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SIMULATIONS OF THE KETTLE REBOILER SHELL SIDE THERMAL-HYDRAULICS WITH DIFFERENT TWO-PHASE FLOW MODELS

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ABSTRACT

A CFD approach is presented for the simulation and analyses of the kettle reboiler shell side thermal-hydraulics with two different models of two-phase flow - the mixture and two fluid model. The mixture model is based on solving one momentum equation for two-phase mixture flow and a closure law for the calculation of the slip between gas and liquid phase velocities. In the two fluid modeling approach the momentum balance is formed for each phase, while the gas-liquid interaction due to momentum exchange at the interface surface is predicted with an empirical correlation for the interface friction coefficient. In both approaches the two-phase flow is observed as two inter-penetrating continua. The models are solved for the two-dimensional geometry of the kettle reboiler shell side vertical cross section. The CFD numerical method based on the SIMPLE type algorithm is applied. The results of both liquid and vapour velocity fields and void fraction are presented for each modeling approach. The calculated void fraction distributions are compared with available experimental data. The differences in the modeling approaches and obtained results are discussed. The main finding is that the void fraction distribution and two-phase flow field strongly depends on the modeling of the slip between liquid and gas phase velocity in mixture model or on the interface friction model in two fluid model. The better agreement of the numerically predicted void fraction with the experimental data is obtained with the two fluid model and an interfacial friction model developed for the conditions of two-phase flows in large volumes of kettle reboilers or different designs of steam generators.

KEYWORDS

kettle reboiler, thermal-hydraulics, numerical simulation, computational fluid dynamics

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REFERENCES [view full list]

1. Dowlati R., Kawaji M., Chan A.M.C., Pitch-to-diameter effect on two-phase flow across an in-line tube bundle, AIChE J. 36 (1990) pp. 765 772
2. Whalley P.B., Hewitt G.F., Reboilers, in: G.F. Hewitt, J.M. Delhaye, N. Zuber (Eds.), Multiphase Science and Technology, vol. 2, Hemisphere Publ. Co. (1986), pp. 275 331
3. Tujikura Y., Oshibe T., Kijima K., Tabuchi K., Development of passive safety systems for Next Generation PWR in Japan, Nucl. Eng. Des. 201 (2000) pp. 61 70
4. Dowlati R., Chan A.M.C., Kawaji M., Hydrodynamics of two-phase flow across horizontal rod bundles, J. Fluids Eng. 114 (1992) pp. 450 456
5. Dowlati R., Kawaji M., Chan A.M.C., Two-phase crossflow and boling heat transfer in horizontal tube bundles, J. Heat Transfer 118 (1996) pp. 124 131
6. King M. P., Jensen M. K., Local heat transfer and flow pattern distributions in a kettle reboiler, Two-Phase Flow Modelling and Experimentation (1995) pp. 1289-1296
7. Gebbie J.G., Jensen M.K., Void fraction distributions in a kettle reboiler, Exp. Therm. Fluid Sci. 14 (1997) pp. 297 311
8. Burnside B.M., 2-D kettle reboiler circulation model, Int. J. Heat Fluid Flow 20 (1999) pp. 437 445
9. Edwards D.P., Jensen M.K., A two-dimensional numerical model of two-phase heat transfer and fluid flow in a kettle reboiler, HTD-159, Phase Change Heat Transfer ASME, (1991)
10. Pezo M., Stevanovic V.D., Stevanovic Z., A two-dimensional model of the kettle reboiler shell side thermal-hydraulics, accepted for the publication in International Journal of Heat and Mass Transfer, (2005), available on-line at www.sciencedirect.com
11. Sanyal, J., Vasquez, S., Roy, S., Dudukovic, M.P., Numerical simulation of gas-liquid dynamics in cylindrical bubble column reactor, Chemical Engineering Science, 54 (1999) pp. 5071-5083
12. Rasohin, N.G., Nuclear Power Plants Steam Generators, Atomizdat, Moscow, 1980.
13. Groeneveld D.C., Snoek C.W., A comprehensive examination of heat transfer correlations suitable for reactor safety analysis, in: G.F. Hewitt, J.M. Delhaye, N. Zuber (Eds.), Multiphase Science and Technology, vol. 2, Hemisphere Publ. Co., (1986) pp. 189 193
14. Ishii M., Zuber N., Drag coefficient and relative velocity in bubbly, droplet or particulate flows, AIChE J. 25 (1979) pp. 843 855
15. Rousseau J.C., Houdayer G., Advanced Safety Code CATHARE Summary of Verification Studies on Separate Effects Experiments, in: Proceedings of the Second International Topical Meeting on Nuclear Reactor Thermal Hydraulic-NURETH 2, Santa Barbara, USA, 1983
16. Spalding D.B., Developments in the IPSA procedure for numerical computation of multiphase-flow phenomena with interphase slip, unequal temperatures, etc, in: T.M. Shin (Ed.), Numerical Properties and Methologies in Heat Transfer, Hemisphere Publ. Co., (1983) pp. 421 436
17. Pezo M., Two-dimensional numerical simulation and analyses of the kettle reboiler shell side thermal-hydraulics, Master Thesis, University of Belgrade, 2004
18. Cornwell K., Duffin N.W., Schuller R.B., An experimental study of the effects of fluid flow on boiling within a kettle reboiler tube bundle, ASME Paper No. 80-HT-45