approximately 25% complete - it was unclear how many of the partners had really been needed to date. Given their specific assignments, it was expected that they will be utilized appropriately throughout this project.

Reviewer 3:

The reviewer noted that adding a national laboratory partner would help strengthen the project team.

Reviewer 4:

The reviewer explained that, in fact, there were three more-or-less competing projects, including SuperTruck, which meant that there were consortia formed around every OEM, so it will be difficult for a research institute to collaborate with another institute involved in a competing project. All projects had involved a research institute, an OEM with machining expertise, a foundry, a university and other experts.

Reviewer 5:

The reviewer remarked that the project team was missing a major aluminum company to make the alloy.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the project's future's work for 2014 was focused on validating the model findings, refining the alloy composition, and testing these revised materials. All these tasks were appropriate and pushed the work toward the 2014 go or no-go milestone related to model and experiment agreement.

Reviewer 2:

The reviewer commented that the project defines needs but does not yield the answers through the development of a new alloy.

Reviewer 3:

The reviewer noted that a commercialization plan should be developed in the project.

Reviewer 4:

The reviewer explained that the aim to develop better theory and models for optimization of the alloy was definitely the way to validate the alloy concept models through microstructural analysis and mechanical tests, or to develop parametric alloy systems from the validated alloy concepts. It would be nice if the researchers could explain in the 2015 session the link with the introduction of alternate chemical species to further improve high-temperature stability, ductility, fatigue properties and castability with the enhanced models.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the project was focused on developing improved materials in order to allow higher-efficiency operation of engines.

Reviewer 2:

The reviewer explained that lightweight material that can withstand higher temperatures can help to reduce the weight of internal combustion engines, and therefore reduce fuel consumption (by allowing more payload to the vehicle for HD vehicles, or less empty weight for LD vehicles).

Reviewer 3:

The reviewer commented that this project's work was relevant to the DOE goals for advanced engine efficiency because materials such as these will be necessary to enable higher-temperature operation and ensure durability while reducing weight.

Reviewer 4:

The reviewer noted that lighter materials lead to a lighter and more efficient vehicle.

Reviewer 5:

The reviewer explained that with approximately 75% of the project left to go, there was a great deal of work still needing to be done. It appeared to be logically organized and should be able to address remaining objectives and barriers.

Reviewer 6:
The reviewer opined that a new alloy was needed for the project.

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

Reviewer 1:
The reviewer stated that the resources appeared to be sufficient for this project, with GM providing cost share investment for the work.

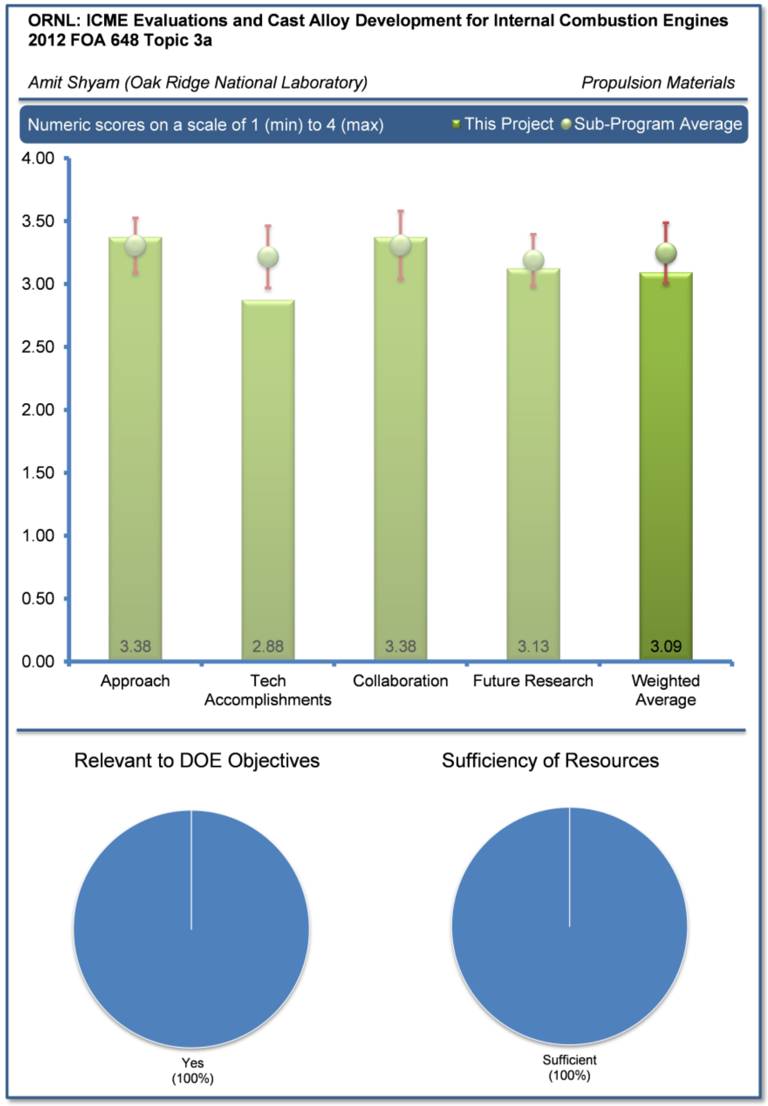
Reviewer 2:
The reviewer said that the project funding appeared to be sufficient.

Reviewer 3:
The reviewer noted that the resources appeared to be sufficient at this point.

Reviewer 4:
The reviewer commented that developing and validating a new material was a very costly and time-consuming process, but more resources did not automatically generate better results.

Reviewer 5:
The reviewer noted that since little alloy design is taking place without aluminum producer, too much funding was being spent without a pathway to a marketable alloy.

ORNL: ICME Evaluations and Cast Alloy Development for Internal Combustion Engines 2012 FOA 648 Topic 3a: Amit Shyam (Oak Ridge National Laboratory) - pm062



Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the project had a thorough approach with ICME models and cost estimation but not as a final activity. This person acknowledged, however, that it was also early in the research.

Reviewer 2:

The reviewer stated that there the ICME approach to development of the new alloys was logical, and it was good to see that the plans include some sort of commercialization step, as well as the cost analysis, since both are important to eventual widespread use of the material. The gap analysis for ICME code would generally help users of this process more.

Reviewer 3:

The reviewer indicated that the approach was well defined; various commercial packages available are being evaluated. The reviewer added that one of the barriers identified was the non-availability of ICME-based alloy development and this project was one of three that address this issue.

Reviewer 4:

The reviewer remarked that the utilization of ICME to identify materials that meet or exceed baseline metrics might lead to ultra-high performing alloys. The reviewer added that coordination with Ford and GM, if possible, should be encouraged, as there may be an opportunity to leverage the work being performed under projects pm060 and pm061.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the project team was on track for the first major milestone, a selection of alloy family.

Reviewer 2:

The reviewer said that the project had been running for a year and the progress reported was adequate. The reviewer pointed out that only the characterization of the material is completed and ICME efforts are in progress. The reviewer stated that the problem is that the alloys being evaluated are all existing and do not have the required properties. The reviewer added that the predictions based on this effort might not be able to identify the high-strength alloys.

Reviewer 3:

The reviewer stated that it was difficult to judge, because the project had started later than the other two and no results were shown. Also, the reviewer noted that four baseline materials have been selected and delivered and are undergoing tests now. The reviewer said hopefully the researchers can explain in next year's review why the secondary dendrite arm spacing (SDAS) of approximately30 μm is such an important factor for the selection of these base materials.

Reviewer 4:

The reviewer indicated that the accomplishments were somewhat limited here, but the project has only been underway for a few months. The reviewer observed that the project team has already characterized the baseline materials, including microstructure characterization that will be used for ICME work.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that two major CRADA partners (Chrysler and Nemak) covered the OEM and supplier areas, and also included are software providers, some of which are participating in other, similar projects in the portfolio.

Reviewer 2:

The reviewer observed that the team was fully equipped and well balanced.

Reviewer 3:

The reviewer remarked that, in fact, there were three more-or-less competing projects, like SuperTruck, which means that there were consortia formed around every OEM and that it would be difficult for a research institute to collaborate with another institute involved in a competing project. All projects involve a research institute, an OEM with machining expertise, a foundry, a university, and other experts.

Reviewer 4:

The reviewer remarked that the project team was strong with national laboratory and industry partners. The reviewer said that adding an academic institution would strengthen the team even more.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the future work appeared to be logical and should accomplish the stated goals.

Reviewer 2:

The reviewer noted that hopefully the researchers can tell in the 2015 review how the link was made between the investigation of the baseline materials and the enhanced materials, or the new alloys.

Reviewer 3:

The reviewer commented that the project plan should provide a pathway to identify alloys with targeted performance. The reviewer added that any ultra-high-performing alloys that do not meet the cost parameters for this project should be identified and possibly assessed for other applications where cost is less of a concern.

Reviewer 4:

The reviewer reported that the team needed to look into newer alloy systems rather than existing alloys. The reviewer said that the new elements may be needed to be added to the existing alloys to improve high-temperature strength. The reviewer added that if the team was aware of this fact it is not evident from the presentation.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that the lightweight material that could withstand higher temperatures can help to reduce the weight of the internal combustion engines and therefore reduce fuel consumption, by allowing more payload for HD vehicles or less empty weight for LD vehicles.

Reviewer 2:
The reviewer remarked that as the requirements for engine components are increasing, the time taken to develop new alloys is also increasing, and developing ICME-based models will accelerate this development and make powertrain components more efficient.

Reviewer 3:
The reviewer commented that this work is relevant to DOE's efficiency goals, as these materials will enable lighter engines that can accommodate higher cylinder pressures and temperatures.

Reviewer 4:
The reviewer said that lighter materials will lead to a lighter and more efficient vehicle.

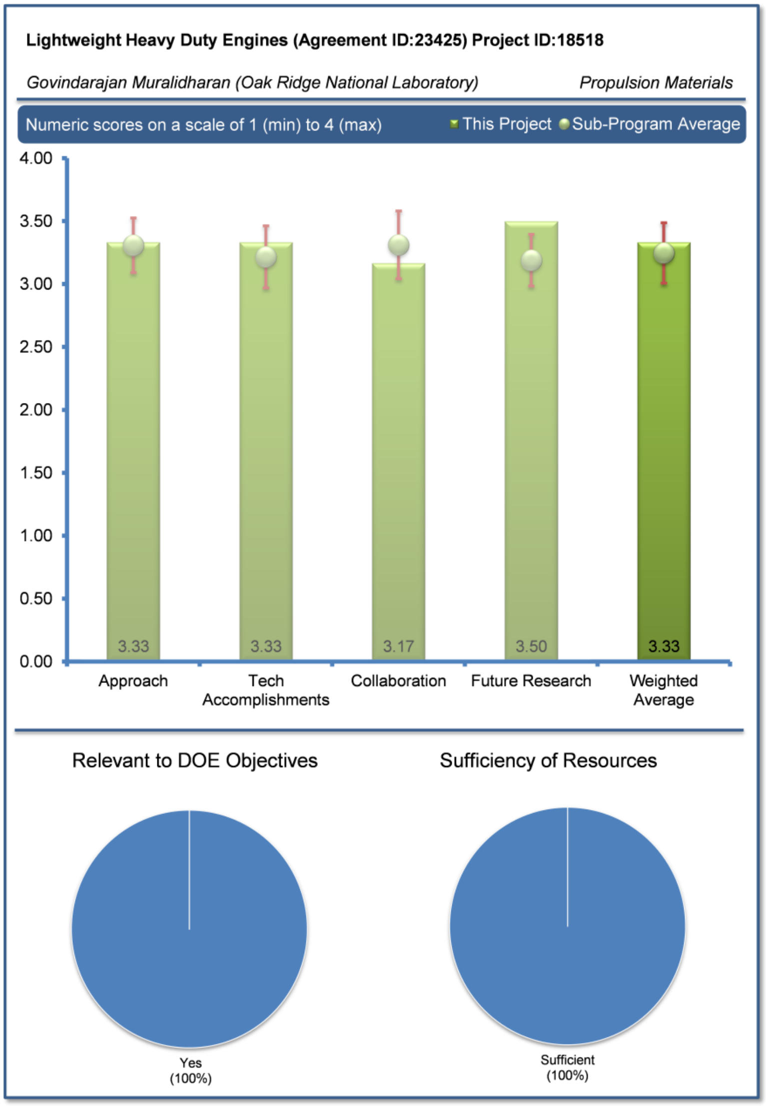
Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said that funding appeared to be sufficient.

Reviewer 2:
The reviewer reported that the funding appeared sufficient for this project. The reviewer added that the funding included a cost share of around $2 million beyond the DOE funding.

Reviewer 3:
The reviewer stated that developing and validating new material is very costly and time-consuming, but more resources do not automatically lead to better results.

Lightweight Heavy Duty Engines (Agreement ID:23425) Project ID:18518: Govindarajan Muralidharan (Oak Ridge National Laboratory) - pm063



Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the low thermal conductivity aspect of this work was interesting as a way to improve efficiency by retaining heat in-cylinder. The reviewer added that the project team was focusing on pistons and exhaust manifolds as target components as a result.

Reviewer 2:

The reviewer commented that piston activities just started up. The reviewer stated that heat moves rapidly through a substance with high thermal diffusivity because the substance conducts heat quickly relative to its volumetric heat capacity or thermal bulk. The reviewer added that it was not completely clear why the selection was made for alloy 625 coatings applied to 4140 steels, probably the base piston material, at ORNL using laser-based technique. The reviewer also said that the exhaust manifold project had delivered first results that were very promising.

Reviewer 3:

The reviewer stated that a well-defined project plan was established and followed. The reviewer also observed a low-cost approach to solving the materials challenge.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the milestones appeared to be well on-track to meet goals, and progress has been good so far. The reviewer also said that it is good to see that an alloy previously developed by DOE researchers, CF8C-plus, was being used again for its optimal properties in exhaust applications. The reviewer added that piston coatings were an interesting idea to reduce heat conduction. The reviewer stated that it would be interesting to see how these coatings withstand conditions seen in combustion chambers. The reviewer presumed this had already been explored to some extent.

Reviewer 2:

The reviewer observed that the CRADA delay and lower funding levels had slowed progress; however, acceptable progress was still being achieved.

Reviewer 3:

The reviewer commented that, regarding the piston, it was not clear if the observed 25% decrease in thermal diffusivity up to 300ºC is a good step in the direction of meeting the goal. The reviewer added that, regarding the exhaust manifold, it was not clear how the materials were selected using finite element calculations. The CF8C-plus material performed well and has the best oxidation resistance. The reviewer reported that the D5S material showed a wide scatter; if there is a reason for the points at the left, and if these could be addressed, perhaps this material could be a cheaper candidate as well.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project was between ORNL and Cummins and no other participants were identified or collaborations discussed explicitly, but it appeared that this should be sufficient.

Reviewer 2:

The reviewer pointed out that the project was a CRADA established between Cummins and ORNL.

Reviewer 3:

The reviewer said for the exhaust manifold there was a working relationship with a foundry, but for the piston, no company other than Cummins was mentioned. In the past, piston suppliers had done a lot of research on this topic, but perhaps not with the technology used in this project. The reviewer added that by involving a piston supplier perhaps some relevant information could be obtained.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the future work plan was appropriate and will be addressing the durability and manufacturing aspects of the coated/multi-material pistons, which will be important for the viability of the technology. The reviewer added that engine testing of the prototype CF8C-plus manifold was an appropriate next step.

Reviewer 2:

The reviewer indicated that this project leveraged the success of a previous project CF8C-plus where CF8C-plus was now being considered as a possible base alloy to improve specific properties needed for the piston application.

Reviewer 3:

The reviewer provided a more general, but applicable, observation that projects that are directly linked to a CRADA do not give many details about future research on which comments can be made.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reported that this project was relevant to the DOE objectives of increased engine efficiency, as the materials developed would allow the increased operating temperatures and pressures likely required by future efficient engines.

Reviewer 2:

The reviewer said that lighter materials lead to a lighter, more efficient vehicle.

Reviewer 3:

The reviewer stated definitely for the piston. The reviewer added that for the exhaust manifold it was more a potential cost/price reduction, currently often for high-temperature application, the more expensive Ni-resist is used.

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

Reviewer 1:

The reviewer commented that resources appeared sufficient, and that the resources included a 50% cost share from Cummins, which showed a commitment from the OEM.

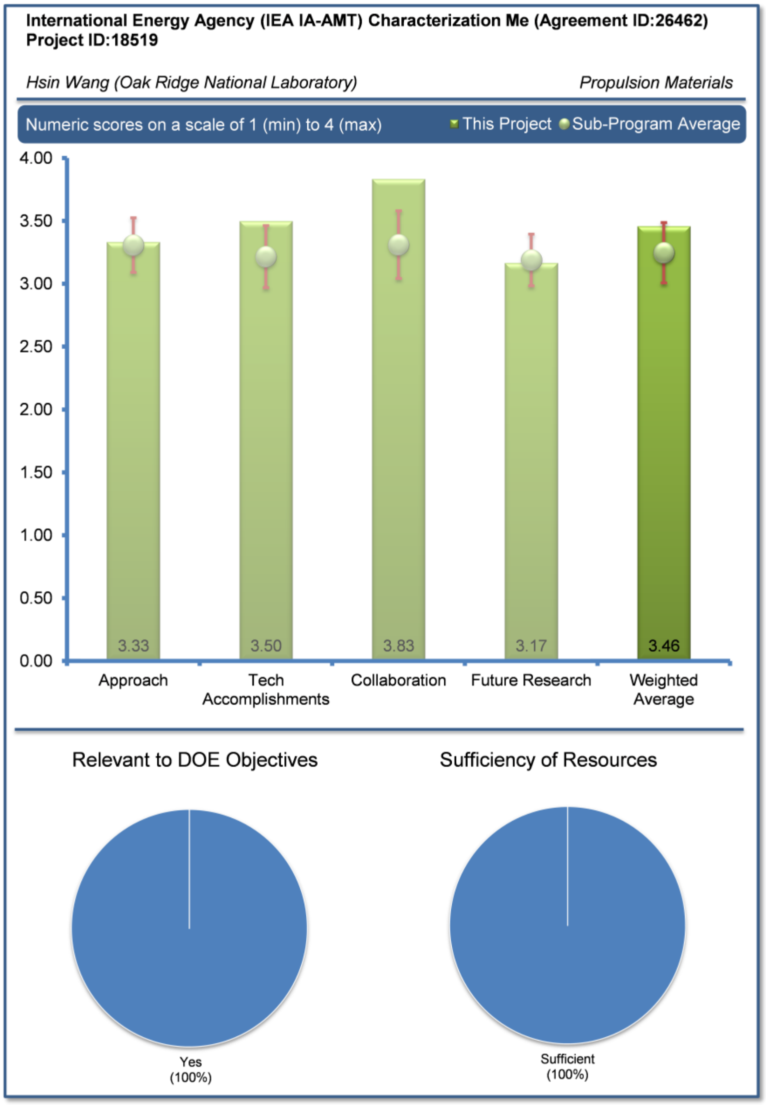
Reviewer 2:

The reviewer stated that funding appeared sufficient.

Reviewer 3:

The reviewer said that it was difficult to comment, because this was a CRADA with Cummins and no detailed planning for the whole project was shown.

International Energy Agency (IEA IA-AMT) Characterization Me (Agreement ID:26462) Project ID:18519: Hsin Wang (Oak Ridge National Laboratory) - pm064



Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work - the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the approach to material property standardized testing via round robin testing was effective. Also, the reviewer said that international collaboration to improve consistency in testing was needed and this approach addresses that issue. The reviewer added that the go or no-go decision point allowed for a project exit, if needed.

Reviewer 2:

The reviewer commented that the approach to the round robin testing seems to have been successful and logical. The reviewer added that looking at the measurement implications at the materials and devices levels was a good idea.

Reviewer 3:

The reviewer observed that the introduction of new material standardization definitely helped, and also, in order to get consistent data, that can be used in simulation models.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer reported that the project team had completed round robin testing for multiple test labs. The reviewer added that there seems to be some improvement in the variability among labs, particularly on specific heat, a main source of error identified previously. Also, the reviewer stated that the team had considered factors affecting thermoelectric efficiency tests and proposed a reasonable solution for improving the accuracy of the tests.

Reviewer 2:

The reviewer commented that the round robin and survey was complete and that a report was under development.

Reviewer 3:

The reviewer stated that the project showed different results for the new material that can be used in future thermoelectric generator (TEG) systems for the different labs and the improvements from the last round-robin tests. Also, the results were the input for the Annex-VIII work. The reviewer added that it was not completely clear, especially for those laboratories that are using the same equipment, if the differences were due to noise, system accuracy, or other factors such as weight and load put on the sample or ambient conditions.

For the Seebeck coefficient, some laboratories used a different number of measuring points. The reviewer asked if it was possible to draw a conclusion for the desired number of points.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that there was a wide-ranging and multi-national list of partners. The reviewer indicated that collaboration was necessary for round robin testing, and appeared to have been very good.

Reviewer 2:

The reviewer pointed out that very comprehensive partnerships were established.

Reviewer 3:

The reviewer commented that, world-wide, well-known laboratories were involved in this project.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the development of international test standards through international collaboration would be an important future step for this work.

Reviewer 2:

The reviewer reported that it was not completely clear as to what should be the addition in Annex-XIX to Annex-VIII in which this future work has to go. The reviewer hoped that the researchers could make advisements to such international organizations as the International Organization for Standardization for a more detailed description about how the tests should be performed in order to reduce the differences in outcome, even if the same equipment was used.

Reviewer 3:

The reviewer indicated that additional materials should be considered for test standardization, specifically new interconnected materials.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the waste-heat recovery systems could reduce fuel consumption, and added that new materials were needed for the TEG technology. The reviewer commented that this project was relevant for this reason.

Reviewer 2:

The reviewer commented that this work was broadly relevant to DOE goals for increased efficiency through advanced technologies; however, future relevance was unclear given DOE's decision to discontinue thermoelectrics work.

Reviewer 3:

The reviewer said that lighter materials led to lighter, more efficient vehicles.

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

Reviewer 1:

The reviewer stated that funding appeared sufficient to complete this work.

Reviewer 2:

The reviewer said that funding appears sufficient.

Reviewer 3:

The reviewer remarked that more resources would not speed-up these kind of activities in which many external partners are involved.

Acronyms and Abbreviations

Acronym	Definition
3D	Three-dimensional
Ag	Silver
AHSS	Advanced high-strength steel
Al	Aluminum
AMR	Annual Merit Review
ANL	Argonne National Laboratory
APS	Advanced photon source
ASC	Ammonia slip catalyst
BTE	Brake thermal efficiency
C	Carbon
Ca	Calcium
CFC	Carbon fiber composites
CFD	Computational Fluid Dynamics
CI	Compression ignition
CRADA	Cooperative Research and Development Agreement
Cu	Copper
DOD	Department of Defense
DOE	Department of Energy
DPF	Diesel Particulate Filter
EGR	Exhaust Gas Recirculation
EV	Electric Vehicle
FSP	Friction Stir Processing
FSW	Friction Stir Welding
FY	Fiscal Year
GATE	Graduate Automotive Technology Education
GM	General Motors Corporation
HC	Hydrocarbon
HD	Heavy-Duty
HDD	Heavy-Duty diesel
HOV	High-occupancy vehicle
HVAC	Heating, ventilation, and air conditioning
ICME	Integrated Computational Materials Engineering
IP	Intellectual Property
K	Potassium
LCCF	Low-cost carbon fiber
LD	Light-duty
Mg	Magnesium
MMV	Mapping, modeling and visualization
MMV	Multi-material vehicles
MPa	Megapascal
Na	Sodium

Acronym	Definition
NASA	National Aeronautics and Space Administration
N_2	Nitrogen
N_2O	Nitrous oxide
NDE	Non-destructive evaluation
Ni	Nickel
NO_x	Nitrogen oxides
NREL	National Renewable Energy Laboratory
NTRC	National Transportation Research Center
NVH	Noise, vibration, and hardness
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
PI	Principal Investigator
PNNL	Pacific Northwest National Laboratory
Pt	platinum
PZT	Lead zirconate titanate
R&D	Research and Development
SAE	Society of Automotive Engineers
SCR	Selective catalytic reduction
SDAS	Secondary dendrite arm spacing
Si	Silicon
TEG	Thermoelectric Generator
UAB	University of Alabama at Birmingham
USCAR	U.S. Council for Automotive Research
VTO	Vehicle Technologies Office
WBG	Wide Bandgap

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