

CHAPTER 7

CONCLUSIONS

(1) The critical heat flux (CHF) mechanism is considered tightly connected to the flow pattern. A new mechanistic CHF model is developed for the most often encountered subcooled boiling flow pattern (the first kind of flow pattern). The model is based on the liquid sublayer dryout mechanism. The model is simple with explicit physics meaning, and is characterized by the absence of empirical constant. The model is tested over a very large data bank, showing a good accuracy through a wide range of physics scope.

(2) The model is compared with the Celata model in the prediction ability for the CHF and important parameters (U_B , L_B , D_B and δ). Although the prediction approaches of the two models differ greatly, it is interesting to see that the important parameters are predicted with no big difference. The parametric trends of the CHF are summarized and interpreted in the paper from the model theory viewpoint. The CHF is an increasing function of the coolant subcooling and mass flux. The influence of the pressure on the CHF turns out to be negligible. The effect of the inner diameter is to decrease the CHF as it increases. The ratio of the tube length to inner diameter L/D is ascertained to be an independent characteristic parameter on the CHF. The effect of L/D is to decrease the CHF when L/D increases, showing a threshold inside which the L/D effect is very significant while beyond which the influence of L/D is small.

(3) Although originally developed for peripheral uniform heating, straight tube condition with water used as coolant, the model also shows good adaptation to non-uniform, twist tape insert and non-water system (liquid nitrogen and refrigerant 113). The model is also adapted successfully to the both emergences of the twist tape insert and peripheral non-uniform heating conditions.

(4) The model shows a tendency of over-prediction at low L/D condition, especially at high-pressure condition. The possible reasons are analyzed as:

(a) The error in the calculations of the NVG point, exit true quality and void fraction.

As we know, the correlations we used in the proposed liquid sublayer dryout model for the calculations of the NVG point, true quality and void fraction are something empirical and are developed for the thermal hydraulic fully developed region. Therefore, their suitability at low L/D condition, where thermal hydraulic is far from fully developed, is quite doubtful.

Actually, with careful model selections for the true quality and void fraction, the proposed model prediction ability for the low L/D data can be improved a lot. For example, by replacing the Ahmad models for the true quality and void fraction with

the Jafri model and Dix model respectively, the present model shows a better prediction ability for the low L/D data.

(b) The change of the CHF triggering mechanism

Under low L/D condition, especially at high-pressure condition, the film boiling that caused due to the wall temperature exceeds the homogenous nucleation temperature may occur earlier than the CHF caused by the liquid sublayer dryout mechanism. The CHF then is determined by the film boiling. The change of the CHF triggering mechanism is considered the main reason for the over-prediction tendency at low L/D condition.

Besides, the model also shows a phenomenon that under some extreme conditions, such as at high pressure or high mass flux, sometimes the final calculated q doesn't equal to the assumed q_m even when the assumed q_m has converged to a point. Although the CHF under such circumstance can be predicted astonished well by doing a little modification to the calculation of the vapor blanket equivalent diameter D_B , the true reason for the phenomenon is considered due to the change of the flow pattern (The first kind of flow pattern is replaced by the second kind of flow pattern) near the CHF, which consequently causes the change of the CHF triggering mechanism. A criterion is developed for the determination of the flow pattern near the CHF and further, the CHF triggering mechanism for the second kind of flow pattern is discussed. Because the calculated CHF by doing the modification to the vapor blanket equivalent diameter is actually the lowest possible CHF value (q_{NVG}) and is occasionally just the same as the analyzed CHF value, the CHF is therefore predicted successfully.