Analysis of Microchannel Heat Exchanger for Electronic Equipments Cooling using SiO_2/Water Nanofluid

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Abstract—In this work the experimental and numerical investigation for the improved heat transfer characteristics of parallel type microchannel heat sink using SiO_2/water is done. The fluid flow characteristics is also analyzed for the parallel type microchannel. The experimental results of the heat transfer using SiO_2/water is compared with the numerical values. The results in this work suggest that the best heat transfer enhancement can be obtained in a system with water-cooled micro channel with parallel type fluid flow. The heat transfer from smaller area is achieved through microchannels.The maximum heat transfer is achieved in microchannels with minimum pressure drop across it.

Keywords—Parallel type,Microchannel Heat sink, Heat Transfer enhancement , Friction factor, Nanofluid SiO_2/Water.

INTRODUCTION

The application of micro channels in heat transfer was first proposed by Tuckerman and Pease [1] in the electronic chip which could be effectively cooled by means of water flow in microchannels fabricated on the circuit board on which the chips are mounted. The need for thermal management in high end power electronic workstations cooling,application servers and data centers [2] is an exceedingly demanding area that requires continuous research efforts to develop efficient and cost competitive cooling solutions. Some of the commonly used heat transfer fluids are the Air, ethylene glycol and engine oil for the past some decades[3].

The water was formulated by Lee et al [4]without any chemical dispersants and performed experiments to show that water have good suspension and dispersion characteristics and high thermal conductivities. The importance of micron size mechanical devices are emphasized both in commercial and scientific application [5,6]. Kandlikar et al[7].also insisted the the need of micro system in for heat transfer enhancement in micro scale devices.

Jung-Yeul et al [8] have reported that the Nusselt number increases with increasing Reynolds number in laminar in his experimental study. Microchannel heat exchangers are classified as micro, meso, compact and conventional heat exchanger based on channel diameters [9]. In this study the heat transfer characteristics of water /SiO2 flowing through Parallel MC and hydraulic diameter of 0.81mm is investigated.

EXPERIMENT STUDY

PREPERATION OF NANOFLUID

Gamma Silicon Dioxide was used for the preperation of γ SiO_2Nanofluid with water as the Base material. γSiO_2nanoparticales were dispersed in 3.5 lits of ultra pure double distilled water under sonification at different volume fraction say 0.01,0.02,0.03,0.1,0.2,0.3 and tested for the heat trasfer property of the material in the microchannel.

PROPERTIES OF WATER

The standard properties of water is

Density	=1000 kg/m^3
Thermal conductivity	=0.56 W/mK
Specific Heat Capacity	=4.217 KJ/kgK

PROPERTIES OF NANOPARTICLES

Various researchers have published the properties of nanoparticles and thermal properties of nanofluids as the basis of research on nanofluids applications. The published specific heat, thermal conductivity and density of SiO2 nanoparticles is

Density	= 2.4x103 kg/m^3
Specific Heat Capacity	= 680 j/kgK
Thermal Conductivity	= 1.3W/Mk

DIAGRAM FOR MICROCHANNEL

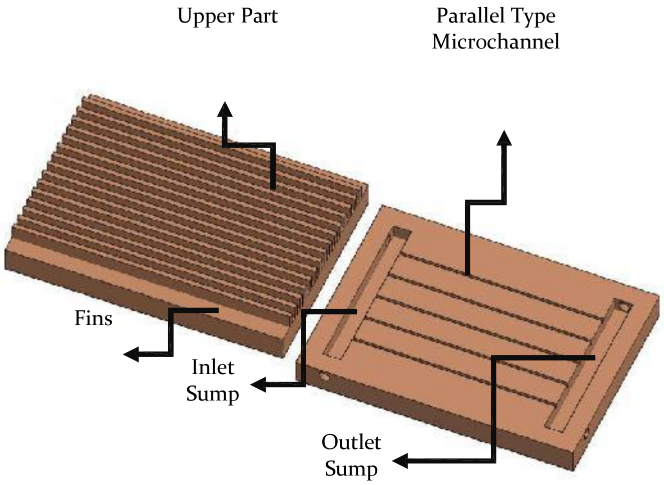


Fig.(1) Three Dimensional View

As per the given dimensions, Fig.(1) can be machining using a EDM process. With help of bed type surface grinding machine, a copper plate can be grinded and inlet, outlet sumps can be drilled using a milling process. Upper part and Lower part is brazed after the machining process respectively.

THEORITICAL DATA ANALYSIS

HYDRAULIC DIAMETER

A Hydraulic Diameter can be used for to circulate the SiO2 nanofluids with base fluid in parallel type microchannel. It can be calculated using this formula,

$$Dh = 2WH/(W+H)$$

where,

W - Width of the microchannel = 0.8mm

H - Height of the microchannel = 0.9mm

Using this formula we calculated the hydraulic diameter is 0.81mm.

THEORITICAL HEAT TRANSFER COEFFICIENT

Theoritical heat transfer can be calculated using this formula,

$$h= Nu.k/D$$

where,

Nu - Nusselt Number = 0.024Re0.7Pr0.9
k - Thermal conductivity
D - Hydraulic Diameter

REYNOLDS NUMBER

Assuming the Reynolds number between 100 to 1300,

$$Re =UD_h/Vf$$

VISCOSITY

Viscosity for nanofluids formula is

$$\mu nf =\mu bf(1+2.5)*Ø$$

From this we found the Flow velocity, U is $2.3177x10^{-4}$ m/s.

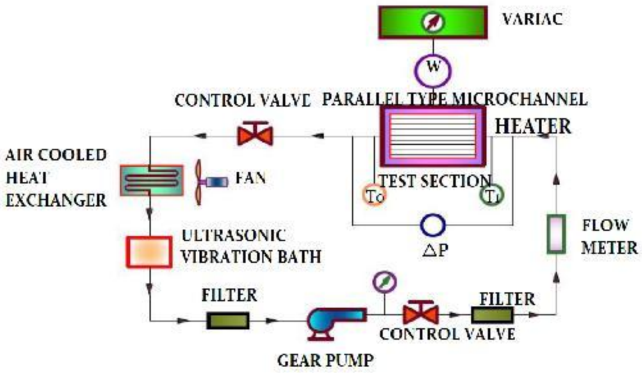
CORRELATIONS FOR NANOFLUIDS

a) Density = (1- Ø)Pbf + ØPp

b) Specific heat capacity =(1- Ø)Cbf +Ø(Cp)p
c) Thermal Conductivity
={(kp+2kbf+2(kp-kbf)(Ø))/(p+2kbf-2(kp-kbf)(Ø))}kbf

From this, the theoretical heat transfer coefficient is $7.022x10^{-6}$ W/m^2K.

EXPERIMENTAL SETUP



The experimental setup consists of a Ultrasonic vibration Bath, Pump, Filter, Flow meter ,Micro-channel, Heater and Air cooled heat exchanger. SiO2 nanofluids are stored in the ultrasonic vibration bath and it acts as a reservoir and sonificator. A heater is fixed on the surface of the microchannel. A pump is attached between the bath and the microchannel to circulate nanofluids through the entire circuit. The unwanted micron size particle are removed using filters. Flow meter is placed between the pump and micro channel. Fluid flow rate is controlled by the control valve and it is placed between the pump and channel.

The pressure gauges are fixed at the inlet and outlet of the micro channel and used to measure the pressure drop of the channel. When the nano fluid passes through microchannel, it absorbs some amount of heat supplied by the heater and the excess heat carried by the nano fluid is released when it passes through the air cooled heat exchanger, then the fluid moves to the bath and the cycle is repeated. The entire set-up is kept airtight in order to prevent any leakage of the fluid.

CONCLUSIONS

In this work the heat transfer characteristics of parallel type microchannel heat sink with SiO_2water is experimented. The convective heat transfer coefficient for the low volume percentage there is considerable enhanced thermal conductivity for the water. Thermal performance of water in all concentration study showed has better efficiency. Temperature distributions on the parallel type MC were very higher using pure water.

Thermal Resistance of the MC heat sink was decreased when using water.When the volume fraction is increased in the water, then the water thermal conductivity increases considerably. The experimental performance study of MC load with water proved. In this work, a parallel type microchannel heat exchanger can try to prove that the high heat transfer absorption rate, here a rectangular duct used to flow the fluids. After the design, experimental work has been fabricated and analysed.

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