Transient Response of Thermal Stress at a PWR Pressurizer Surge Line Pipe Subjected to Internally Thermal Stratification

Jong Chull Jo, Seon Jae Kim, Young Hwan Choi, and Hho Jung Kim
Korea Institute of Nuclear Safety
19 Kusung-dong, Yusung-ku, Taejon 305-338, Korea

Abstract

This paper presents the numerical calculation results of the transient response of thermal stress at a pressurizer surge line pipe model of pressurized water reactor (PWR) subjected to internally thermal stratification. The transient temperature distributions in the piping system used as the requisite input data for the stress analysis are obtained by conducting three-dimensional numerical analysis of the unsteady conjugate heat transfer for the piping system with a finite wall thickness. A primary emphasis of the present study is placed on the investigation of the effects of surge flow direction on the determinations of the thermal stress distributions in the pipe wall. In the present numerical analysis, the thermally stratified flows (insurge and outsurge flows) in the pipeline are simulated using the standard $\kappa-\varepsilon$ turbulent model. The unsteady conjugate heat transfer analysis method is implemented in a finite volume thermal-hydraulic computer code based on a non-staggered grid arrangement, SIMPLEC algorithm and higher-order bounded convection scheme. The finite element code ANSYS is employed for the thermal stress analysis to calculate non-dimensional stress distributions at the piping wall as a function of time. Some numerical calculations are performed for a simplified PWR pressurizer surge line piping model with a shortened length, subjected to internally thermal stratification caused either by insurge or outsurge flow with a specified velocity, and the results are discussed in detail.