Two-Dimensional Unsteady Conjugate Heat Transfer Analysis of a PWR Pressurizer Surge Line Pipe Subjected to Internally Thermal Stratification

Jong Chull Jo, Yun Il Kim, Sang Jin Cho, Ju Yeop Park, and Sang Jae Kim
Korea Institute of Nuclear Safety
19 Kusung-dong, Yusung-ku, Taejon 305-338, Korea

Abstract

This paper addresses two-dimensional numerical analysis of the unsteady conjugate heat transfer in a PWR pressurizer surge line pipe subjected to internally thermal stratification. The analysis is performed both for the out-surge and in-surge flows in the pressurizer surge line. In the present numerical analyses, the thermally stratified flow in the pipe line during both surge flows are modeled as natural convection for the case where the stratified flow is at a standstill or forced convection for the case where the stratified flow flows slowly enough to be a laminar flow. The finite volume method presented in this paper employs a body-fitted, non-orthogonal grid system to accommodate the pipe wall of circular geometry and the variable interface of the two fluids at different temperatures. This study investigates in detail the effects of surge flow direction, surge flow velocity and interface level of the two thermally stratified fluids on the determination of the transient temperature distributions in the pipe wall. As the result, the circumferential temperature distributions in the pipe wall obtained by changing the interface level of the stratified level are found to be physically plausible. In addition, it is shown that the predictions without taking account of the effects of surge flow direction and velocity can yield less conservative results of the temperature gradients and thermal stresses in the pipe wall. Therefore, it is recommended to take into account the surge flow direction and velocity effects in the analysis for determining reasonably the temperature distributions in the pipe wall subjected to internally stratified flow.