管内サブクール流動沸騰CHFに関する実験的研究 Subcooled Flow Boiling CHF in Short Tubes

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1. Introduction

The accurate prediction of flow boiling CHF is quite necessary because it plays an important role in the effective design and safety assessment of heat exchange components. CHF prediction relies heavily on empirical correlations derived from experimental CHF databases. This paper confirmed the pool boiling CHF correlations can be applied to the previously existing flow boiling CHF data obtained for heated sections by many researchers. This study is an analytical research prior to a further experimental research.

2. The nonlinear characteristics of subcooled flow boiling CHF for a vertical cylinder in water

As figured out in the previous research¹⁾, the saturated and subcooled pool boiling CHF correlations based on HI mechanism are as follows:

$$q_{cr,sat} = K_1 h_{fg} \rho_g \left[\sigma g (\rho_l - \rho_g) / \rho_g^2 \right]^{1/4} \quad (1)$$

$$q_{cr,sub} = q_{cr,sat} \left[1 + K_2 \left(\rho_l / \rho_g \right)^{0.69} \left(c_{pl} \Delta T_{sub} / h_{fg} \right)^{1.5} \right] \quad (2)$$

The pool boiling CHFs at higher pressures for higher subcoolings, resulting from HSN, was expressed with the following empirical correlation :

$$q_{cr,sub} = K_3 \Delta T_{sub}^{0.73} \quad (3)$$

Fig.1 CHF vs. subcooling for fixed flow velocities of 0, 2.0 and 4.04 m/s at various pressures for vertical cylinder

All the experiments for a vertical cylinder were carried out by Kataoka et al.²⁾ A platinum vertical test cylinder of 1.2 mm in diam. and 72 mm in length was located at a center line of a round vertical tube section with water flowing upward.

As shown in Fig.1, the flow boiling CHFs for the subcoolings measured were well expressed by the Eqs. (1) (2) and (3) by replacing K_1 , K_2 , K_3 into factors related to flow velocity. The flow

boiling CHFs measured are divided into two CHF groups for lower and higher subcoolings. This anomalous trend of flow boiling CHFs for subcoolings is similar to that of pool boiling CHFs for the subcoolings.

3. Experimental apparatus under construction

Fig.2 Schematic diagram of experimental apparatus

Figure 2 shows the schematic diagram of the experimental apparatus under construction for the study on flow boiling CHF with FC-72 flowing in short tubes. The flow loop is mainly linked with SUS304 stainless steel tube capable of pressures up to 2MPa. The test sections are platinum tubes, which are vertically oriented with FC-72 flowing upward. FC-72 is contained in the storage tank and will be deaerated by vigorous boiling for at least 30 minutes. Then the working liquid is fed to a canned circulation pump which circulates the liquid through the loop. The flow velocity is controlled by regulating the power frequency to the pump motor. The flow velocity is measured with turbine flow meter. The desired inlet temperature will be kept with a preheater. The pressurizer is used to control the liquid pressure via saturated vapor.

4. Conclusions

It was confirmed that the subcooled water flow boiling CHF versus the outlet subcooling for the test sections as a vertical metal strip suspended in the channel with rectangular cross section are well described by the extended pool and flow boiling CHF correlations representing CHF resulting from HI and the explosive-like HSN previously presented.

References

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- 2) Kataoka I., Serizawa A. and Sakurai A., "Transient Boiling Heat Transfer under Forced Convection," Int. J. Heat and Mass Transfer, Vol. 26, 1998, 583-595.