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The Enhancement of Heat Transfer Analysis on Micro Pin-Fin in Segmental Baffle Heat Sink

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Abstract

To increase the heat transfer from the compact heat sink, in this work, different micro fins are used inside the heat sink having a double segmental baffles arrangement. For analysing the effect of different shapes of fins, four different shapes were considered during the work that is the circular, triangular, square, and hexagonal shapes of fins with the same cross-sectional area. Temperature, pressure, and velocity variation throughout the heat sink with change in Reynolds number was evaluated in each shape of fins. The overlapping of the baffles also affects the performance of the heat sink. Four different sets of overlapping (i.e., 0, 20, 40, and 60%) cases were considered during the work with different shapes of fins and evaluated the performance. Through CFD analysis it is found that a double segmented heat sink with 20% overlapping having the hexagonal shape of fins shows the maximum heat transfer as compared to another shape of fins.

Keywords- heat sink, micro pin-fin, shapes of fin, turbulator, heat transfer

1. Introduction

A heat sink also commonly spelled heat sink is a passive heat exchanger that carries the heat produced by an automated or a power-driven maneuver to a fluid medium, over and over again air or a fluid lubricant, where it is dissipated away as of the system, thus permitting instruction of the apparatus hotness at maximum intensities. In workstations, heat bowls are utilized to cool central processing units or graphics processors. Heat sinks are utilized with high potential semiconductor mechanisms like power transistors and optical electronics likewise lasers as well as diodes (LEDs), where the heat indulgence aptitude of the constituent within is laughable to reasonable its hotness. A heat sink is intended to make the best use of its external part in interaction with the refrigerating standard nearby it, like the different fluids. Heat sinks accessory approaches, as well as current edge resources too, distress the die temperature of the joined trip. Thermal epoxy resin or thermal blubber recover the heat span presentation by satisfying air breaches amongst the heat sink with the heat communicator on the expedient. A heat sink is frequently completed out of Cu or Al. metallic copper is utilized since it has numerous needed belongings for thermally effective as well as strong heat exchangers. A heat sink changes thermal energy from a higher temperature apparatus to a lower heated liquid media. The gaseous media is normally air but could be water too, lubricants or oil. If the unsolidified media is water, the heat sink is normally known as a cold slab. In thermal science, a heat sink is a heat that may capture an uninformed expanse of hotness other than suggestively varying temperature. Experimental heat sinks for microelectronic apparatus always had a temperature greater than the atmospheres to the allocation of heat by three modes of heat transfer convection, radiation, as well as conduction.

2. **Solid modelling**

For performing the numerical analysis of heat sink, Ansys fluent software was used during the work. First the CFD analysis of heat sink was done and validate its results with the karami et.al (1). In order to validation the numerical analysis of heat sink, same geometric and boundary conditions was considered during the work as considered by karami et al. the development of the CFD model of heat sink was mention in the below section.

Table.1 Geometric parameters considered for solid model of heat sink

Parameter	Value (mm)
Length of the heat sink	24
Width of the heat sink	6
Height of channel	1
Length of the section in which pins and baffles are placed	15
Pin fin diameter	0.5
Pin fin height	0.5
Length of middle baffles for double segment	3.20
Height of baffle	0.5
Thickness of baffles	0.1
Length of coastal baffles for 20% overlap	1.72
Length of coastal baffles for 40% overlap	2.04
Length of coastal baffles for 60% overlap	2.36
Length of coastal baffles for 0 % overlap	1.40

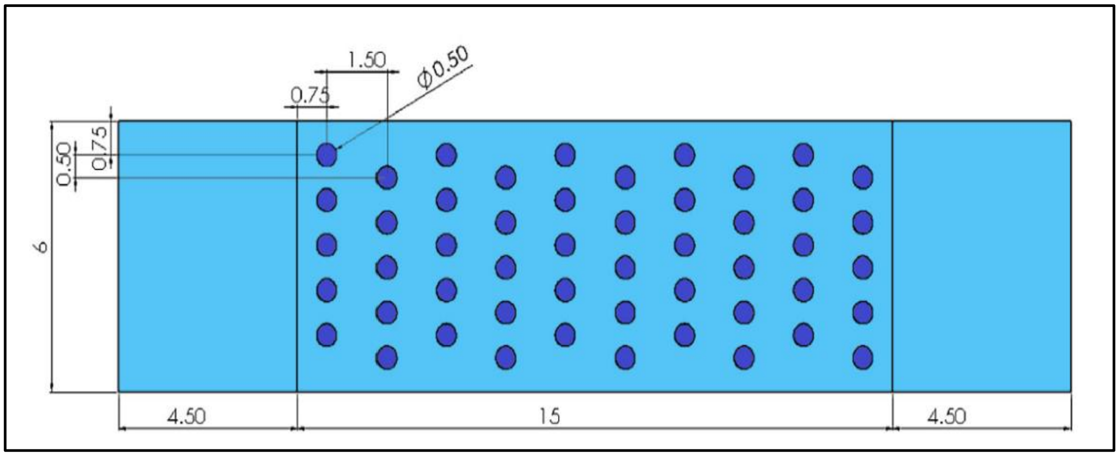

Fig.1 geometric parameters of heat sink considered during the work (1)

On the basis of above mention geometric conditions of heat sink solid model was made in ansys design modular. The solid model of hear sink having micro pin fins with double segment baffles is shown in the below figure.

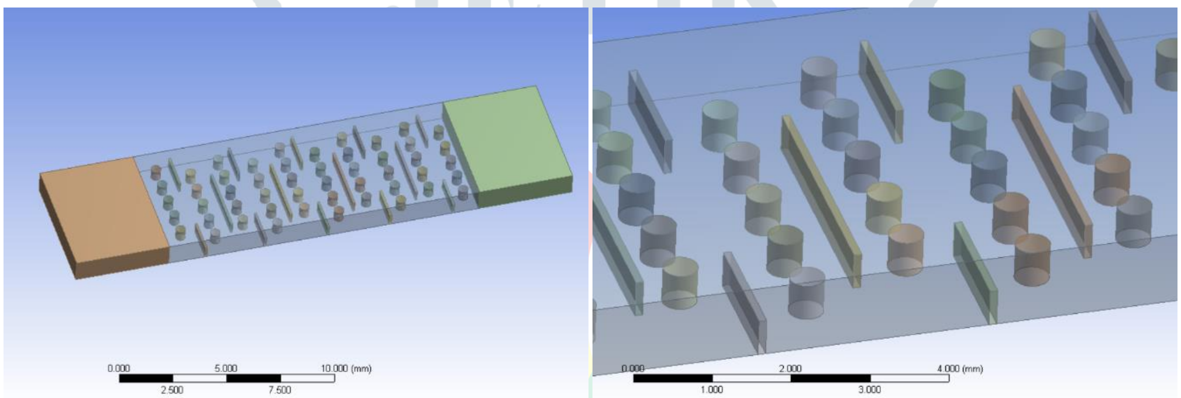

Fig.2 solid model of heat sink with circular micro pin fins with double segment baffles.

3. Meshing

For performing the numerical analysis of heat sink, discretization of heat sinks in to number of different elements was done. In order to check the grid independency, heat sink geometry was discretised with different numbers of element and calculate the heat transfer coefficient for Re – 50. Through numerical analysis it is found that with 858748 number of elements, optimum result is coming. So, it is concluded that after increasing the number of elements beyond the mention value there is no any such change was observed during the work.

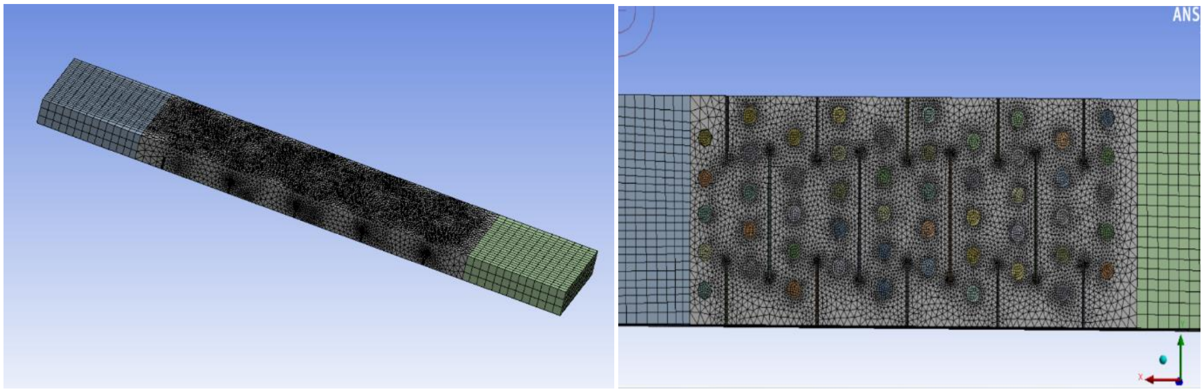

Fig.3 Meshing and mesh refinement of heat sink.

4. Boundary condition and solution method

In order to validate the numerical analysis of heat sink, same boundary conditions were considered as considered by karami et al. at the inlet of water 293 K temperature was considered. The heat sink base plate temperature was 373 k, no slip conditions was also considered at all inside wall of heat sink. Velocity inlet and pressure outlet condition was considered during the work. At inlet different Re number was considered according to different cases in each case of geometry of heat sink. Adiabatic wall condition was considered for all outside all of heat sink. Selection of proper solution method to perform numerical analysis is very important, because with change in solution method the result get varies or it may also possible that with the selection of wrong method the problem cannot get solved. Here it selects the coupled based second order upwind methods for the CFD analysis of micro fins heat sink.

5. Circular shape micro fins

In the initial case of analysis heat sink having circular micro fins with double segmental baffles was considered during the work to validate the CFD analysis of heat sink. As karami et al. optimize the arrangement of fins and baffles, the most efficient case was considered for the validation work. Four different Re number was also considered during the work that is 50, 100, 150 and 200. At each Re number temperature, pressure and velocity distribution throughout the heat sink was analysed through CFD.

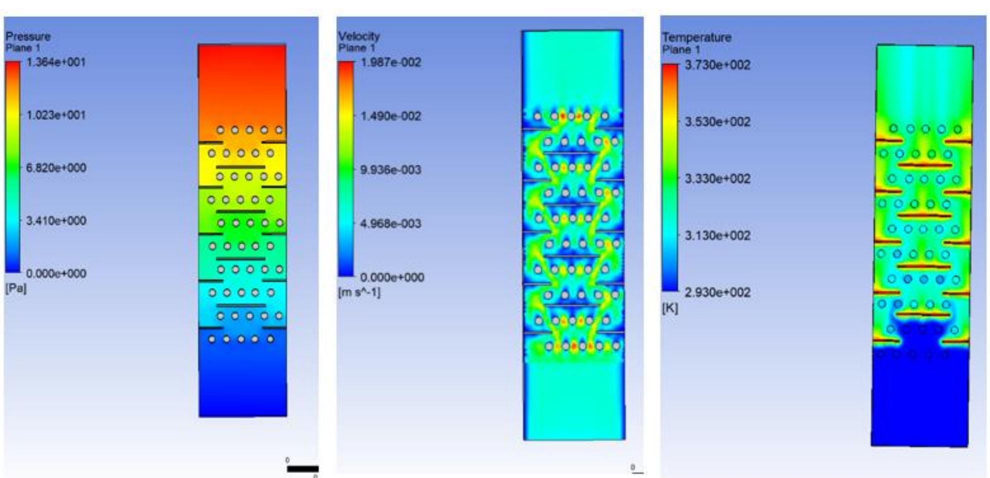

Fig.4 Pressure, velocity, and temperature variation inside the heat sink for Re – 50

After calculating the value of pressure prop and heat transfer coefficient at different Re numbers for circular micro fins double segmental baffle heat sink comparison was done with the karami result.

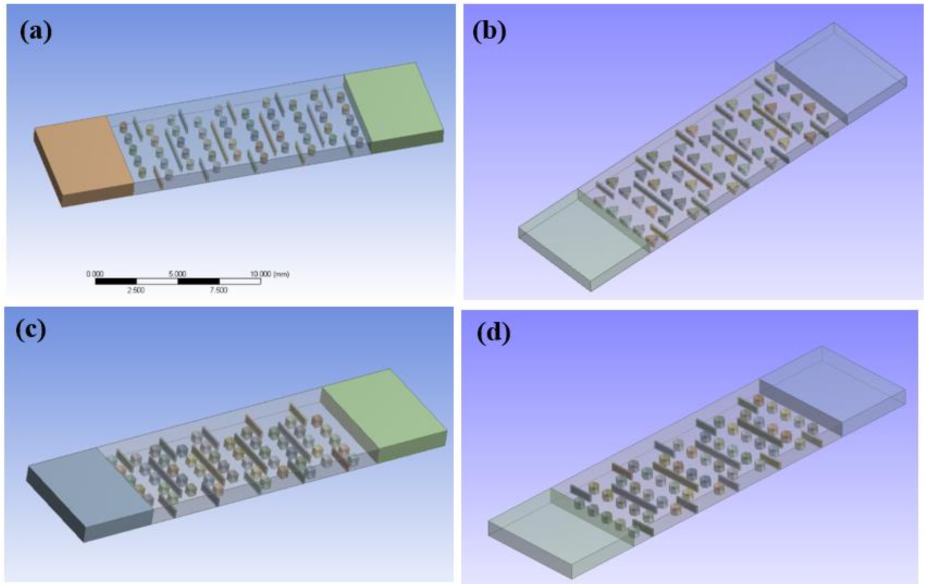

Fig.5 solid model of heat sink with (a) circular, (b) triangular, (c) square, and (d) hexagonal shape of fin

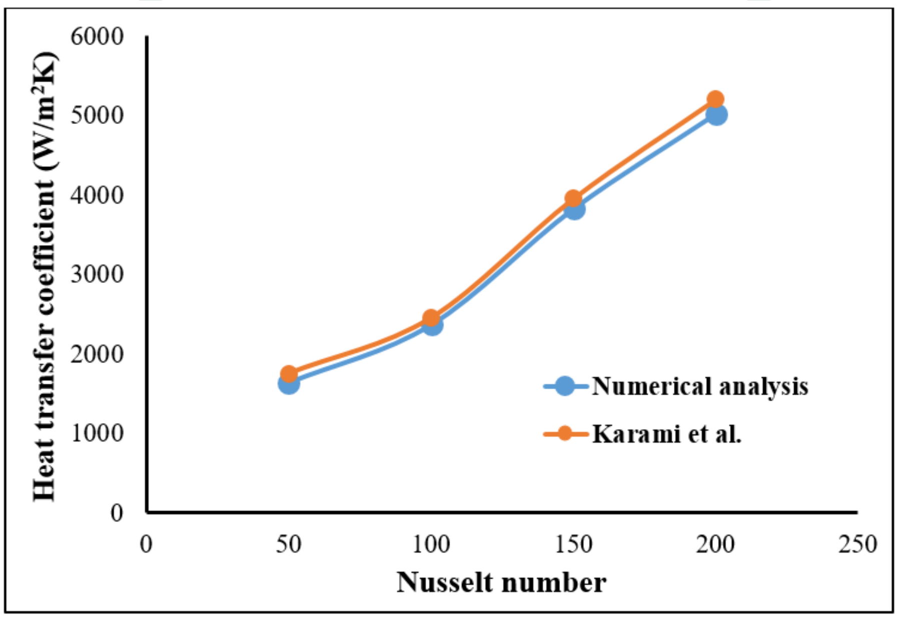

Fig.6 Comparison of value of heat transfer coefficient.

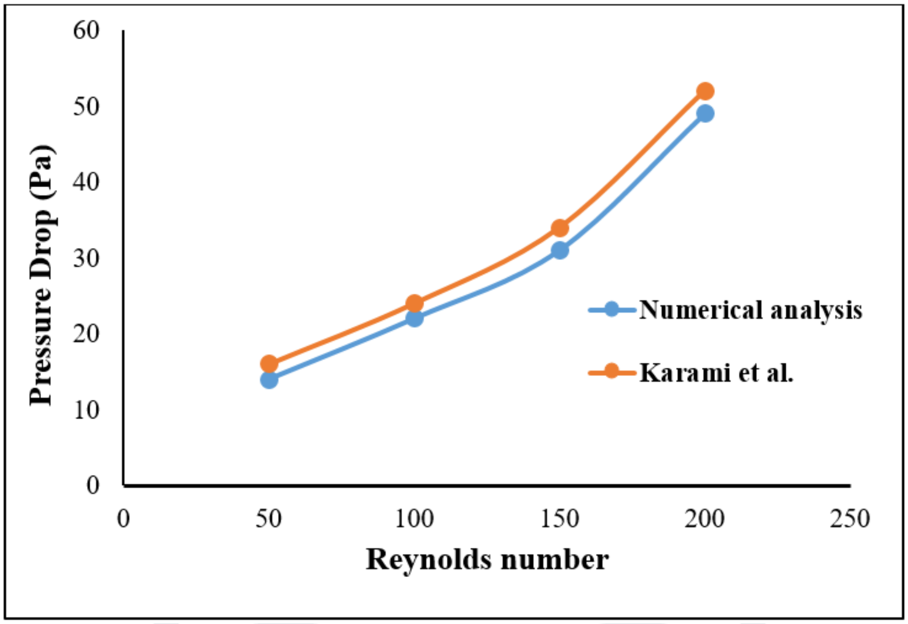

Fig.7 Comparison of value of pressure drop inside the heat sink.

From above graph it is found that the value of pressure drops and heat transfer coefficient calculated through numerical analysis is close to the value of pressure drop and heat transfer coefficient mention in karami et.al. In case of heat transfer coefficient, the value of Error percentage for different Re number is under 10% which means the value of heat transfer coefficient calculated through numerical CFD analysis is correct.

6. Heat sink with different shapes of fins

Here in this case, the triangular, square, circular and hexagonal shape of the fins which is having same cross-sectional area as circular fins was considered. The height and side of the triangular fins are 0.5 and 0.67 mm. The square shape having side length of 0.44 mm. The hexagonal having side length of 0.275 mm and the circular shape having diameter of 0.5 mm. The other boundary conditions will remain same.

7. Comparison of different shapes of fins

After performing the CFD analysis of heat sink with different shape of micro-fins at different overlapping conditions of baffles comparison was done. For comparing the performance of different heat sink, each type of micro-fins design was compared at different overlapping percentage of baffles for different Reynolds number. The comparison was mainly done on the basis of heat transfer coefficient and pressure drop inside the heat sink. Through contour plots the variation of velocity, pressure, and temperature distribution throughout the sink was easily identified.

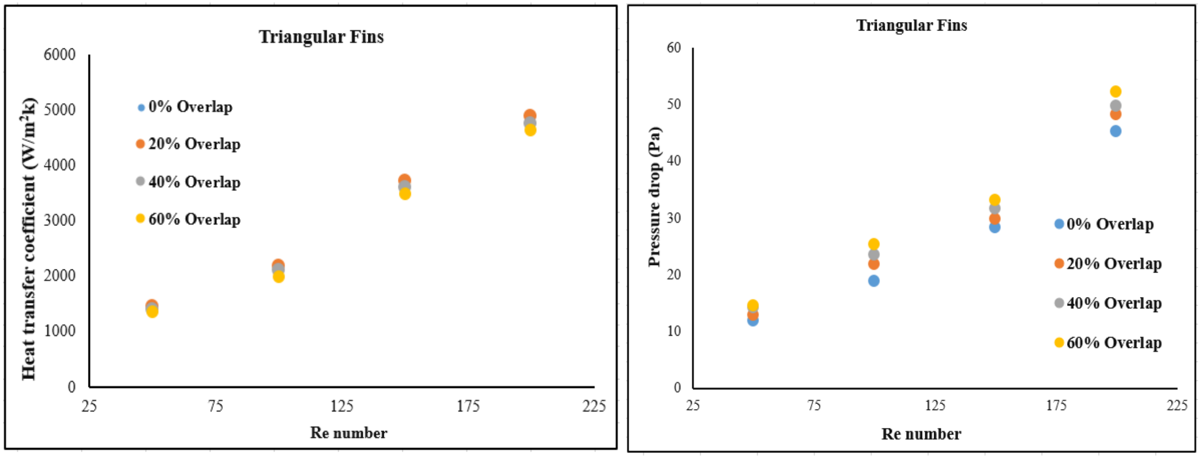

Fig.8 Comparison of value of heat transfer coefficient and pressure drop for different percentage of overlapping for triangular shape of fins

With triangular shape of fins, 60% overlap of fins shows the maximum pressure drop, whereas 0% overlap shows the minimum value. Through graph it is also observed that with change in design of fins there is marginal change in pressure drop in triangular shape of fins. Through comparison it is found that for triangular fins, 20% overlapping shows the maximum heat transfer as compared to other cases of overlapping. Whereas 60% overlapping shows the minimum heat transfer as compared to others. With increase in Re numbers heat transfer get increased.

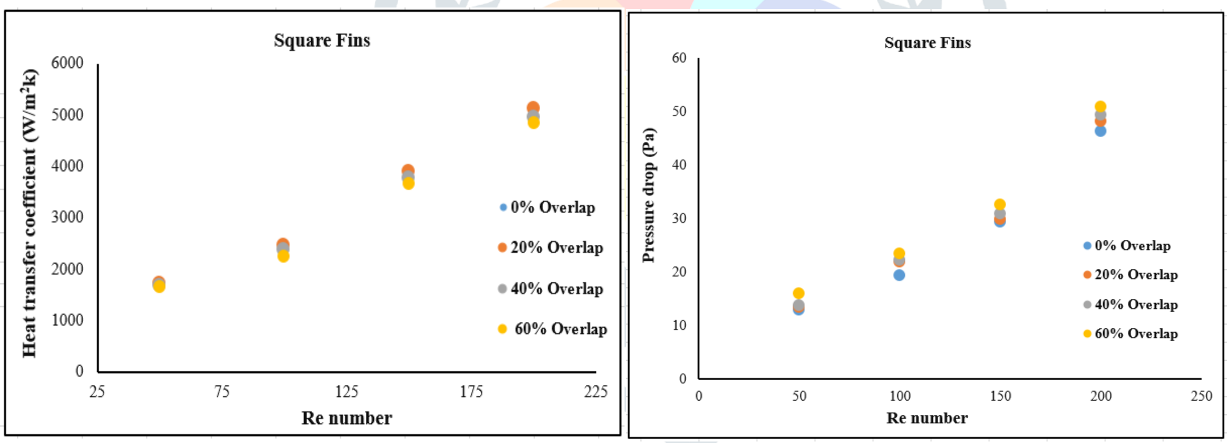

Fig.9 Comparison of value of heat transfer coefficient and pressure drop for different percentage of overlapping for square shape of fins

For pressure drop inside the sink, square shape of fins 60% overlapping shows the maximum value, whereas 0% overlapping shows the lowest value. Square fins show the higher pressure drop at 60% overlapping as compared to triangular fins. For square shape of fins 20% overlap shows the maximum heat transfer, whereas 60% overlap shows lowest heat transfer as compared to other percentage of overlap. For 20% overlapping, the heat transfer for square fins is more as compared to triangular shape of fins.

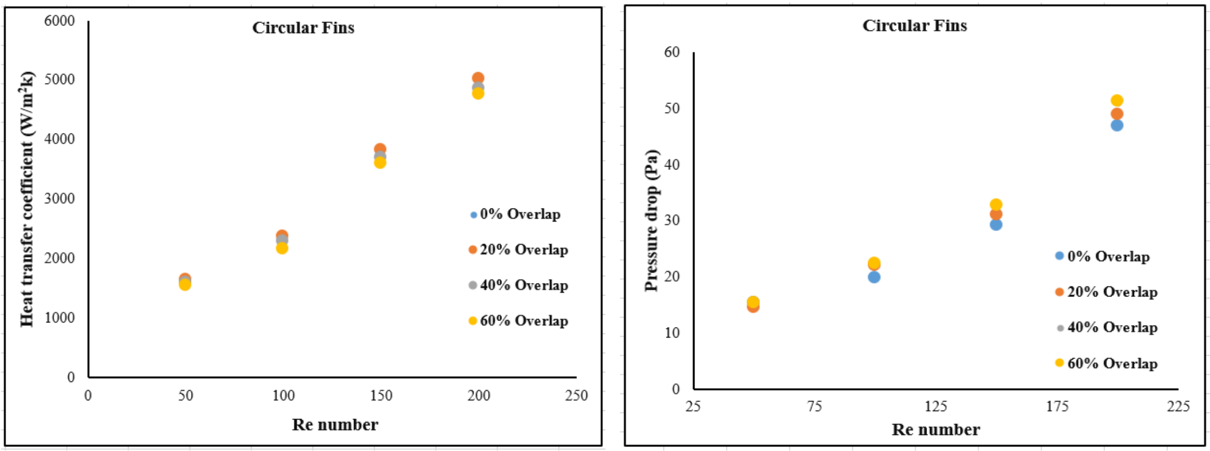

Fig.10 Comparison of value of heat transfer coefficient and pressure drop for different percentage of overlapping for circular shape of fins

As other cases, circular fins also show the maximum pressure drop for 60% overlapping and 0% shows the lowest pressure drop. Circular shape of fins shows the higher pressure as compared to hexagonal shape and lower as compared to square and triangular fins. For circular shape of fins 20% overlapping shows the maximum heat transfer, whereas 60% shows the lowest value and 0 and 40% shows the intermediate value. At each percentage of overlapping, circular fins show the higher value of heat transfer as compared to triangular fins and shows lower value as compared square and hexagonal shape of fins.

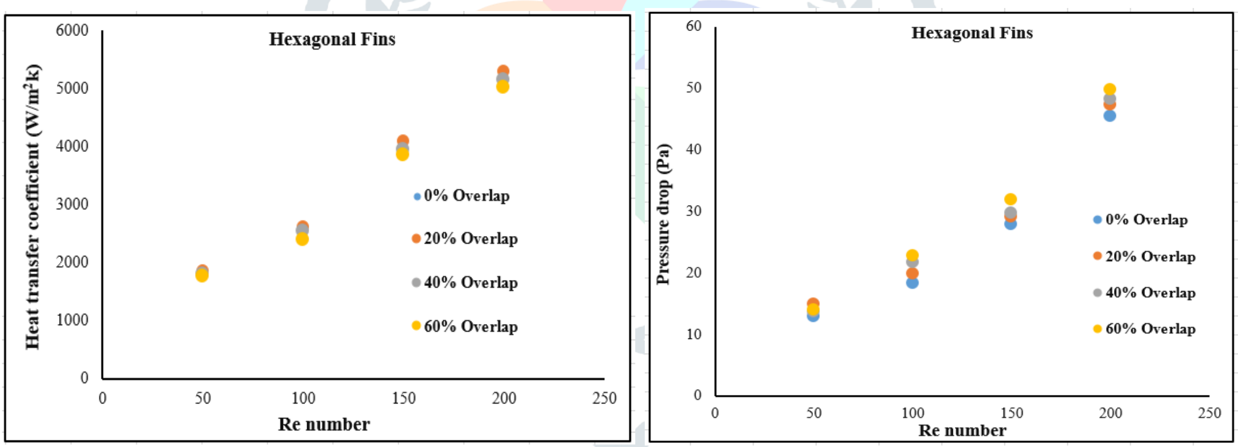

Fig.11 Comparison of value of heat transfer coefficient and pressure drop for different percentage of overlapping for hexagonal shape of fins

For hexagonal shape of fins 60% overlapping shows the maximum pressure drop. The pressure drop for hexagonal shape of fins is less as compared to triangular and square shape of fins. 20% overlapping shows the maximum heat transfer as compared to others, whereas 60% overlapping shows the lowest heat transfer. Hexagonal fins show the higher heat transfer as compared to triangular and square shape of fins at each Reynolds number.

8. Conclusion

The CFD analysis of plate fin heat sink was done to analyzed the effect of different processes parameters on their performance and measure the velocity, pressure and temperature variationv throughout the sink. Through numerical analysis it was found that, shape of the fins affect the performance of heat sink, and it gets also changed with different percentage of overlapping of the turbulators. In each case of fins shape geometry, 20% shows the better performance as compared to others. And out of triangular, square, hexagonal and circular shape of geometry, hexagonal shape shows the higher heat transfer from heat sink as compared to others at each Re number.

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