Modelling and Optimization on the Microchannel Heat Convection of Two Phase Flow Model based on Numerical Simulation and Calculation

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***Abstract*—In this paper, we conduct research on the microchannel heat convection of the two phase flow model based on the numerical simulation and calculation. In the previous study, once found in the microchannel fluid under different conditions of dryness, reflect the different flow patterns and heat transfer model. Due to the fluid in the process of flow in microchannel, heating boiling gradually by the wall, its degrees along the flow direction is a variable, this makes the description of the flow and heat transfer is more complicated. To enhance the research efficiency and effectiveness, in this research we use numerical simulation and calculation for optimization. The theoretical background is verified and discussed in the main part. In the future, more simulation will be conducted.**

Keywords-Microchannel, Heat Convection, Two Phase Flow, Numerical Simulation, Calculation.

Introduction

The single-phase flow and flow boiling in microchannel has more in-depth research, but to another main way of heat transfer in microchannel flow condensation research is quite limited. Microchannel flow in the cooling process is, in fact, the micro heat pipe, lab on a chip, micro fuel cell and miniature space thermal physical process in the thermal control system as studies the process of condensation in the microchannel, for these high-tech device or component design and optimization of operation has important application prospect and academic value.

Condensing flow in the microgravity environment for a long time, although there have been some theoretical analysis, but as a result of microgravity experiment environment is difficult to achieve. The existing experimental data is very few, so it is difficult to verify the reliability of the model. In the mm and micro gravity of two-phase flow in the pipe is relatively small, the influence of the gravity environment microchannel can be as "equivalent system" condensation experiments to simulate the microgravity environment. Because in microchannel condenser, main force for surface tension, so there is reason to believe that microchannel condensing flow pattern of the flow and the heat transfer characteristics of towel with conventional scale channel wipes the flow pattern and the heat transfer characteristics of will there is a big difference [1-2].

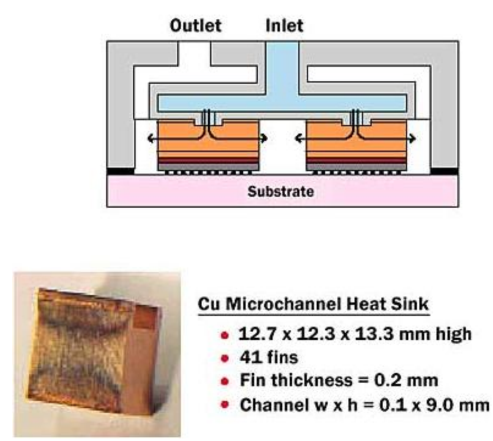

Figure 1. The Sample Microchannel Model

As shown in the figure one, we illustrate the sample microchannel model that will be taken as the example in the later sections. Because of microchannel scale small, precision through the experiment bubble deformation, from observation or measurement, and the length of the bubble from later, size and the distribution of flow field and the pressure in the channel is difficult. With the rapid increase of computer technology, the numerical simulation research in the micro channel flow as the main means and major the progress has been made. At present, the study of two phase flow interface movement commonly used numerical method with the level set method, fluid volume function method, marker particles unit method, the phase field method and so on, these methods for further research on micro channel and two-phase flow provides an efficient and the convenient way. In this paper, we conduct research on the microchannel heat convection of the two phase flow model based on the numerical simulation and calculation. The detailed steps will be introduced in the later sections.

The Proposed Perspective and Methodology

The Background Review. For microchannel, one cannot avoid the question is: compared with the macro scale, microscale problem has the characteristics of small scale and large surface area. Volume ratio, therefore, in the research process of microchannel flow and heat transfer in the process, we must to understand that macro scale can ignore the capillarity and surface effect for more detailed research.

In the micro channel in fluid flow and the heat transfer characteristics research, there are many problems to be solved. Such as the bubble produced during the boiling heat transfer has the great influence on flow and heat transfer. According to the shape of the bubble of the current laboratory studies have found, has bubble flow, the massive flow, slug flow and annular flow and so on a variety of flow pattern. Under a state of the working condition of different flow patterns, the fluid flow and heat transfer condition have bigger difference the shape of each bubble internal heat transfer condition is complex as the more aggravated the difficulty of the microchannel heat transfer within the research.

Theoretically, the research could be roughly separated into the following aspects. (1) Research in the impacting factors of microchannel boiling inside. When boiling in microchannel, fluid is a big difference to conventional channel. Because the channel diameter, friction, viscous stress between the bubbles during nucleate boiling and interact with each other, the heat transfer mechanism of this field is very complicated, and in this even less conventional boiling heat transfer mechanism in definite time for more complex microscale level channel and boiling heat transfer research is the difficulty of the high. There are a lot of scholars have conducted research. (2) Microchannel boiling heat transfer inside the relational research. When making the design of heat exchanger, need according to certain experience in heat exchange equation through theoretical analysis and calculation, as the basis of the design. Due to the fluid boiling in microchannel heat transfer mode and influencing the factors of the complexity of the diversity of the original will be used for the design of large scale heat exchanger of empirical no longer apply. Therefore, in order to guide the micro channel heat exchanger structure design, need to come to the conclusion that under the condition of microchannel flow heat transfers correlations. Many research institutions and scholars at home and the abroad adopt different fluid, the structure of the pipeline, a lot of research on heat flux and mass flow rate, according to the analysis of experimental data, summed up the applicable to different heat transfer and flow under the condition of the empirical formulae. (3) The flow pattern and the study of the bubble. Because of the microchannel walls in the face of bubble pressure, the influence of boundary layer and the effect of capillarity and surface tension, won't appear in many channel flow pattern, may there is some flow pattern have not been discovered so far, in has been found that the flow pattern, how to define and distinguish between also have no a unified standard. Therefore, two phase flow in a micro channel research is still at the preliminary stage while it remains to be further developed [3-4].

The Microchannel Flow and Heat Transfer in the Experiment. To conduct in-depth, detailed understanding of the characteristics of a device or system and the working state, the experiment is an effective solution. Therefore, the main work of this chapter is microchannel gas liquid two phase flow boiling heat transfer characteristics in the experimental study. According to the experiment purpose, design, processing and assembly meet microchannel flow boiling heat transfer and basic parameter acquisition experiment device and system. Different medium, mass flow and heat transfer process of heat flow density under the condition of experiment test and record related parameters. On different conditions of fluid parameters such as the dryness, convective heat transfer coefficient was calculated, and compared the fluid physical properties, the effect of mass flow rate and heat flux on heat transfer characteristics. Working medium in the thermostatic bath is heated at constant temperature, through the constant flow pump into the microchannel after extraction by the flow meter. At this point, the microchannel has been electric heating rod, the wall temperature than the temperature of the working medium, microchannel between wall and fluid medium began to produce heat. When low heat flux density, working medium may not occur in the process of the flowing through micro channel, only embodied in outlet temperature higher than the inlet temperature, flow after the microchannel heat exchanger in cooling and then return to thermostatic bath ready to continue cycle. Wall temperature can be generally expressed as formula one [5].

$$q'' = -\lambda \frac{dt}{dx}$$

(1)

In the vertical direction, heat transfer can be regarded as one-dimensional is between the two points on the heat flow density and density of measuring point and the microchannel wall is equal. Therefore we can re-write the formula 1 as the follows.

$$-\lambda \frac{T_{tc2} - T_{tc1}}{\Delta x_{tc}} = -\lambda \frac{T_{tc1} - T_s}{\Delta x_s}$$

(2)

Due to the low flow in microchannel inlet temperature, the corresponding between fluid and wall temperature difference is bigger, so along the flow direction, each measuring point of heat flux is reduced gradually. On the analysis of the experimental data also found this feature for each heating conditions, given a certain heat flux density, average heat flux from each measuring point. Average of the microchannel wall heat flux can be generally summarized as follows.

$$\bar{q}_x'' = \frac{1}{8}\sum_{x=1}^{8} q_x''$$

(3)

As mentioned earlier, the fluid enters microchannel with the temperature below the boiling point. When the flowing fluid in the channel, by the heating wall, gradually began to boil when a certain temperature is reached, this article thinks that the boiling point is the location of the substance in the micro channel reaches the boiling point and distance between the microchannel entrances. Therefore, working medium in microchannel began to absorb heat for until boiling can be expressed as follows.

$$q_{eff} = \bar{q}'' \cdot D_w \cdot l_b$$

(4)

Microchannel, when working medium, after the boiling fluid temperature in the local saturation temperature, part of the liquid absorption wall of the heat and boil. The quality percentage of liquid called dryness, by energy balance available:

$$\eta \bar{q}_x'' D_w \left(l_x - l_B\right) = m h_{fg} x_e$$

(5)

According to Newton's law of cooling, can launch microchannel substance in gas liquid two phase flow is formed after boiling flow expression of the convective heat transfer coefficient.

$$h = \frac{\eta \overline{q"}(w+\delta)}{A(T_w - T_s)(w+2\eta_f d)}$$

(6)

When using deionized water as working medium for experiments, it can be clearly observed in the microchannel appeared a lot of bubble size is larger. Through these bubbles, that can see the micro channel and the violent boiling phenomena, and can significantly distinguish the microchannel gas liquid two phase flow in areas of single-phase flow and liquid flow in the area. Compare a heating voltage condition, the corresponding point of wall temperature can be found, along the microchannel flow direction, the wall temperature as the working medium flow and smooth. While it is possible in a fall between two continuous temperature measuring points, but overall trend is rising temperature. Near the exit position, due to the heat dissipation, temperature is all more or less some drops, and the closer the export location that wall temperature drop. Compare different heating voltage under the condition of wall temperature of each point can be seen as the voltage wall temperature rise gradually.

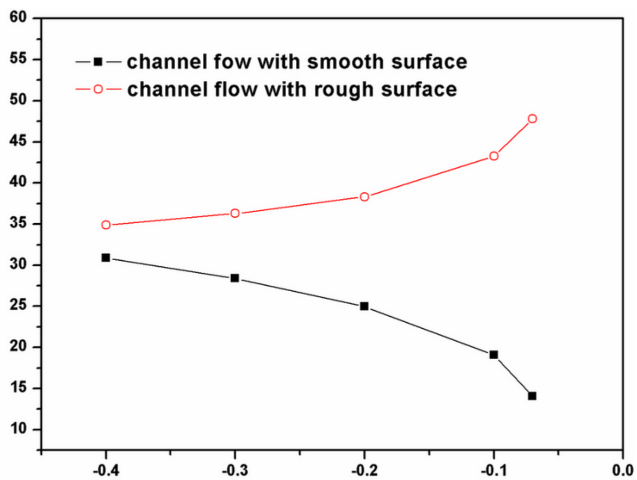

Figure 2. The Simulation Results on the Surface Status

The Numerical Calculation of Heat Transfer Process. It is obtained through the experiment research and data analysis in the process of microchannel flow and heat transfer in boiling some laws. But the objective conditions, by experiment is not only able to freely and widely for different structure of the microchannel using different medium in different flow rate, voltage and under the situation of the comprehensive experiment; On the other hand, because of the restriction of the microchannel structure characteristics, it is difficult to use the experimental methods to obtain more detailed in the process of the boiling heat transfer parameters. Along with the computer technology and numerical simulation technology has made the great progress, at present a computer program to simulate the microchannel internal flow and boiling condition in detail [6-7].

To numerically simulate the model, we therefore list the corresponding calculations and the related parameters as the follows. Continuous equation is based on the law of conservation of mass revised form of the formula could be generally expressed as the follows.

$$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho u_x)}{\partial x} + \frac{\partial(\rho u_y)}{\partial y} + \frac{\partial(\rho u_z)}{\partial z} = 0$$

(7)

Any contains the flow of the heat transfer process must satisfy the law of conservation of energy, the increase of energy in unit time infinitesimal body rate is equal to the micro unit time outside to the original body of net heat plus the work done outside of the original body, its expression is as follows.

$$\frac{\partial(\rho E)}{\partial t} + \nabla\left[u(\rho E + p)\right] = \nabla \cdot \left[\lambda \nabla T - \sum_j h_h J_j + (\tau \cdot \vec{u})\right] + S_h \quad (8)$$

Local velocity, pressure and other quantities in time and space with irregular pulsating fluid flow, become turbulent. Will speed pulsation of second-order correlation is expressed as the product of the average velocity gradient and the turbulence viscosity coefficient is the turbulent transport coefficient model. This paper selects the mixture model to calculate, it is a simplified model of multiphase flow can be simulated in two phase or multiphase fluid or particles cases of different velocity of flow, the main implementation solution of mixed phase continuity equation, momentum equation and energy equation, the relative velocity equation and the volume fraction of a second, etc. For multiphase flow in the gas phase and liquid phase, we usually obtain the listed features.

$$\begin{cases} \frac{\partial}{\partial t}\left(\rho_{m,g}\right)+\nabla\cdot\left(\rho_{m,g}\vec{v}_{m,g}\right)=\dot{m}_g \\ \frac{\partial}{\partial t}\left(\rho_{m,1}\right)+\nabla\cdot\left(\rho_{m,1}\vec{v}_{m,1}\right)=\dot{m}_l \end{cases}$$

(9)

Conclusion

In this paper, we conduct research on the microchannel heat convection of the two phase flow model based on the numerical simulation and calculation. With the rapid increase of computer technology, the numerical simulation research in the micro channel flow as the main means and major the progress has been made. At present, the study of two phase flow interface movement commonly used numerical method with the level set method, the fluid volume function method, marker particles unit method, the phase field method and so on, these methods for further research on micro channel and two-phase flow provides an efficient and the convenient way. In the recent future, we will conduct more related experiment for optimization and modification.

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