A HEAT TRANSFER ENHANCEMENT ANALYSIS of MICRO FLOW CHENNAL - REVIEW

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Abstract— **In our research work its considered Due to the high performance of electronics components, Heat dissipation becomes a significant issue for stable operation of components. Micro channels provide very high heat transfer coefficients because of their small diameters. In this study, two dimensional fluid flow and heat transfer in a rectangular micro channel heat sink are analyzed using FLUENT as solver with water as cooling fluid. With strong literature study it is found that down to 50 µm of hydraulic diameter, macro scale model can be applicable. Three channels of height 50 µm, 100 µm and 150 µm are considered. The study is mainly focused on Nusselt Number and height effects on micro channel thermal performance. The highest temperature is encountered at the heated surface of the heat sink immediately above the channel outlet.**

Keywords— **High Performance ,Micro Chennal,Heat Transfer,Cfd.**

I. INTRODUCTION

1.1 ABOUT MICRO CHANNEL:

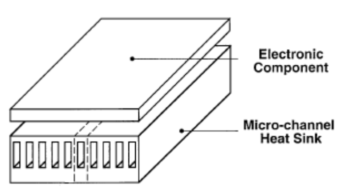


Figure 1.1 About Micro Channel

1.2 Compact Heat Exchanger:

The large surface area in compact heat exchangers is obtained by attaching closely spaced thin plate or corrugated fins to the walls separating the two fluids. Compact heat exchangers are commonly used in gas-to-gas and gas-to liquid (or liquid-to-gas) heat exchangers to counteract the low heat transfer coefficient associated with gas flow with increased surface area. In a car radiator, which is a water-to-air compact heat exchanger, for example, it is no surprise that fins are attached to the air side of the tube surface.

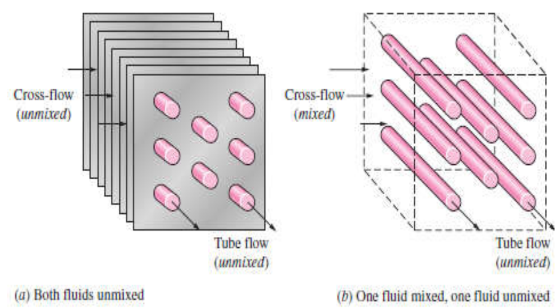


Figure 1.2 Heat exchanger inside of micro channel

1.3 About Computational Fluid Dynamics:

Computational Fluid Dynamics is the art of replacing the integrals or the partial derivatives in these equations with discredited algebraic forms, which in turn are solved to obtain numbers for the flow field values at discrete points in time and/or space. The end product of CFD is indeed a collection of numbers, in contrast to a closed-form analytical solution.

1.4 About Fluent

Fluent is computational fluid dynamics code widely used for flow and heat transfer modelling applications. The first step in analysis is pre-processing which involves building a model or importing one from a CAD package, applying finite volume based mesh, and entering data. Once the numerical model is prepared, FLUENT performs the necessary calculations and produces the desired results. The final step in analysis is post processing, which involves organization and interpretation of data and images.

Packages tailored for specific applications such as electronic cooling, ventilating systems, and mixing are also available. Fluent can handle subsonic or supersonic flows, steady or transient flows, laminar or turbulent flows, Newtonian or non-Newtonian flows, single phase or multi phase flows, chemical reaction including combustion, flow through porous media, heat transfer, and flow induced vibrations.

II. LITERATURE SURVEY

This chapter presents the review of literature about use of Micro channel characteristics. A review are considering as given below:

Jun Yao et al [1] proposed that the channel height has significant effect on the friction factor at smaller diameters (i.e. 0.3 mm). Channel heights have little influence on the thermal resistances compared to other parameters, but clearly the smaller the channel height, the smaller the thermal resistance. In the low Reynolds number regime, the study results show similar trends and magnitude range as those obtained by other researchers, both experimentally and numerically.

Zetao Ma et al [2] showed introduction of internal pin patterns beneath the die could lead to reduction of maximum junction temperature of LED dies, but could not achieve relative uniformity in temperature distribution among the LEDs in the array, due to the configuration of the liquid-cooling module. With the flow rates increasing, the maximum die temperature decreases, and being kept below target temperature approximately $80^{o}C$ with considerably high power consumption. The maximum die temperature variation also increases which may lead to other problems such as the stability of electrical current input, uniformity patterns of light output, and the longevity of the LED devices, etc.

Sun Hongwei et al [3] analyzed that heat transfer under the condition of uniform heat flux demonstrate that the velocity-jump and temperature-jump have opposite effect on Nusselt number; the temperature-jump is more sensitive. When the Knudsen number is between 0.001 and 0.01, the slip-flow has an effect of enhancement for the heat transfer in micro-channel.

Pan Min-Qiang et al [4] observed that (i) the velocity distributions among microchannels with right-angle manifold are much more uniform than the one with oblique-angle manifold, but the heat transfer area per unit volume of the microchannel plate with right-angle manifold is smaller than the one with oblique-angle manifold. (ii) The magnitude of heat transfer area per unit volume dominates the heat transfer performance of plate-type micro heat exchange, while the velocity distribution among microchannels shows little effects.

U. S. Choi et el [5] has observed that performance of water-cooled and liquid-nitrogen-cooled microchannel heat exchangers clearly shows the superiority of a microchannel heat exchanger with liquid-nitrogen as the working fluid. The use of sub-cooled liquid-nitrogen in microchannel heat exchangers allows almost three fold increases in power density compared with water, mainly because silicon microchannels can be designed to provide a larger heat transfer area at cryogenic temperatures than at room temperature.

Yoon Jo Kim et al [6] have investigated and showed that increases of channel depth and channel base thickness are useful in reducing the wall temperature. The effect of channel width change was found not to be significant. For improved thermal performance, it is better to keep the channel side-wall thickness small; however, wider spacing between channels offers more vertical direction routing capacity. A two-phase cooling scheme provided enhanced thermal performance as compared with single-phase cooling due to the higher heat transfer coefficient and relatively constant fluid temperature. However, R134a and R227ea were not suitable for the chip cooling application, due to the resulting high interior pressures. Thermal performance of the two-phase water cooling was significantly degraded because of its poor hydraulic properties

K.V. Sharp et al [7] experimentally showed that the flow of a liquid in microchannels should be represented well by continuum theory unless the channel dimensions approach the slip length at the wall, estimated to occur for channels and tubes whose dimensions lay below a few microns. More importantly, they show that the transition to turbulence first begins in virtually the same Reynolds number range as that found for macro-scale flow: Re_D =1,800–2,300.Lastly, within the transition range, the behavior of the each microscale flow property — pressure drop, mean velocity and RMS velocity — is consistent with macroscale data. Thus, the behavior of the flow in microtubes, at least down to 50 micron diameter, shows no perceptible differences with macroscale flow.

Yu-Tang Chen et al [8] have experimentally predicted that the effects of the friction and viscosity coefficient for the fluid in the microchannels are much significant than the macros. In the heat transfer characteristics, the experimental results show that the phase changing process in the microchannels absorbs the heat and reduces the working temperature of the environment. Additionally, the hydraulic diameter of the microchannels larger than 83μm is possible for bubble nucleation is obtained and the critical bubble nucleation for methanol between 57−83 μm is also found.

G. Hetsroni et al [9] have experimentally found out that the comparison of experimental results to those obtained by conventional theory is correct when the experimental conditions were consistent with the theoretical ones. The experimental results corresponding to these requirements agree quite well with the theory. For single-phase fluid flow in smooth micro-channels of hydraulic diameter from 15 to 4010 μm, in the range of Reynolds number Re < Recr the Poiseuille number, Po is independent of the Reynolds number, Re. For single-phase gas flow in micro-channels of hydraulic diameter from 101 to 4010 μm, in the range of Reynolds number Re < Re_{cr}, Knudsen number $0.001 \leq Kn \leq 0.38$, Mach number $0.07 \leq Ma \leq 0.84$, the experimental friction factor agrees quite well with the theoretical one predicted for fully developed laminar flow. The behavior of the flow in micro-channels, at least down to 50 μm diameter, shows no differences with macro-scale flow.

Joe Dix et al [10] have formulated three recommendations based on their study : 1) all geometrical designs should be symmetrical when incorporating multiple fluid paths, 2) an optimal balance between heat transfer surface area and resulting system pressure drop should be found in order to maximize both heat transfer and fluid flow performance, and 3) purified water is still a good choice as working fluid in MCHEs compared to other available cooling fluids.

Jyh-tong Teng et al [11] were done for the microchannel heat exchanger with rectangular channels having hydraulic diameter of 375 µm for two cases (counter-flow and parallel-flow). Heat transfer behaviors of the single-phase fluid inside the microchannel were determined. The heat flux of 17.81×104 W/m^2 (or 17.81 W/cm^2) was achieved for water from the hot side of the device having the inlet temperature of 70 ºC and mass flow rate of 0.2321 g/s and for water from the cold side having the inlet temperature of 22.5 ºC and mass flow rate of 0.401 g/s. With all cases done in this study, the heat flux obtained from the counter-flow is always higher than that obtained from the parallel-flow. As a result, the microchannel heat exchanger with counter-flow should be selected to use for every case.

Mohd Nadeem Khan et al [12] have suggested that $Nu = A.Re^B$ can also be used for predicting the average Nusselt Number under fully developed flow in circular Microchannels. Also from the above analysis it is quite comfortable to say that in order to enhance the heat transfer the flow must follow Petukhov equation, but this predication based on theoretical analysis. In actual case it is very difficult to predicate under what circumstances heat transfer is maximum because a lot of factors like temperature gradient, pressure gradient, surface roughness, boundary condition etc are involve.

Sidy Ndao et al [13] have observed that Single objective optimization of either the thermal resistance or pumping power may not necessarily yield optimum performance. The multiple-objective optimization approach is preferable as it provides a solution with different trade-offs among which designers can choose from to meet their cooling needs. The choice of a coolant has a significant effect on the selection of a cooling technology for a particular cooling application and should, therefore, be taken into consideration along with other design factors, such as geometric configuration, system mass, volume, cost, manufacturability, and environmental benevolence. For relatively very low pumping powers, the micro-channel heat sinks offer lowest thermal resistances. Jet impingement cooling yields very high heat transfer coefficients. However, to make efficient use of this technology, it should be coupled with sufficiently large heat transfer surface area to increase the product hA_h.

Poh-Seng Lee et al [14] have predicted that the heat transfer coefficient increased with decreasing channel size at a given flow rate. The experimental results were compared against conventional correlations to evaluate their applicability in predicting microchannel heat transfer. The wide disparities revealed that the mismatch in the boundary and inlet conditions between the microchannel experiments and the conventional correlations precluded their use for predictions.

G.P. Celata [15] has observed that As far as liquid single-phase flow heat transfer is concerned, there is more and more the general agreement on the validity of macroscale knowledge going down to microscale. No new phenomenon has been ascribed to the microscale, though some aspects typically neglected in macroscale must be accounted for in microscale for a proper evaluation of heat transfer data (this comment being valid also for single-phase fluid flow). The scale reduction gives relevance to some effects such as viscous dissipation (or viscous heating, due to the general large pressure drop associated with microchannel flow), thermal entrance (due to the generally short geometry of microchannels) and axial length (associated with the general large thickness of the microchannels), which becomes very important in microscale. Occurrence of scaling effects can also be used to identify the threshold between micro- and macroscale, which depends not only on the geometry but also on fluid physical properties.

G. Hetsroni et al [16] observed that Axial conduction in the fluid and wall affects significantly the heat transfer in micro-channels. At laminar flow two heat transfer regimes may be considered. The first of them takes place at Re > 150 and the axial conduction number is less than M = 0.01. Under this condition the heat transferred through the solid substrate may be neglected and adiabatic boundary conditions may be imposed at the inlet and at the outlet manifolds to solve conjugated three-dimensional heat transfer problem. The second one occurs at Re < 150, M > 0.01. In this case the heat transferred through the solid substrate should be taken into account. The effect of energy dissipation on heat transfer in micro-channels is negligible under typical flow conditions.

A. E. Bergles et al [17] have predicted that Flow distribution in parallel microchannels is not considered to be a problem with the usual subcooled inlet conditions. There appear to be no barriers to incipient boiling in microchannels, so vapor will appear without difficulty. Water is clearly not a problem, but highly wetting fluids may experience temperature overshoots. Conjugate effects may become important in microchannels such that CHF occurs in the region near the heater, whereas the opposite side of the channel may have conventional boiling. Many microchannel blocks have a high thermal conductivity and the heat transfer coefficient is rather uniform circumferentially; thus, the heat flux is uniform around the circumference ~except for the adiabatic cover plate in the case of rectangular channels.

Weilin Qu et al [18] have found that two types of two-phase dynamic instability, pressure drop oscillation and parallel channel instability. Pressure drop oscillation was associated with fairly periodic, large-amplitude fluctuations in inlet and outlet pressure as well as heat sink temperature. This type of instability was completely suppressed by throttling a control valve situated upstream of the heat sink. Parallel channel instability produced only mild fluctuations in the pressure and temperature. Pressure drop across the heat sink was fairly constant with increasing heat flux for single-phase liquid flow, but increased appreciably when boiling commenced inside the micro-channels. A pressure drop model was constructed, which accounts for single-phase and two-phase regions, as well as inlet contraction pressure loss and exit expansion recovery.

Liang Gong et al [19] were found that wavy surfaces can be potential candidates for performance improvement in low Re laminar flow regime with proper tuning and selection of the geometric and flow parameters without employing any extraneous mixing aids. The performance improves with increase in Reynolds number and the wave amplitude. The better performance of large amplitude channels was ascribed to the thinning of boundary layer at the wave peaks as a result of the compounding effect of geometry and the flow velocity. In summary, the performance of wavy channels compares or exceeds the performance of a straight channel for $Re \geq 20$ by up to 26%. With proper tailoring of the wavy surfaces using further analysis and optimization, it is anticipated that enhanced performance can be observed even for $Re < 20$.

Milnes P. David et al [20] proposed a next generation device design where the microchannels and membrane are side-by-side instead of stacked. This design provides the best optical access, low leakage, and flexibility to engineer membrane characteristics. Potential membrane materials include porous silicon and super hydrophobic CNT or ZnO nanotube forests.

Gajanana C. Birur et al [21] were concluded the following remarks, A MEMS-based pumped liquid cooling system suitable for microspacecraft thermal control applications is being developed at the Jet Propulsion Laboratory (JPL). The cooling system consists of a working fluid circulated through microchannels by a micropump. A numerical model was developed to predict the hydraulic and thermal performance of the microchannel heat exchanger devices used in this cooling system. First generation micro channel heat exchanger devices were fabricated and tested, and the experimental results are in excellent agreement with the numerical predictions. The preliminary results have shown that the single-phase liquid (water) cooling can remove heat fluxes of over 25 W/cm^2 from the electronic packages. The current focus of this ongoing investigation is using the numerical model as a design tool for optimization of the microchannel heat exchanger geometries and integrating a micropump which can provide the pressure head and °ow rate required.

Intel [26] recommended that complete thermal solution designs target the Thermal Design Power, instead of the maximum processor power consumption. Thermal solution should be designed to dissipate this target power level. TDP is not the maximum power that the processor can dissipate.

Lian Zhang et al [22] have developed silicon test devices with nearly-constant heat flux boundary conditions to study forced boiling convection in microchannels. Rectangular channels with hydraulic diameters between 25 and 60 µm and aspect ratios between 1 and 3.5 were fabricated and tested, and recorded the pressure and wall temperature distribution during phase change. A thermal circuit model and a detailed two-phase microchannel flow model yielded predictions in reasonable agreement with the measured pressure drop and wall temperature distribution. Both models should prove very useful for microchannel design. The experiments show that boiling occurs in plasma-etched microchannels with these dimensions without excessive superheating.

Rémi Revellin et al [23] have suggested that one of the promising technologies to replace air-cooling of micro-processor chips is flow boiling in microchannels, where the high heat flux dissipation from micro-processor chips can be highly non-uniform due to the presence of multiple localized hot spots. To better dissipate the hot spot heat flux for a channel of fixed length, a microchannel heat sink should follow the following recommendations: the diameter should either be very small or quite large. The local hot spot size should be short, the number of local hot spots as few as possible and the distance between two hot spots as large as possible. To limit the increase of the pressure drop when increasing the mass flux and reducing the micro channel diameter, one design solution would be to place the fluid inlet at the mid-point along the length of the micro channel element and have an exit at both ends. This design solution would be beneficial if the local hot spot is situated at the mid-point along the micro-processor. The analysis here is presented for the variation in CHF along one micro channel but it is easily applied to all micro channels.

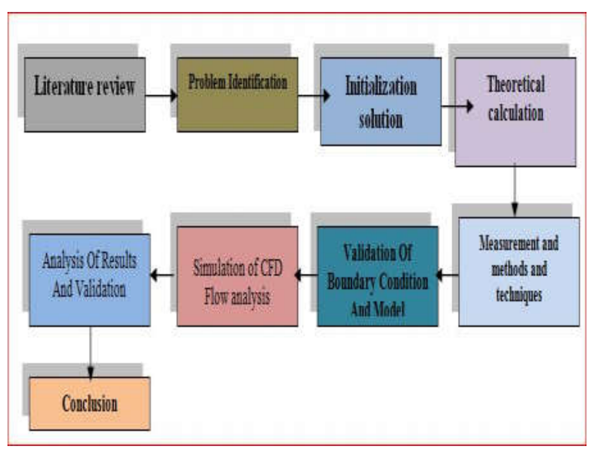
III. PROBLEM IDENTIFICATION AND METHODOLOGY

In this section problems accrue , basic heat transfer equations will be outlined for the thermal analysis of a µHEX and Electronics parts. Then effective mean temperature difference of the fluids inlet and outlet temperatures will be investigated to determine the heat transfer. The overall heat transfer coefficients will be introduced in this analysis. Heat transfer effectiveness, heat capacity rate ratios and number of transfer unit will be determined. Then basics behind the electronics cooling will be discussed. At last cooling load of electronic equipment will analysed.

IV. OBJECTIVE

In our project main objective is For improved thermal performance, it is better to keep the channel side-wall thickness small; however, wider spacing between channels offers more vertical direction routing capacity. A two-phase cooling scheme provided enhanced thermal performance as compared with single-phase cooling due to the higher heat transfer coefficient and relatively constant fluid temperature.

V. RESEARCH METHODOLOGY



VI. THEORETICAL HEAT EXCHANGER AND ELECTRONICS COOLING

A heat exchanger typically involves two flowing fluids separated by a solid wall. Heat is first transferred from the hot fluid to the wall by convection, through the wall by conduction, and from the wall to the cold fluid again by convection. Any radiation effects are usually included in the convection heat transfer coefficients.

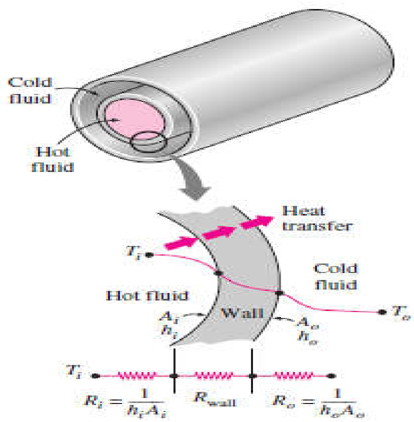


Figure 2.1 Reaction Flow analysis of Heat transfer

Calcultaion :$R_{total} = R_i + Rwall + Ro = 1/hiAi + \ln(D_o/D_i) / (2\pi kL) + 1/h_oA_o)$

In the analysis of heat exchangers, it is convenient to combine all the thermal resistances in the path of heat flow from the hot fluid to the cold one into a single resistance R, and to express the rate of heat transfer between the two fluids as

$$Q = \Delta T/R = U\ A\ \Delta T$$

where U is the **overall heat transfer coefficient,** whose unit is $W/m^2 \cdot °C$, which is identical to the unit of the ordinary convection coefficient h. Canceling ΔT, above equation reduces to

$$R=1/h_iA_i+ \ln(D_o/D_i) / (2\pi kL) + 1/h_oA_o)$$

When the wall thickness of the tube is small and the thermal conductivity of the tube material is high, as is usually the case, the thermal resistance of the tube is negligible **($R_{wall} \approx 0$)** and the inner and outer surfaces of the tube are almost identical **($A_i \approx A_o \approx A_s$)**. Then above equation for the overall heat transfer coefficient simplifies to

$$1/U \approx 1/h_i + 1/h_o$$

where **$U \approx U_i \approx U_o$.** The individual convection heat transfer coefficients inside and outside the tube, h_i and h_o, are determined using the convection relations.

VII.ANALYTICALLY EXPRESSED ANALYSIS OF HEAT EXCHANGER

$$Q = m_c c_{pc}\ (T_{cout} - T_{cin})$$

and $$Q = m_h c_{ph}\ (T_{hin} - T_{hout})$$

where the subscripts c and h stand for cold and hot fluids, respectively, and

$$C_c = m_c c_{pc} \quad \text{and} \quad C_h = m_h c_{ph}$$

The heat capacity rate of a fluid stream represents the rate of heat transfer needed to change the temperature of the fluid stream by 1°C as it flows through a heat exchanger. Note that in a heat exchanger, the fluid with a large heat capacity rate will experience a small temperature change, and the fluid with a small heat capacity rate will experience a large temperature change. Therefore, doubling the mass flow rate of a fluid while leaving everything else unchanged will halve the temperature change of that fluid. With the definition of the heat capacity rate above, the rate of heat transfer can be expressed as

$$Q = C_c\ (T_{cout} - T_{cin})$$

and

$$Q = C_h\ (T_{hin} - T_{hout})$$

VII. CONCLUSION

In our research consist strong literature survey it is found that macro scale fluid flow and heat transfer can be applicable hydraulic diameter down to 50 μm. So micro channel has to designed such way that hydraulic diameter greater than 50 μm. Single-phase fully developed flow in micro channel can be considered as macro scale fully developed laminar flow and can be modelled easily. But two phase flow in micro channel cannot be modelled as two phase macro scale flow. Two phase flow in micro channel will have greater heat transfer coefficient than single phase flow in micro channel. But poor heat transfer takes in the two phase water flow in micro channel, due to its degrading thermal properties.therotically Calculated and derivate it.

VIII. FUTURE SCOPE

1. Relation between Processor case temperature and ambient temperature has to be found out
2. Two different cross-sectional (Circular and Rectangular) Micro channel heat exchangers for i7 / i5 processor will be designed with minimum pressure drop.
3. Two dimensional fluid flow and heat transfer analysis will be carried out in designed micro channels using fluent to find which one is optimum for chosen processor in computational Fluid dynamic analysed.

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