Study on the Mechanism of Vapor Film Collapse in Film Boiling around a Vertical Finite-Length Cylinder

Nagasaki University Graduate School of Engineering

Win Pa Pa Myo

ABSTRACT

Saturated and subcooled film boiling heat transfer around a vertical finite-length cylinder has been investigated analytically to predict the local heat transfer coefficients at the bottom surface and vertical lateral surface with smooth vapor-liquid interface. Correlations of heat transfer for the vertical finite- length cylinder with top and bottom horizontal surface has been already analyzed by Momoki et al.(2007) and this correlations equations for heat transfer are in good agreement with the experimental data in prediction the average heat transfer rate of the cylinders in saturated and subcooled water. In the present study, experimental observation results on vapor film collapse start from the lower corner of the silver vertical finite-length cylinder is focused to discuss with the local heat transfer characteristic and we would like to applied this correlations to estimate the local and average heat transfer rate at the corner of the horizontal bottom and vertical lateral surfaces of the cylinder. However, these correlations on local heat transfer rate at the end of the bottom surface gives infinite value and its cannot apply in discussion of film collapse start. So, to examine the local heat transfer characteristic at the corner of the bottom surface and vertical lateral surface, Shigechi et al.(1999) analysis for film boiling heat transfer on horizontal bottom surface was modified in order to get finite vapor film thickness at the end of the bottom surface to predict finite value of local heat transfer coefficient at this end. In this modification, the vapor film thickness at the end of the bottom surface can be predicted to estimate the local heat transfer rate and the prediction of the average heat transfer rate are also in good agreement with the results of the previous method. Moreover, the local heat transfer coefficient at the end of the bottom surface can be predicted and discussed local heat transfer characteristic at the lower edge of the vertical cylinder.

The local heat transfer rate through the bottom surface and vertical lateral surface are described in terms of local Nusselt number with degree of superheat and by applying average heat transfer rate through on each surface of the cylinder, total heat transfer rate of the cylinder can be predicted and its match well with the experimental total heat transfer rate with ±15 % .The results on local heat transfer coefficient shows the highest value at the corner of the bottom surface and vertical lateral surface and it can be confirmed the experimental results of the vapor film collapse start at the lower corner of vertical silver cylinder on saturated film boiling.

In order to predict and investigate the local heat transfer performance on the horizontal bottom and vertical lateral surfaces in subcooled film boiling, we apply the average heat transfer enhancement factor by the liquid subcooling to the estimated local values by the methods for saturated film boiling on each surfaces. Local heat transfer rate at the lower end of the vertical lateral surface are found higher than any other area of the cylinder surface in subcooled film boiling and it suggests the lowest temperature at that corner to be film collapse start. Furthermore, the temperature field inside the vertical cylinder is treated as the two dimensional unsteady heat conduction problem and the boundary condition at the cylinder surfaces are given as the local heat transfer coefficient at the bottom surface and vertical lateral surface with smooth vapor-liquid interface. It was also found that the lowest temperature point is at the corner of the bottom surface and vertical lateral surface and it agrees with the vapor film collapse start at the lower corner of the vertical silver cylinder on saturated and subcooled film boiling.