PREDICTION OF A SUBCOOLED BOILING FLOW WITH MECHANISTIC WALL BOILING AND BUBBLE SIZE MODELS

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Extended Abstract

Subcooled boiling is one of the crucial phenomena for the design, operation and safety analysis of a nuclear power plant. In recent years, developers of multiphase CFD (Computational Fluid Dynamics) codes focused their development activity on the mechanistic prediction of DNB (Departure from Nucleate Boiling) in PWR. Wall boiling model is one of the key parameters for this purpose. In order to enhance prediction capability of the subcooled boiling flow, an advanced wall boiling model consisting of a mechanistic bubble departure model (Klausner et al., 1993), Hibiki et al.'s (2009) active nucleate site model and Cole's bubble departure frequency model was explored for the CFD code. To ensure a wide range applicability of the advanced wall boiling model, each model was evaluated separately according to the flow conditions such as pressure, temperature and flow rate. Finally, the advanced wall boiling model was implemented into the STAR-CD as a form of user FORTRAN file. One of the other important parameters for an accurate prediction of the subcooled boiling flow is bubble size which governs interfacial transfer terms between two phases. In this study, the S-gamma model, which was developed for the STAR-CD (Lo, 2006), was applied as a bubble size model.

For the validation of the present wall boiling and bubble size models, benchmark calculations were carried out against SUBO and DEBORA subcooled boiling flow data. Working fluid of SUBO test is steam/water and its pressure condition is about 2 bars. In contrast to this, working fluid of DEBORA test is Refrigerant-12 (R-12) and phasic density ratio of the tests is equivalent to that of steam/water around 90~170 bars. Therefore, present benchmark calculation covers wide range pressure condition of steam/water.

The calculation results confirms that the new mechanistic wall boiling and bubble size models follow well the tendency on the change of flow conditions and they can be applicable to the wide range of flow conditions including nominal and postulated accidental conditions of nuclear power plant.