Comparative study of CFD and 3D thermal-hydraulic system codes in predicting natural circulation phenomena in a small-scale pool test facility

Audrius Grazevicius[1], Anis Bousbia-salah[2]
[1]Laboratory of Nuclear Installation Safety, Lithuanian Energy Institute, Breslaujos str. 3, LT-44403, Kaunas, Lithuania
[2]Bel V, Walcourtstraat 148, 1070 Brussels, Belgium

Abstract:

Natural circulation phenomena have been nowadays largely revisited after the Fukushima-Daiichi accident. The objectives were to investigate the possibilities to incorporate passive safety systems for heat removal under accidental conditions. Generally, systems consisting in large pools of water are used to provide heat sink for removing heat from the reactor or containment buildings. Such process provide reliable and efficient emergency cooling specially for design extension conditions including multiple failure accidents. Therefore detailed flow information, such as multi-dimensional local temperature and flow velocity, turbulence intensity, and turbulent energy, is required to evaluate the multi-dimensional flows and their associated heat transfers mechanisms. Assessment studies of such phenomena rely generally on CFD codes having the capabilities to describe the 3D microscopic phenomena occurring at small-scale geometries. However, recent studies emphasized the possibilities to use the capabilities of 3D thermal-hydraulic system codes for some specific cases [1]. Generally, acceptable results are obtained. However, due to the lack of validation using experimental data, the predictions of such tools may not be accurate especially for natural flow regimes where complex phenomena like flow mixing, temperature stratification, flow recirculation and instabilities, could take place.

In the present study, an experimental test case based on a small-scale pool test rig experiment performed by Korea Atomic Energy Research Institute [2], is considered for code-to-code and code-to-data comparison. The assessment is carried out using the ANSYS Fluent and the 3D thermal-hydraulic system CATHARE codes. The objective is to assess and compare their prediction capabilities with respect to the experimental measurement. It was observed that, notwithstanding the numerical and modelling differences in the used approaches, similar prediction results are obtained. Nevertheless, additional investigations efforts are still needed for a better representation of the considered phenomena.

References

[1] A. Bousbia salah, j. Vlassenbroeck, Assessment of the CATHARE 3D capabilities in predicting the temperature mixing under asymmetric buoyant driven flow conditions, Nucl. Eng. Des., 265, 469, 2013.
[2] S. Kim, D. E. Kim, S. U. Ryu, S. T. Lee, D. J. Euh, Experimental investigation on the natural convection flow in pool boiling, Nucl. Eng. Des., 280, 262-268, 2014.