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Pressure Drop Effect on Mini-Scale Heat Sink by Multi-phase: Review & Prediction

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Abstract

The pressure drop on a boiling flow for a micro-channels of heat sink was reported with the R123 as a working liquid for this heat sink. The liquid has an inlet temperature (20 °C), (8) mass flux speeds for same inlet temperature (160 -300 kg/m^2.sec) and the heat applied to vary from (10 to 15 kW/ m^2). So, a square copper of micro channels of heat sink has (25) channels each channel has (0.1 mm) channel height and (0.5 mm) width channel. So, the prediction of single-phase and for two-phase of heat transfer coefficient and predictive of wall temperature was addressed in this paper. This paper also guessed a heat flow of micro-channels. A piece of copper plate has dimensions (25 mm) width by (25 mm) length and (5 mm) depth was subsequently developed for a square of copper plate. So the square copper on micro-channels of heat sink had heated by an electric heate.So It has been reported and documented that the properties of geometrical structure and test piece metal contribute to the prediction of single-phase and for two-phase heat transfer coefficient functions. An iteration process by excel software was employed to get properties of flow heat such as; a single-phase and two-phase on pressure drop of heat transfer was clearly been laminar also a fully developed on this flow, a prediction on wall of temperature, a prediction on fluid of temperature at prediction tests. A potential mechanism of heat transfer was reported for micro-channels of heat sink. So results on the main of this paper to acquire an inlet and an outlet a prediction of heat flow, such as a temperature of liquid; a temperature of wall; a coefficient of heat transfer. In addition to mention for some of numerical results such as the liquid of Reynolds number had (54-101) also two-phase of Reynolds number had (412-846); a single-phase of pressure drop was (50-211) Pascal. At end, I would like to mention that no experimental data come of prediction set-up so that R 123 data come on prediction analysis was only employed by equations of heat transfer at guess set-up Very similar to real lab tests under to same conditions.

Keywords: Boiling, Two-phase, Pressure drop, Heat sink.

1. Introduction

The key subject of this study is to get a pressure drop on project system. A lot of technique such as employing micro-channels had recommended for increasing of heat transfer in the electronic and electronic devices. For multi-phase flows or single flows of fluid or air streamed into them **[1–5]**.Ibtisam A. Hasan; Iman S. Kareem; Duha Adil Attar **[6]** had investigated an array of pin fins heat sinks in order to create a cooling system for PV panels. So 1-D analysis condition was employed to transfer an excess heat via the PV panel with the heat sink by existing to predict an operation temperature of the PV panel by Theoretical and panel performance has been investigated empirically. Hayder Mohammed Hasan **[7]** was numerically studied to micro-channel of heat exchanger SIMPLE algorithm via finite volume method also employed FORTRAN code to get the distribution of temperature for their project.It is assumed to that a steady-state and a system pressure close to atmosphere. It is obtain that the flow is laminar and was fully developed; an iteration process is employed to simulate a technique of pressure drop to heat transfer. In so far as we know no previous investigation has reported to get properties of heat transfer as a prediction only. It is not the topical, of this review to characterize or Remind all the work that has been investigated or published of this subject but instead to evaluate several of the objective consequences and produce an estimation of where we attitude today. So , the researchers are recommended to refer to other comprehensive surveys on micro-channel of heat transfer for the flow of single-phase and for the flow of two-phase via Mehendal et al**.[8]**, Kandlikar **[9],** Huo et al. **[10],** Kandlikar and Grande**[11]**, Bergles et al. [**12**] and Thome et al. **[13**].Jiang et al.**[14],** Harms et al.**[15]**, Jiang et al.[16] were reported and studied for a transition from laminar to turbulent flow became an issue of micro-channel was reported due to some investigations had pointed that a transitional zone started at a lower Reynolds number than at traditionally expected data. The determinations to present on this investigation are: (1) to prepare new pressure drop data for R123 on single-phase and on two-phase to micro-channel, (2) to get a substantial parametric trend and an explore the possibility of a mechanism on pressure drop to heat transfer, (3) to guess on the accuracy of previous to correlations of micro-channel at guessing the new data, and (4) to enhance a new pressure drop to heat transfer correlation for R123 on boiling tests of micro-channel to heat sink.

2. Theory

A guess of heat transfer on parameters to the flow is presented according to the fluid of wall temperatures at the system pressure as a point to temperature; As seen in Fig.1, a specification indicates that only a single heat flux distribution can exist on the solid-fluid interface.A dominant effect on the wall conduction, as seen in the 2-D array; first-D array was perpendicular to the second-D array was liquid flow R123 parallel to the R123 liquid flow, a thermal conductivity for the following equation, was not observed eventually **[17]&[18]**.

$$\delta^2 T/\delta y^2 + \delta^2\, T/\delta z^2 = 0 \qquad (1)$$

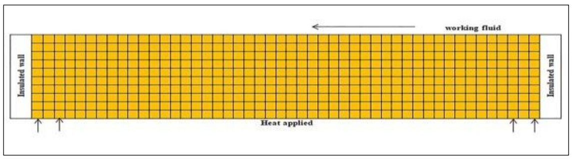

Fig.1 Wall Conduction of copper test Piece **[17]&[18]**

Where (y) is perpendicular to flow axis; (T) is a temperature in a copper wall. Heat conduction in eq.(1) was discovered by the partition to the square cell region has (0.5 mm) square.An energy balance to be achieved by each cell, as shown in Fig.1. **[17]&[18]**

$$T_{i,j} = \delta y^2\left(T_{i+1,j} + T_{i-1,j}\right) + \delta z^2\left(T_{i,j+1} + T_{i,j_1}\right)/2\,(\delta y^2 + \delta z^2) \quad (2)$$

Where (δz) and (δy) are the cell size.So eq.(2) was meant to vary from boundary conditions that are iteratively solved to the point where the temperature at each cell is the same as previously predetermined a guess error of (0.003) by the iteration method. The value for (ΔT_{Sat}) at the critical cavity radius can be gained as**[19]:**

$$\Delta T_{sat} = \sqrt{\frac{8.8\,\sigma\, T_{sat}\, q''}{\rho_V\, h_{LV}\, K_L}} \qquad (3)$$

The calculation of boiling number is found by:-

$$Bo = q'/G\, h_{LV} \qquad (4)$$

The calculation of convection number is found by:-

$$Co = [(1-x)/x]^{0.8}[\rho_V/\rho_L]^{0.5} \qquad (5)$$

The exit quality can be found by using**[19]**,

$$x = 1/h_{Lg}\left[q'/m - C_p(T_{sat} - T_{in})\right] \qquad (6)$$

The calculation of two-phase coefficient to flow boiling is found by **[19]:-**

$$h_{tp} = h_L[0.6683\, Co^{-0.2}\,(1-x)^{0.8} + 1058.0\, Bo^{0.7}\,(1-x)^{0.8}\;\, F_{F1}\,] \qquad (7)$$

The calculation of Nussle number can be found by**[19]:-**

$$NU = h_L k_L/D_h \qquad (8)$$

Where prandtls (Pr); number as follows[**19]**:

$$P_r = \frac{C_p\, \mu_L}{k_L} \qquad (9)$$

The Reynolds number can be found by**[19]-**

$$R_e = \rho_L V D_h/\mu_L \qquad (10)$$

In where (D_h), seen by

$$D_h = A_{hc}/P_{hc} \qquad (11)$$

The Reynolds number for single-phase & two-phase regions are found respectively by **[19]**.

$$Re_L = (G(1-\ x)D_h)\ /\ \mu_L \qquad (12)$$

$$Re_v = (G\, x\, D_h)/\mu_v \qquad (13)$$

Fraction factor can be calculated by.

$$f_{laminar}R_e = 24(1 - 1.3553 + 1.946\beta^2 - 1.7012\beta^3 + 0.95641\beta^4 - 0.2537\beta^5) \qquad (14)$$

The single-phase of pressure drop can be found by:-

$$\Delta P_{sp} = 2\, f_{laminar}\, \rho_L V^2 \frac{L}{D_h} \qquad (15)$$

The friction and acceleration of pressure gradients on eqs (16) ,(17), and (18) respectively are calculated as follows**[19]**:-

$$\left(\frac{DP_L}{DZ}\right)_L = \frac{2\, f_L G^2(1-x)^2}{D_h \rho_{L;}} \qquad (16)$$

$$\left(\frac{DP_L}{DZ}\right)_v = \frac{2\, f_v G^2 x^2}{D_h \rho_v} \qquad (17)$$

$$X^2 = \left(\frac{DP_L}{DZ}\right)_L / \left(\frac{DP_L}{DZ}\right)_v \qquad (18)$$

The two-phase of multiplier can be calculated by**[19]:-**

$$\varphi_l{}^2 = 1 + \frac{12(1-e^{319 D_h})}{X} + \frac{1}{X} \qquad (19)$$

The two-phase set of pressure drop per unit length can be calculated by:-

$$\Delta P_{L,tp} = \left(\frac{DP_L}{DZ}\right)_L\ \varphi_l{}^2 \qquad (20)$$

The acceleration of pressure drop can be calculated by:-

$$\Delta P_a = G^2 V_L x \qquad (21)$$

The total of pressure drop to single-phase of pressure dropas well as two-phase of pressure drop and by acceleration pressure drop can be n be calculated by:-

$$\Delta P_T = \Delta P_{sp} + \Delta P_{tp} + \Delta P_a \qquad (22)$$

3. The Set-up

The set-up has (3) main elements; a flow loops, a copper test section; a micro-channel of complex geometry and a test piece of copper.

3.1 Flow loop

Assume that the set-up has a novel technology of development plan before the boiling test in Fig.2. In the test sequence, the running liquid R123 has been degassed for approximately (2-5) hours in the higher thermal test in order to remove any a dissolved gas is pushed into the atmosphere from the set-up. The valve at the top of a the preheater was occasionally opened to allow the dissolved gas to fly into the atmosphere. In addition, any test pressure was closed to ambient pressure. After extracting the gas from the R123 working fluid, remove the liquid R123 by the accumulation of the pump. The main goal of the coarse filter is to prevent major debris. A finer filter was employed during boiling tests .So, the optimal R-123 was calculated based on a mass flow and an inlet temperature (M_L; T_{in}). So, during the inspection, a coarse filter is employed to block large particles. The mass speed was balanced by a flow meter and a by-pass valve was located in front of the micro-channel of complex geometry. The heat modified controller for fluid R123 was moved to pre-heater to create the appropriate for temperature inlets to move to a complex geometry of micro-channels of copper housing .A pre-heater was connected to the controller unit. Before of conditions of steady-state needed to be maintained. A working fluid R123 has passed through to flow loop to the equipment. A procedure takes about (2-4) hours to stabilize the situation. The temperature of a heater and a copper housing can continuously pushes the movement. In this case, the heating duration is approximately (30 to 80 minutes), and the heating time employed is reset by an iterative process via the boiling test in order to maintain a device pressure be similar to the environment for all tests.

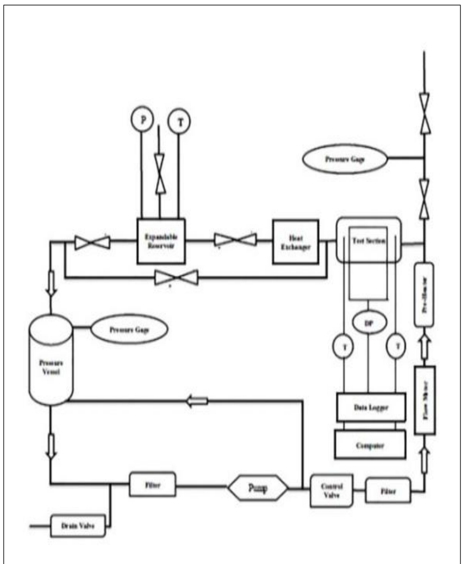

Fig.2. The Flow Loop[17]

3.2 Test section

Figs. (3 & 4) show a copper on test section composed of (3) parts: a copper housing, a top cover, a complex geometry of micro-channel. The top bodies, a bottom box and so all the foundations are made of copper, a copper box was employed. So; **Figs. (3 & 4)** are seen the copper of the test portion of this study is seen on analytical analysis top housing comprises a complicated micro-channel of complex geometry. It was fitted with an inlet plenum; an outlet plenum was equipped by pressure; a temperature port for receiving at similar sensors was prepared.

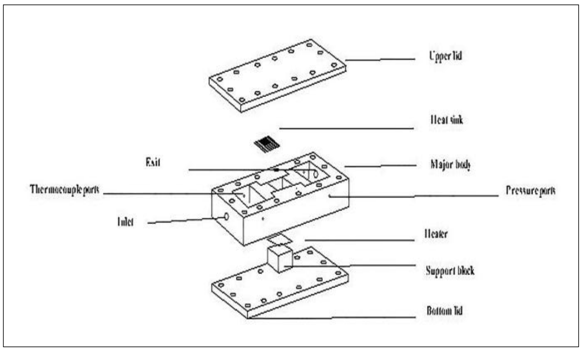

Fig.3. Test housing [18]

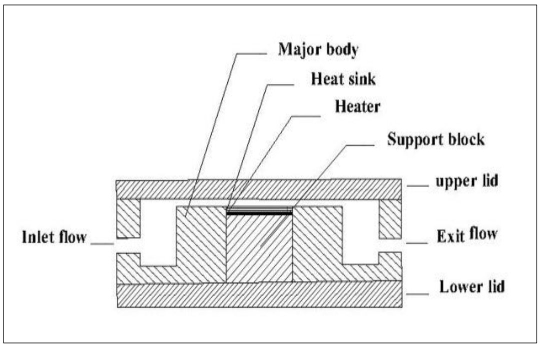

Fig. 4. Test section [18]

3.3 Test piece

Fig. (5) is seen the elements that had been obtained on the copper to micro-channel of complex geometry; therefore, (6) thermo-couple posts, (1) each on inlet plenum, an outlet plenum, and (4) underneath micro-channel of complex geometry zone .So all thermo-couples are employed to obtain an inlet temperature and an outlet temperature.A wall temperature of thermocouples with a sample diameter of (0.5 mm) was pushed through (2) holes for an inlet position and (2) holes for an outlet position, drilled both of them (4 mm) below the channel surface with a drilled (10 mm) and (20 mm) in a test piece from the inlet end respectively. Thermocouples had empolyed to measure the heat sink's stream on temperature distribution . These holes allowable (4) sheathed k-type thermocouples and all thermocouples had calibrated in an exceedingly water bath and had accurate to (±0.4 ºC) approximately.A groove is cut out on the surface of the top housing to line an O-ring.A copper to a micro-channel of complex geometry so channel had an altitudinous footprint on the surface to the housing of copper was (25 mm by 25 mm).

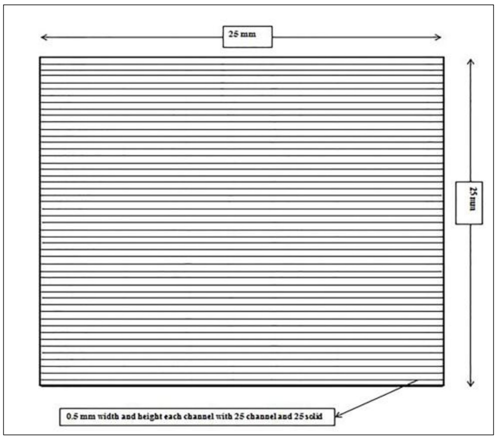

Fig.5. Test piece of micro-channel [17]

3. Results and discussion

For a presented heat flux, pressure drop clearly decreases with increasing of mass flux as seen in Fig.(6) until boiling intensifies, after that point, pressure drop decreases dramatically with the increase of mass flux because of the higher number and frequent vapor of bubble generation. Due to the segmented flow of R123-liquid and R123-vapor; the pressure drop was started decreasing by the first of mass flux then it was declined until on last one of mass flux. Pressure drop is observed to increase for a copper surface in the zone of single-phase was fully developed, but in the boiling zone was fully developed, it was hard to guess the additional pressure drop resulted from the copper surface if we compared to another plate surface.

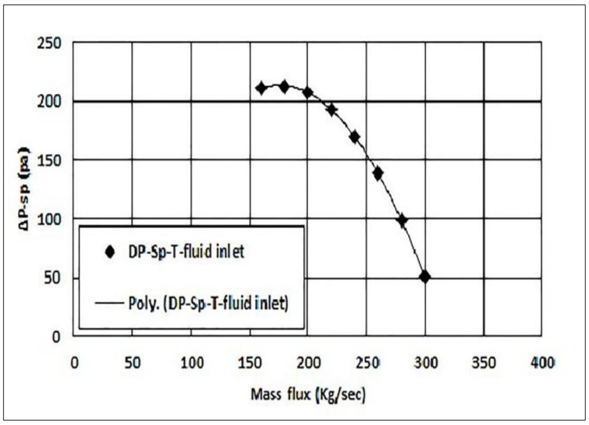

Fig.6. Pressure drop versus mass flux

As seen in **Fig.7**.The pressure drop for the single-phase liquid was shown to be approximately a power relationship So; pressure drop of single-phase was decreased dramatically with the increase of heat flux due to high heat flux was obtained higher pressure drop.As well as; Interesting stability for flow has been also been periodically observed with all single-phase on R123-liquid tests due to liquid flow had been laminar and also to liquid has fully developed for all tests.

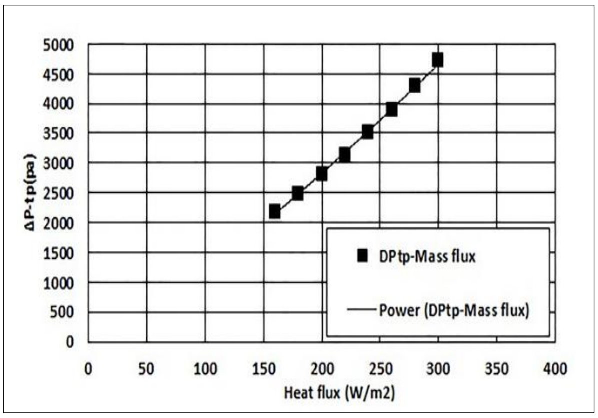

Fig.7. Pressure drop versus heat flux

As seen in to chart a two-phase to pressure drop has been seen as a function of exit quality in **Fig. 8**. The predictable data indicates to when the exit quality is lower the pressure gradient increases polynomial function with to the increase of vapor quality. The pressure drop has was increasing almost polynomial as the two-phase flow and an exit quality increase at low values of exit quality. So, a further increase of exit quality correspond to a moderate increase to pressure drop on two-phase.

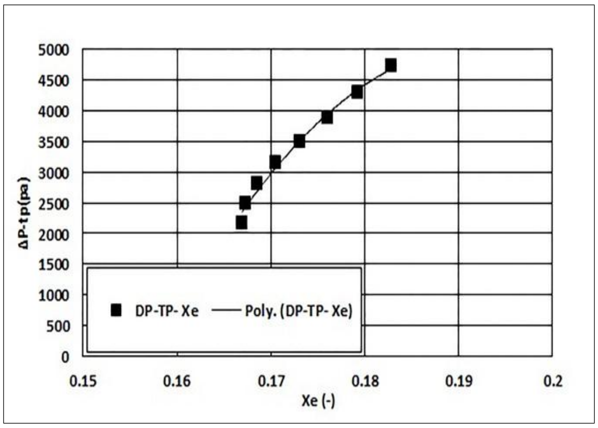

Fig.8. Pressure drop versus exit quality

Reynolds number of two-phase has shown for the range of flow velocities in **Fig. 9**. Reynolds number at the vapor and liquid data of the copper channel has been seen to increase with increasing flow velocity, with vapor Reynolds number data significantly higher than liquid Reynolds number data. The data deduced for a constant flow velocity has been included. So, the influences of wall conduction are showed to significantly influence data results. The fully-developed data and laminar flow are also included. The guessed error in the prediction of Reynolds number has assumed ± 8%.All data are importantly above this, despite the outlet data having a length to diameter ratio of twenty mm.

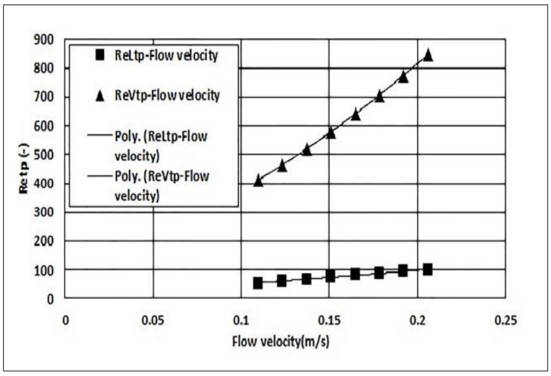

Fig.9. Reynolds number on two-phase versus flow velocity

Conclusions

The following conclusions are transmitted based on iteration analysis and equations of Heat transfer carried out in the present work.

1. Prediction investigation has proved better than or similar to traditional test of micro or mini-scale of heat sink.
2. The topical of this present work was to get a pressure drop of single-phase and a pressure drop for two-phase in a micro-channel heat sink using R-123 as coolant fluid. To achieve this goal, suitable predictable facilities had been designed and fabricated both for the synthesis of copper on heat sink and for convective and for conduction heat transfer tests
3. The boiling of pressure drop had been divided into a single-phase zone as well as two-phase zone. Many correlations had been employed to predict for pressure drop.
4. The two-phase to pressure drop depends substantially on the mass flux; as well as increases almost polynomial by increasing exit quality at different for mass fluxes.
5. A flow was forced convection at all tests.
6. The flow of pressure drop on single-phase, as well as two-phase had been laminar and fully developed for all at mass fluxes.

Nomenclature

A_{hc} = area of channel heat temperature
C_p = specific heat, kJ / kg.K
D_h = hydraulic diameter, m
h_{tp} =two-phase of heat transfer coefficient ,W/m^2.k
K_L =Thermal conductivity of liquid, W / m .K
L = length of micro-channel, mm
NU =Nussle number
q'' = heat flux (W/m^2)
Re = Reynolds number
Pr = prandtls number
T = temperature, ^{o}C
T_{in} = inlet temperature, ^{o}C
T_L = liquid temperature, ^{o}C
T_{sat} = salutation temperature, ^{o}C
TW = wall temperature, ^{o}C
V =liquid velocity, m/s
W = width of micro-channel, mm
χ = exit quality (-)
Z = Flow direction, mm

Greek symbols

ρ_L = Density of a liquid , kg/m^^{3}
μ_L = Dynamic viscosity N.s /m^2

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