Numerical models used for the modelling of the transport of fibrous insulation debris

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Abstract

Mineral wool insulation material applied to the primary cooling circuit of a nuclear reactor maybe damaged in the course of a loss of coolant accident (LOCA). The insulation material released by the leak may compromise the operation of the emergency core cooling system (ECCS), as it maybe transported together with the coolant in the form of mineral wool fiber agglomerates (MWFA) suspensions to the containment sump strainers, which are mounted at the inlet of the ECCS to keep any debris away from the emergency cooling pumps. In the further course of the LOCA, the MWFA may block or penetrate the strainers. In addition to the impact of MWFA on the pressure drop across the strainers, corrosion products formed over time may also accumulate in the fiber cakes on the strainers, which can lead to a significant increase in the strainer pressure drop and result in cavitation in the ECCS. Therefore, it is essential to understand the transport characteristics of the insulation materials in order to determine the long-term operability of nuclear reactors, which undergo LOCA.

An experimental and theoretical study performed by the Helmholtz-Zentrum Dresden-Rossendorf and the Hochschule Zittau/Görlitz[1] is investigating the phenomena that maybe observed in the containment vessel during a primary circuit coolant leak. The study entails the generation of fiber agglomerates, the determination of their transport properties in single and multi-effect experiments and the long-term effects that particles formed due to corrosion of metallic containment internals by the coolant medium have on the strainer pressure drop.

The focus of this presentation is on the numerical models that are used to predict the transport of MWFA by CFD simulations. A number of pseudo-continuous dispersed phases of spherical wetted agglomerates can represent the MWFA. The size, density, the relative viscosity of the fluid-fiber agglomerate mixture and the turbulent dispersion all affect how the fiber agglomerates are transported. In the cases described here, the size is kept constant while the density is modified. This definition affects both the terminal velocity and volume fraction of the dispersed phases. Only one of the single effect experimental scenarios is described here that are used in validation of the numerical models. The scenario examines the suspension and horizontal transport of the fiber agglomerates in a racetrack type channel. The corresponding experiments will be described in an accompanying presentation (see abstract of Seeliger et al.).

Keywords: Mineral Wool Fiber Agglomerates, Loss of Coolant Accidents, Containment Sump, Computational Fluid Dynamics, Multiphase Flow

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