ORNL Talk

TRITIUM TRANSPORT IN THE FLUORIDE-SALT COOLED, HIGH-TEMPERATURE NUCLEAR REACTOR (FHR) AND AN OVERVIEW OF FHR RESEARCH AT UW MADISON

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Fluoride-salt cooled high-temperature reactors (FHR) are cooled by liquid fluoride salt mixtures, and fuelled with solid fuel. The baseline coolant is flibe ($2LiF\text{-}BeF_2$). The fuel form is particle-encapsulated fuel (TRISO fuel particles), compacted in a graphite matrix to form fuel elements that can be spheres, plates, or other shapes, depending on the design. The baseline Mark 1 FHR design (designed by UC Berkeley) uses a nuclear air combined cycle (NACC) for power conversion, and the primary salt is used to directly heat compressed air in coiled tube air heaters (CTAHs). The goal of FHRs is to provide an energy technology with a short commercialization timeline and significant safety advantages compared to advanced light water nuclear reactors currently under construction, at costs that are competitive with natural gas power plants.

Tritium is produced in the PB-FHR core from neutron activation of ^6Li in the fluoride salt coolant, and all of the isotopes of hydrogen readily diffuse through metallic structures at the reactor operational temperatures of 600 to 700^oC. The CTAH are the dominant leakage path of tritium from the reactor system to the atmosphere. The FHR core produces on the order of 1000 times the tritium emitted as liquid and gaseous effluents by pressurized water reactors (PWRs) operating today in the United States, per electrical power produced. It is the intent of the FHR designers to maintain normal operation tritium emission rates close to those from PWRs. Thus, an additional sink for tritium must be designed into the PB-FHR salt coolant system, in order to keep the tritium air emission rates under one thousandth of the tritium production rate in the core.

The graphite matrix fuel elements have the potential of acting as an effective tritium sink for the core. This presentation will present the ongoing research at UW Madison on characterizing the phenomenology for hydrogen isotope transport in flibe and in the graphite matrix fuel elements, and will provide an overview on the modeling efforts for quantifying the effectiveness of the fuel elements as a tritium sink for the FHR system. This presentation will also provide an overview of other ongoing research projects at UW Madison, with application to the FHR, in the areas of corrosion, chemistry control, and thermal-hydraulics.

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 as a chemical engineer 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.