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Numerical modeling of oxygen mass transfer in a wire wrapped fuel assembly under flowing lead bismuth eutectic

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Abstract

Corrosion of steels in lead bismuth eutectic (LBE) cooled reactors can be mitigated by forming a protective oxide layer on the steel surfaces. The amount of oxygen necessary to ensure continuous oxide layer formation on fuel cladding depends on the characteristics of the steel and on the local temperature, local oxygen concentration and velocity of the LBE in contact with the steel. The most critical areas from a corrosion point of view are high temperature and low oxygen concentration regions. Wire-wrapped fuel assemblies (FAs) which are foreseen to be used in LBE cooled reactors, are characterized by hot spots and quasi-stagnant areas where oxygen could be depleted. Experimental measurements to verify whether the oxygen concentration in those critical areas is sufficiently elevated for oxide layer formation, are practically impossible . This information can be however obtained by numerical modeling. This paper focuses on the development of a numerical model of oxygen mass transfer in a 19-pin scaled fuel assembly (FA) representative of the MYRRHA reactor core. Oxidation of steels and oxygen transport from the bulk of the LBE to the surface of steels were simulated simultaneously. The simulations provide a local oxygen concentration mapping at steel/LBE interface enabling to identify the regions of the core which could be prone to corrosion due to oxygen depleted LBE. Operation recommendations for the MYRRHA reactor were given based on the simulation results.

Keywords

Lead bismuth eutectic (LBE), oxygen mass transfer, oxidation, wire wrapped fuel assembly.

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