DOE-ID NEPA CX DETERMINATION
Idaho National Laboratory

CX Posting No.: DOE-ID-INL-19-083

SECTION A. Project Title: Next-Generation High-Temperature Compact Heat Exchanger Developed Using Additive Manufacturing Techniques with Embedded Sensor Capability

SECTION B. Project Description and Purpose:

The proposed action aims to develop a next-generation high-temperature compact heat exchanger (HX) using additive manufacturing (AM) techniques with embedded sensor capability. HXs are key components in advanced reactors because they serve as the interface between the intermediate coolant and power conversion system or process application. The HX serves as the coolant boundary and must be constructed to maintain system integrity under normal, off normal, and accident conditions. For next generation reactors, efficient energy transfer for power production or industrial applications depends on being able to incorporate HXs between the nuclear heat transport system and the process using the heat. Advanced compact HXs using AM are being pursued to support cost and performance goals for commercially competitive designs. These HXs also have applications in the aerospace, energy, and chemical industries.

For the advanced compact HX technology to be adopted and commercialized, researchers and developers need to evaluate the thermal and mechanical performance of the HX for code acceptance and end-user design assurance. Information from this evaluation also enables performance and reliability management by tracking changes in HX internal conditions during transients and over the life of the component. Sensors embedded in the HXs gather needed data. There is no commercial technology available to embed sensors in advanced compact HXs fabricated with AM. Therefore, the proposed action also uses AM to embed sensors within the HX and uses thermocouples to demonstrate the feasibility of embedding sensors in HX components.

Despite longstanding use of HXs in many industries, fabricating HXs remains expensive and time-consuming. In some cases, joining different HX components requires welding, diffusion bonding, brazing materials together, or other bonding processes. Such methods, particularly between dissimilar materials, are prone to failure. Join failure can cause leaks between the cold and hot fluids or a loss of containment. AM processes are uniquely equipped for dissimilar material welding. AM also offers new properties and shapes not possible through conventional manufacturing processes. In addition, structural changes and AM techniques could enhance the strength to widen the temperature applicability range and enhance component longevity.

The project has four goals:

1. Prove manufacturing feasibility of novel HXs operating under extreme conditions (high temperature, high corrosive, and neutron irradiation environments) for next generation reactors, including micro-HX systems, using AM techniques
2. Develop a way to embed sensors (thermocouple used in demonstration) in HX components to allow measuring performance properties (e.g., temperature) important to overall reactor system efficiency
3. Develop an integrated manufacturing process for next-generation HXs with embedded thermocouples
4. Develop and implement an objective feasibility matrix for the chosen fabrication techniques with the focus on commercialization maturity, economics, design efficiency, and resiliency.

The proposed action evaluates the following three AM for HX manufacturing concepts to identify the best combination and integrated approach based on technical and economic approaches:

- A powder feed direct energy deposition process
- A wire feed direct energy deposition process
- A plasma direct ink-jet printing process (for the miniaturization of the actual sensor fabrications, aerosol ink-printing may be considered).

Work will be performed at INL facilities. Design work will take place at the Engineering Research Office Building. Fabrication will likely take place at the Energy Innovation Laboratory. Follow-on work may involve testing the heat exchangers in a flow loop. In addition, a subcontract between INL and a university (to be determined) will be executed for two students to assist with the design and fabrication of the component for this project.

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

Minor air emissions are expected during the fabrication process.

Generating and Managing Waste

Some industrial waste is expected to be generated. No hazardous waste generation is anticipated.

Releasing Contaminants

Chemicals will be used and will be submitted to chemical inventory lists with associated Safety Data Sheets (SDSs) for approval prior to use. The Facility Chemical Coordinator will enter these chemicals into the INL Chemical Management Database. All chemicals will be managed in accordance with laboratory procedures. When dispositioning surplus chemicals, project personnel must contact the facility Chemical Coordinator for disposition instructions.

Although not anticipated, there is a potential for spills when using chemicals. In the event of a spill, notify facility Environmental Staff. If the Environmental Staff cannot be contacted, report the release to the Spill Notification Team (208-241-6400). Clean up the spill and turn over spill cleanup materials to WGS.

Using, Reusing, and Conserving Natural Resources

All applicable waste will be diverted from disposal in the landfill when possible. Project personnel will use every opportunity to recycle, reuse, and recover materials and divert waste from the landfill when possible. The project will practice sustainable acquisition, as appropriate and practicable, by procuring construction materials that are energy efficient, water efficient, are bio-based in content, environmentally preferable, non-ozone depleting, have recycled content and are non-toxic or less-toxic alternatives. New equipment will meet either the Energy Star or Significant New Alternatives Policy (SNAP) requirements as appropriate (see http://www.sftool.gov/GreenProcurement/ProductCategory/14).

SECTION D. Determine Recommended Level of Environmental Review, Identify Reference(s), and State Justification: Identify the applicable categorical exclusion from 10 Code of Federal Regulation (CFR) 1021, Appendix B, give the appropriate justification, and the approval date.

For Categorical Exclusions (CXs), the proposed action must not: (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environmental, safety, and health, or similar requirements of Department of Energy (DOE) or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment or facilities; (3) disturb hazardous substances, pollutants, contaminants, or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-excluded petroleum and natural gas products that pre-exist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources (see 10 CFR 1021). In addition, no extraordinary circumstances related to the proposal exist that would affect the significance of the action. In addition, the action is not “connected” to other action actions (40 CFR 1508.25(a)(1) and is not related to other actions with individually insignificant but cumulatively significant impacts (40 CFR 1608.27(b)(7)).

References: National Environmental Policy Act (NEPA) Implementing Procedures, Final Rule, 10 CFR 1021 Appendix B to Subpart D, Categorical Exclusion B3.6,"Small-scale research and development, laboratory operations, and pilot projects."

Justification: Project activities are consistent with 10 CFR 1021 Appendix B to Subpart D, Categorical Exclusion B3.6, "Siting, construction, modification, operation, and decommissioning of facilities for small-scale research and development projects; conventional laboratory operations (such as preparation of chemical standards and sample analysis); and small-scale pilot projects (generally less than 2 years) frequently conducted to verify a concept before demonstration actions, provided that construction or modification would be within or contiguous to a previously disturbed or developed area (where active utilities and currently used roads are readily accessible). Not included in this category are demonstration actions, meaning actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment."

Is the project funded by the American Recovery and Reinvestment Act of 2009 (Recovery Act) ☐ Yes ☒ No

Approved by Jason Sturm, DOE-ID NEPA Compliance Officer on: 01/07/2020