Micro Nuclear LLC
partnered with
Idaho National Laboratory

RFA-17-14575, Development of the Microscale Nuclear Battery

YEAR AWARDED: 2017

TOTAL PROJECT VALUE: $190K (DOE: $152K, COST SHARE: $38K)

STATUS: Completed

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DESCRIPTION: The concept of generating energy from nuclear fuel dissolved in molten salt has been around since the 1960s. Looking toward improved safety and efficiency, many organizations worldwide have undertaken the research and development of molten-salt reactors, with the possibility of a commercially deployed reactor by 2030. Working with Idaho National Laboratory under this voucher, Micro Nuclear LLC sought to determine the design feasibility of its Molten Salt Nuclear Battery (MsNB) by performing computational analysis and discussing the likely multiphysics modeling challenges while coupling thermal hydraulics and neutronics. To help Micro Nuclear with a deployment strategy, the study provided design considerations, a database for primary coolant choices, and a simple economic case study. Researchers developed a tool to determine how many heat pipes will be required to conduct heat effectively and also carried out a preliminary comparison with a compact heat exchanger.

BENEFIT: This project defines an MsNB as a nuclear (fission) heat source capable of providing heat to power a small 5-MWe commercial gas turbine. Currently, several molten-salt reactor designs are actively being pursued; however, most rely on pumps to circulate the molten salt and several stages of conventional tube and shell type heat exchangers. The Micro Nuclear team has developed an alternative reactor configuration that eliminates pumps by providing a natural circulation primary flow design and eliminates heat exchanger tubes with the application of passive heat pipes. The configuration of this reactor design is an entirely novel concept.

IMPACT: The developed code was applied to a high-heat load problem and a low-heat load problem with different wick structures and working fluids. In both cases, the developed tool was able to calculate the number of heat pipes and the temperature-pressure profile within the heat pipe. It also demonstrated that the heat pipe performance falls within the performance limits.

LESSONS LEARNED: While the developed tool in this project was intended for designing heat exchange systems for nuclear power plants, it can be extended for non-nuclear applications.

SIGNIFICANT CONCLUSIONS: Preliminary analyses indicate the fundamental efficacy of the concept in terms of MsNB size/scale from steady-state neutronics calculations, natural circulation, and heat transfer estimates. Further refined computational analyses are required to advance the technical understanding and to assess the technology readiness level for this concept.

NEXT STEPS: Micro Nuclear, Idaho National Laboratory, and a consortium of eight universities led by the University of Idaho have submitted a grant proposal to the U.S. Department of Energy. If awarded, funding will go toward the validation and completion of the initial MsNB design, including manufacturing at Premier Technology, a company based in Blackfoot, Idaho. Micro Nuclear also has been discussing a path forward with DOE's National Reactor Innovation Center program.