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#5-253 Westinghouse eVinci™ Microreactor Heat Pipe Flow Monitoring System

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Westinghouse Electric Company, LLC is developing the eVinci™ microreactor, a next generation reactor capable of rapid deployment to several unique energy applications. The eVinci™ is designed to produce an energy output of 5MWe and15MWth for eight or more full-power years before refueling. The microreactor's innovative heat pipe design combines technological innovation with the support of 60+ years of commercial nuclear design, engineering, and licensing experience. The eVinci's compact design allows for transportability and rapid, on-site deployment, reducing the costs of onsite construction. The distinctive eVinci™ design enables a cost-competitive and resilient power solution with superior reliability and minimal maintenance.
Unlike traditional Generation III water coolant reactors, the eVinci™ microreactor takes advantage of heat pipes to extract thermal energy from the reactor core. Heat pipes are exceptionally efficient heat transfer mechanisms, capable of moving thermal energy across its isothermal length with no moving parts, a typical heat pipe configuration can be seen in Figure 1. The heat transfer mechanism of a heat pipe is made possible by leveraging the transfer of energy between phase changes of the working fluid. A flow network is established within the heat pipe by creating a pressure boundary between the two phases of the working fluid. The high efficiency and reliability of heat pipes make them an ideal technology for application for the nuclear industry. eVinci™ heat pipes are designed to operate at temperature ranges greater than 800℃, enabling efficient conversion of thermal energy to electrical energy. Although temperature of the heat pipe is not the only variable that should be considered when discussing the transfer of thermal energy through the system. Recall that the heat pipe can generally be considered an isothermal system. As such, a heat pipe's power may fluctuate while its temperature stays constant. Unexpected fluctuations in heat pipe power can cause non-uniformities within the core and higher than designed stresses in the core. Therefore, there is a critical need to measure both power and temperature of a heat pipe during operation
Measuring heat pipe temperature is a non-technical challenge in the nuclear industry due to the large amount of well-established nuclear grade temperature sensing technology. However, measuring heat pipe power can prove to be a difficult task due to the heat pipes isothermal nature and closed flow network. Traditional methods for measuring heat pipe power use calorimetric heat balance measurements between the evaporator and condenser ends. Calorimetric balances work well in a controlled environment on a single heat pipe but is prohibitively complex when applied to a nuclear core block configuration . The core block configuration limits physical space for instrumentation on each individual heat pipe. Furthermore, the calorimetric balances do not provide direct insight into the thermodynamic flow conditions within a heat pipe. To address the need for a both heat pipe power and temperature measurements a non-invasive system is required to measure the power of heat pipes during operational temperatures exceeding 800℃.
To address the heat pipe power measurement knowledge gap and enable a more robust heat pipe measurement methodology, Westinghouse is developing an eddy-current based sensor system capable of measuring heat pipe power. The sensor designed by Westinghouse builds upon an established Eddy Current Flow Meter (ECFM) technology used in legacy molten metal fast reactors. The HPFMS does not perturb the flow and does not require penetration inside the hermetically sealed heat pipes. Testing of the system was conducted on a heat pipe at various temperatures and power conditions. The test conducted established first of a kind insights of heat pipe by actively measuring the internal flow dynamics of a heat pipe, and demonstrated the first application of an eddy current sensor at temperatures exceeding 800℃. The operational physics, sensor design, system engineering, experimental setup, and test results from the experiment will be discussed in this

report.

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