A Review of Design and Development of Mini and Micro Channels Heat Exchanger

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***Abstract* - Mini and Micro channel heat exchanger have been increasingly applied in air conditioning, refrigeration, heating and ventilation, air space application field due to its higher efficiency heat transfer rate, more compact structure, and lower cost. The application of Design, development and characteristics of mini and micro channels heat transfer and fluid dynamics are summarized in this paper. Different iteration developed different author to applied design of mini and micro heat exchanger are also summarized in this paper. The method about Geometry and thermodynamics and the advantage and disadvantage of the mini and micro channels heat exchanger are analyzed.**

***Keywords* - *(*Mini and Micro channel heat exchanger, Charactristic of Fluid Flow, Charactistic of Heat transfer)**

I.INTRODUCTION

Mini and Micro channels heat exchangers with reliable and high thermal performance has beedn the study focous of the cooling application in Space equipments. In resent year, with increasing demand for light weight and rising copper prices, copper substitation is aslo a wide sprade concern. Under the premise of meeting the heat exchanger demand, min and micro channels heat exchanger can reduse eqipment weight, improve the device compact.Most of reserchers are focoused on convection and conduction on heat exchanger analysis.The improvement of mini and micro heat exchanger design resent year most of resercher focoused in Radiation heat transfer. So manufacturing cost can be redused and the produt competitiveness can be improved by using aluminiums.Mini and micro channels heat exchanger has been extensive reserched and applied in cooling of electronic eqipment.

The Concept of mini channles heat exchanger was first praposed and used by R.B.Fleming[1] in 1967. He prasented in Advaces cryogenics on effect of flow distribution in parallel channels of counter flow heat exchanger. The concept of micro-channel heat exchanger was first proposed and used by Tuckerman and Pease[2] in 1981.Micro-channel heat exchanger is defined by Mehendale.S.S as if the hydraulic diameter of heatexchanger is less than 1mm. Micro-channel heat exchangers for heat exchanging between two different fluids was first developed out by the Swift in 1985[3].

To meet the rapid development of modern microelectronic mechanical requirements of heat transfer, micro-channel heat exchangers began to be used in cooling high-density electronic devices in the 1980s, then appeared in the MEMS(microelectronic mechanics system) industry in the 1990s. With studies on properties of micro-channel in depth and application in the promotion of electronic cooling,advantages of micro-channel heat exchanger which a traditional heat exchanger can not match gradually appear. And micro-channel heat exchanger began to enter the refrigeration and air conditioning industry. Compared with the conventional heat exchanger, micro-channel heat exchanger is very different in flow characteristics and heat transfer characteristics due to structural and other differencesAt present, the micro-channel heat exchanger has been applied in automotive air conditioning system. In household air conditioner field, technology of micro-channel heat exchanger applied in single-cold air-conditioner condenser has gradually matured, however, this technology face big challenges, such as complex gasliquid two-phase uniform streaming.[4]

II. RESEARCHES AND ADVANCES IN ABROAD AND INDIA

Researches in fluid dynamics and heat transfer characteristics of mini and micro channel heat exchanger.

Fundamental issues related to flow boiling in minichannels and microchannels. Flow boiling in small hydraulic diameter channels is becoming increasingly important in many diverse applications. The effects of the channel size on the flow patterns, and heat transfer and pressure drop performance are reviewed in the present paper. The fundamental questions related to the presence of nucleate boiling and characteristics of flow boiling in microchannels and minichannels in comparison to that in the conventional channel sizes (3 mm and above) are addressed.[5]

In 2002 Weilin Qu and Issam Mudawar [6] were analyzed three-dimensional heat transfer in micro-channel heat sinks. In this study, the three-dimensional fluid flow and heat transfer in a rectangular micro-channel heat sink are analyzed numerically using water as the cooling fluid. The heat sink consists of a 1-cm^2 silicon wafer. The micro-channels have a width of 57 lm and a depth of 180 lm, and are separated by a 43 lm wall. A numerical code based on the finite difference method and the SIMPLE algorithm is developed to solve the governing equations. The code is carefully validated by comparing the predictions with analytical solutions and available experimental data. For the microchannel heat sink investigated, it is found that the temperature rise along the flow direction in the solid and fluid regions can be approximated as linear. The highest temperature is encountered at the heated base surface of the heat sink immediately above the channel outlet. In 2003 Akimi Serizawa[7] From Japan was presented

Several distinctive flow patterns, namely, dispersed bubbly flow, gas slug flow, liquid ring flow, liquid lump flow, annular flow, frothy or wispy annular flow, rivulet flow, liquid droplets flow and a special type of flow pattern are identified both in air–water and steam–water systems, and their special features are described. It has been confirmed that two phase flow patterns are sensitive to the surface conditions of the inner wall of the test tube. It has been evidenced that a stable annular flow and gas slug formation with partially stable thin liquid film formed between the tube wall and gas slugs appeared at high velocities under carefully treated clean surface conditions. At lower velocities, dry and wet areas exist between gas slug and the tube wall. The cross-sectional average void fraction was also calculated from photographs, showing a good agreement with the Armand correlation for air–water flow in lager tubes.

In 2003 Weilin Qu, Issam Mudawar[8] were also investigated that Flow boiling heat transfer in two-phase micro-channel heat sinks the first of a two-part study concerning measurement and prediction of saturated flow boiling heat transfer in a water-cooled micro-channel heat sink. In this paper, new experimental results are discussed which provide new physical insight into the unique nature of flow boiling in narrow rectangular micro-channels. Results indicate an abrupt transition to annular flow near the point of zero thermodynamic equilibrium quality, and reveal the dominant heat transfer mechanism is forced convective boiling corresponding to annular flow. Contrary to macro-channel trends, the heat transfer coefficient is shown to decrease with increasing thermodynamic equilibrium quality. Effect of developing flow and thermal regime on momentum and heat transfer in micro-scale heat sink. Authors are developing micro-channel heat transfer and fluid flow has been investigated experimentally in rectangular micro-channels of Dh = 440 lm, having water as a working fluid. Infrared technique was used to design and built a micro-channel test section that incorporate internal fluid temperature measurements. The new method that provides information about the fluid temperature distribution inside the channel and provides validation for the methods used to determine the local and average Nusselt numbers. The experimental results have been compared with theoretical predictions from the literature and results obtained by numerical modeling of the present experiment in 2007. The experimental results of pressure drop and heat transfer confirm that including the entrance effects, the conventional theory is applicable for water flow through micro-channels. These results differ from the conclusions of several researches. It was shown that data presented by some researches can be due to entrance effects.[9]

In 2009 G. Hetsroni , A. Mosyak, E. Pogrebnyak, and Z. Segal were presented Heat transfer of gas–liquid mixture in micro-channel heat sink. They are investigated to study heat transfer in parallel micro-channels of 0.1 mm in size. Comparison of the results of this study to the ones obtained for two-phase flow in ‘‘conventional” size channels provides information on the complex phenomena associated with heat transfer in micro-channel heat sinks. Two-phase flow in parallel micro-channels, feeding from a common manifold shows that different flow patterns occur simultaneously in the different micro-channels: liquid alone (or single-phase flow), bubbly flow, slug flow, and annular flow (gas core with a thin liquid film, and a gas core with a thick liquid film). Although the gas core may occupy almost the entire cross-section of the triangular channel, making the side walls partially dry, the liquid phase always remained continuous due to the liquid, which is drawn into the triangular corners by surface tension.[10]

Numerical model of a two-phase microchannel heat sink electronics cooling system. Microchannel heat sinks using two-phase flow boiling have excellent potential for cooling high heat flux electronic devices. A numerical model of a two-phase cooling system using microchannel heat sinks is presented. This is supplemented with transient heat conduction models of the heat sink and heat exchanger and with various state of the art empirical correlations to close the equations. Finite volume discretization and the SIMPLE algorithm are used to solve the mixture conservation equations of mass, momentum and energy. The numerical code is verified using the method of manufactured solutions. This method reveals in 2012 that the numerical order in space and time is consistent with the expected values from theory, second order and first order, respectively. Further some illustrative results of the model are validated using experimental measurements. These results agree well with each other and indicate good predictive capability of the system model.[11]

Mini and Micro channels Heat exchanger optimiztion

The traditional heat transfer performance can be improved by using the micro-channel structure. The micro-channel geometry and size have significant impact on the performance of heat exchanger. Therefore, there will be great significance to explore the optimal structure of micro-channel during the micro-channel heat exchanger design.[12]

In 2007 T. Bello-Ochende[12] optimized Constructal cooling channels for micro-channel heat sinks This paper documents the geometric optimization of a three-dimensional micro-channel heat sink. The objective is to minimize the peak temperature from the walls to the coolant fluid. The optimization is performed numerically by using the finite volume method. The numerical simulation was carried out on a unit cell with volume ranging from 0.1 mm3 to 0.9 mm3 and pressure drop between 10 kPa and 75 kPa. The axial length of the micro-channel heat sink was fixed at 10 mm. The cross sectional area of the micro-channel heat sink is free to morph with respect to the degree of freedoms provided by the aspect ratio and the solid volume fraction. The effect of the total solid volume fraction and the pressure drop on the aspect ratio, channel hydraulic diameter and peak temperature is investigated. Same year 2007 Lingai Luoa, Yilin Fana,Weiwei Zhang, Xigang Yuan, and Noel Midoux were optimized constructal distributors to a mini crossflowheat exchanger and their assembly configuration optimization. In this paper, the idea of coupling constructal distributors/collectors with a mini crossflow heat exchanger (MCHE) to solve the problem of flow misdistributions is presented. After a brief description of the design and scaling laws of the constructal distributor, experimental and simulation results have been discussed to investigate relations among flow distribution, heat transfer and pressure drop. It is shown that the introduction of constructal distributors and/or collectors could improve the quality of fluid distribution and consequently lead to heat transfer intensification of the MCHE, but it also results in higher pressure drops.[13]

In resent year 2012 Fabio De Bellis[14] optimized with the use of CFD. They optimized CFD optimization of an immersed particle heat exchanger. An innovative immersed particle heat exchanger has been recently proposed by the authors: it makes use of very small solid particles as intermediate medium to perform heat transfer between two gas flows at different temperature. The potential of such heat exchanger has been already demonstrated by the authors, who have developed a 1D model for the computation of the pipe length that ensures a prescribed heat exchange and for the evaluation of the influence of particle characteristics. As completion of the heat exchanger design procedure, this paper provides a numerical procedure for the design optimization of the other geometric parameters defining the heat exchanger, such as diameters and angles of inlet and outlet pipes and particle injection mode. The objective of this numerical optimization is to maximize the heat exchanger efficiency by maximizing the dispersion of the particles falling in countercurrent within the flow.

In current year 2013 Mostafa Keshavarz Moraveji, Reza Mohammadi Ardehali[15] were optimized CFD modeling (comparing single and two-phase approaches) on thermal performance of Al2o3/water nanofluid in mini-channel heat sink. Three-dimensional steady-state governing partial differential equations was discretized using finite volume method. Influences of some important parameters such as nanoparticle concentration and Reynolds number on the enhancement of nanofluid heat transfer have been investigated. The difference between the two-phase models results was marginal, and they were more precise by comparison with experimental reference data than single phase model. Besides with regard to the most precise and less CPU usage and run time, mixture model was chosen to obtain a correlation based on dimensionless numbers for the Nusselt number and friction factor estimation.

III. CONCLUSIONS

As per review of different authors ppers releted with mini and micro channels heat exchanger in recent years, mini and micro-channel heat exchanger have been more widely applied in the refrigeration and air conditioning industry, Space application and Electronics Application and researches related to such theory and problem has attracted the world-wide attention. Most of authors most concentrated in before designing the mini and micro-channel heat excahnger , Most important for how to heat transfer more possible of pressure loss and heat transfer characteristics must be accurately predicted, while the theoretical basis which can accurately guide the design is not yet mature and there is no uniform industry standard in manufacturing.

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