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Molten Salt Corrosion in Nuclear Energy Systems

Abstract:

Molten salts have many applications in nuclear engineering, for example, pyroprocessing for used nuclear fuel treatment for which molten chloride salts are used, and molten salt reactors for which both chloride salt (molten salt fast reactors) and molten fluoride salts (molten salt thermal reactors) are used. All those systems are operated at high temperatures. Available knowledge has shown the molten salts are corrosive to most of common structural materials such as stainless steels. The corrosion become more severe when there are impurities that affects the redox potential such as oxygen and HF. For pyroprocessing, the accumulation of dissolved fission products may change the redox potential of the salt solution and increase corrosion. On the other hand, an oxide reduction process is needed to covert oxide fuels into their metallic forms for electrorefining, during which oxygen is produced at the anodic electrode. The oxygen also changes the redox potential. For molten salt reactors, the impurities in the salt may come from fission, corrosion, transmutation as well as air and water ingestion. All these impurities may change the redox potential and leads to corrosion. For example, the corrosion product FeCl_2 can be an oxidant of Cr which is structural materials and lead to formation of CrF_2 or CrF_3 .

Therefore, one of key concerns of using molten salt in nuclear applications is their compatibility with structural materials. The present seminar will cover both experimental measurements including loop tests, crucible tests and electrochemical tests and modeling predictions including electrochemical and mass transfer models on both molten chloride and fluoride salt corrosion. The metallurgical factors, the historical development of corrosion resistant alloys and recent attempts, the key environmental factors influencing corrosion in various nuclear systems, electrode kinetics, thermodynamic properties, and the corrosion prevention techniques will be analyzed. Based on the available data, the mechanisms of the corrosion will be discussed and the corrosion mitigation methods are proposed. One of the corrosion mitigation methods is to control the redox potential, therefore, the seminar will analyze the current available redox control methods. Some fission products, such as Te, also plays important roles on molten salt corrosion. This seminar will also analyze the fission product effects on material corrosion, especially, on the inter granular cracking corrosion of Ni-base alloys.

Bio:

Prof. J. Zhang has been a professor of the Nuclear Engineering program in Virginia Polytechnic Institute and State University since January 2017. He was an associate professor at the Ohio State University (OSU) through Sept. 2012 to Dec. 2016. Before that, Prof. Zhang had been a staff scientist of Los Alamos National Laboratory (LANL) through 2004 to 2012, and a postdoc research associate through 2001 to 2004. Prof. Zhang is the director of the Nuclear Materials and Fuel Cycle Research Center. The center focuses on studies of advanced used nuclear fuel reprocessing, safeguards and non-proliferation, nuclear materials, material compatibility and materials corrosion in advanced and current nuclear reactors. Ongoing research activities in Prof. Zhang's research team are: 1) Nuclear Materials compatibility (materials corrosion, degradation and characterization, FCCI of metallic nuclear fuel), 2) Nuclear Fuel Cycle Technology, 3) Electrochemical Separation and technology development, 4) Advanced Coolant and cladding Materials. Prof. Zhang has published 100+ peer reviewed Journal papers.



Faculty Host: Professor Guang Lin If you would like to meet Dr. Zhang please contact secretary Maggie at hao41@purdue.edu for scheduling assistance.