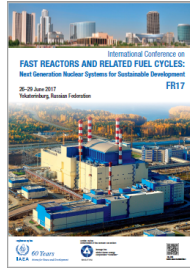


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Computational modeling of flow blockage in fuel subassemblies and molten material relocation in sodium cooled fast reactors

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The heat generating fuel pins in Sodium cooled Fast Reactors (SFR) are arranged in a tightly packed triangular pitch within a hexagonal sheath forming a fuel subassembly (SA). Due to the compact design, formation of local flow blockage inside the SA is possible. Such blockages are expected to grow gradually and the core monitoring thermocouples which are located at the top of the SA are capable of detecting these blockages at their infancy. But, large size blockages may not be detected by the thermocouples due to low velocity of sodium issuing from the blocked subassembly eventually leading to core damage. The extent of damage propagation before reactor shuts down depends on the size of the blockage and its rate of growth. The thermal hydraulics phenomena involved during damage progression are very complex, involving phase change heat transfer with moving solid-liquid interfaces. To investigate (i) the sequence of damage progression, (ii) possibility of Total Instantaneous Blockage (TIB) detection by online monitoring of the sodium outlet temperature from the neighboring SA and (iii) determination of number of SA that are likely to get damaged severely before reactor shutdown etc. a transient enthalpy based thermal hydraulic model has been developed. The transient model considering multi-material and multi-phase flow features adopts an explicit finite difference method employing Voller's algorithm for interface tracking. The model has been validated against published benchmark data. The SA that are likely to get damaged during a TIB event is determined to be seven.

During a CDA, a significant fraction of the hot molten fuel moves downwards and gets relocated to the core catcher. The core catcher design requires prior knowledge of core-melt relocation time which is the time taken for the molten fuel to reach the lower plenum from the active core region. The initial thermal load on the core catcher is primarily dictated by the core melt relocation time. By mathematical models, upper and lower bounds for core-melt relocation time for postulated accident conditions of Protected Loss of Heat Sink (PLOHS) accident and Unprotected Loss of Flow Accident (ULOFA) have been determined. The potential of a multi layer core catcher in handling the debris generated from a whole core melt down accident has been assessed by CFD studies.

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