Investigating heat transfer in horizontal micro-HTGRs under normal and PCC conditions

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ABSTRACT:

Experimental research will be conducted to understand heat transfer inside graphite matrices and external reactor vessel surfaces of horizontal microscale High Temperature Gas-cooled Reactors (HTGRs) or micro-HTGRs. Horizontally-oriented micro-HTGRs are expected to be located inside a shipping or transport container and will dissipate heat to the air of the container which may be cooled naturally or by fans installed in the container. An advantage for micro-HTGRs for passive safety can be due to a larger surface-to-volume ratio thus heat dissipation rate per unit volume can be higher than in high power HTGRs. External convective heat transfer from the reactor vessel surface may vary strongly from bottom to top and can be influenced by the ambient container air flow induced by natural convection or forced convection via container exhaust fans. Convective and radiative heat transfer from the horizontal micro-HTGR can lead to azimuthal variation in vessel surface temperatures and heat flux, which can in-turn result in different internal cooling rates in different prismatic blocks and can impact block-to-block conduction/radiation heat transfer.

The existing scaled high temperature test facilities at KSU and CCNY will be used to simulate normal operation and Pressurized Conduction Cooldown (PCC). The focus of these experiments will be to generate flow and temperature benchmark data including the peak core temperature and peak vessel temperatures under PCC conditions. At KSU, an existing horizontal high temperature experimental facility, equipped with thermographic imaging and distributed temperature sensing, will be used to characterize the heat transfer in the horizontal prismatic blocks of graphite representing core and reflector regions. KSU will lead the investigation of conduction-radiation heat transport within the prismatic blocks and the heat transfer from outer boundary in a horizontal test set-up under loss of flow scenarios. At CCNY, a high pressure and high temperature flow loop exists for HTGR related research; it has been previously used to provide benchmark data. A unique feature of this facility is that the test section can be oriented horizontally. The facility can be operated under prototypical HTGR conditions and will be used to study flow laminarization under normal operating conditions and PCC scenarios. Both experimental setups at two universities will be placed in the scaled model of Transport ISO Container with provisions to allow for container air flow and infra-red sensors for monitoring of surface temperatures and cooling rates. Thermal maps of the vessel outer surface will be obtained using IR camera. Detailed temperature and flow data inside and outside the vessel will be obtained at both facilities and used to characterize heat transfer paths for horizontal micro-HTGRs from the core to vessel surface and container environment.