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"Experimental Investigation for Heat Transfer of Microchannels by Liquid Forced Convection"

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ABSTRACT
Experiment is conducted to investigation the single phase forced flow convection by using working fluid as water and ethanol following through a microchannel with rectangular cross-section .A fully developed turbulent convection regime is found to be initiate about Re= 100~1500. The fully developed turbulent heat transfer can be predicated by well known Dittus-Boelter correlation by modifying the empirical constant coefficient from 0.023 to 0.00805. the calculated results are quite good with the experimental data the transition and the laminar heat transfer behaviour in microchannel are very unusual and complex and strong effected by liquid temperature, velocity and microchannel size

Keywords- **Heat transfer, Micro channels, liquid fluid, forced convection, heat transfer.**

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I. INTRODUCTION

In light of its remarkable preferred position for down toearth applications, microfabrication or nanotechnology, initially rising up out of the innovation created for incorporated circuits, has extended quickly into such fields as bioengineering and biotechnology, aviation, smaller than normal warmers and little warmth exchangers, gadgets and microelectronics, materials handling, and meager film statement advancements, and has brought about momentous commitments to the advancement of current highinnovation. Additionally, it might give new apparatuses to looking at physical wonders, and flexibly newopportunities for tentatively contemplating andestimating the warm wonders that are hard to measureincommon circumstances.its extraordinary advantage for practical applications, microfabrication or nanotechnology, originally emerging from the technology developed for integrated circuits, has expanded rapidly into such fields as bioengineering and biotechnology, aerospace, mini heaters and mini heat exchangers, electronics and microelectronics, materials processing, and thin film deposition technologies, and has resulted in remarkable contributions to the development of modern high technology. Moreover, it may provide new tools for examining physical phenomena, and supply new possibilities for experimentally studying and measuring the thermal phenomena that are difficult to measure in usual situations. The analyses of heat transfer phenomena in the above-mentioned applications and new technological developments offer new and unique areas of research. For example, owing to the urgent needs for cooling electronic components and devices, microscale heat transfer technologies such as mini heat exchangers with flow channels having dimensions ranging from the order of several hundred to 0.1 micrometers have been developed. These microchannels and mini heat exchangers have found their application in reactors for modification and separation of biological cells, selective membranes and liquid/gas chromatographies. As pointed out by Yang and Zhang , the last decade of the twentieth century may witness rapid progress in research of microscale and nanoscale transport phenomena. Microscale heat transfer and transport phenomena are expected to be quite different from those in customary situations. Tuckermann and Pease demonstrated that the electronic chip can be effectively cooled by means of water flow in microchannels fabricated on the circuit board on which the chips are mounted. Their results also indicated that the heat transfer coefficient of laminar flow through microchannels might be higher than that of turbulent flow through normally sized channels. Wu and Little, Pfahler et al., and Choi et al. noted that the flow and heat transfer characteristics of fluid through microchannels or microtubes departs from the thermofluid experimental results for convectional-sized channels.

II. LITERATURE REVIEW

Aly M. A. Soliman et all state that In the study, an experimental investigation to theperformance of the solar cells coupled with heat sink is presented. Indoorexperimental setup was designed and assembled to investigate the impact of usingheat sink cooling system on the performance of solar cells. Halogen lamps used tosimulate the solar radiation and the study is carried out at different solar radiationvalues. Moreover, the study is carried out at natural and forced air to cool the heatsink. The results show that using heat sink cooling system enhances theperformance of the solar cell. Temperature of solar cell decreased by about 5.4 %and 11 % by using heat sink cooling system at natural and forced air over the heatsink, respectively. Moreover, the efficiency and power of the solar cell systemincrease by about 16 % when heat sink cooling system is used.[1]

Mushtaq I. Hasan et all state that In this paper using of the phase change materials(PCMs) in a micro-channel heat sink (MCHS) is numerically investigated. The air isfirst used in heat sink and then four phase change materials (paraffin wax, n-eicosane,p116 and RT41) have been used as cooling mediums in different types and differentconfigurations at different ambient temperatures. Constant heat flux is applied on thebase of heat sink and mixed (convection and radiation) boundary condition is applied atthe top surfaces of heat sink.The results showed that, using of the phase change materials in micro-channels heatsink with different configurations lead to enhance the cooling performance of micro heatsink. The phase change material should be selected according to its melting temperatureaccording to the certain application as different phase change martials caused differentvalues of reduction in heat sink temperature in range of ambient temperature due todifference in melting temperatures of PCMs. The cost of materials depends on theclassification of the PCM (organic and inorganic) and quantity of PCMs used in a certainapplication.[2]

Afzal Husain, Kwang-Yong Kim et all state that The present study deals with thenumerical optimization of microchannel heat sink with the help of surrogateanalysis and evolution- ary algorithm. Two design variables related to themicrochannel depth, width and fin width are chosen and their ranges are decidedthrough preliminary calculations of three-dimensional Navier–Stokes and energyequations. Objective functions related to the heat transfer and pressure drop i.e,thermal resistance and pumping power are formulated to analyze the performanceof the heat sink. Water with temperature dependent thermal properties is used ascoolant for steady, laminar fully developed flow in the silicon microchannels.Using the numerically evaluated objective function, polynomial response surface isconstructed for each objective function. Evolutionary algorithm for multiobjectiveoptimization is performed to obtain global Pareto optimal solutions. Trade off between objectives is found and analyzed with the design variables and flowconstraints.[3]

Sunil Kumar et all state that The nanofluids have increased interest in manyengineering fields due to its excellent thermophysical properties, which can be easilyused in microchannel heat sinks by many roles for performance improvement. Thepurpose of this review summarizes the important published articles on the enhancementof the convective heat transfer in microchannel heat sinks using nanofluids. Numerousstudies have been done to find the effect of different nanofluids flow through microchannel heat sinks on thermal performance. In this work a comparative study is alsocarried out to select be micro channel heat sink shapes for maximum heat transfer andminimum friction losses.[4]

III. TEST FACILITY AND EXPERIMENTAL DESCRIPTION.

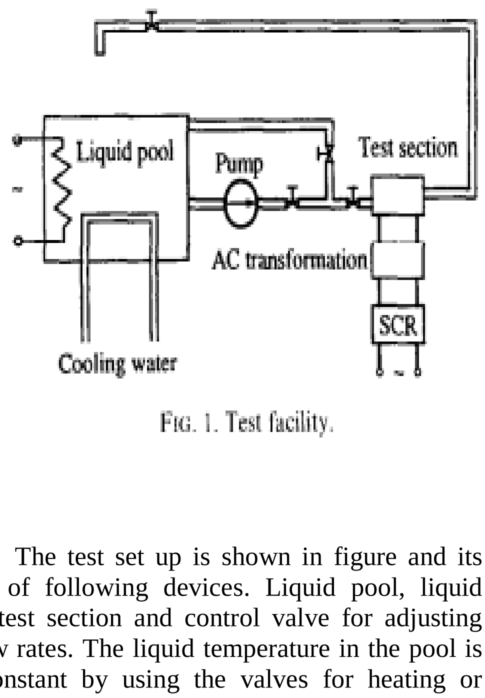

FIG. 1. Test facility.

The test set up is shown in figure and its consist of following devices. Liquid pool, liquid pump, test section and control valve for adjusting the flow rates. The liquid temperature in the pool is kept constant by using the valves for heating or cooling. The liquid is pumped in the pumping line the part of it followed through a test section and returns to the pool and part flowed through the by pass tube line to the pool with the experimental set up. It is convenient to adjust the flow rate and maintain steady liquid flow rates. An open- loop systems is selected for the investigation and flow rate is determined by the method of weighting. The microchannel structures to be tested is made up of stainless steel plate 18 mm wide and I25 mm onwhichthe microchannels are machined in parallel. As shown below.

Figure 2 is a schematic diagram showing details of the test section. The thickness of the region of the plate where the microchannels were machined was 2 mm. The tested length of the microchannel was 45 mm. There were six kinds of microchannel structures utilized in this investigation. Each microchannel cross-section was rectangular with different widths and identical channel height of 0.7 mm. There were N (4 or 6) microchannels with identical gcometries evenly distributed on each test plate. The geometrical parameters of the tested microchannel structures are summarized in Table 1. Thermocouples for measuring liquid temperature were located at the inlet and outlet of the test section. In addition, six thermocouples were mounted on the back of the microchannel plate, three thermocouples at the upstream end and another three at the downstream end, to measure the plate wall temperature. The stainlesssteel plate on which the microchannels were machined was electrically heated by directly connecting the plate to an AC electrical-current transformer matched with an SCR voltage regulator that provided low voltage and high electric current. Hence, high, uniform heat flux was supplied along the test section. The input voltage and current were adjusted to control the applied heat flux. By this heating method, the heat was generated in the microchannel plate, which may be a better way to simulate the heat generated by electronic components.

Heat transfer through microchannels

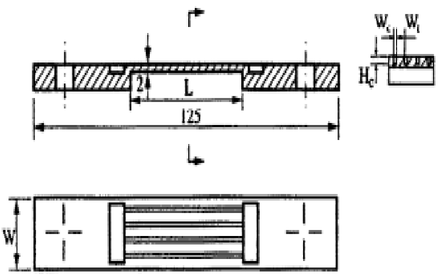

Fig. 2. Test section (dimensions in mm).

Table 1. Geometric parameters of test section

Test section	L (mm)	W (mm)	W_c (mm)	W_t (mm)	H_c (mm)	N
No. 1	45	18	0.8	3.4	0.7	4
No. 2	45	18	0.6	3.6	0.7	4
No. 3	45	18	0.4	3.8	0.7	4
No. 4	45	18	0.4	2.4	0.7	6
No. 5	45	18	0.2	4.0	0.7	4
No. 6	45	18	0.2	2.6	0.7	6

IV. RESULTS AND DISCUSSION.

The experimental results of Nusselt number, NM. are plotted vs Reynolds number, Re, for water in, and for methanol.The experiments previously conducted on methanol, with test sections Heat transfer through microchannels 71 No. 3-6 only, have been reported in ref. [18]. When Re is greater than about 1500. the data on the h - T, curves with smaller or nearly zero slope departing from equation (10) are in the transition zone. When the deviation or transition appears, Nu is almost independent of Re for a given liquid velocity and inlet temperature as h does not depend upon T, in Fig. 3. Then, Nu sharply goes down with decrease of Re where the transition region may be going to terminate and a new heat transfer mode may take place. There are three different regions similar to those discussed above. Prior to the transition zone, Nu recedes with Re. This is expected to be the laminar flow zone. There is a very narrow area in which flow is altered from the laminar to the transition regime. Nu is approximately not affected by the increase of Re after transition has occurred. The latter is referred to as the transition zone as in other cases; however, Nu is smaller.

V. CONCLUSION

The single-phase forced convective heat transfer characteristics of water/methanol flowing through microchannels with rectangular cross-section were experimentally investigated. The results provide significant data and considerable insight into the behaviour of the forced-flow convection in microchannels. They show that liquid convection characteristics are quite different from those of the conventional cases and can be summarized as follows.

- For single-phase liquid forced convection through microchannels, a fully developed heat transand regime is initiated at about Re =

100&1500. transition to turbulent mode is influenced temperature, velocity and microchannel size. The well known Dittus-Boelter equation wasmodified with the only difference of empirical constant, to predict heat transfer; the rests are in quite s, good agreement with experiment data for fully developed turbulent flow.

- Transition and laminar heat transfer in micro channels are highly strange and complicated. compared with the conventionally sized situation. The range of transition zone, and heat transfer characteristics of both transition and laminar flow are highly 10. affected by liquid temperature. velocity and microchannel size

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