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Research Article

Study and Analysis on Micro Channel Heat Sink in Trapezoidal Shape Upper Flow for High Performance

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Abstract

In this paper, the pressure loss and heat transfer are investigated for Trapezoidal shape of micro channel in upper flow arrangement for investigating the high performance of micro channel. Micro channels for Re numbers ranging from 90 to 900 are investigated. Splitting the fluid leads to an enhanced heat transfer, but at the same time the pressure loss is increased. The shapes of the micro channel for the flow arrangement are investigated and have a significant influence on both, pressure loss and heat transfer. Fluid flow and heat transfer are simulated for upper flow arrangement with Trapezoidal shape. The aim of this work is to get an impression of the physical behavior in small elements that enable the development of new liquid cooling systems with higher cooling ability and higher effectiveness.

Keywords: *Trapezoidal shape of micro channel etc.*

Introduction

With the improvement of computational speed, thermal management becomes a serious concern in computer system. CPU chips are squeezing into tighter and tighter spaces with no more room for heat to escape. Total power-dissipation levels now reside about 110 W, and peak power densities are reaching 400–500 W/mm2 and are still steadily climbing. As a result, higher performance and greater reliability are extremely tough to attain. Common fabrication techniques enable the production of many different micro Channel cross-sectional shapes, including rectangular, circular, triangular, and trapezoidal. Much effort has been directed in recent years to characterize the heat transfer behavior of fluid flow in ducts of various shapes and sizes. Heat sinks are considered one of the solutions for thermal management of micro electromechanical electronic devices as they are the most researched and cost-effective components. It has been proven that smaller channel dimensions used in heat sinks result in higher heat transfer performance, but at the same time, it leads to higher pressure dropper unit length. Various authors have studied the option of using the liquid flow based micro-channel heat sink (MCHS) as a solution for thermal management. Tuckerman and Pease started their pioneer experimental work on the suitability of high-performance heat sinks for cooling of very large-scale integration (VLSI) systems. Following their research outcome, in the past three decades, a number of experimental, theoretical, and numerical studies have been carried out for the evaluation of performance of MCHSs for a number of applications. Sobhan and Garimella gave a comparative study on heat transfer and fluid flow in micro-channels by considering various heat inputs and flow rates. Since the pioneering work of Tuckerman and Pease in 1981, many studies have been conducted on micro-channel heat sinks as summarized by Phillips and more recently, by Morini. The need for cooling in high power dissipation (100 W/cm^2) systems in several scientific and commercial applications such as microelectronics requires something beyond the conventional cooling solutions.

A number of studies have investigated the thermal design optimization of micro-channel heat sinks to determine the geometric dimensions that give optimum performance. For the heat transfer study purpose, the channel walls were assumed to behave as fins. With the increasing heat production of electronic devices, the air cooling technology reaches its limits, whereas liquid cooling represents a promising opportunity to develop cooling devices with much higher heat transfer coefficient. Today's rapid IT development requires high PC performance capable of processing more data and more speedily. To meet this need, CPUs are assembled with more transistors, which are drawing more power and having much higher clock rates. This leads to an ever-larger heat produced by the

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CPU in the computer, which will result in a shortened life, malfunction and failure of CPU. The reliability of the electronic system will suffer if high temperatures are permitted to exist. Therefore, removal of heat has become one of the most challenging issues facing computer system designers today. However, conventional thermal management schemes such as air-cooling with fans, liquid cooling, thermoelectric cooling (DiSalvo FJ, 1999; Simons RE, 2010; Xie H, 1998; Nquyen T, 2000), heat pipes (Lv YG, 2006), vapor chambers (Koo, J, 2004) and vapor compression refrigeration (Koo, J, 2005) have either reached their practical application limit or are soon become impractical for recently emerging electronic components. Therefore, exotic approaches were regarded as an alternative to these conventional methods in sufficient for cooling further high power processors.

As the fluid is passing through the different section of the micro channel the distribution of the fluid in the passage is disturb the flow condition of the fluid that affect the velocity and thermal boundary layer of the flow. As flow is reached fully developed there is no change in the velocity of the fluid layer. The thermal and velocity boundary layer are playing an significant role in the fluid flow in micro channel. The different shapes of micro channels are used to dissipate the large amount of heat from the system or electronic circuit. As a practical cooling fluid, the liquid metal must satisfy the following requests: non-poisonous, non-caustic material, low viscosity, high thermal conductivity and heat capacity. Most studies in this approach employed the classical fin theory which models the solid walls separating micro channels as thin fins. The heat transfer process is simplified as one-dimensional, constant convection heat transfer coefficient and uniform fluid temperature. However, the nature of the heat transfer process in MCHS is conjugated heat conduction in the solid wall and convection to the cooling fluid.

Analysis procedure

The micro Channel heat sink modeled in this investigation consists of Trapezoidal shapes of micro channels for fluid flow. The entrance and the exit of the coolant are from the upper flow arrangement. The aspect ratio and the hydraulic diameter for the trapezoidal micro channel heat sink are assumed to be same. The arrangement of fluid flow is from the upper of the micro channel. The two different fluids are used one is the water and another is nano fluid with thermal conductivity 10 times of water. This investigation has to be carried out for the high performance of the micro channel. This study can help to clarify some of the variations in the previously published data and provide a fundamental insight into thermal and fluid transport process occurring in the micro channel heat sinks designed for electronic cooling and other application. The analysis is based on the following assumptions:

- Steady state flow.
- Incompressible fluid.
- Laminar flow.
- Constant properties of both fluids and solid.
- Effects of viscous dissipation are negligible.

Mathematical Formulation

The convective heat transfer between a surface and an adjacent fluid is prescribed by Newton's law of cooling.

$$Q = h\,A\,(t_s - t_f) \qquad (1)$$

Based on above assumptions, the governing equations for fluid and energy transport are

Fluid Flow

$$\nabla \bullet V = 0 \qquad (2)$$

$$\rho(V \bullet \nabla V) = -\nabla p + \mu \nabla 2V \qquad (2.1)$$

Energy in fluid flow:

$$Pcp(V \bullet \nabla T) = k \nabla 2T \qquad (3)$$

Energy in heat sink solid part:

$$k_s \nabla Ts = 0 \qquad (4)$$

The boundary conditions for these equations are related to the heat sink operating conditions.

Computational Domain

A schematic of the Trapezoidal micro channel heat sink is illustrated with upper flow arrangement. The flow arrangement from upper is shown in the figures.

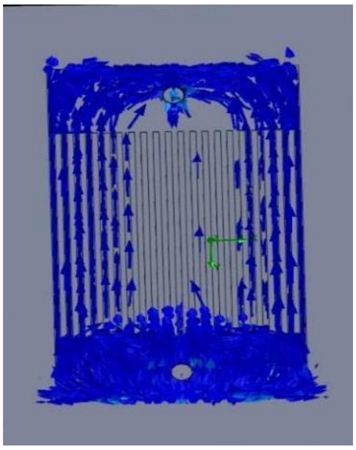

Fig. 1 Upper flow arrangement

Solution Method

The fluid flow & thermal analysis of fluids based upon upper flow arrangements of fluid has been carried out.

To analyses the performance of micro channels using liquid water and the nano fluid with thermal conductivity 10 times of the water as coolant. The micro channel is used with same aspect ratio and the hydraulic diameter. It is known that increasing flow rate affects the performance; hence the flow rate has been kept same in all the cases by adjusting the inflow velocity according to cross-sectional

Results and Discussion

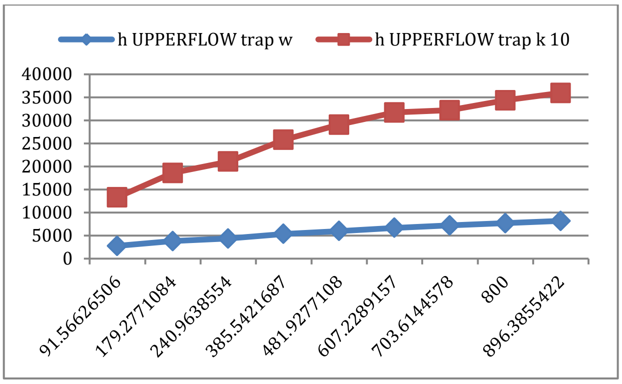

Fig.2

Curve between the heat transfer coefficient and Reynolds number

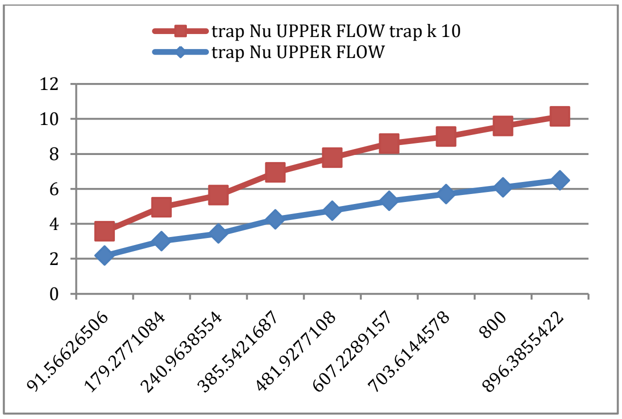

Fig.3

Curve between the Nusselt number and Reynolds number

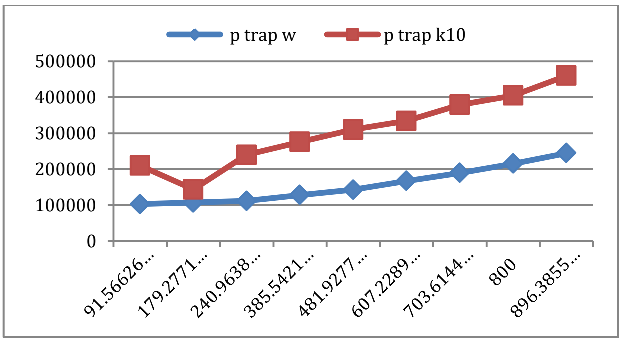

Fig.4

Curve between the pressure drop and Reynolds number

Conclusion

This all analysis is done on the basis of simulation for the Trapezoidal shape of micro channel heat sink for upper flow arrangement to investigate the role of heat transfer coefficient and pressure drop.

1. In this investigation concluded that comparisons between the water and custom nano fluids having thermal conductivity 10 times more of water for Trapezoidal shape of micro channel heat sink for upper flow to predetermining the effect of pumping power and thermal resistance.
2. Thermal resistance and pumping power are the parameters that are depend upon the geometrical and flow parameters.
3. In this investigation we conclude that value of heat transfer coefficient in case of water is 10000w/m²k & value of custom nano fluid is 35000w/m²k.

Nomenclature

A	Area exposed to heat transfer
c_p	Specific heat (J kg−¹ K−¹)
h	Coefficient of convective heat transfer(W m−² K−¹)
k	Thermal conductivity
t_s	Surface temperature
t_f	Fluid temperature
V	fluid velocity(m/s)
μ	Viscosity
P	Pressure
ρ	Density
nu	Nusselt number
Re	Reynolds no.
R_{th}	Thermal resistance
PP	Pumping power
t	Upper flow
rect	Rectangle

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