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#4-255 Experiment and sensor design of an in-core thermal conductivity measurement of metallic fuel

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Thermal conductivity of nuclear fuel systems is a critical parameter for reactor performance and safety, particularly under accident scenarios. An improved thermal conductivity probe, based on a modified line source technique, has been developed to measure the thermal properties of the surrounding material in which it is embedded. A pioneering irradiation experiment has been designed for the Advanced Test Reactor (ATR) at Idaho National Laboratory (INL) and is currently undergoing assembly. This experiment aims to measure the thermal property evolution of metallic fuel throughout irradiation using this probe. The metallic fuel, uranium with 10 weight percent zirconium (U-10Zr), is an ideal candidate for this experiment due to its high and growing commercial interest as a high-density, good thermal performance fuel, making it suitable for applications including compact high-power-density reactor designs (micro reactors). The experiment includes a reference stainless steel sample and three metallic fuel specimens: a sodium-bonded, slotted, and annular geometry. Each specimen enrichment is unique to establish prototypic sodium fast reactor linear heat generations rates in each specimen. The thermal conductivity changes that occur through interconnected porosity and sodium infiltration will be captured when sufficient fuel burnup is achieved over three ATR cycles. In addition to the transient line source method, the thermal conductivity probe also functions as a thermocouple, capable of measuring the centerline temperature in the fuel specimen. These temperature measurements, along with external boundary temperature measurements and heat generation rates, can serve as alternative measurements of the thermal conductivity of the specimens. This study will present the theory and fabrication process of the novel thermal conductivity probe, as well as its electronic operating mechanism based on resistivity measurements using a lock-in amplifier. A detailed discussion of the ATR experimental device and the incorporation of this unique instrumentation will be provided. Results from preliminary testing prior to irradiation will also be presented.

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