

EFFECT OF DIFFERENT SHAPES OF MICRO FINS IN DOUBLE SEGMENT BAFFLE HEAT SINK

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Abstract: According to today's requirement compact heat sink with high specific heat transfer coefficient is required. In the same order to increase the heat transfer from compact heat sink, here in this work different shapes of micro fins are used inside the heat sink having double segmental baffles arrangement. For analysing the effect of different shape of fins four different shapes was considered during the work that is circular, triangular, square and hexagonal shape of fins having same cross sectional area. Temperature, pressure and velocity variation throughout the heat sink with change in Reynolds number was analysed in each case of fins shape. It also calculates the heat transfer coefficient and pressure drop inside the heat sink for different cases of analysis. Through CFD analysis it is found that heat sink with hexagonal shape of fins shows the maximum heat transfer as compared to other shape of fins.

Keywords: Heat sink, Fins shapes, Heat transfer, Reynolds number, Pressure drop

Introduction

Heat sinks are basically used to extract heat from the source and dump it in to the environment. With the development of technologies, the size of the electronic devices decreases and with this heating problem occurs which degrade the performance of equipment's. heat sink with high specific heat transfer rate are the requirement of current market. In the same order to increase the performance of heat sink, here in this work effect of different shapes micro fins with double segmental baffle on heat sink performance was analysed. Here it considered four different shapes of micro fins having same cross sectional area that is circular, triangular, square and hexagonal shape. For analysing the effect of different Reynolds number for different shapes of micro fins four different Re numbers was considered during the work that is 50, 100, 150 and 200. In each case of analysis velocity variation, pressure variation, temperature distribution, heat transfer coefficient and pressure drop was calculated. In the initial case of analysis that is in validation case, effect of circular micro fins was analysed. For all the different shapes of micro fins height and cross sectional area is same. The effect of different shapes of micro fins was analysed in the below section.

Validation of CFD analysis of heat sink having micro pin fins

For performing the numerical analysis of heat sink Ansys fluent software was used during this work. Here first the CFD analysis of heat sink was done and validated its result with the result given in karami et.al (1). In order to perform the validation of heat sink numerical analysis, 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.

Development of solid model of heat sink with micro pin fins

For making the solid model of heat sink as considered in karami et al. same geometric parameters was considered as mention in the paper. The geometric parameters considered for solid model of heat sink is mention in the below table.

Table.4.1 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
Baffles width for double segment	3.33
Height of baffle	0.5
Thickness of baffles	0.1

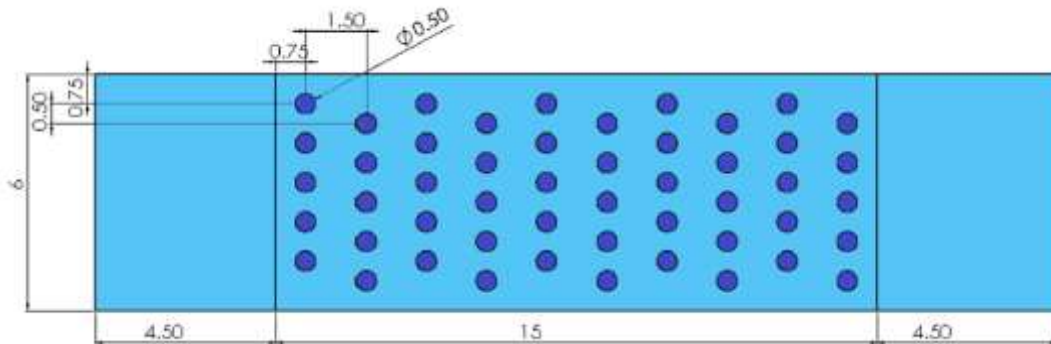


Fig.4.1 geometric parameters of heat sink considered during the work (1).

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.

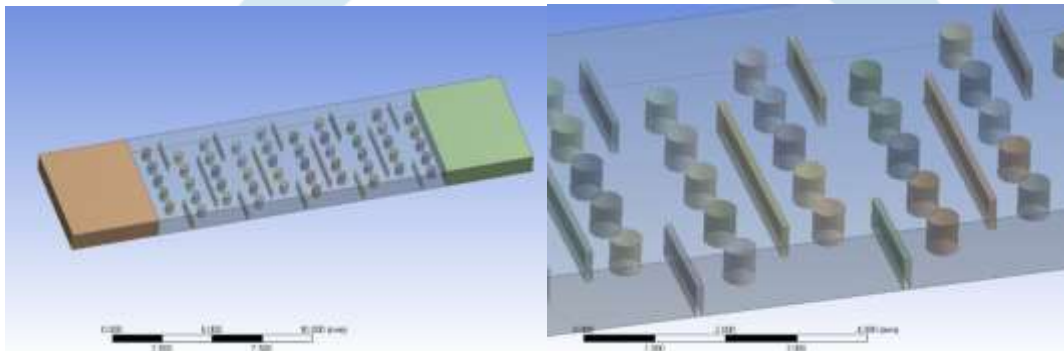


Fig.4.2 solid model of heat sink with circular micro pin fins with double segment baffles.

Karami et al. (1) optimizes the different arrangement of micro circular pin fins and baffles and concluded that heat sink having double segment baffles arrangement shows the maximum heat transfer and efficiency as compared to other. So for the validation of heat sink CFD analysis, here in this work it considered the most efficient double segmented micro pin fin heat sink. After making the solid model of heat sink meshing was done.

Meshing of the heat sink

For performing the numerical analysis of heat sink, discretization of heat sink 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 element, optimum result is coming. So it is concluded that after increasing the number of elements there is no any such change was observed during the work. For further analysis, 858748 number of elements was considered during this work. The meshing of solid model of heat sink having circular micro pin fins is shown in the below figure.

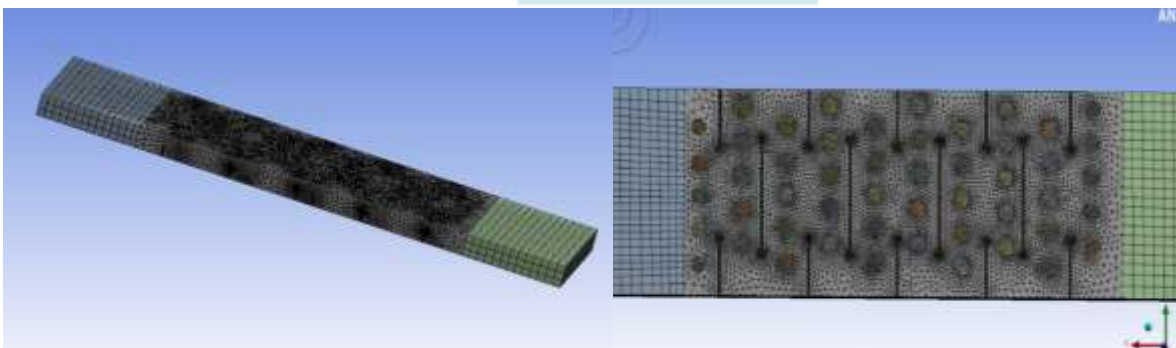


Fig.4.4 meshing of heat sink.

For the enhancement of result and better numerical analysis, it is necessary to have mesh refinement in critical zones of heat sink. Refinement was also done in the area of two different medium contact region. After mesh refinement name selection of different component of heat sink was done.

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. The selection of couple method is shown in the below figure.

4.13 Heat sink with circular shape micro fins heat sink

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. For comparison value of heat transfer coefficient and pressure drop inside the heat sink was also calculate numerically.

4.14 For Re – 50

In this case of analysis 50 Re number was considered for water at the inlet of heat sink. The different contour plot of heat sink at this Re number is shown in the below figures.

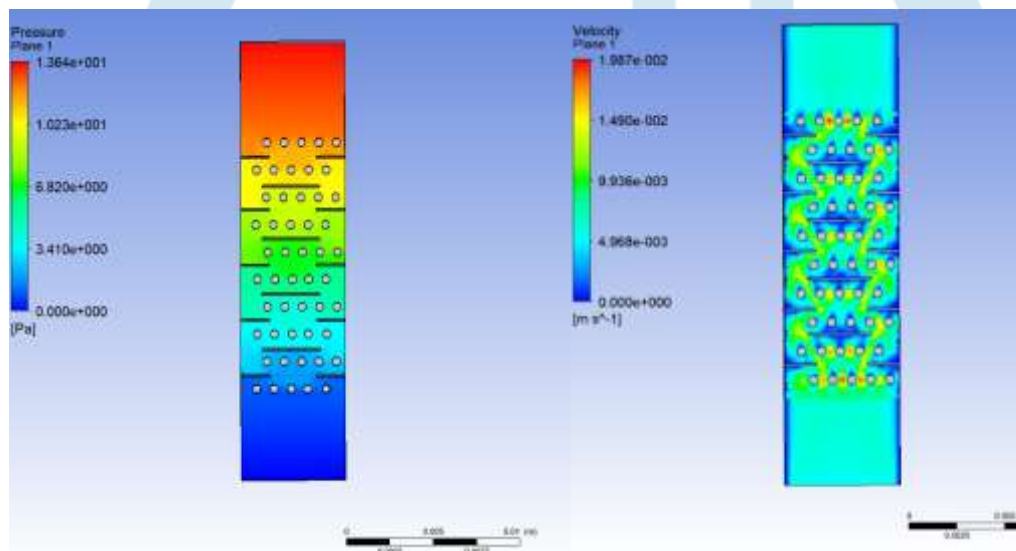


Fig.4.16 Pressure variation and velocity variation inside the heat sink for Re – 100.

Above figures show the variation of pressure and velocity throughout the heat sink. From pressure contour plot it is found that there is a sharp change in pressure from inlet to outlet of heat sink. Whereas in velocity variation, near to fin significant changes in velocity was clearly observed during the work.

Comparison of different parameters

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.

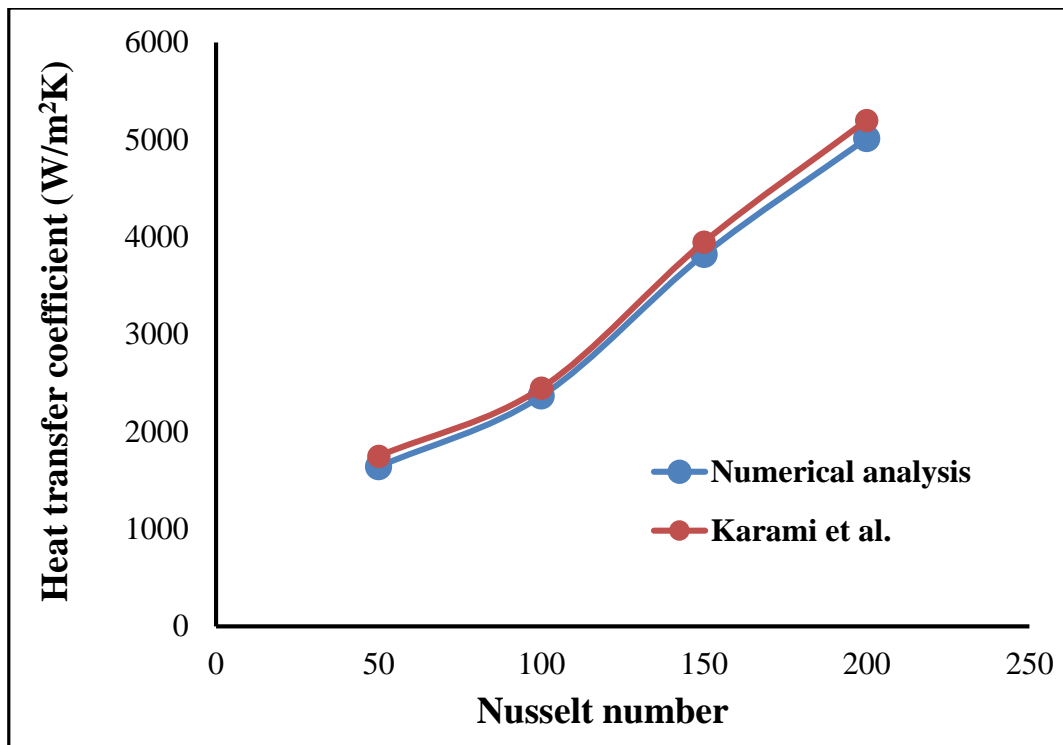


Fig.4.31 Comparison of value of heat transfer coefficient.

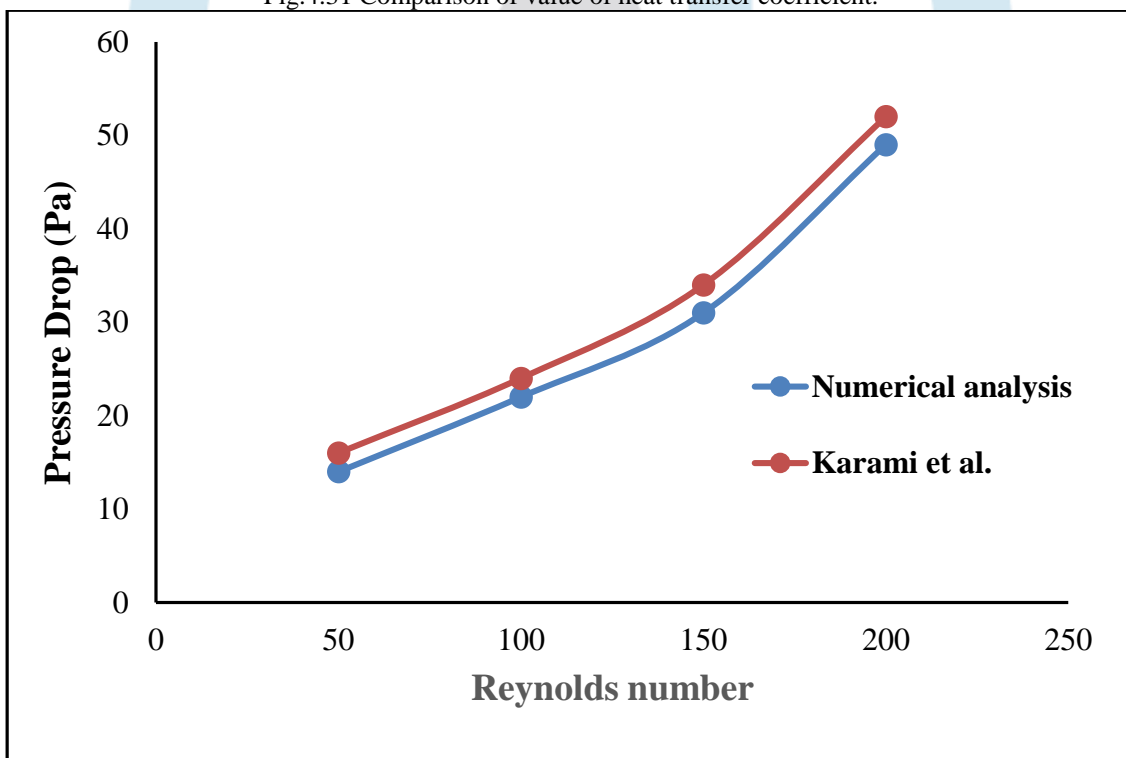


Fig. comparison of value of pressure drop inside the heat sink.

From above graph it is found that the value of pressure drop 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. Whereas pressure drop value percentage error is also under the range of 12 %, which is also acceptable.

Heat sink having triangular shape micro fins

Here in this case of analysis the shape of the fins is triangular, which is having same cross sectional area as circular fins. The height of the triangular fin will remain same, whereas other boundary conditions will also remain same. With triangular shape of fins four different Re number was considered.

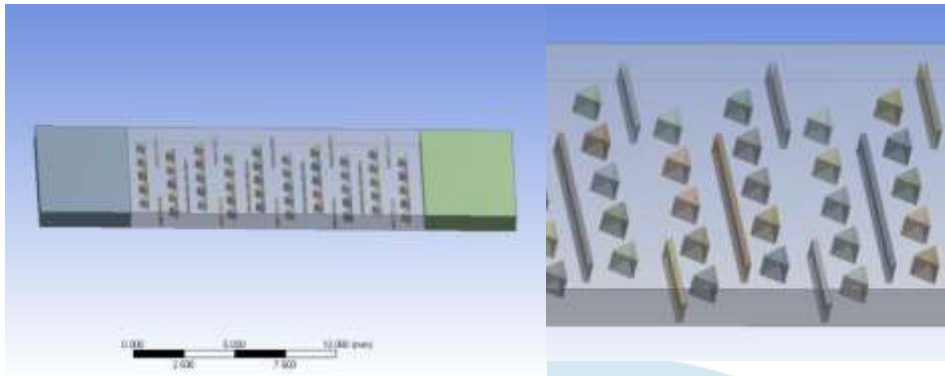


Fig. Solid model of heat sink having triangular shape of micro fins.

For Re- 50

The contour plots for this Reynolds number is shown in the below

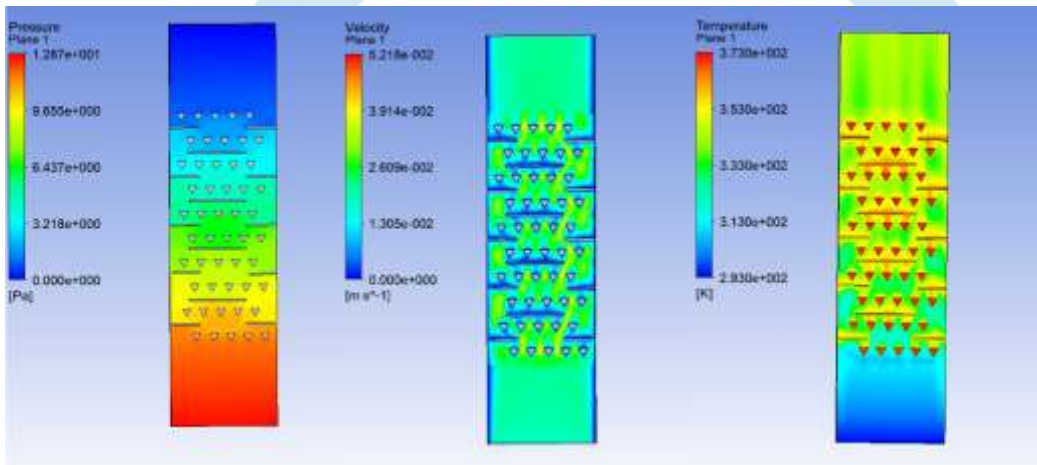


Fig.5.4 pressure, Velocity and temperature variation for triangular fins at Re- 50.

From above figure it is found that pressure in triangular shape of fins is less whereas velocity is more. In terms of water temperature inside the heat sink, water temperature is more as compared to circular fin it means that heat transfer from heat sink having triangular shape fin is less as compared to circular fins.

Table. Value of heat transfer coefficient and Pressure drop for triangular shape of fin.

Re	Heat transfer coefficient (W/m ² k)	Pressure Drop (Pa)
50	1442	12.5
100	2184	20.7
150	3716	29.5
200	4889	48

Comparison of different shapes of fins

After finding the different parameters values for different shape of fins at different Re numbers comparison was done. the comparison was mainly done on the basis of pressure drop inside the heat sin and heat transfer coefficient of heat sink for different shapes of micro fins. The value of pressure drop and heat transfer coefficient for different shape of fins at different Re number is mention in the below table.

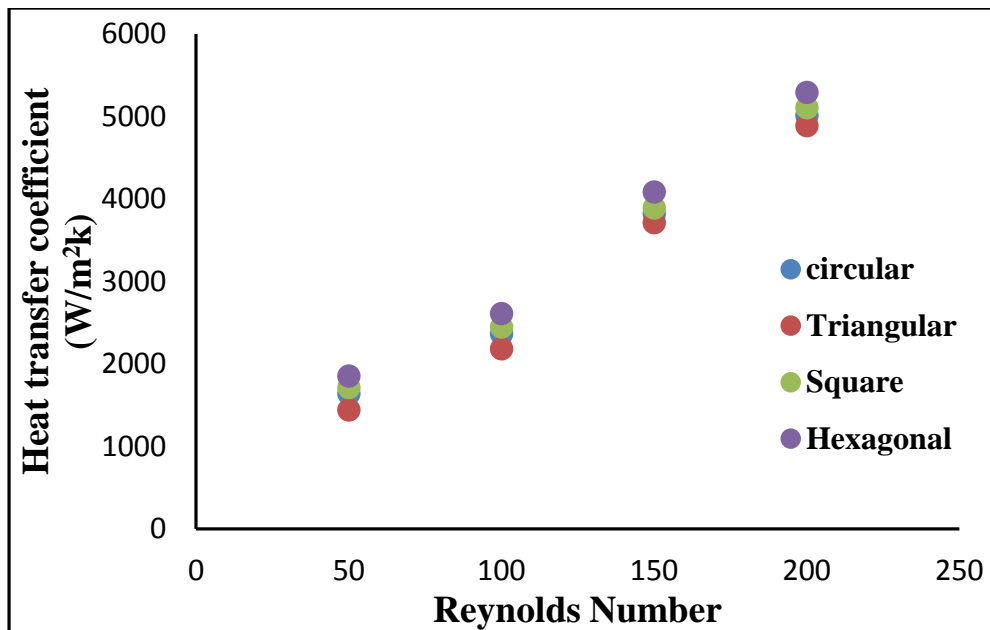


Fig. Comparison of value of heat transfer coefficient for different heat sink geometry.

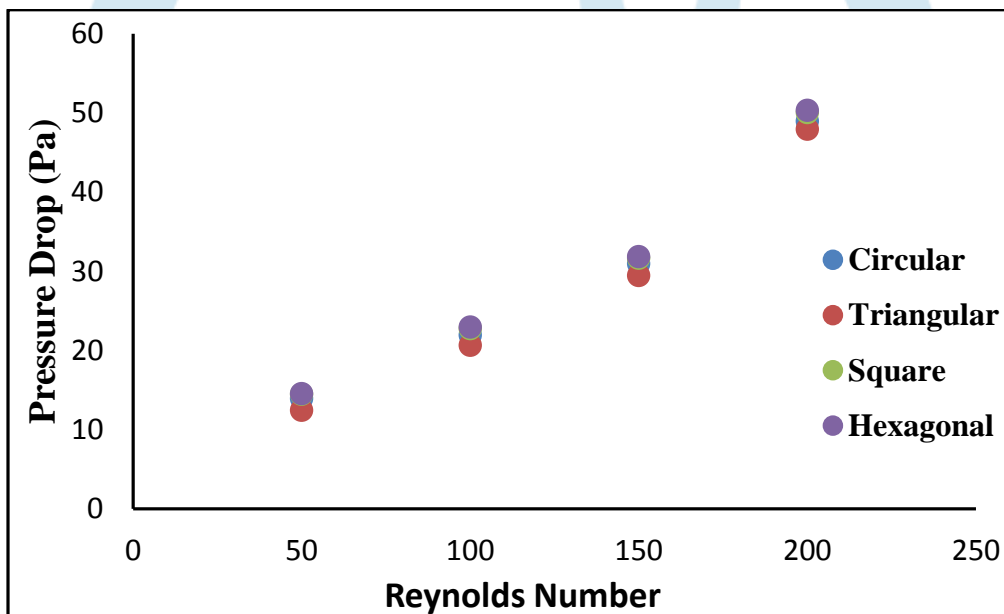


Fig. comparison of pressure drop for different shapes of fins at different Reynolds number.

From above comparative graph it is found that with hexagonal shape of micro fins, the heat transfer coefficient is more as compared to other shapes of fins. There is very nominal increase in pressure drop for hexagonal shape of fins as compared to other, which does not affect its performance. With increase in Re number the heat transfer gets increases whereas the pressure drop inside the heat sink get also increased. Triangular shape of fins shows the minimum heat transfer coefficient as compared to other, whereas it also shows the minimum pressure drop.

Conclusion

CFD analysis of Heat sink having micro fins with double segmental baffles was successfully done. Through CFD it is found that with change in shape of micro fins and Re number the performance of heat sink gets change. With increase in Re number the velocity, pressure drop and temperature variation inside the heat sink varies, which plays an important role in the enhancement of heat sink performance. With hexagonal shape of fins, the heat transfer is more as compared to other shape of fin. With hexagonal shape of fins, the pressure drop inside the heat sink is very nominal higher as compared to other shape of fins. For hexagonal shape of fins, the heat distribution inside the heat sink and mainly in between two fins is more uniform as compared to other shape of fins which make it more efficient for heat transfer. With hexagonal shape of fin, the velocity variation inside the heat sink is also more uniform as compared to other fins which is shown in velocity contour plots.

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