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Experimental study on sodium insulation interaction and its effect on structural material

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Sodium, owing to its high heat transfer properties and excellent compatibility with structural materials is the preferred coolant for Liquid Metal cooled Fast Breeder Reactors (LMFBR). Apart from its favorable properties, sodium also poses a concern due to high chemical reactivity with air. Accidental sodium leaks from secondary circuit may result in fire due to sodium reaction with oxygen and moisture in ambient air. Usually, leak incidents with leak rates above 100 g/h are detected by leak sensors. However, if the leak origin is a pin hole or a hairline crack, sodium leak can go undetected and may not lead to fire. In fact, sodium reacts with thermal insulation mounted over the piping and oxygen available within leak vicinity. The solid reaction products can settle near the leak path and eventually plug the leak path, even before the leak detectors respond. The structural material at the leak zone can undergo localized degradation under the influence of sodium, oxides and other reaction products of sodium. A detailed experimental investigation was carried out to study sodium interaction with thermal insulation and effects of reaction products on the structural material. Sodium leak experiments were performed with rock wool insulation and specimens of SS-316 LN at a temperature of 300oC in air. Subsequently, post test analysis of the samples by using X-ray Diffraction (XRD) revealed presence of silicates and aluminates of sodium in the outer layers and complex ternary and quaternary oxides of sodium, iron, chromium and nickel in the inner layers. Field Emission Scanning Electron Microscopy (FESEM) analysis of the specimen revealed deposition of oxides on the exposed surface. Elemental analysis of samples was carried out by Energy Dispersive Spectroscopy for deducing the leaching of chromium, nickel and iron from the exposed surface. Fatigue crack growth test of the exposed specimen was done for assessment of reduction in fatigue life. The paper briefs about the interaction of sodium with thermal insulation, characterization methods for reaction product analysis and consequent degradation of structural material.

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