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Experimental Investigation of Vertical Downward Flow Boiling Heat Transfer inside Horizontal Mini Rectangular Channel

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Abstract: *The present work is carried to determine the two phase heat transfer coefficient during flowing vertical downward in the minichannel. The minichannel test section is made up of aluminum having hydraulic diameter 1.33mm. The experiments were carried out by varying mass flow rate from 0.1g/sec to 0.3g/sec of steam at three different vapour qualities of 0.2, 0.4 and 0.6. The result showed as the heat flux increases there is an increase in two phase heat transfer coefficient upto 20000W/m^2 ^{0}C. In addition to that there is a decrease in treand of heat transfer coefficient for vapour quality.*

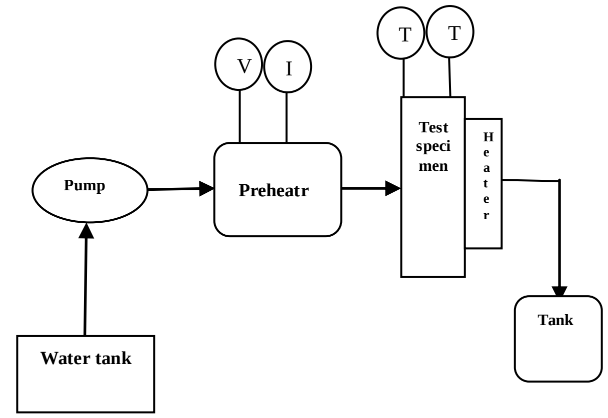
Keywords: *Heat transfer coefficient, Heat flux, Mass flow rate.*

I. INTRODUCTION

Rapid development in science and technology resulted in increase in the heat flux in electronic device. The traditional cooling technique facing difficulties in exhacting the heat at the limited allocated surface. Two phase cooling showed the promising to overcome the problem. Experimental results for small diameter tubes also obtained the heat transfer coefficients that are high or less independent of vapor quality and mass flux. And it is depend on saturation pressure and heat flux, the demand of increasing in flow boiling is that high heat fluxes have once again gained importance in an application such as electronics cooling and Micro-Electro Mechanical Systems (MEMS) devices. One of the first explores the works demonstrating the potential of small passages for heat transfer enhancement was performed by Bergles [1].Recent advances in very large-scale integration (VLSI) technology and Micro-Electro Mechanical Systems (MEMS) have resulted in the ability to construct many heretofore unimagined mechanical devices on a single silicon wafer. Because microchannels with noncircular cross-sections comprise an integral part of these silicon-based Microsystems and may be heated asymmetrically, functional designs require that the fluid flow and heat transfer characteristics in these microchannels be known and understood. In addition, the microminiaturization of electronic devices and resulting increased packaging density and associated high heat fluxes [2].Evaluated the heat transfer coefficient in rectangular microchannels in 50*25m^2. He predicted thermal profile on the chip and compared with experiments. He shows the pressure drop predictions using homogenous flow model were in good agreement with data. Experimentally studied critical heat flux in circular channels with diameters of 2.54 mm and 0.510 mm. The length of the heated channels is 10mm. And the working liquid is R-113. In this, critical heat flux is found to be independent of the inlet sub cooling at low flow rates because of fluid reaching the saturation temperature in a short distance into the heated channels. The author correlation was used for predicting the heat transfer coefficient. Number of reasherers like Bergles, A. E[1], I. Mudawar[2], P.A. Kew, K. Cornwell[3], M.W. Wambsganss.et al[4], Y.Y. Yan, T.F. Lin[5], G. Hetsroni.et al[6], Weilin Qu, Issam Mudawar[7], Bowers and Mudawar [8],Buasubranian Koo.et al, [9].

II. EXPERIMENTAL SETUP

The flow diagram of experiment setup as shown in fig (1). It consists of pump, digital pressure gauge preheater and thermocouples and two take initially the dimineral heater is filled into the steam. The water is pumped into the preheater where it reaches to the saturation state of the water. The saturated water was then pumped into the test specimen. The wall temperature was measured at different point as shown in fig. The steady state is identified when the readings of the thermocouples remains unchanged. After reaching the steady state all the temperature, pressures were measured.



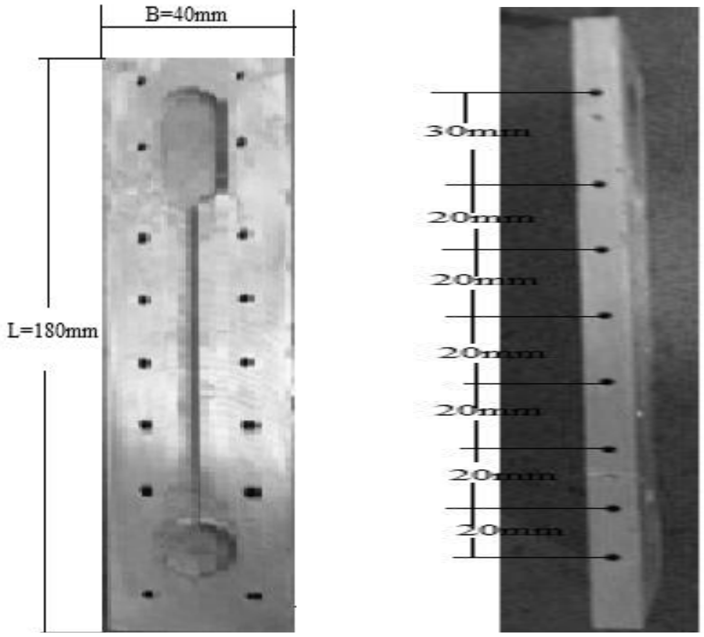


Figure1: Fig shows Experimental set up

III. FIGURES AND TABLES

1. Operating Parameter

Table -1: Operating Conditions

Mass flow rate(g/sec)	Dryness fraction (X)	Heat (Q in Watts)			
		Q1	Q2	Q3	Q4
0.1	0.2	10	20	30	40
	0.4	10	20	30	40
	0.6	10	20	30	40
0.2	0.2	10	20	30	40
	0.4	10	20	30	40
	0.6	10	20	30	40
0.3	0.2	10	20	30	40
	0.4	10	20	30	40
	0.6	10	20	30	40

2. Results and Discussions

2 (a) Effect of heat flux on wall temperature for m=0.1g/sec, 0.2g/sec and 0.3g/sec.

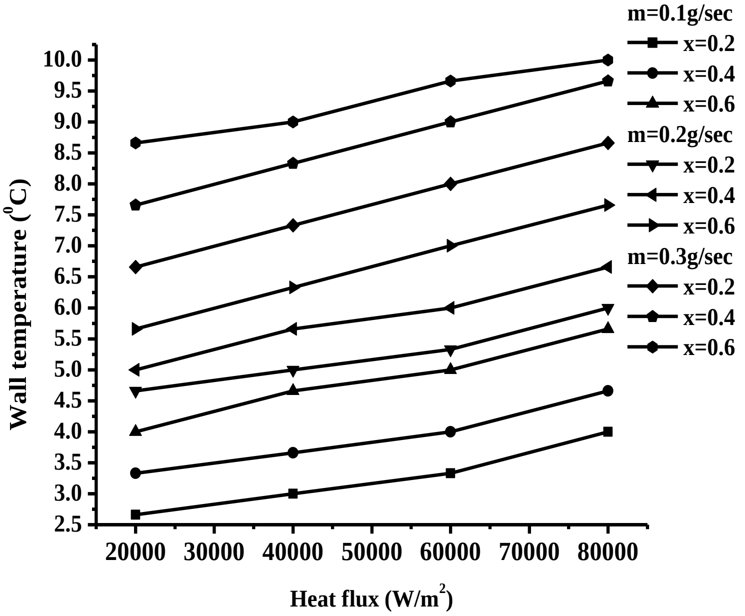


Fig (a)

FigIII.2 (a) shows the variation of heat flux on wall temperature for three different dryness fractions i.e. x=0.2, 0.4 and 0.6 with mass flow rates of m=0.1, 0.2 and 0.3g/sec respectively. It can be noticed from the figure that heat flux increases with increasing wall temperature due to the lower surface tension. Highest wall temperature was found at highest dryness fraction x=0.6.

2 (b) Effect of heat flux on heat transfer coefficient for m=0.1g/sec, 0.2g/sec and 0.3g/sec.

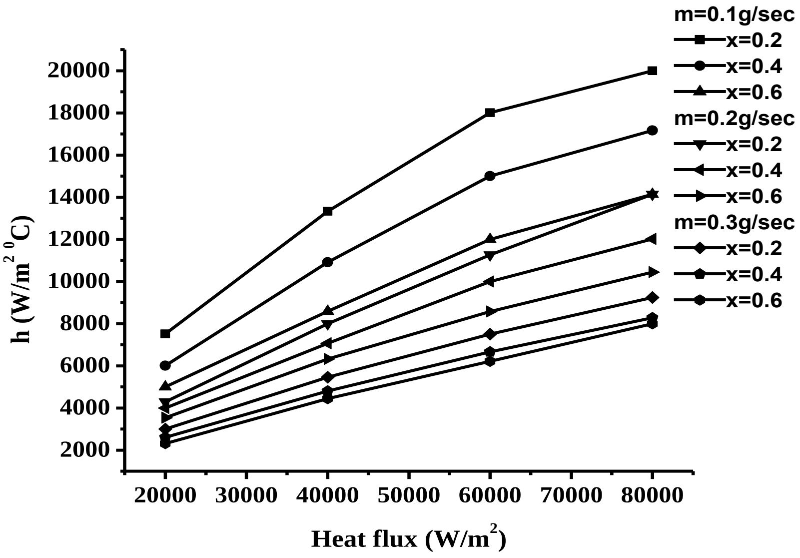


Fig (b)

FigIII.2 (b) shows the variation of heat flux on heat transfer coefficient for three different dryness fractions i.e. x=0.2, 0.4 and 0.6 with mass flow rates of m=0.1, 0.2 and 0.3g/sec respectively. It can be noticed from the figure that heat transfer coefficient increases with increase in the heat flux, because increase in the heat flux increases the wall super heating temperature and at higher wall super heating temperature higher heat transfer will takes place in both cases. Highest heat transfer coefficient was found at lower dryness fraction x=0.2.

2 (c) Effect of dryness fraction on heat transfer coefficient for m=0.1g/sec, 0.2g/sec and 0.3g/sec

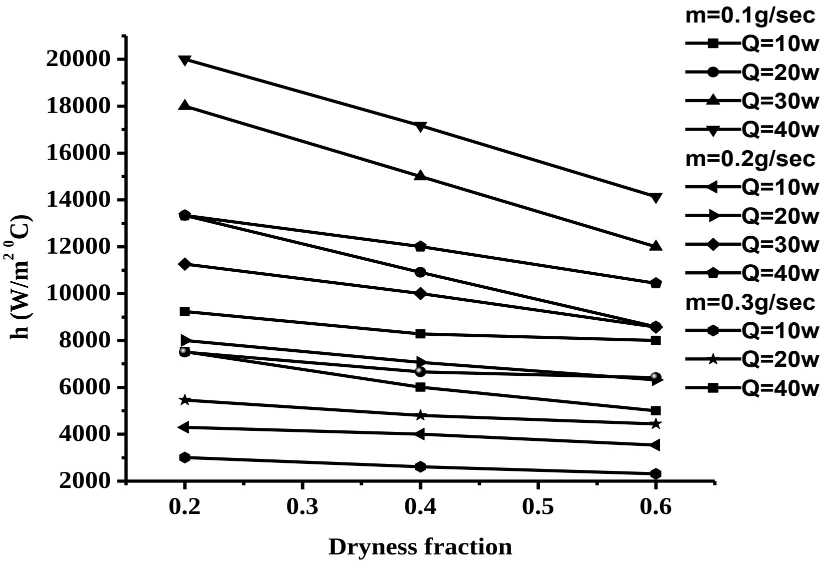


Fig (c)

FigIII.2 (c) shows the variation of dryness fraction on heat transfer coefficient for the different heat input i.e. Q=10W, 20W, 30W and 40W with mass flow rates of m=0.1g/sec, 0.2g/sec and 0.3g/sec respectively. It is observed from the above figure that heat transfer coefficient decreases with increasing dryness fraction due to the lower shear stress at the wall surface and increase in thermal resistance. Higher heat transfer coefficient is obtained at higher heat input.

IV. CONCLUSION

As heat flux increases there was an increase in wall temperature. For high heat flux there was greater heat transfer coefficients upto 20000W/m^2 ^{0}C. And also at higher heat fluxes there was slow increase in two phase heat transfer coefficient. The heat transfer coefficient decreases with increasing dryness fraction due to the lower shear stress at the wall surface and increase in thermal resistance. Higher heat transfer coefficient is obtained at higher heat input.

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