Development and Validation of a CFD code to Model Accidental Leak of Water/Steam/Hydrogen in BWR during a Beyond Design Basis Accidents

PK Malhotra, SG Ghadge, NPCIL, India
Anil Kumar, Fluidyn, India

In a Boiling Water Reactor a break of the re-circulation line and the failure of the Emergency Core Cooling System will cause a leak of a mixture of liquid water, steam, and hydrogen at high pressures into the drywell. This leak has a potential to create an explosive mixture of hydrogen, air and steam. The objective of this work is to develop a CFD model to compute the distribution of hydrogen, steam and air during such 'Beyond Design Basis Accidents'.

Typically the sequence of the above mentioned accidents is characterized by large flow rates, of the order of a few thousands of kg/s, through the leaks for prolonged periods of a few thousands of seconds. Combined with the large volumes of the computational domains and long periods of the interest to be handled, the short time-scales associated with the large flow rates makes the accurate calculation of such scenarios highly time consuming affair. The objective of the present work is to develop a numerical model which can reduce the overall time required to conduct such studies. The CFD model developed during this work uses an implicit method for time integration of the three dimensional Navier-Stokes equations. The spatial discretization is done using a Finite Volume Method. The two phase flow is modeled by a homogeneous equilibrium model using various sub-models for phase change in the bulk and near the walls. The heat transfer through the various structures present inside and around the flow domain is modeled using Finite Element Method. The CFD model is validated against the measurements available from various experiments, such as the one conducted in ThAI facility. The calculations conducted so far suggest that the implicit method can reduce the computational time by about a factor of three compared to fully explicit methods. The model is further extended to unstructured grids and is being parallelized. These modifications reduce the overall calculation times by decreasing both the time required to set-up the physical problem (including the geometry and mesh) and the computational times further.