Performing the computational analysis for the investigation of the effect of fin height and arrangement on the performance of microchannel heat sink

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***Abstract*: In this work, the effect of fin height with the new arrangement was analysed two different shapes of fins (i.e. circular and rectangular) were considered during the work within the new pattern arrangement. 0.5- and 0.25-mm height was considered during the work. A total of six cases were considered during the work, in which the height and design of the fins get varied. Through CFD analysis, it is found that for Case-2 heat sink shows better performance as compared to others. This shows that heat sink with circular fins of new pattern arrangement shows the better performance as compared to others.**

***Keywords*: Heat sink, Micro-fins, Height effect, flow behaviour, performance, Micro-channel.**

1. Introduction

Typically, high-power semiconducting devices like power transistors and the electronics devices such as diodes, lasers acquire heat in substantial quantities and then these ingredients are insufficient to distribute heat, as their dissipation ability is significantly low. For this reason, heating up of the equipment prospects to early inability and may trigger the collapse of the whole circuit or system's efficiency. Therefore, to overcome these unfavourable factors, heat sinks need to be presented for cooling intention [1,2]. The integrated level of electronic devices has been rapidly increasing. Along with this, the heaviness of the component has been on the decrease. It has led to higher heat flux produced by those parts due to less area of contact with atmospheric air. There has been also an upsurge in the catastrophe rate of the element due to overheating. Karami et al**.** [1] In the present analysis, a micro pin fin heat sink using a baffle wherever gives the detailing of untainted water runs over and are pretend as well as analysed in three dimension using ANSYS Fluent in the laminar limit of $52 \leq Re \leq 252$. At this point we have taken to alter the baffle's nature as well as extents for inspecting the influence of perplex on the transfer of heat. Prajapati et al**.** [2] in this analysis, transfer of heat as well as flow of fluid behaviour were calculated mathematically in quadrangular equalised micro channel heat sinks through variable length of fin. Seven diverse conditions were measured by changing the fin length around 0.3 to 1.0 mm. fully surrounded heat sink predictable conformation of 1.0 mm fin length has one of the circumstances though left out six heat sink conformations kept exposed to the area amid fin uppermost sides as well as shield wall.

2. Developing the CFD model

For doing the CFD analysis of initial heat sink model as considered by khatib et al., first the solid mode of heat sink was made. The solid model of heat sink was made on the basis of geometric parameters considered by khetib et al. The geometric parameters of heat sink considered for numerical analysis is mention in the below table.

Table.1 The Geometric parameters of heat sink

Parameter	Value
Length of the heat sink	16 mm
Width of the heat sink	6 mm
Height of the heat sink	1 mm
Fin height	0.5 mm
Fin base dimension	0.5 mm

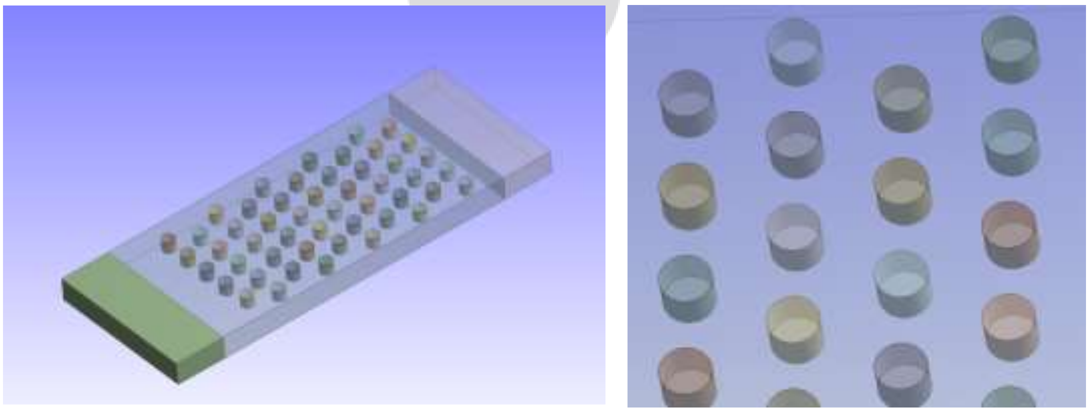

Fig.1 Solid model of heat sink considered for the numerical analysis

3. Meshing

For performing the numerical analysis of heat sink it is necessary to discretize the solid model of heat sink in to number of elements. For checking the dependency of the nodes and element, heat sink was discretized in to different number of nodes and elements and calculates the desired result. Through number of numerical runs, the nodes and element dependency was overcome. For final analysis in this work, we have discretized the heat sink in to 373603 number of elements as mention in the below figure. For mesh refinement different tools were used to refine the mesh in different zone.

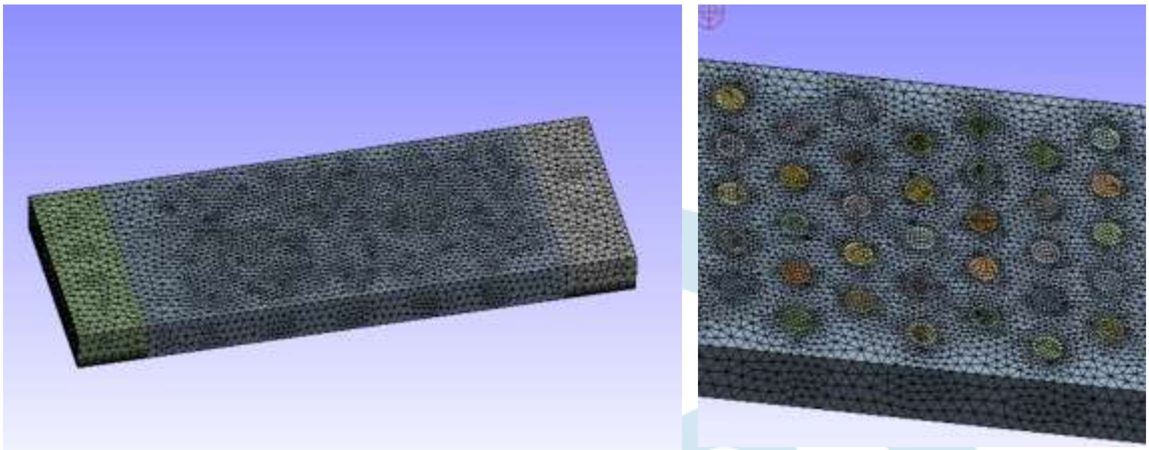

Fig.2 Mesh refinement and interface in between fins and air

4. Effect of height of fins in new pattern arrangement

As previous work had already shown that change in shape and height of fins shows the great variation in heat transfer and pressure drop inside the heat sink.

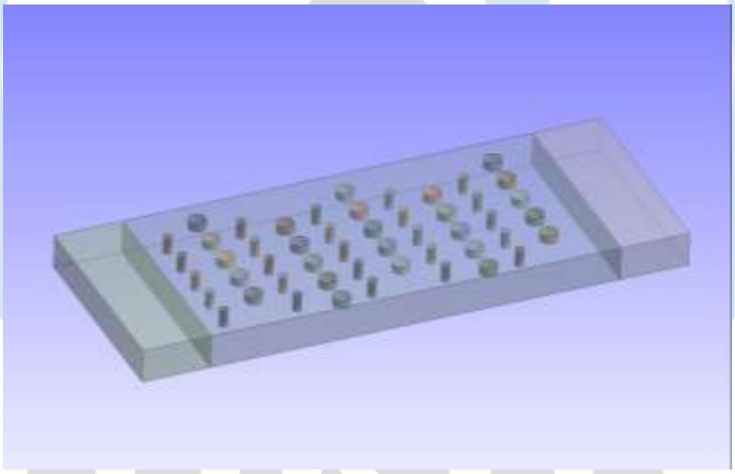

Fig.3 Solid model and arrangement of fins of heat sink for case-1

As new pattern arrangement of fins was proposed in this work. It is necessary to analysed the effect of height of fins on heat transfer. In the same order, this work considered 2 different height of fins that is 0.25 and 0.5 mm. and Total six cases were considered during the work, (1) circular fins with 0.5 mm height of first row and 0.25 mm height of second row, (2) circular fins with 0.25 mm height of first row and 0.5 mm height of second row, (3) rectangular fins with 0.5 mm height of first row and 0.25 mm height of second row, (4) rectangular fins with 0.25 mm height of first row and 0.5 mm height of second row, (5) circular fin with all rows of 0.5 mm height, and (6) rectangular fin with all rows of 0.5 mm height.

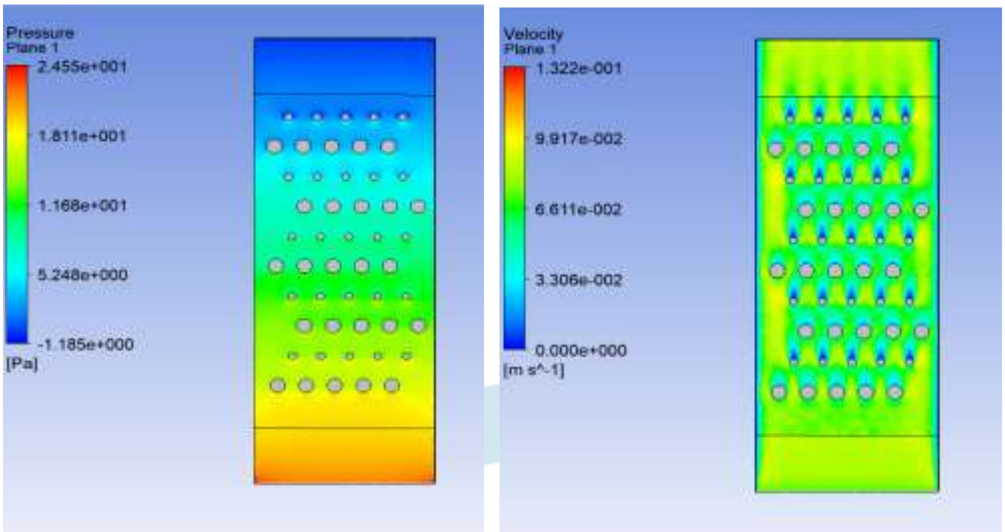

Fig.4 Velocity and pressure variation of heat sink for case-1 at Re-200

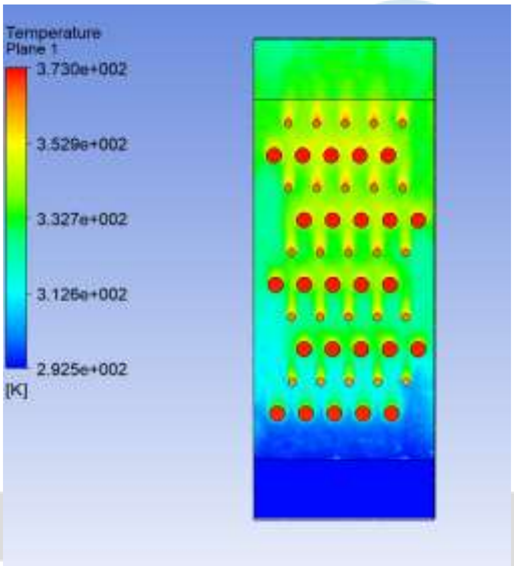

Fig.5 Temperature variation inside the heat sink for case-1 at Re-200

The contour plots of the velocity, pressure and temperature variation throughout the heat sink give clear understanding the change in parameters with the change in arrangement of fins. As compared to previous arrangement, the variation of velocity and temperature for case-1 is more intense which ultimately helps in increasing the heat transfer from the heat sink.

5. Comparison of different design of heat sinks

After doing the CFD analysis of heat sink comparison of different design of sink was done. The comparison of done on the basis of heat transfer rate, coefficient and pressure drop throughout the heat sink. The comparative graph for different design of heat sink is shown in the below figures.

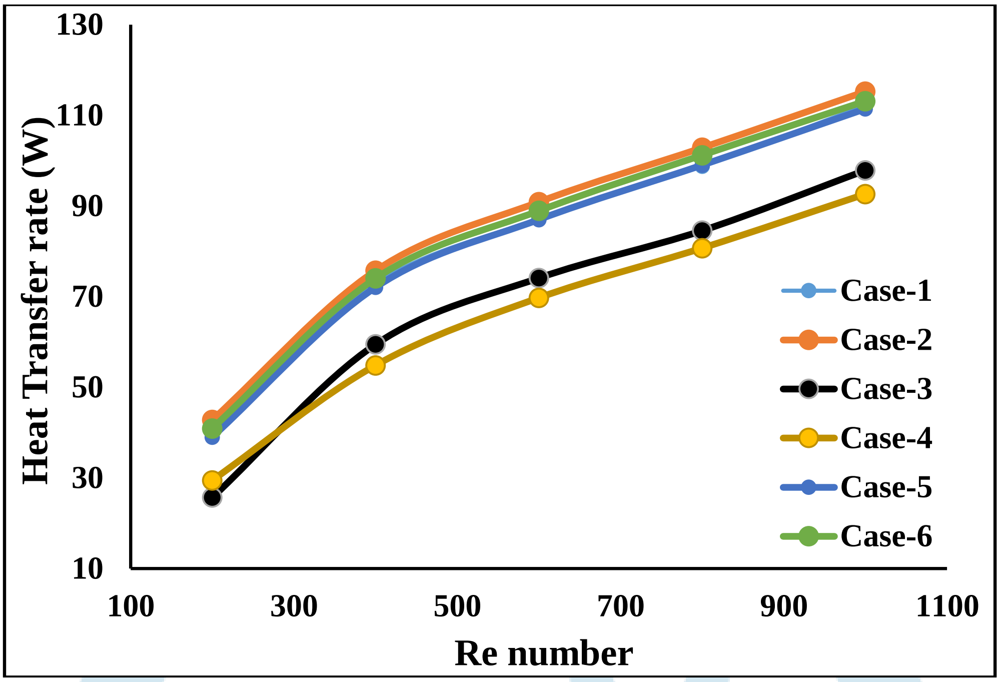

Fig.6 Comparison of value of heat transfer rate for different cases of heat sink

From figure, it is found that with increase in Re number the value of heat transfer gets increases and the same kind of trend was followed in each case of design. For case 2 the value of heat transfer rate is more as compared to others at each Re number. Through graph it is found that for rectangular shape of fins that is for Case-3 and 4 the value of heat transfer rate is significantly less as compared to other cases which is mainly due to huge formation of eddies inside the sink. The variation of coefficient for different design of sink is shown in below figure.

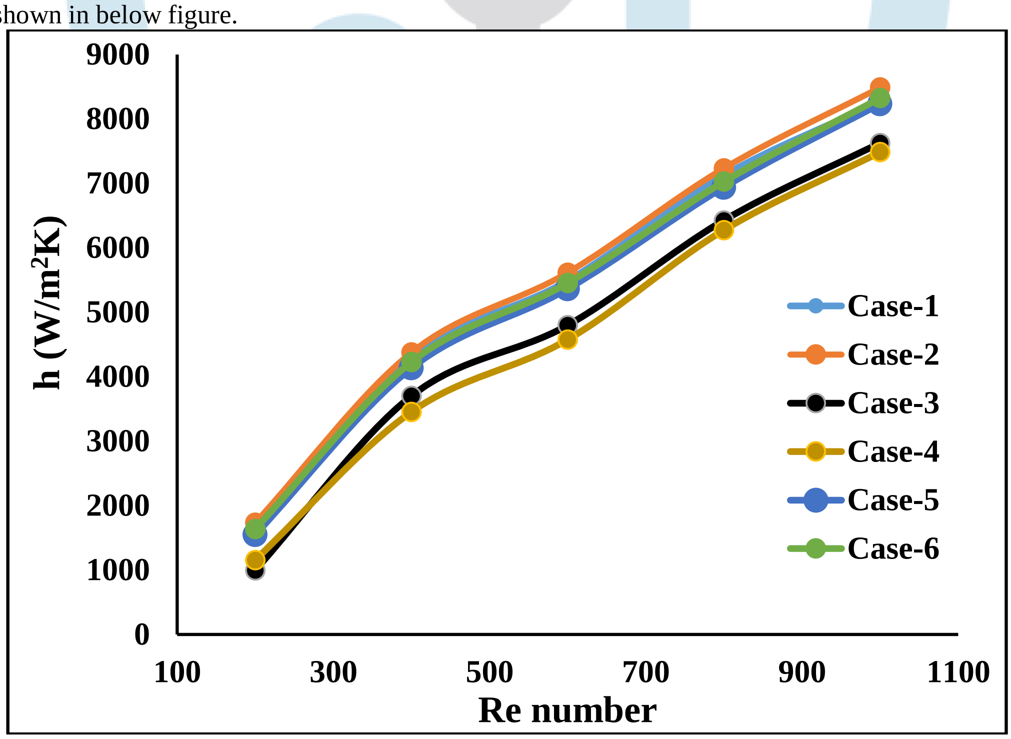

Fig.7 Comparison of value of heat transfer coefficient for different cases of design of heat sink

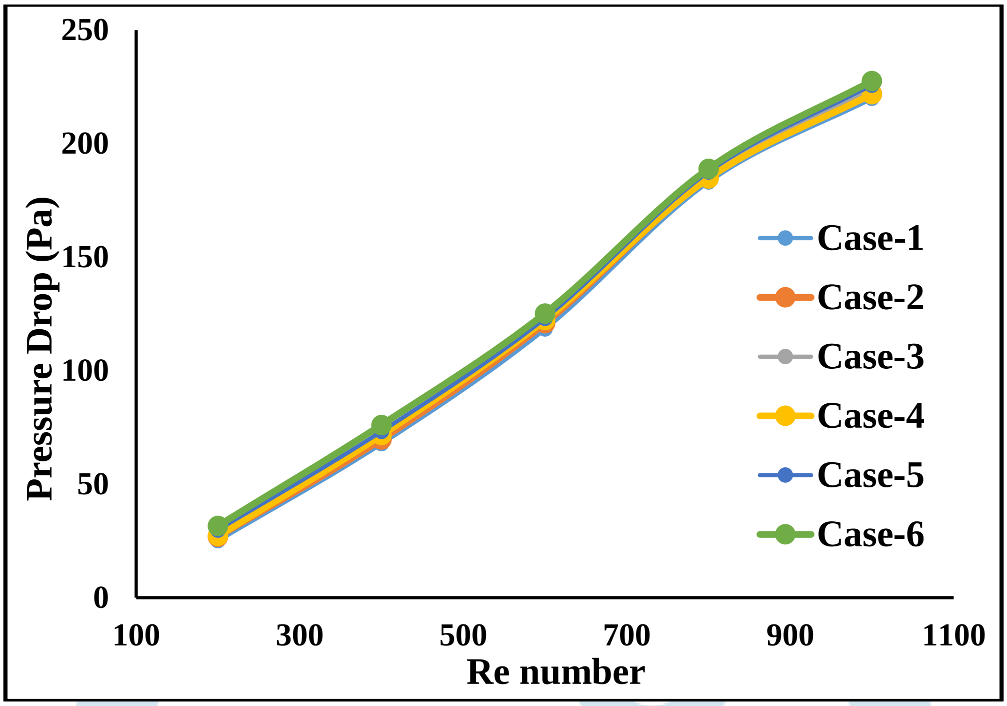

Fig.8 Comparison of pressure drop for different cases of design of heat sink

From figure it was found that for case-2 the value of heat transfer coefficient is more as compared to others. This shows the maximum heat transfer from the heat sink as compared to other designs. The value of pressure drop for case-2 belongs to the middle of the variation which means there is no any shape change in pressure drop with change in design of the heat sink. Through CFD analysis it was found that case-2 shows 66.7% more heat transfer as compared to Case-3, whereas it is 45.26 % more than the Case-4 heat transfer. Overall, the heat transfer in case-2 is more as compared to others cases of heat sink.

6. Conclusion

Through analysis it was found that the heat transfer rate and heat transfer coefficient of the heat sink increases with an increase in Re number for each case of design. The value of heat transfer rate for Case-2 circular fins with 0.25 mm height of the first row and 0.5mm height of the second row is more as compared to other designs of the sink at each Re number. Through CFD analysis it was found that case-2 shows 66.7% more heat transfer as compared to Case-3, whereas it is 45.26 % more than Case-4 heat transfer. Overall, the heat transfer in case-2 is more as compared to other cases of the heat sink. Same trend was also followed in heat transfer coefficient and it is also increasing with increase in Re numbers. The comparative graph of heat transfer rate, it is found that for rectangular shape of fins arrangement that is for Case-3 (rectangular fins with 0.5mm height of first row and 0.25mm height of the second row) and Case-4 (rectangular Fins with 0.25mm height of first row and 0.5mm height of the second row) the value is comparatively much less as compared to other cases.

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