Cost Reduction of Advanced Integration Heat Exchanger Technology for Micro-Reactors

PI: Greg Nellis, UW-Madison

Collaborators: Mark Anderson, Michael Corradini (UW-Madison), Andrew Foss (INL), Harold Maguire (Westinghouse)

Program: Nuclear Reactor Technologies

ABSTRACT: _Micro-reactors have the potential to provide mobile, long life power and process heat for a variety of applications. These systems are inherently simple, safe, and reliable with a small footprint that enables easy transport and operation. The heat pipe micro-reactor is especially attractive; this concept utilizes a reactor in which fuel is interspersed with heat pipes to create a monolithic core with minimal moving parts. A substantial challenge with this approach is the heat pipe integration heat exchanger (HPIHX) required to integrate the condenser ends of the heat pipes with the end-user application. The potential application space for micro-reactors is large and therefore direct integration with power generation, chemical processing, and energy storage systems or indirect integration with HVAC and water purification systems may be required. The HPIHX technology is a high-cost component of the micro-reactor system that is also critical to its overall reliability and performance.

This project will specifically develop and demonstrate HPIHX technology based on the currently used printed circuit heat exchanger (PCHE) manufacturing and assembly approach. This approach has substantial advantages over competing HPIHX configurations including technical maturity, low cost, high heat transfer coefficients in a cross-flow configuration, compactness, low susceptibility to blockage, high pressure and temperature capability, and the ability to embed advanced fiber-based sensors. The proposed work will therefore develop a technology that advances the future deployment of micro-reactors by improving their system-level performance, reliability, and cost; specifically, the technology will facilitate their integration into a broad range of end-user applications.

The project will develop and integrate a detailed HPIHX component model with a lower order system model to allow optimization in the context of the Westinghouse eVinci micro-reactor/power block application. The resulting optimal HPIHX will be procured and demonstrated in sCO_2 at the UW-Madison. A second HPIHX system optimized for operation with N_2 will be procured and integrated with the MAGNET facility at INL in order to demonstrate the technology applied to a very different end-use application.

The key outcomes of the project include:

1. Development and validation of micro-reactor integration heat exchanger design tools.
2. Validation and verification benchmark data useful for relevant NEAMS systems codes such as SAM.
3. Development of further data for ASME Boiler Pressure Vessel code case for PCHE to be used for nuclear applications
4. Development of an optimal HPIHX design for the eVinci^{TM} micro-reactor.
5. Demonstration of a sub-size HPIHX for sCO_2 and N_2 working fluids.
6. Train several graduate students for future employment in the nuclear industry.