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Thermal hydraulic investigation of sodium fire and hydrogen production in top shield enclosure of an FBR following a core disruptive accident

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During Core Disruptive Accident (CDA) in a pool type SFR, primary sodium from hot pool is expelled into the top enclosure, which is vented to reactor containment building (RCB). Sodium coming in contact with oxygen and moisture undergoes combustion and forms sodium oxide / sodium peroxide and hydrogen releasing large amount of heat. The phenomenon of sodium combustion in the form of pool fire and reaction of sodium with moisture present in the air producing hydrogen has been mathematically modeled. The rate of reaction is taken as a function of the oxygen concentration and moisture content in the air. Various parameters, viz., temperature, pressure, density, inlet and outlet air flow rates in the enclosure are estimated by numerically solving the appropriate governing equations. A rapid increase in enclosure pressure is observed initially at the start of combustion but it falls afterwards when natural circulation of RCB air is established. Concentration of various constituents of air in the enclosure, viz., oxygen, nitrogen, moisture and hydrogen are estimated during the combustion period. It is found that the hydrogen concentration in the enclosure is within auto ignition limit. As the combustion starts, hydrogen concentration increases, remains fairly constant during stable combustion period and comes down after the reaction is over. Heat absorbed by structural materials within the enclosure is calculated and it is found that the rise in temperature of the structural materials is within 10℃. Sensitivity of the results to the values of emissivity and humidity has been assessed.
Considering the formation of sodium peroxide during combustion, it is found that the duration of combustion is longer as compared to the reaction forming only sodium oxide. Hydrogen concentration in the enclosure increases in this reaction. The maximum temperature of air is found to increase by ˜ 25 K due to the formation of sodium peroxide. By considering the reaction rate as a function of available sodium, the duration of combustion increases and the maximum temperature in the enclosure decreases with the peak hydrogen concentration remaining nearly same. Full paper would address the modeling approach and evolution of various parameters and sensitivity analysis.

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