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Heat Transfer and Fluid Flow Analysis on Microchannel Heat Sink with Varying Plenum Size

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Abstract :Computational fluid analysis study has been carried out to find a better prospect of perfect design, shape and plenum size microchannel heat sink (MCHS). Distinctive structure parameters were chosen to plan microchannel heat sink with shifting channel planum sizes of 10 mm, 20 mm and 30 mm. The material taken of circle type heat sink is taken as copper. The liquid taken is plane fluid. Amid liquid stream distinctive speed stream states of significant worth 0.25 lpm, 0.50 lpm and 0.75 lpm were chosen. In computational liquid examination changing weight, temperature and speed conditions impacts were additionally contemplated. Huge weight drop is recorded in the speed rating of 0.25 lpm. Speed readings were recorded high en 30 mm plenum estimate with 0.75 lpm speed stream. Investigation gives thought of an ideal structure fit as a fiddle with stream of liquid at 0.75 speed stream. The stream space were understood utilizing ANSYS programming as economically accessible for CFD examination. A special plan is set up from the examination which can exchange extensive measure of warmth in the state of microchannel heat sinks with microchannel length of 48 mm long and with other chose structure paramters. To accomplish more warmth expulsion from the MCHS the microchannel estimate upgrade is done diagnostically. For ordinary convective warmth trade coefficient, outlet temperature, grinding and weight drop, siphoning power and warm impediment have been plotted against Nusselt number qualities for various stream conditions. By settling the correct control of the liquid stream and warmth exchange propensity of a 3-dimensional MCHS has been accomplished computationally.

KEYWORDS:Micro channel heat sinks (MCHS), Nusselt number, Aspect ratio.

I. INTRODUCTION

The electronic components and computers are required to do work at a faster speed, so high powered integrated circuits were manufactured.All the fast circuits and gadgets produce heat motions which dependably acuse the circuits with high temperatures. Research is going on since 1981 by **Pease and Tuckerman** [1] in which microchannel heat sink work in straightforward way. Microchannels are machine processed on back of alluminium or other metal plates of electronic parts in facilitated circuits. Whatever the warmth is created by the electronic segment or circuit is exchanged to the coolant by constrained convection.

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The micron size of microchannels cause a reduction in thickness of warm limit layer which diminishes the convective résistance to warm exchange which produces high cooling rates. Tuckerman proposes that laminar stream is wanted stream rate for warmth expelling with mean of microchannels. With a created improved method to foresee the best angle proportion of microchannel Tuckerman accomplishes high warmth exchange.
He utilized water as a coolant in investigations. While looking at stream contact there found a high head misfortune. A short writing audit is given to advance of the investigation of warmth exchange and liquid stream in microchannel heat sinks.**Z.-Y. Guo**[28] had investigated the heat transfer in a rectangular stream channel. They are utilizing gas as coolant and found the impacts of heat exchange loss up to 38%. 40%. They tended to that low pumping force portrays the microchannels as great heat exchangers and higher surface to volume proportion of heat sinks.

P. Naphon [36] has mortally researched that Non-Darcy limit layer stream of non-coordinating genuine fluid. They changed over the present overseeing mostly differential conditions into nonlinear traditional differential conditions by closeness change. They deduced that the skin grating coefficient increments and Nusselt number depreciats with addition in ferro magnatic parameter. The examination was passed on with attractive ferro particles over a permeable directly expanding surface considering the Ohmic dissipating close by mixed convective warmth trade.Smaller scale channels are progressively significant for satisfactory at warmth expulsion in microelectronic gadgets. The need to empty broad measure of warmth created from microelectronic devices for adequate limit was first looked into by Pease and Tuckerman [1]. They had inquired about the execution of microchannels as warmth exchanger, using water as coolant and proposed the use of high perspective microchannels to diminish heat block.
Fedorov and Visakanta [13] Modeling of transport in miniaturized scale directs can be partitioned in to two classifications. In the primary, technique utilized for full scale channels are legitimately executed to assess the execution of smaller scale channel heat sinks.
L. Jiang [22] numerically recreated a constrained convection heat move happening in silicon based smaller scale channel heat sinks has been led utilizing a disentangled three-dimensional conjugate warmth exchange model.
X. F. Peng [8] directed a comparable kind examination by building up a completely express two dimensional incompressible laminar Navier-Stokes solver in crude variable definition utilizing a Cartesian amazed matrix.
T.C. Hung [30] researched the MCHS execution using nanofluid as a coolant is examined.

Two sorts of Nano fluids, Cu– H2O and CNT– H2O are used in this examination. The MCHS structure is shown as the penetrable medium and two-condition model was used to delineate the fluid and warmth move in the MCHS.

II. CFD ANALYSIS

Computational analysis has been done with ansys engineering simulation and 3D design software in which a copper plate of size 110 mm diameter is taken for the experimentation. The microchannel wall is assumed of diameter 2.5 mm given on the outer edge then the two plenum inlet & outlet plenum were drawn which were connected with the microchannels whose length has been kept fixed at 35 mm. A Heat flux of 50 watt per sq. cm. was given at the centre of the plate.

An simulation of flow type is made to run in which base liquid is taken as water. Fluid is made to enter from the centre/inlet plenum which is of diameter 10 mm, 20 mm, 30 mm. Various fluid flow rates were taken in simulation as 0.25 lpm, 0.5 lpm, 0.75 lpm.

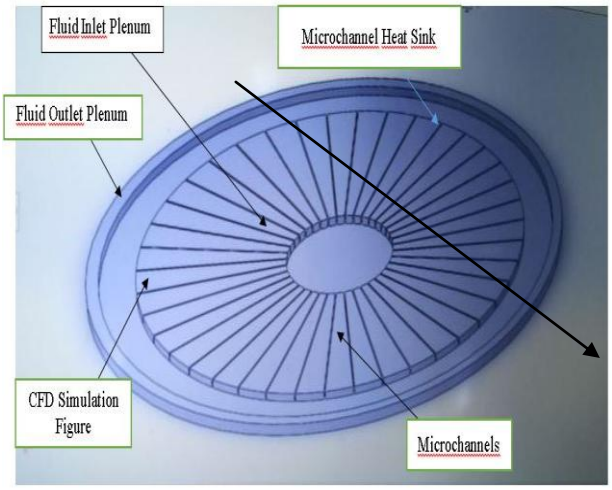

Fig.1.1 Microchannel Heat Sink Simulation

During simulation as shown in fig.1.1 study was done on the pressure, temperature and velocity components. Reynold numberswere also calculated from the middle of the channel. Nusselt number was also calculated to check the heat transfer between the two surfaces. The flow diagrams of velocity temperature and pressure are attached alongwith. Observations are taken out through the simulation. The work has been done on the different inlet plenum sizes 10mm, 20mm & 30 mm. In accordance with the size of the outer plenum has also changed which can be visualized from the flow diagrams.

III. OBSERVATIONS

Computational fluid analysis of microchannel heat sink is done in ansys software. Examination is done on a copper plate with width 110 mm. Two plenum were made as gulf and delta for stream of the fluid that were associated with 35 mm long microchannels. With three stream appraisals 0.25 lpm, 0.5 lpm, 0.75 lpm. The table 1 is inferred with stream rate readings with distance across of channel as 10 mm, 20 mm, 30 mm. The Copper heat exchange coefficient results between 350 w/m-k to 594 w/m-k. The estimation of warm conductivity is inferred as 0.6 w/m-k. Distinctive nature of liquid is assessed from the examination with impact of Nusselt number variety.

Table 1. Nusselt no. for different fluid flow

S.No.	Flow Rate (LPM)	Dia.Inlet (m)	C.H.T.C (w/m²-k)	T.C. (w/m^2-k)	Nu
1	0.25	0.01	192	0.6	2
2	0.5	0.01	502	0.6	4
3	0.75	0.01	227	0.6	2
4	0.25	0.02	87	0.6	1
5	0.5	0.02	300	0.6	3
6	0.75	0.02	223	0.6	2
7	0.25	0.03	150	0.6	1
8	0.5	0.03	167	0.6	1
9	0.75	0.03	200	0.6	2

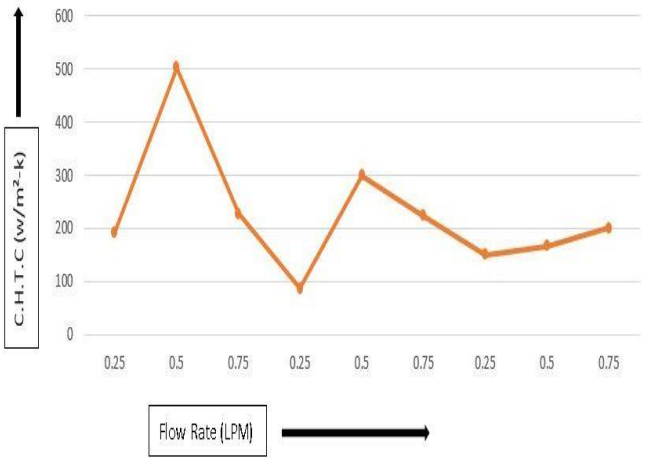

Fig. 1.2 Heat transfer coeff. for copper with different flow rates

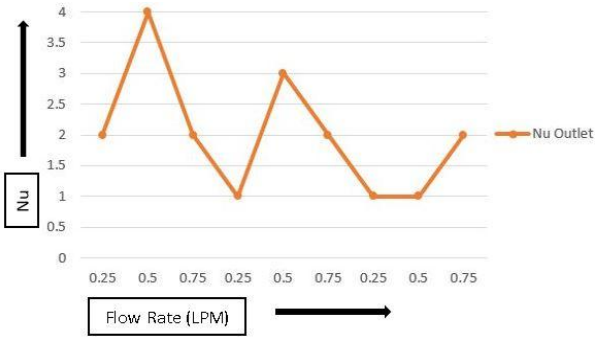

Fig. 1.3 Nu. number for different flow rates

The figure 1.2 demonstrates the examination of the warmth exchange by microchannel heat sink amid the cfd investigation for various stream rates openings at plenum. The fig. 1.3 demonstrates the examination done on nusselt number variety amid different perceptions of liquid streams at stream evaluations 0.25 lpm, 0.50 lpm, 0.75 lpm.

IV. RESULTS

1. Result observations from Pressure
a. Withdiameter 10 mm

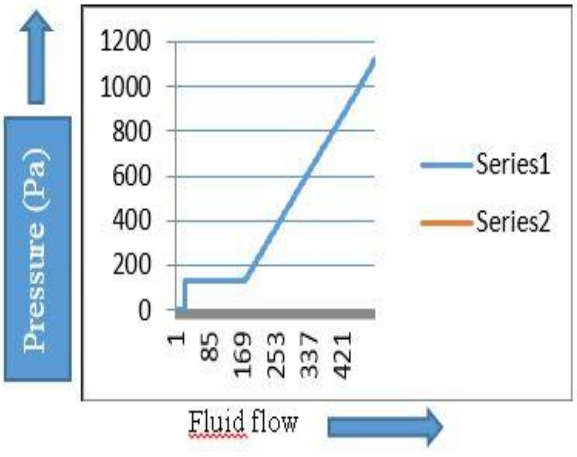

Fig. 1.4 Fluid flow at 0.25 lpm

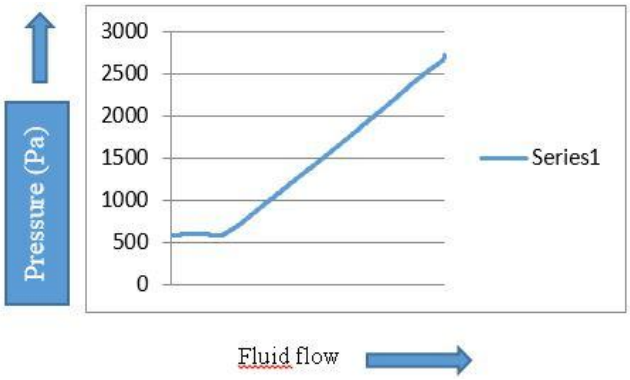

Fig. 1.5 Fluid Flow (m/s) 0.50 lpm

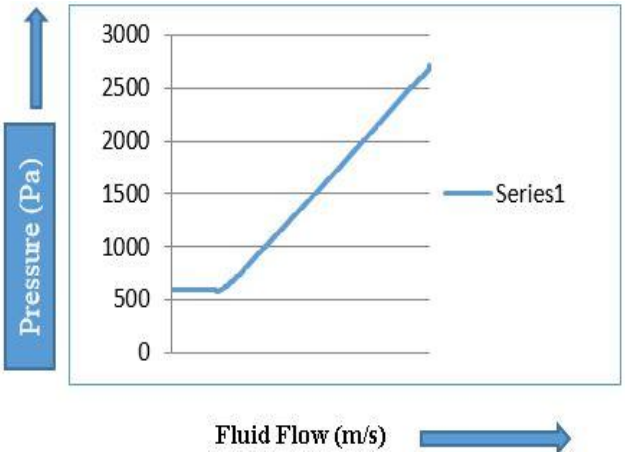

Fig.1.6 Fluid Flow at 0.75 lpm

At flow rate 0.25 lpm

Figure 1.4 shows the microchannel heat sink computational analysis values of pressure (Pa) that goes from 1 Pa to 180 Pa with the value of the fluid flow is evolved between 1 m/s to 20 m/s. As seen in the graphical analysis the pressure is denoted by blue colour section named as series 1. The fluid flow value is denoted by brown colour as series 2. As the flow rises with stream line is derived between 3m/s to 172 m/s. An increase in pressure is shown by a straight line evolving from 172 m/s flow to 436 m/s onwards flow at a pressure value 1155 Pa.

At flow rate 0.5 lpm

Figure 1.5shows the microchannel heat sink computational analysis values of pressure (Pa) goes from 0 Pa to 1200 Pa with the value of the fluid flow is evolved between 1 m/s to 421 m/s. As seen in the graphical analysis the pressure is denoted by blue colour section named as series 1. The fluid flow value is denoted by brown colour as series 2. As the flow rises a stream line is derived between 3m/s to 169.6 m/s. An increase in pressure is shown by a straight line evolving from 170 m/s flow to 421 onwards flow at a pressure value 1155 Pa.

At flow rate 0.75 lpm

Figure 1.6 shows the microchannel heat sink computational analysis values of pressure (Pa) goes from 508 Pa to 2530 Pa with the value of the fluid flow goes from 169 m/s to 360 m/s. As seen in the graphical analysis the pressure is denoted by blue colour section named as series 1. As the flow rises astream line evolves. An increase in pressure achieves shown by straight line at outlet plenum evolving from 562 Pa flow to 2570 pa onwards.

Colour contours at 0.75 LPM:

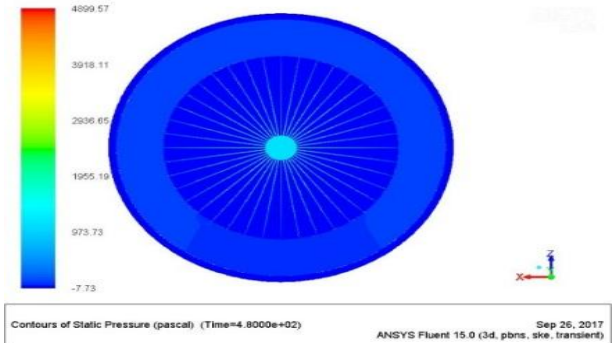

Fig.1.8 At 0.75 lpm colour contours

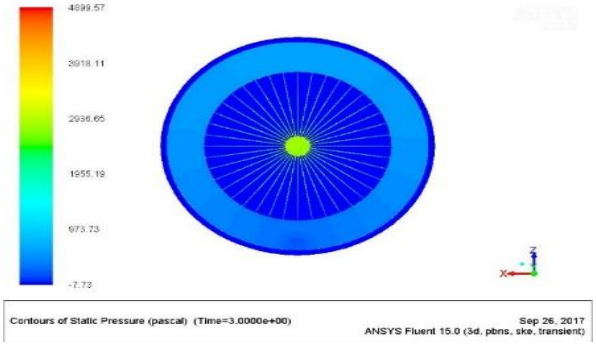

Fig.1.9 At 0.5 lpm colour contours

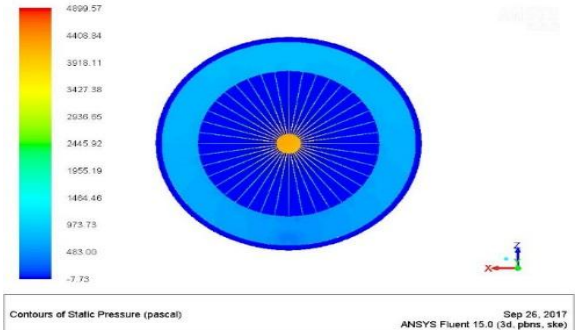

Fig. 1.10 At 0.75 lpm colour Contours

The pressure colour contours at different lpm's shows a negative in pressure and velocity drop at 0.5 lpm. A record in pressure rise is recorded at 0.75 lpm.

2. Pressure observation results for diameter 20mm

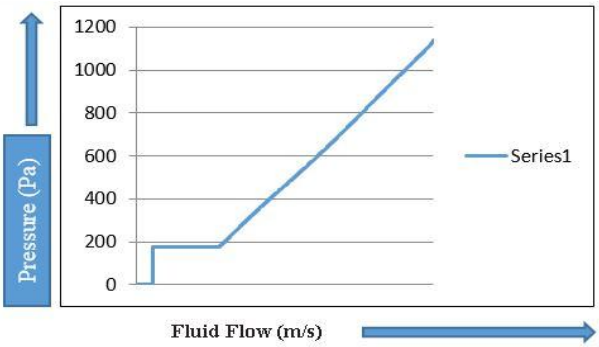

Fig. 1.11 Fluid Flow 0.25 lpm

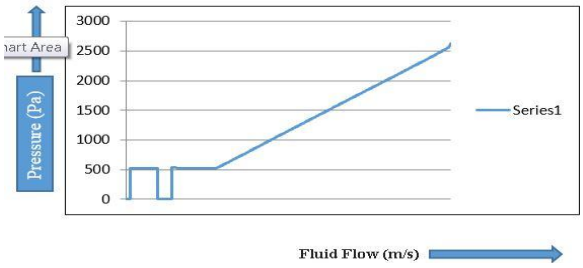

Fig.1.12 Fluid Flow (m/s) at 0.50 lpm

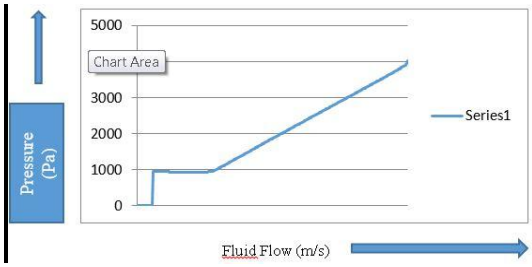

Fig.1.13 Flow Rate 0.75 lpm

Fluid Flow 0.25 LPM

The figure 1.11 shows the microchannel heat sink computational analysis values of pressure (Pa) goes from 0 Pa to 120 Pa at fluid flow 80 m/s. As seen in the graphical analysis the pressure is denoted by blue colour section named as series 1. As the flow rises a stream line is achieved from flow 120 m/s to 290 m/s. An increase in pressure is shown by a straight line evolving from 190 Pa to 1140 Pa onwards.

At Fluid Flow 0.5 LPM

The figure 1.12 shows the microchannel heat sink computational analysis values of pressure (Pa) from 70 Pa to 500 Pa at fluid flow 18 m/s streamline to 80 m/s. With a drop in pressure is recorded as seen in the graphical analysis from 80 Pa to 0 Pa. The pressure is denoted by blue colour section named as series 1. As the flow rises again from 0 Pa to 510 Pa stream line is achieved from flow 510 Pa to 2600 Pa.

At Flow Rate 0.75 LPM

The figure 1.13 shows the microchannel heat sink computational analysis values of pressure (Pa) from 0 Pa to 990 Pa at fluid flow 90 m/s streamlined to 280 m/s. The pressure is denoted by blue colour section named as series 1. The flow rises from 280 Pa to 3990 Pa.

Colour Contours from CFD analysis

With dia. 20mm

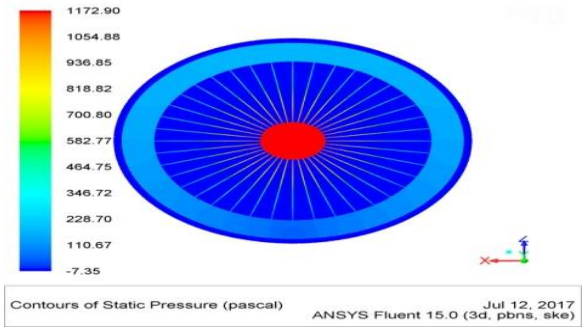

Fig.1.14 Flow Rate 0.25 lpm colour contours

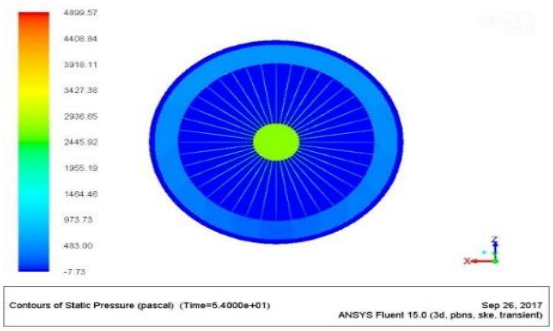

Fig. 1.15 Flow rate 0.5 lpm colour contours

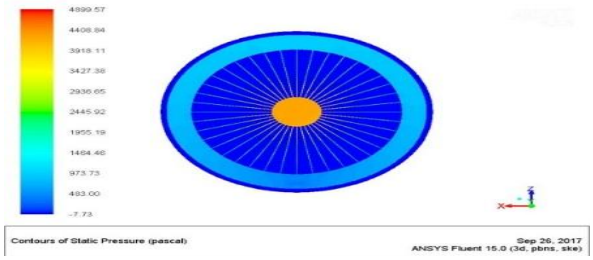

Fig. 1.16 Flow rate 0.75 lpm colour contours

Pressure observation result with Diameter 30 mm

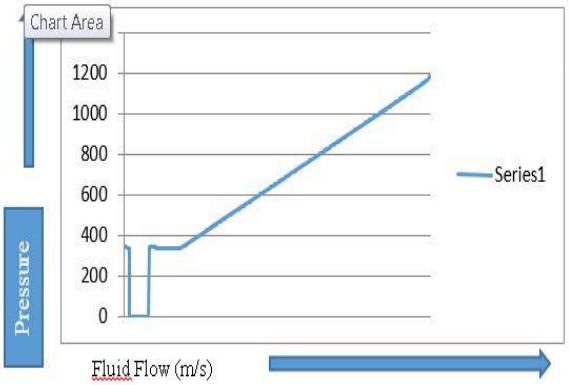

Fig. 1.17 Fluid Flow 0.25 lpm

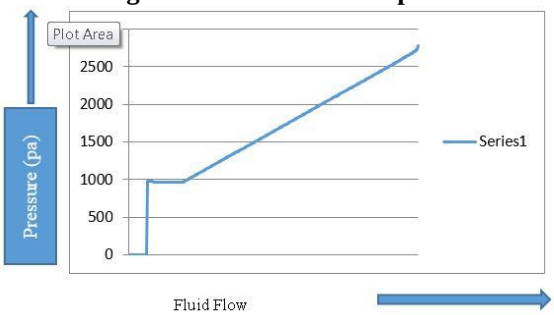

Fig.1.18 Fluid Flow (m/s) at 0.50 lpm

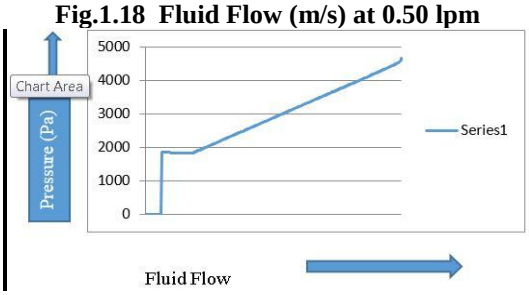

Fig.1.19 Flow Rate 0.75 lpm

At Flow Rate 0.25 m/s

With microchannel Diameter 30mmheat sink the figure 1.17 shows the heat sink computational analysis values of pressure (Pa) from 260 Pa to 0 Pa at fluid flow 10 m/s streamline to 40 m/s. With a drop in pressure was recorded as seen in the graphical analysis. The pressure is denoted by blue colour section named as series 1. The flow rises again from 260 Pa to 1160 Pa.

At Fluid Flow 0.5 m/s

With Diameter 30mm of microchannel heat sink the figure 1.18 shows the microchannel heat sink computational analysis values of pressure (Pa) from 0 Pa to 1000 Pa at fluid flow 70 m/s streamline from 40 m/s. With a drop in pressure was recorded as seen in the graphical analysis. The pressure is denoted by blue colour section named as series 1. The flow rises again from 1230 Pa to 2640 Pa.

Fluid flow0.75 m/s

With Microchannel heat sink diameter 30mm the figure 1.19 shows the microchannel heat sink computational analysis values of pressure (Pa) rises from 40 Pa to 1870 Pa with fluid flow streamlined. The pressure is denoted by blue colour section named as series 1. The flow rises again from 1870 Pa to 4370 Pa.

With Dia. 30 mm

Colour Contours at 0.25 m/s LPM

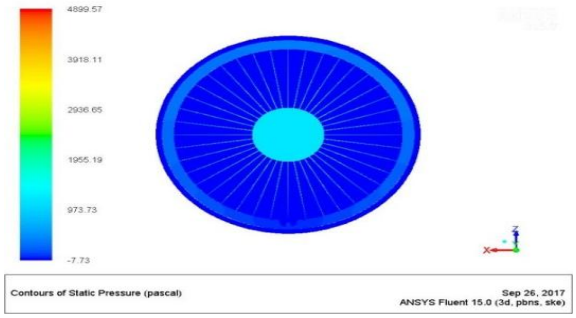

Fig.1.20 Flow rate 0.25 lpm

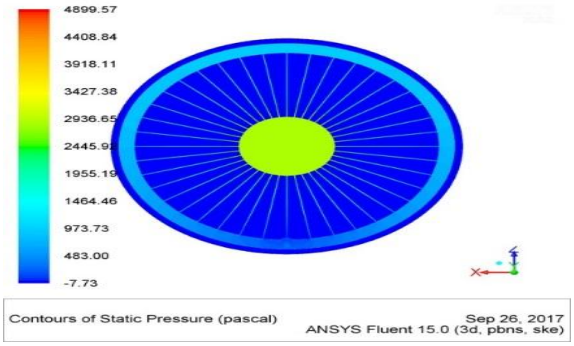

Fig.1.21 Flow rate 0.5 lpm

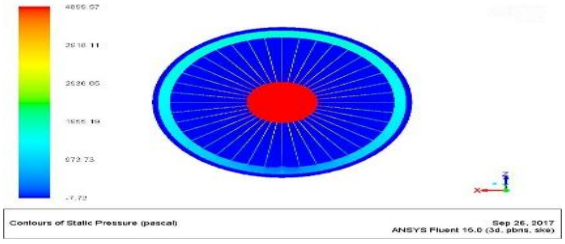

Fig.1.22 Flow Rate 0.75 lpm

3. Temperature observation result from with Dia. 10 mm

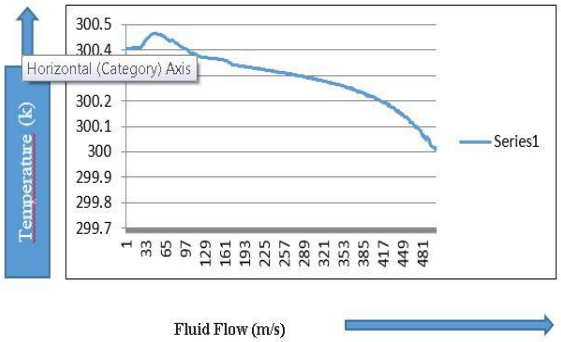

Fig. 1.23 Fluid Flow 0.25 lpm

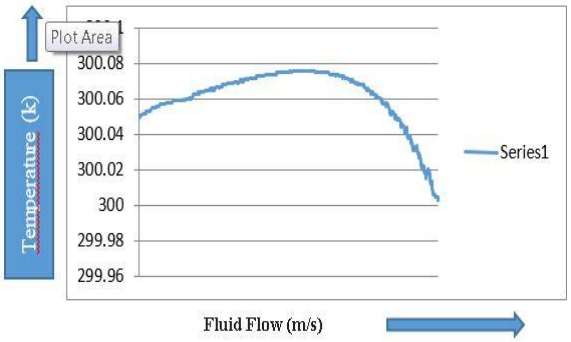

Fig.1.24 Fluid Flow (m/s) at 0.50 lpm

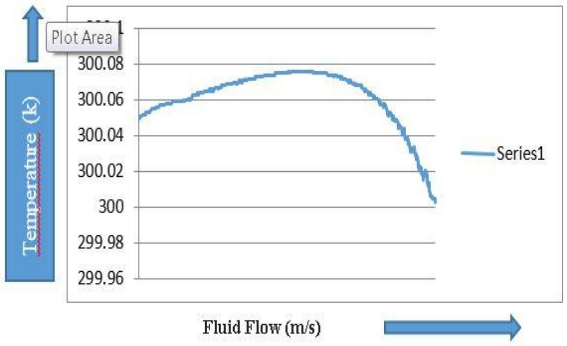

Fig.1.25 Flow Rate 0.75 lpm

At Flow Rate 0.25 lpm

The figure 1.23 shows the microchannel heat sink computational analysis values of temperature (K) from 300.4 k to 300.5k with a downstream flow variation in pressure recorded till 300 Pa. at outlet fluid flow. The temperature is denoted by blue colour section named as series 1. The fluid flow variation is shown by a streamline from 1 m/s to 481 m/s.

Flow Rate 0.5 LPM

Figure 1.24 shows heat sink microchannel with diameter 30mm. Temperature (K) from 300.4 Pa to 1000 Pa at fluid flow 70 m/s streamline from 40 m/s. With a drop in pressure was recorded as seen in the graphical analysis. The pressure is denoted by blue colour section named as series 1. The flow rises again from 1230 Pa to 2640 Pa.

At Flow Rate 0.75 LPM

Figure 1.25 shows heat sink microchannel with diameter 10mm. Temperature (K) rises to 300.7 Pa. At fluid flow 0 m/s to 420 m/s. A drop in pressure was recorded as seen in the graphical analysis to 300 k.

With Diameter 10 mm

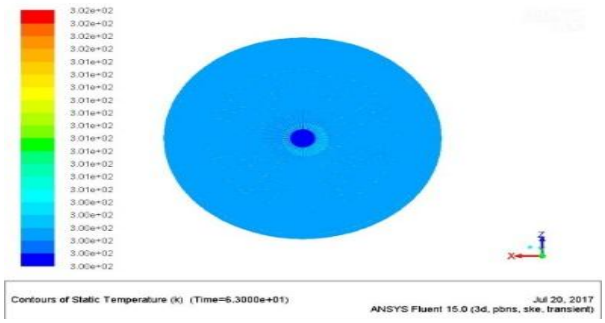

Fig.1.26 Flow Rate 0.25 lpm

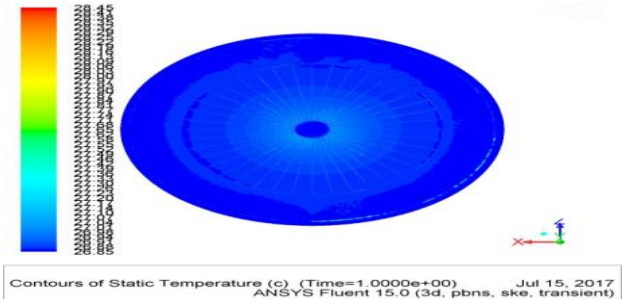

Fig.1.27 Flow Rate .5 lpm

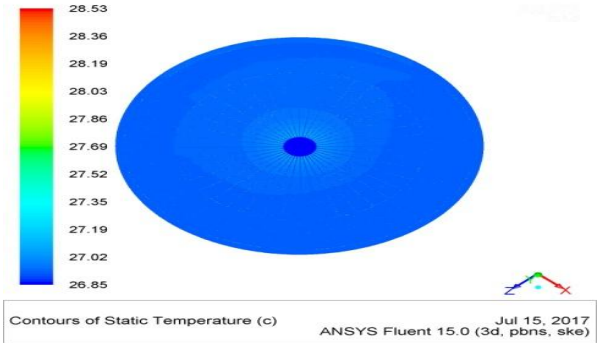

Fig.1.28 Flow Rate .75 lpm

4. Result observations with microchannel heat sink Diameter 20mm

Temperature Observations

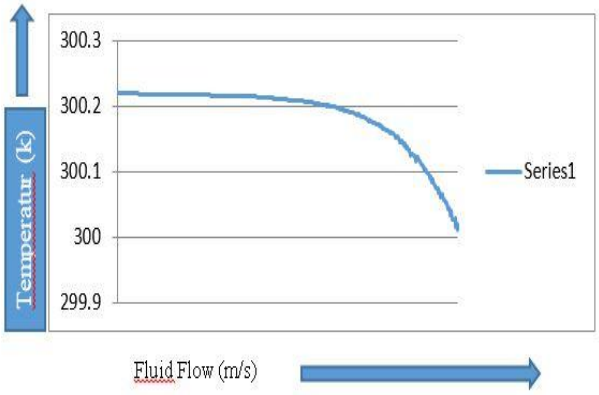

Fig.1.29 Flow Rate 0.25lpm

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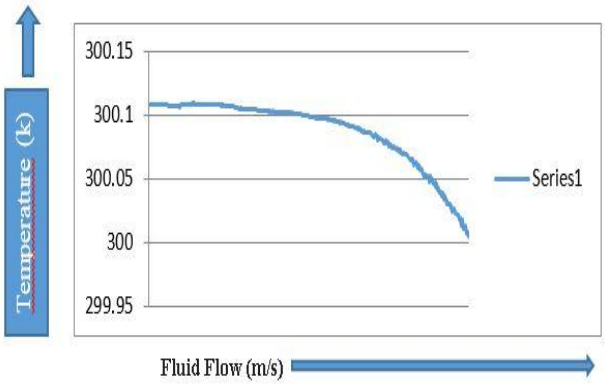

Fig.1.30 Flow Rate .5 lpm

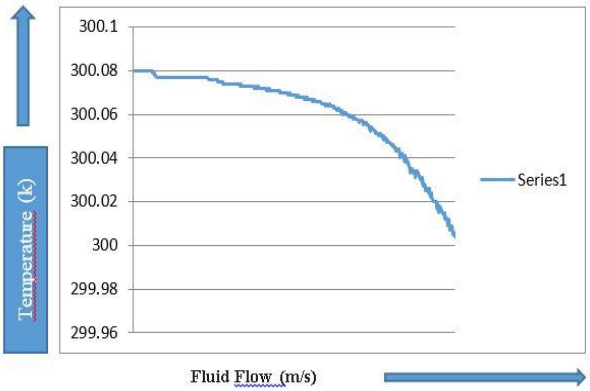

Fig.1.31 Flow Rate .75 lpm

At Flow Rate 0.25 LPM

The figure 1.29 shows the values of temperature (K) from 300.269 k to 300 k with a downstream flow variation in pressure recorded till 300.02 Pa. at outlet fluid flow. The temperature is denoted by blue colour section named as series 1.

Flow Rate 0.5 LPM

Figure 1.30 shows heat sink microchannel with diameter 30mm. Temperature (K) from 300.4 Pa to 1000 Pa at fluid flow 70 m/s downstreams from 300.08k to 300.0 k. With a drop in pressure was recorded as seen in the graphical analysis. The pressure is denoted by blue colour section named as series 1.

At Flow Rate 0.75 LPM

Figure 131 shows heat sink microchannel with diameter 10mm. Temperature (K) rises to 300.7 Pa. At fluid flow 0 m/s to 420 m/s. A drop in pressure was recorded as seen in the graphical analysis to 300 k. The pressure is denoted by blue colour section named as series 1.

CFD colour contours with Diameter 20

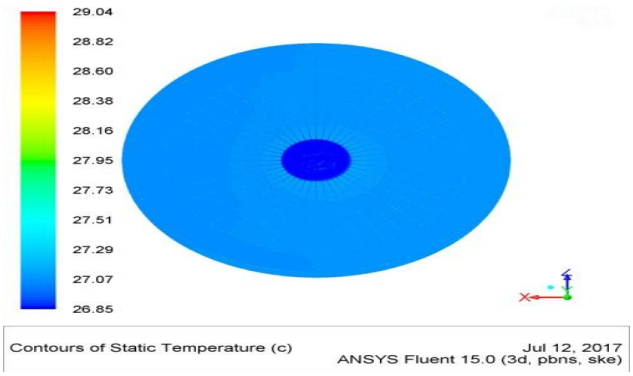

Fig. 1.32 Flow Rate .25 lpm

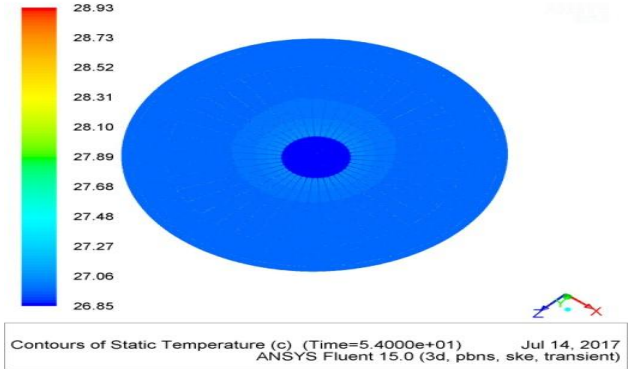

Fig. 1.33 Flow Rate .5 lpm

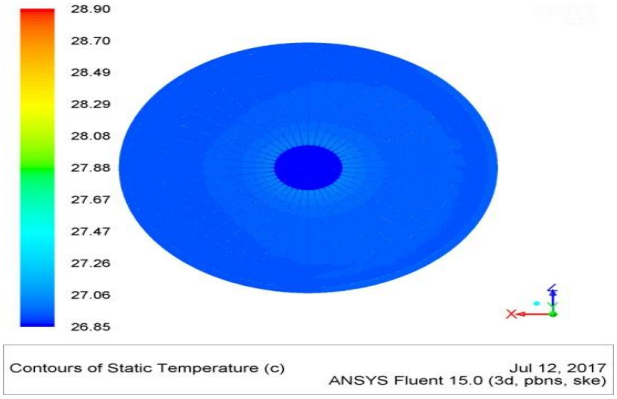

Fig. 1.34 Flow Rate .75 lpm

5. Temperature observations result colour contours with microchannel heat sink Diameter 30mm

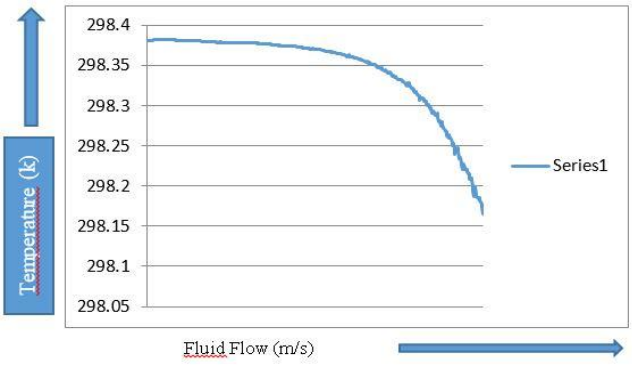

Fig. 1.35 Flow Rate .25 lpm

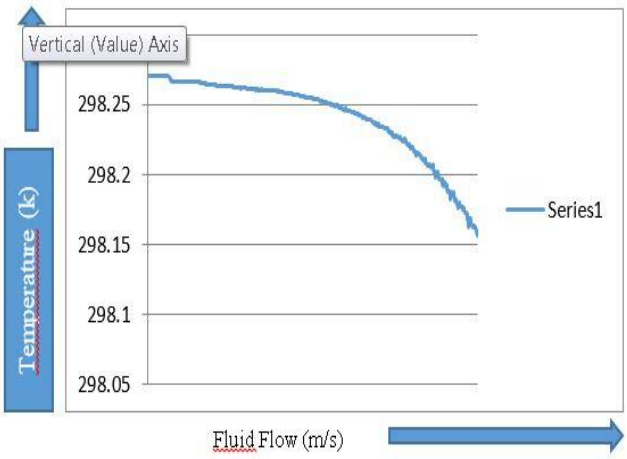

Fig. 1.36 Flow Rate .5 lpm

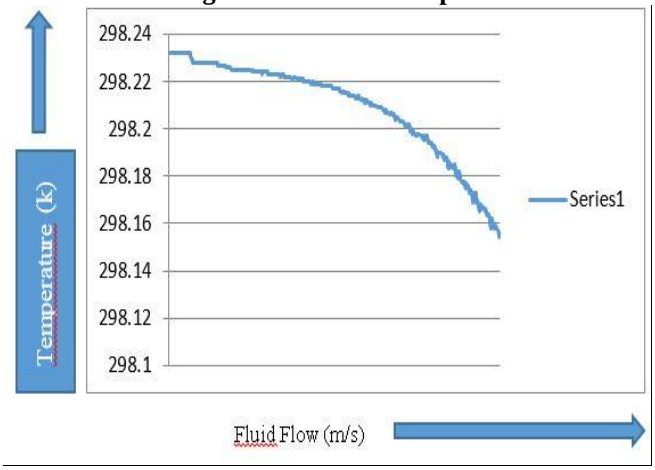

Fig. 1.37 Flow Rate .75 lpm

At Flow Rate 0.25 lpm

The figure 1.35 shows the microchannel heat sink computational analysis values of temperature (K) at298.38 kwith a downstream flow variation in temperature recorded till 298.1 Pa. at outlet fluid flow. The temperature is denoted by blue colour section named as series 1. The fluid flow variation is shown by a streamline drop from 298.2 m/s to 298.4 m/s.

Flow Rate 0.5 LPM

Figure 1.36 shows heat sink microchannel with diameter 30mm. Temperature (K) stands at 298.34 Pa. With a drop in pressure was recorded as seen in the graphical analysis. The pressure is denoted by blue colour section named as series 1.

At Flow Rate 0.75 LPM

Figure 1.37shows heat sink microchannel with diameter 30mm. Temperature (K) retains at 298.28 k at fluid flow 0.75 m/s. A drop in pressure was recorded as seen in the graphical analysis upto 298.12 k. The pressure is denoted by blue colour section named as series 1.

With Diameter 30mm

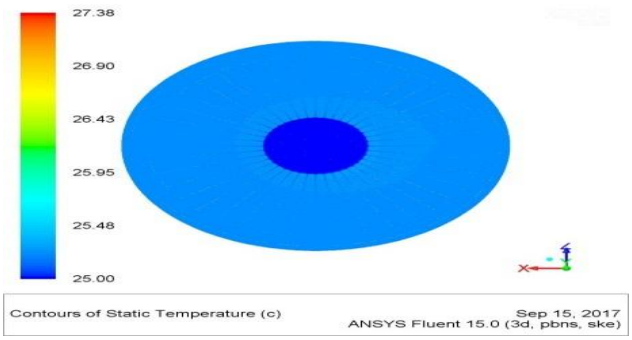

Fig. 1.38 Flow Rate .25 lpm

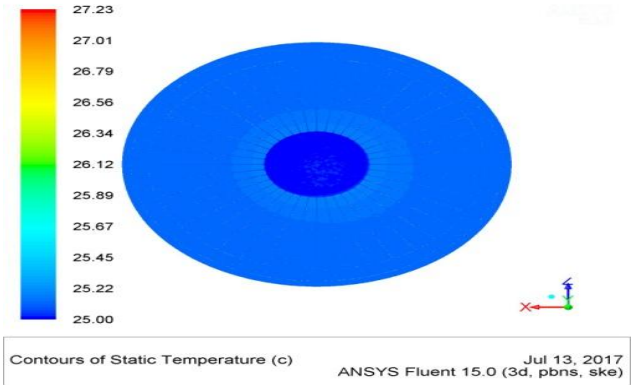

Fig. 1.39 Flow Rate .5 lpm

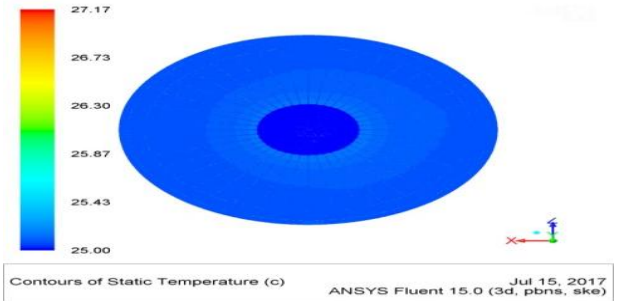

Fig. 1.40 Flow Rate .75 lpm

6. Velocity analysis results from CFD with Diameter 10mm

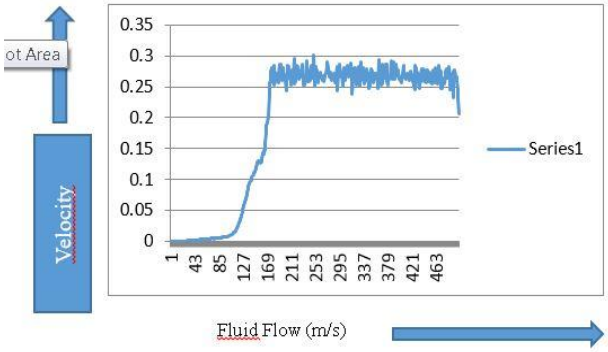

Fig. 1.41 Flow Rate .25 lpm

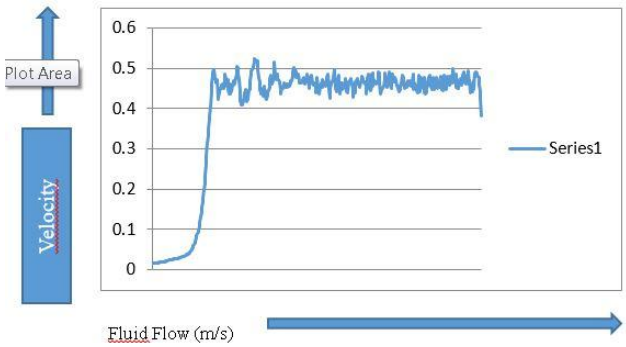

Fig. 1.42 Flow Rate .5 lpm

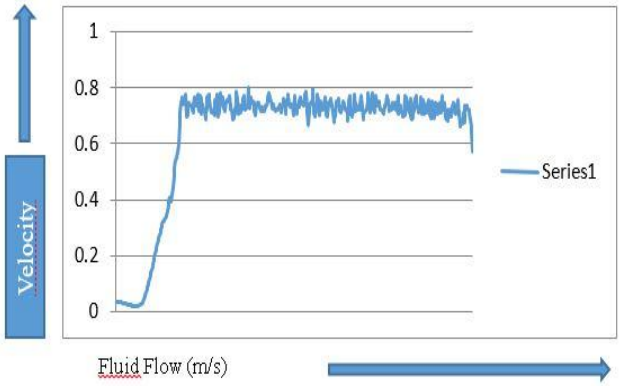

Fig. 1.43 Flow Rate .75 lpm

At Flow Rate 0.25 lpm

The figure 1.41 shows the microchannel heat sink computational analysis values velocity range from from 0.2 m/s to0.3 m/s with a downstream flow variation in velocity is recorded till 0.2 m/s.at outlet fluid flow. The temperature is denoted by blue colour section named as series 1. The fluid flow variation is shown by a streamline from 0.2 m/s to 0.3 m/s.

Flow Rate 0.5 LPM

Figure 1.42 shows heat sink microchannel with diameter 30mm. Velocity from 0.3 m/s to 0.5 m/s fluid flow streamlines from 0.4 m/s. With a drop in velocity was recorded as seen in the graphical analysis. The velocity is denoted by blue colour section named as series 1.

At Flow Rate 0.75 LPM

Figure 1.43 shows heat sink microchannel with diameter 10mm. Velocity rises to 0.8m/s fluid flow. A drop in velocity was recorded as seen in the graphical analysis to 0.58 m/s. The velocityis denoted by blue colour section named as series 1.

Velocity colour contours with diameter 10

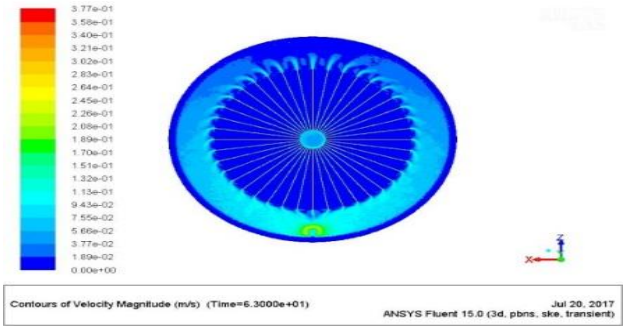

Fig. 1.44 Flow Rate 0.25 lpm

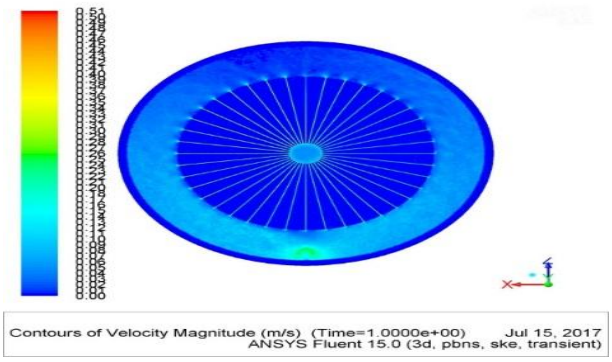

Fig. 1.45 Flow Rate 0.5 lpm

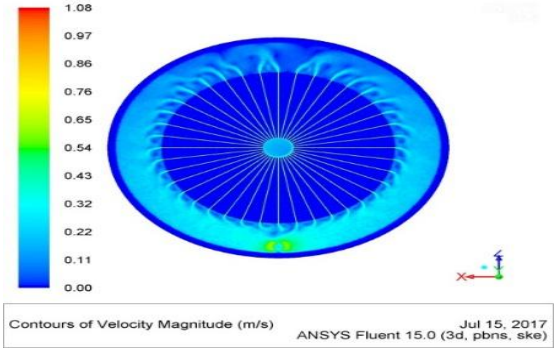

Fig. 1.46 Flow Rate .75 lpm

7. Result observation analysis with Diameter 20 mm

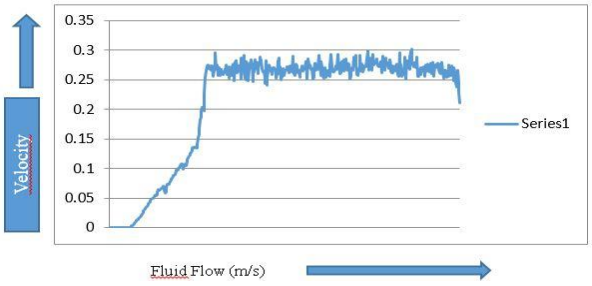

Fig. 1.47 Flow Rate 0.25 lpm

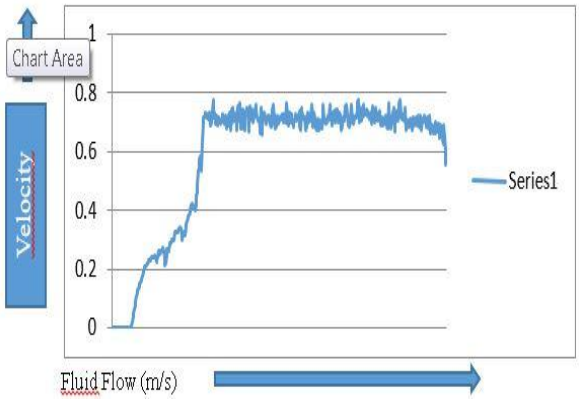

Fig. 1.48 Flow Rate 0.5 lpm

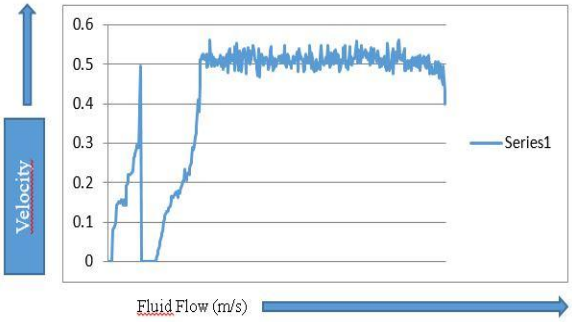

Fig. 1.49 Flow Rate .75 lpm

At Flow Rate 0.25 lpm

The figure 1.47 shows the microchannel heat sink computational analysis gives values of velocityrange from 0.25 m/s to 0.3 m/s with a downstream flow variation in velocity till 0.2 m/s flow at outlet fluid flow. The velocity denoted by blue colour section named as series 1. The fluid flow variation is shown by a streamline from 0.2 m/s to 0.25m/s.

Flow Rate 0.5 LPM

Figure 1.48 shows heat sink microchannel with diameter 30mm. Velocity ranges from 0.1 m/s to 0.5 m/s flow range. With a drop in pressure was recorded as seen in the graphical analysis. The velocity is denoted by blue colour section named as series 1. The flow rises again from 0.4 m/s to 0.5 m/s.

At Flow Rate 0.75 LPM

Figure 1.49 shows heat sink microchannel with diameter 20mm. Velocity rises to 0.8 m/s. At fluid flow 0.58 m/s to 0.7 m/s. A drop in pressure was recorded as seen in the graphical analysis upto 0.6 m/s. The velocity denoted by blue colour section named as series 1.

Colour contour observations with Diameter 20 mm

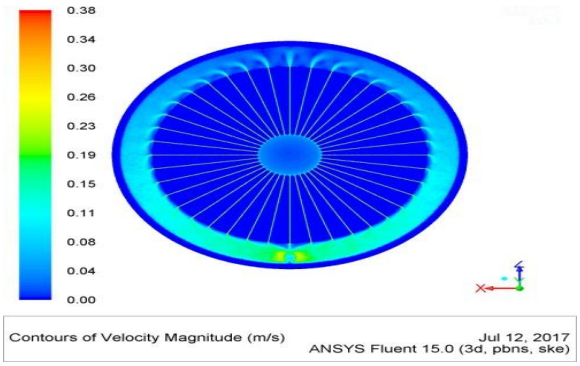

Fig. 1.50 Flow Rate .25 lpm

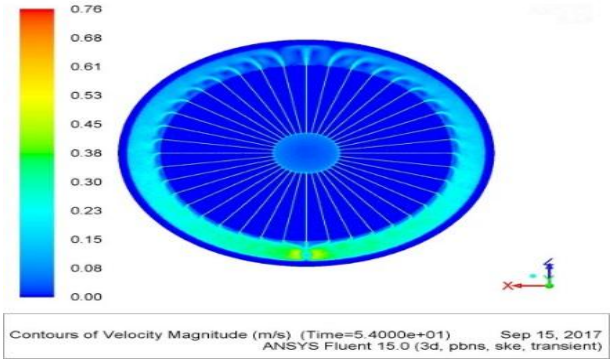

Fig. 1.51 Flow Rate 0.5 lpm

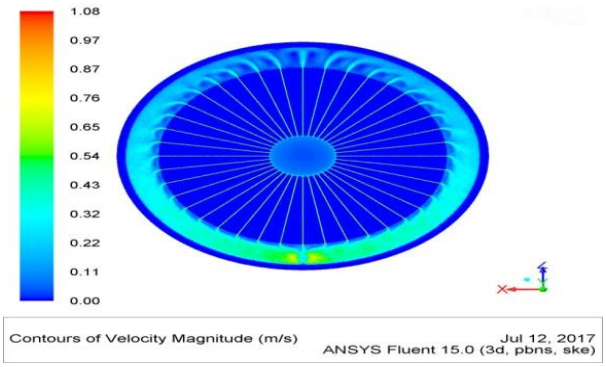

Fig. 1.52 Flow Rate .75 lpm

8. Result observations of velocity with diameter 30mm

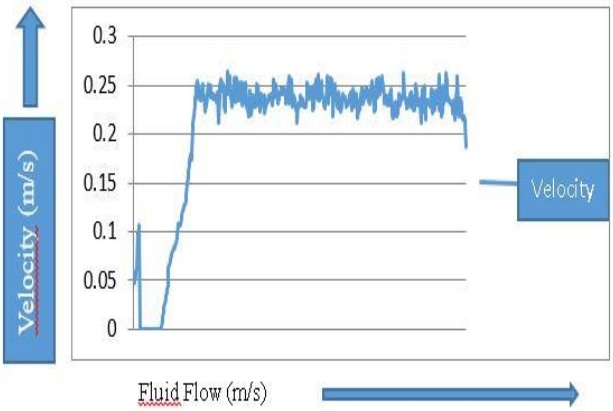

Fig. 1.53 Flow Rate .25 lpm

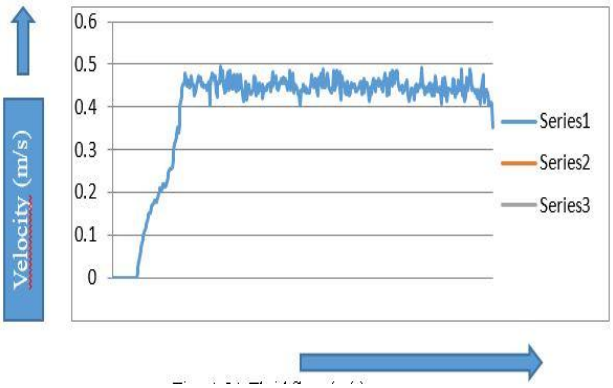

Fig. 1.54 Flow Rate 0.5 lpm

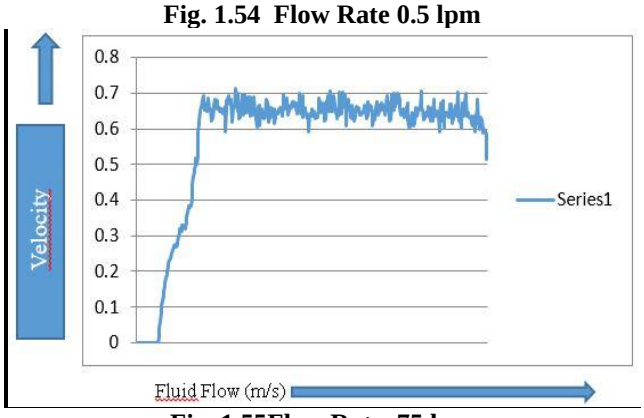

Fig. 1.55Flow Rate .75 lpm

At Flow Rate 0.25 lpm

The figure 1.53 shows the values of velocity (m/s) from 0025 m/s to .25 m/s with straight flow line. At outlet fluid flow. The velocity denoted by blue colour section named as velocity.

Flow Rate 0.5 LPM

Figure 1.54 shows heat sink microchannel with diameter 30mm. velocity 0.045 m/s to 0.467 m/s. The velocity is denoted by blue colour section named as series 1. The flow streamlines between 0.4 m/s to 0.5 m/s.

At Flow Rate 0.75 LPM

Figure 1.55 shows velocity flow in microchannel heat sinkwith diameter 10mm. velocity rises between 0.6 m/s to 0.7 m/s.. A drop in pressure was recorded as seen in the graphical analysis to 300 k. The pressure is denoted by blue colour section named as series 1.

colour contours result observations of Velocity with diameter 30 mm

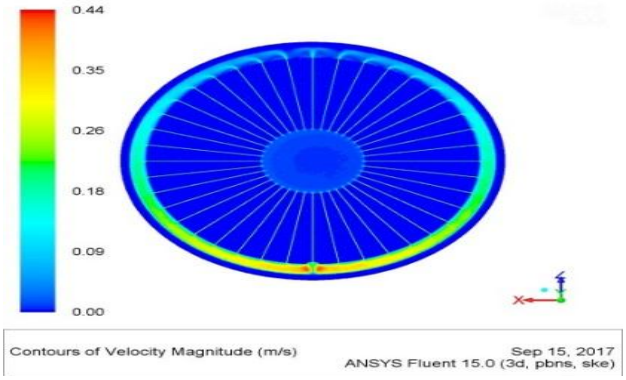

Fig. 1.56 Flow Rate .25 lpm

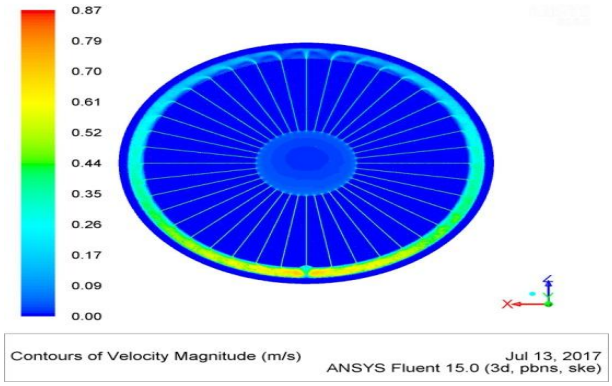

Fig. 1.57 Flow Rate .5 lpm

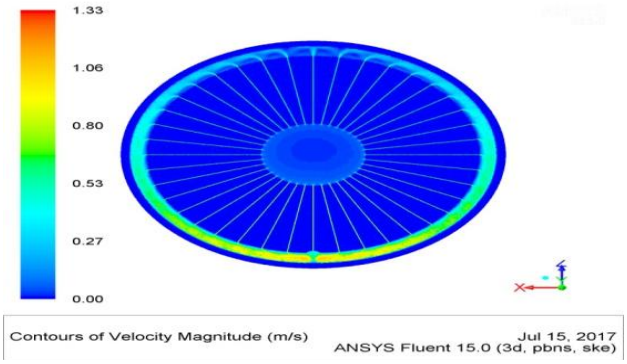

Fig. 1.58 Flow Rate .75 lpm

CONCLUSIONS

1. CFD investigation of the microchannel heat sink Surface unpleasantness inside the microchannel appears to significantly affect stream conduct at the micro scale. Stream progress from laminar stream to violent stream at the infinitesimal dimension has been come about at 0.75lpm might be precise estimation of Reynolds number where change happens for all divider roughnesses.
2. Microchannel heat sinks have 80% of the all-out warmth transition connected to the last 50% of the channel. The 30 mm breadth round plan is sufficiently powerful to improve microchannel heat sink execution.
3. The weight drop of MCHS with distance across 20 mm at .25 lpm and 0.5 lpm were recorded higher than different MCHS structures with 10mm, 0r 30 mm
4. Though the stream speed in MCHS with Diameter 30 mm at .50 lpm qualities higher warmth exchange.
5. Thinking about the distinctive working parameters, for instance, weight drop, Nusselt number, temperature with separation crosswise over 30 mm is favored since it could clear more warmth keeping various parameters at perfect dimension from various cases investigated.
6. Notwithstanding the way that the Nusselt number in MCHS recognitions with width 0.75 stream speed is higher than the other two kinds of stream rates 0.25 lpm and 0.5 lpm.

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