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ASME Response to U.S. Department of Energy Request for Information on Potential Technical Focus Areas for Advanced Manufacturing-Related Traineeships
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About ASME

Founded in 1880, the American Society of Mechanical Engineers (ASME) is a not-for-profit scientific, educational and technical organization which promotes the art and science of engineering to enhance safety and quality of life for all humankind. ASME's 130,000 volunteer members work to promote collaboration, knowledge sharing, career enrichment, and skills development across all engineering disciplines, toward a goal of helping the global engineering community develop solutions to some of humanity's greatest challenges. In furtherance of its public safety mission, ASME also develops and maintains over 500 voluntary consensus standards, including standards for complex machinery such as boilers, pressure vessels, elevators and escalators and items as ubiquitous as nuts, bolts and plumbing fixtures, and works closely with our volunteer community to advance the state of the art in mechanical engineering industrial manufacturing applications.

In further support of its public safety mission, ASME provides conformity assessment services to over 6,500 manufacturers in 75 countries in the areas of boiler, pressure vessel, and nuclear power component certification. This activity ensures that manufacturers throughout the world are knowledgeable and capable of manufacturing to ASME's safety standards. An additional attendant benefit of ASME's certification activities is that it facilitates international trade by reducing the number of regulatory barriers between countries that recognize the ASME mark.

ASME Comments on Potential Technical Focus Areas for Advanced Manufacturing-Related Traineeships

The ASME Committee on Government Relations is pleased to provide this response to the Department of Energy's Request for Information (RFI) on issues related to future EERE-funded graduate-level Traineeships. The views provide here are those of technical experts from the membership of ASME's Manufacturing Public Policy Task Force and Energy Public Policy Task Force, and not necessarily the views of ASME as a whole.

Manufacturing Process Simulation Training

1. **Training for engineers who work in the super/high performance computing.** Many engineers who use high-performance computing systems in a manufacturing setting or application do not have specialized training in using such systems. As digital design engineering and manufacturing becomes more integrated into the U.S. manufacturing

base, our workforce will need specialized training to capture the full potential of these systems[1].

2. **Training in manufacturing process modeling and simulation**, which is a key element in digital/smart manufacturing[2]. Increasingly, companies are relying on process simulation to plan and optimize their processes. Engineers need to have training in the underlying science and simulation tools, training on the use and placement of sensors, an understanding of the materials used to ensure robust sensors, and training relevant to computation modeling need to best use sensor data. This need is well-served by training in high performance computing since many of the process simulation tools are computationally intensive.

3. **Training in advanced sensing, measurement and process control.** This includes new process sensing methods, data analytics methods, and process control methods. This topic forms the basis of the DOE sponsored Smart Manufacturing Institute[3] and it expands on the metrology issue.

4. **Training in data engineering and sciences.** Advanced manufacturing machines and processes generate a large amount of data. Engineers need to be familiar with statistical data modeling and analysis methods (e.g. machine learning) to convert data into useful knowledge that can serve to inform decision making[4]. These techniques are also useful to develop data-driven models for complex manufacturing processes (e.g. additive manufacturing) that are difficult to model using physics-based approaches or they can be used to enhance the predictive accuracy of physics-based process models. Such techniques should include a basic understanding of machine learning, support vector machines and neural networks to accommodate making sense and decisions from the accumulated data. Finally, advanced manufacturing practitioners must develop a basic understanding of the cyber vulnerabilities of their systems.

<u>**Comprehensive Training in Metallurgy**</u>

5. **Create fellowships in metallurgy.** The U.S. aluminum industry directly consumes more than 1.2 percent of all electricity consumed by the residential, commercial and industrial sectors of the economy[5]. Developing an alternative to the Hall-Herault process could have a large impact on U.S. electricity sector and the efficiency of a large part of the U.S. industrial base. DOE had investments to drive down energy in Titanium manufacture, which would change engineering if titanium was a commodity metal. Metallurgy fellowships would help address this issue and counter the aging workforce in the space.

6. **Training for engineers who have advanced metrology capabilities.** Similar to the materials challenges noted above, U.S. manufacturers are now designing very complex

[1] Executive Order 13702 on Creating a National Strategic Computing Initiative
[2] Digital Manufacturing and Design Innovation Institute (DMDII), Strategic Investment Plan http://dmdii.uilabs.org/projects/strategic-investment-plan
[3] DE-FOA-0001263, http://www.grants.gov/web/grants/view-opportunity.html?oppId=279015
[4] NIST, Real-Time Data Analytics for Smart Manufacturing Systems Project https://www.nist.gov/programs-projects/real-time-data-analytics-smart-manufacturing-systems-project
[5] http://www1.eere.energy.gov/manufacturing/resources/aluminum/pdfs/al_theoretical.pdf

parts that need to be verified, and are short of people specialized in the verification and validation of new parts and materials[6]. Also, verification is now coming in the form of 3D and even tomographic data - newer representations that are very different from classical approaches and need to be well understood and integrated into the workforce.

7. **Training on how to process high temperature super alloys or similar materials.** As high performing engines become more common, materials that can withstand higher temperatures will be in greater demand. The new generation of engineers must be trained in processing such material into useful shapes for the next generation of engines/propulsion systems[7].

8. **Processing of advanced materials.** Leverage investments in IACMI[8] and AFFOA[9], as well as LIFT[10]. Not many undergrads and graduate students get exposure to composites, fibers and textures, or processes like hydroforming or powder metallurgy approaches. The U.S. should lay down a foundation for future researchers in these important fields.

Other Training Needs

9. **Exposure to membrane technology to help move away from conventional separation practices, particularly for chemical engineers.** From an energy efficiency standpoint, membrane technology applications could have a very large impact given the large carbon footprint of the petroleum and chemical industries[11].

10. **Training in tribology to counter lost expertise as the community retires[12].** The metrics for justifying tribology are subtle - it's not that the use of a lubricant saves energy, it also prevents defects which would waste significant energy used to produce the defect.

11. **Training in sustainable manufacturing systems design.** Graduate engineers are typically not trained in systems thinking, providing a context for the manufacturing technology being developed through their research. However, it is important for engineers to understand the effect that their process technology can have on the economic, environmental, and social aspects of manufacturing including impacts on internal production control, inventory control, quality control and equipment maintenance systems needed to operate the factory[13].

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[6] FDA, Design and Validation, http://www.fda.gov/downloads/MedicalDevices/NewsEvents/WorkshopsConferences/UCM418417.pdf

[7] DOE, High Temperature Materials for High Efficiency Engines , http://energy.gov/sites/prod/files/2014/07/f17/pm053_muralidharan_2014_o.pdf

[8] IACMI, http://iacmi.org/

[9] AFFOA, http://join.affoa.org/

[10] LIFT, http://lift.technology/manufacturingusa/

[11] NAE, Improving Energy Efficiency in the Chemical Industry, https://www.nae.edu/Publications/Bridge/EnergyEfficiency14874/ImprovingEnergyEfficiencyintheChemicalIndustry.aspx

[12] ASME, Modern Application of Tribology, https://www.asme.org/engineering-topics/articles/tribology/modern-application-of-tribology

[13] NASA, Systems Thinking Development, https://www.nasa.gov/pdf/602298main_44i_systems_thinking_development.pdf

12. **Training in advanced manufacturing for chemical process intensification and energy system miniaturization[14].** Process intensification technologies provide opportunities for engineers to reduce the size and weight of reactors, heat exchangers and separators enabling the use of distributed resources like solar radiation and biomass and energy efficiencies in chemical processes and power plants[15]. Engineers must learn how to design these components and modules for mass production in order for this technology to move forward in the marketplace.

This statement represents the views of ASME's Committee on Government Relations and is not necessarily a position of ASME as a whole.

[14] NSF, Chemical and Environmental Technologies (CT), https://www.nsf.gov/eng/iip/sbir/topics/CT.jsp
[15] DOE, Process Intensification, http://energy.gov/sites/prod/files/2015/02/f19/QTR%20Ch8%20-%20Process%20Intensification%20TA%20Feb-13-2015.pdf