NATURAL CIRCULATION PASSIVE COOLING SYSTEMS AND FREEZING TRANSIENTS IN FLUORIDE-SALT COOLED, HIGH-TEMPERATURE NUCLEAR REACTORS (FHR)

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The Pebble-Bed Fluoride-Salt-Cooled High Temperature Reactor (PB-FHR) is an advanced nuclear reactor concept that combines high temperature and low pressure fluoride salt coolants with high-temperature pebble fuel elements. Conventional nuclear plants (and coal plants) produce heat at 400°C and below and are limited to running steam turbines with power conversion efficiencies below 34%. FHRs are an advanced reactor concept that can generate heat in the 600 - 700°C range, and can be coupled to commercially available gas turbines. Air Brayton turbines running at this temperature enable combined-cycle efficiencies of 65% and above, and provide the capability of natural gas co-firing for power peaking. The objective of the FHR technology is to be commercially competitive with natural gas plants, while providing a low-carbon emission source of energy, and to achieve a relatively short commercialization timeline by relying as much as possible on commercially available technology.

Liquid fluoride salts have very good performance as heat transport fluids; they are high Prandtl-number fluids, with high volumetric heat capacity, low vapor pressure up to 1000°C and above, relatively low viscosity, and high coefficient of thermal expansion. The FHR design takes advantage of the inherent and passive safety features enabled by the heat transfer properties of the fluoride salts and by the robust fuel. This presentation will provide an overview of the heat transport performance of molten fluoride salts in FHR, and of the natural circulation cooling system, on which the reactor relies for passive cooling during an accident scenario. This presentation will also discuss importance of understanding the solidification phenomenology of the salt in order to prevent and mitigate the consequences of overcooling transients.

Short Biography

Raluca Scarlat is an assistant professor at UW Madison in the Department of Nuclear Engineering and Engineering Physics. She has a Ph.D. in nuclear engineering from UC Berkeley, and a B.S. in chemical engineering from Cornell University. Prior to her doctoral studies she has worked for GE and ExxonMobil. In 2011, she advised for Hitachi-GE, in Japan, on post-Fukushima changes to severe accident guidelines for the Japanese fleet of reactors. She has published articles in Nuclear Engineering and Design, Nuclear Instruments and Methods, Journal of Engineering for Gas Turbines and Power, and Progress in Nuclear Energy. Her research interests are in the area of heat and mass transport, thermal-hydraulics, nuclear reactor safety and design, and engineering ethics.