Preliminary CFD simulation of critical heat flux for subcooled water flow boiling in vertical heated tubes

*Kai Wang[1], Nejdet Erkan[1], and Koji Okamoto[1]

[1]The University of Tokyo.

Eulerian two-fluid model coupled with an extended RPI wall boiling model was applied to simulate the departure from nucleate boiling (DNB) under ultra-high critical Heat Flux (CHF) in vertical heated tubes by using CFD.

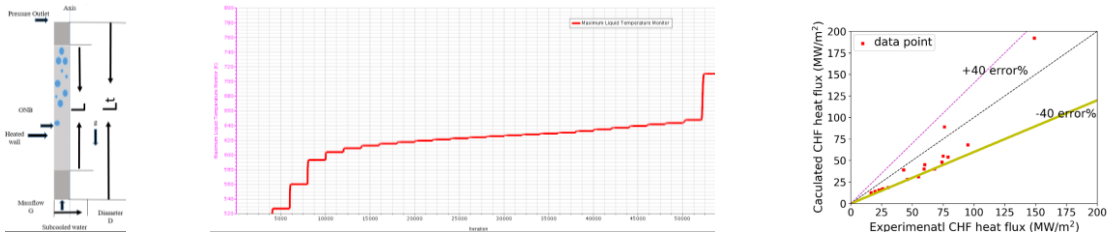
Keywords: Subcooled boiling; Ultra-high critical heat flux; DNB; Critical heat flux model

1. Introduction

One of the most important issues in the nuclear filed is the two-phase flow phenomena with boiling, and subcooled boiling has drawn much attention due to its high heat transfer coefficient. Li et al. [1] used Eulerian Two-fluid model coupled with extended wall boiling model was used to simulate the CHF in both uniform and non-uniform vertical heated tubes under high pressures by using STAR-CCM+.

2. Results

Eulerian multiphase model as well as interphase mass, momentum and energy transfer models is applied to consider the none-equilibrium between two phases. These models are calculated based on the interfacial area density model. Subcooled boiling at wall is modelled by the RPI wall boiling model proposed by Kurul and Podowski [2].



(a) Model (b) Maximum wall temperature change (c) Comparison of calculated CHF with experiment

Fig.1 Simulation results

The schematic image of the tube was shown in fig.1.(a), In the CFD simulation, the inlet subcooling and other boundary conditions are maintained throughout the simulation, only the wall heat flux is increased step by step, usually 2000 kW/m^2 at the beginning small heat flux, 1000 kW/m^2 when the heat flux comes to about 80% of the CHF. At each value of heat flux, the maximum wall temperature is monitored and the maximum wall temperature varying with integration shown in fig.1.(b). Fig. 1.(c) shows the comparison of all the predicted CHF with the experimental data. The prediction meets well with the experimental data. Most of the prediction errors are within 40%. It can be concluded that the boiling curves based on CFD approach can give a good prediction for CHF in a wide range of conditions. But further work can be done to improve the prediction accuracy.

3. Conclusion

Eulerian two-fluid model coupled with extended RPI wall boiling model can be used in the simulation of ultra-high CHF phenomena.

References

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