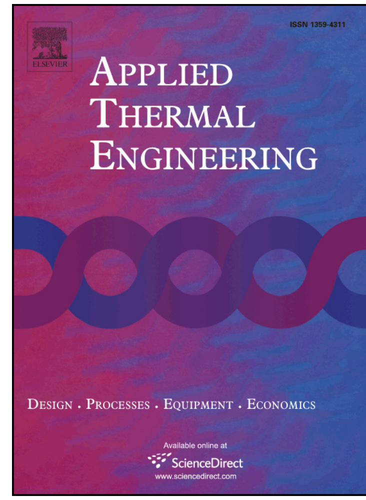

Thermal Hydraulic and Stress Coupling Analysis for AP1000 Pressurized Thermal Shock (PTS) Study under SBLOCA Scenario

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Thermal Hydraulic and Stress Coupling Analysis for AP1000 Pressurized Thermal Shock (PTS) Study under SBLOCA Scenario

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Abstract: Pressurized Thermal Shock (PTS) analysis for AP1000 under Small Break Loss of Coolant Accident (SBLOCA) was performed in this paper. The three-dimensional models of Direct Vessel Injection (DVI) line, Reactor Pressure Vessel (RPV) nozzles and downcomer were established. The mathematic models of three-dimensional thermal hydraulic and stress analysis were introduced. The numerical simulation of thermal-hydraulic mixing was carried out using Computational Fluid Dynamics (CFD) method under SBLOCA scenario. It was found that the temperature distribution in RPV downcomer depended on the injection velocity relative to cross-flow greatly. The RPV cooling center region was moving up with the increase of injection velocity. The temperature distribution was non-uniform along the circumferential orientation on RPV wall and the great temperature gradient was generated between the cooling center and other regions. The AP1000 RPV stress analysis was performed using Finite Element Analysis (FEA) method following thermal-hydraulic mixing study. Results show that the most critical zone was located in the DVI nozzle chamfering under SBLOCA transient. The stress was mainly induced by high temperature gradient and the maximum stress occured when the wall temperature has the largest reduce rate. This work is meaningful for the structure integrity study of AP1000 nuclear power plant.

Keywords: AP1000, Pressurized Thermal Shock, Thermal hydraulics, Stress analysis, LOCA

1. Introduction

The Reactor Pressure Vessel (RPV) is very important equipment in a nuclear power plant, the structure integrity of which should be maintained throughout the whole plant life. The reactor RPV may suffer high thermal stress with extremely thermal gradient led by rapid cooling under the condition of Loss of Coolant Accident (LOCA) transient [1]. The critical operation condition,