Needle Probe for Measuring Thermal Conductivity of Molten Salts

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Many advanced nuclear reactor designs feature molten salts as a coolant alternative to water. Molten salt reactors (MSR), due to thermophysical property advantages over water-cooled reactors, can be operated at higher temperatures and lower pressures, which may lead to improved efficiency and safety. However, the existing thermophysical property data of molten salts is largely deficient. This study seeks to measure the thermal conductivity of FLiBe and FLiNaK salts at high temperatures. The existing data of FLiBe and FLiNaK tends to contradict theory by showing a positive temperature dependence, which is hypothesized to be a result of measurement challenges associated with corrosion, electrical conduction, convection, and radiation. To overcome these obstacles, a modified transient hot-wire needle probe has been developed to test the molten salts in a concentric cylinder geometry. Rapid transient measurements and the concentricity of the probe, thin liquid layer, and crucible will limit natural convection and minimize radiation. The hot-wire apparatus is insulated and then sheathed in Nickel 200 to mitigate electrical conduction and corrosion. The experimental data, which is generated from a modulated heating input, will be analyzed in the frequency domain in order to improve the signal-to-noise ratio relative to traditional time-domain methods of needle probes to overcome limitations associated with the probe's complex geometry. The probe will be validated by testing in water at low temperatures, whose thermal conductivity values are well-established. Additionally, the analytical model, which relies on a thermal quadrupole mathematical approach, will be validated using COMSOL Multiphysics simulations. Ultimately, an accurate characterization of the thermal conductivity of FLiBe and FLiNaK will significantly improve the heat transfer models that govern the performance of advanced reactors and thereby allow nuclear energy to continue being competitive with other power generation technologies.