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Heat Transfer Enhancement and Optimization in Pin Fin Using Different Fin Profiles and Materials by Ansys

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ABSTRACT

The heat conducted through solids, walls, or boundaries has to be continuously dissipated to the surroundings or environment to maintain the system in steady-state conduction. In many engineering applications, large quantities of heat have to be dissipated from small areas. Heat transfer by convection between a surface and the fluid surrounding it can be increased by attaching to the surface thin strips of metals called fins.

The main aim of this thesis is to improve the heat transfer characteristics and to investigate the performance of fin efficiency by using fins of different materials in pin fin apparatus. The investigation will also be done by varying materials and fin shape. 3D model of the pin fin apparatus will be done in Catia.

CFD analysis and Thermal analysis will be done in Ansys to determine heat transfer characteristics Nusselt Number, Heat Transfer Coefficient, Heat Transfer rate by varying materials and fin shape.

INTRODUCTION

The temperature difference with surrounding fluid will steadily diminish as one move out along the fin. The design of the fins therefore required knowledge of the temperature distribution in the fin. The main objective of this experimental set up is to study temperature distribution in a simple pin fin. The rate of heat transfer may depend on the type of fins which we used.

There are two ways to increase the rate of heat transfer:

- To increase the convection heat transfer coefficient h
- To increase the surface areas

But Increasing h may require the installation of a pump or fan or replacing the existing one with a larger one the alternative is to increase the surface area by attaching to the surface extended surfaces called fins made of highly conductive materials such as aluminium convex parabolic fins.

Triangular Fins

The ratio of Actual heat transfer rate from the fin to the Ideal heat transfer rate from the fin. The ratio of Heat transfer rate from the fin of base area Ab to the rate of Heat transfer from the surface of area Ab.

The heat conducted through solids, walls or boundaries has to be continuously dissipated to the surroundings or environment to maintain the system in steady state conduction. In many engineering applications large quantities of heat have to be dissipated from small areas.

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Heat transfer by convection between a surface and the fluid surroundings it can be increased by attaching to the surface thin strips of metals called fins. The fins increase the effective area of the surface thereby increasing the heat transfer by convection. The fins are also referred as “extended surfaces”. Fins are manufactured in different geometries, depending up on the practical applications Most of the engineering problems require high performance heat transfer Components with progressively less weights, volumes, accommodating shapes and costs. Extended surfaces (fins) are one of the heats exchanging devices that are employed extensively to increase heat transfer rates. The rate of heat transfer depends on the surface area of the fin. It increases the contact surface area, for example a heat sink with fins. The heat transferred through the fins provides the problem of determination of heat flow through a fin requires the knowledge of temperature distribution through it. This can be obtained by regarding the fin as a metallic plate connected at its base to a heated wall and transferring heat to a fluid by convection. The heat flow through the fin is by conduction.

Thus, the temperature distribution in a fin will depend upon the properties of both the fin material and the surrounding fluid. In this section, we will analyze certain basic forms of fins, with respect to heat rate, temperature distribution and effectiveness. The experiment is conducted to investigate the effect of the pressure loss and heat transfer characteristics in pin-fin channel, where dimples are located on the pin-fins. An aluminum fin of rectangular cross section with various dimple depth is fitted in a long rectangular duct. In the present work aluminum & brass plate were used as a test surface. Variation of Nusselt Number with Reynolds Number is investigated, with various parameter combinations. The experimental results gives heat transfer coefficient & efficiency of aluminum fin is greater than brass fin. Most of the engineering problems require high performance heat transfer components with progressively less weights, volumes, accommodating shapes and costs. Extended surfaces (fins) are one of the heats exchanging devices that are employed extensively to increase heat transfer rates. The rate of heat transfer depends on the surface area of the fin.

In this the heat transfer rate and efficiency for circular and elliptical annular fins were analyzed for different environmental conditions. From the experimental study it is found that the heat transfer rate in notched fins is more than the unnoticed fins. The average heat transfer coefficient for without notched fin is 8.3887 W/m2K and for 20% notched fins it is 9.8139 W/m2K. Also, the copper gives more heat transfer rate than aluminum plate. As the notch area of fin increases the heat transfer rate also increases. Copper plate gives better heat transfer rate than aluminum plate.

Figure : Pin fin heat sinks from Advanced Thermal Solutions, Inc. (ATS). Pin fin heat sinks provide low thermal resistance at high LFM.

Disadvantages:
The length of the fin is directly proportional to heat transferring rate. But the larger length may be cause of bending in the fins and increases the weight of the engine. Therefore, the overall efficiency of the engine going to decreases.

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LITERATURE SURVEY

VikasBansal et al. presented paper on effect of slot on performance of circular pin fin**.** The study was based on theoretical and computational analysis of circular pin fin made of copper and aluminum. Effect of slot in cross section of circular pin fin along its length on its performance was observed. It was observed that the introduction of slot improves heat transfer rate the fin and reduces cost of pin fin arrays. They also observed aluminum pin fin with one slot transfers, more heat as compared to heat transfer by copper pin fin without slot. The result ended the conclusion that increasing number of slots increases heat because the surfaces area increases and volume decreases, so lesser material is required and hence lesser cost.

Pardeep Singh et al. analyzed the Heat Transfer through Fin with Extensions (such as rectangular extension, trapezium extension, triangular extensions and circular segmental extensions). They compared heat transfer performance of fin with same geometry having different extensions and without extensions. They concluded with the result that use of fins with extensions, provide greater heat transfer, Fin with extensions provide nearly 5 % to 13% more improvement in heat transfer as compared to fin without extensions. They also found that effectiveness of fin with rectangular extensions is higher than other extensions and choosing the minimum value of ambient fluid temperature provide the greater heat transfer rate enhancement.

Balendra Singh et al. analyzed the experimental observation and simulation for rectangular UN notched fin for different thermal loads. The result of the distribution of temperature, velocity vector plot, Nusselt no. and the heat transfer coefficient & heat transfer coefficient increased constantly in all cases but inverted triangular notched fin was giving maximum heat transfer rate. They concluded with the result, that heat transfer rate of inverted triangular notched fin has been increased by almost 50.51% as compared to rectangular unnotched fin. They also find that the increase in average heat transfer rate of inverted triangular notched fin is 50.51%, inverted trapezoidal notched fin is 36.81%, inverted circular notched fin is 37.98%and inverted rectangular notched fin is 26.01% with respect to plane rectangular fin. Hence, they showed efficiency of inverted triangular notched fin is better than others.

N Sahati, F durst demonstrated the enhancement of heat transfer in the present work by using small cylindrical pins on surfaces of heat exchangers and simple relationships were used for the conductive and convective heat transfer to derive an equation that showed which parameters permit the achievement of heat transfer enhancements. Experiments were reported that demonstrate the effectiveness of the results of the proposed approach.

LaxmikantChewanet.al conducted the trails for various material materials on fins by varying Reynolds number and results were obtained. The results showed that with increase in Reynolds number the efficiency and effectiveness of the pin fin decreases. They found aluminum to be most effective among brass, brass with knurling, brass with holes and mild steel.

AAWartyet al. Investigated the performance of pin fins made of three different materials aluminum, brass and stainless steel. They evaluated the influence of design parameter such as length, diameter and material of pin fin on thermal efficiency of natural convention heat sink by experimental setup. The results found to be efficiency of aluminum was maximum followed by brass and then stainless steel.

Yatendra Singh Tomar et al. studied the comparative performance of pin fin arrays

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under the forced convection heat transfer. The parameters like height, diameter, longitudinal pitch and spacing of pin fins were validated by CFD analysis. The circular pin fin array of 6x8 was studied under the air flow velocity of 2.5 m/s. The results showed as transverse pitch of circular pin increases its thermal resistance decreases.

karanSangaj el al. various parameters like shape (rectangular, circular, tapered, conical, parabolic), geometry and material (copper, aluminum, mild steel, brass and stainless steel) of pin fin were compared in ANSYS. The results showed copper circular hollow pin fin and copper rectangular pin fin to be optimum pin fins. It was found that copper and aluminum pin fins with same shape have nearly equal heat transfer. So, it was concluded that aluminum to be optimum material for pin fin due to economic constraints.

Fan Bailin et al. the temperature field and efficiency were analyzed for pin fin radiator. It was found that distribution of temperature field for pin fins depend on length, diameter and spacing etc. and radiator efficiency mainly depends on convective heat transfer resistance, so optimization of radiator structure was achieved by reducing thermal resistance.

METHODOLOGY

MATERIAL PROPERTIES

1. AL
   Density: 2.81g/cc
   Young's modulus: 71.7 Gpa
   Poison's ratio: 0.33
   Thermal conductivity: 173 W/m-K
2. BRASS
   Density: 8.86g/cc
   Young's modulus: 117 Gpa
   Poison's ratio: 0.375
   Thermal conductivity: 233W/m-K
3. COPPER
   Density: 7.94g/cc
   Young's modulus: 110 Gpa
   Poison's ratio: 0.364
   Thermal conductivity: 385* W/m-K

DESIGN

Model 1

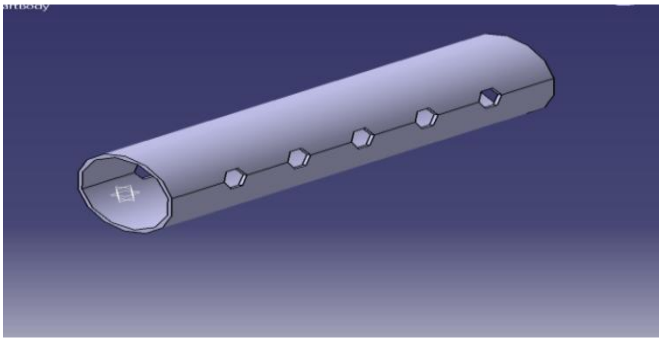

Fig: Isometric view of Hexa holed fin

Model 2

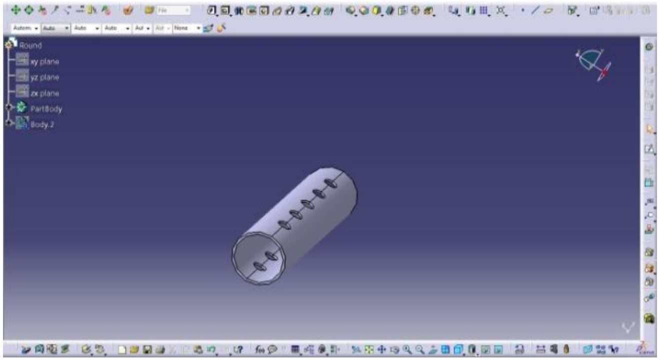

Fig: Isometric view of Round fin

Model 3

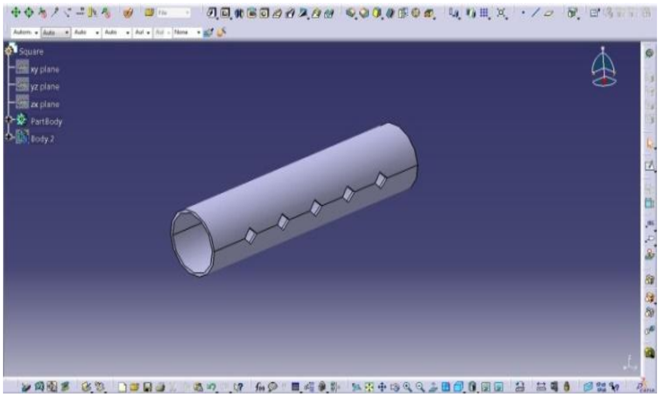

Fig: Isometric view of Square fin

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CFD ANALYSIS OF AN HEXA HOLED FIN USED IN PIN FIN APPARATUS

GEOMETRY

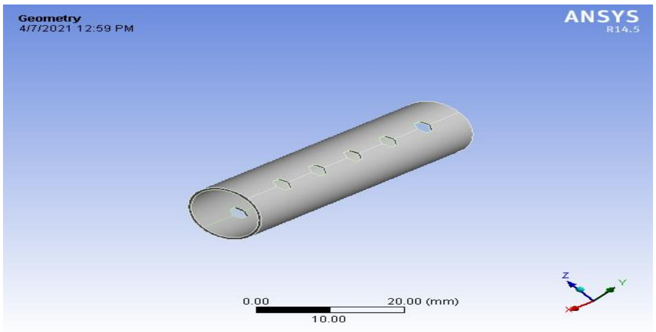

Fig: Geometric file of hexa holed fin

MESHED FILE

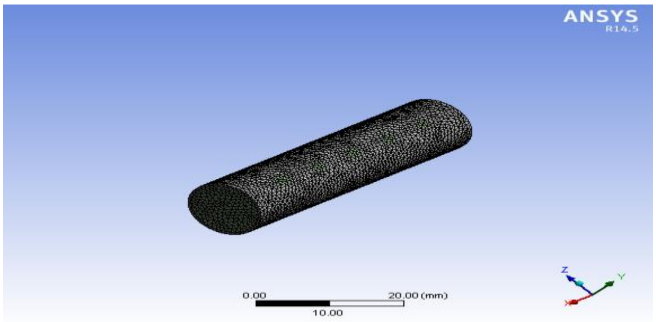

Fig: Meshed file of hexa holed fin

PRESSURE

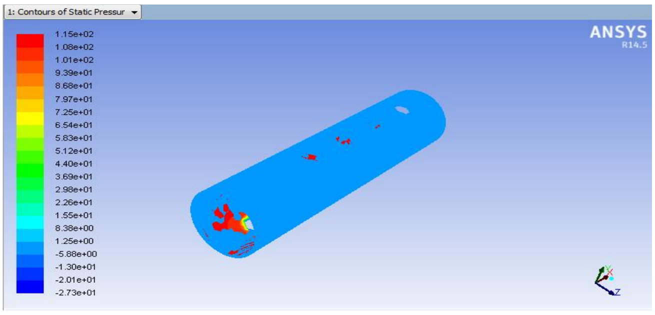

Fig: Pressure result of hexa holed fin

DENSITY

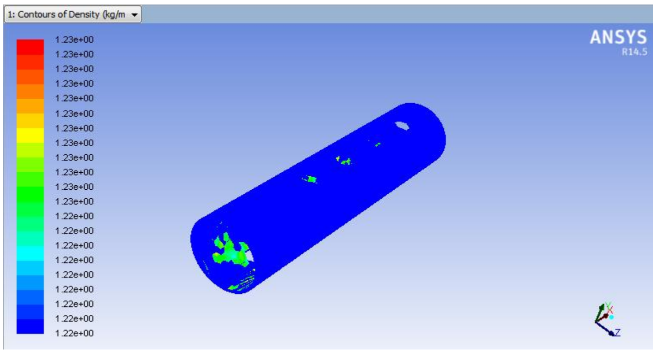

Fig: Density result of hexa holed fin

VELOCITY

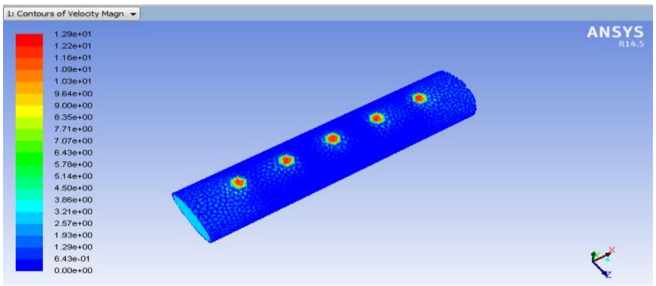

Fig: Velocity result of hexa holed fin

TEMPERATURE

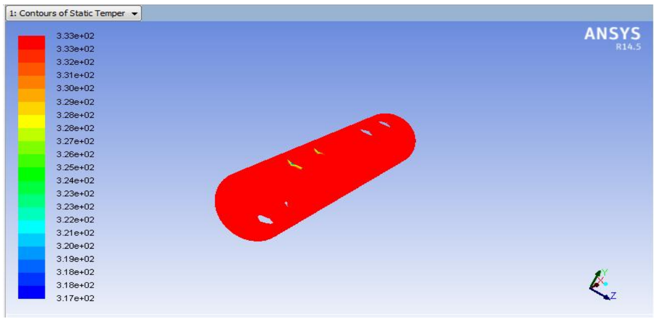

Fig: Temperature result of hexa holed fin

NUSSELT NUMBER

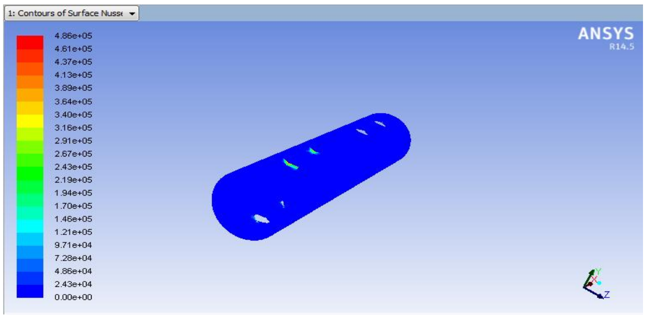

Fig: Nusselt number result of hexa holed fin

MASS FLOW RATE

Mass Flow Rate	(kg/s)
inlet	0.00069612276
outlet	-0.00069608318
Net	3.9581209e-08

HEAT TRANSFER RATE

Total Heat Transfer Rate	(w)
inlet	24.415972
outlet	-24.490007
Net	-0.074035645

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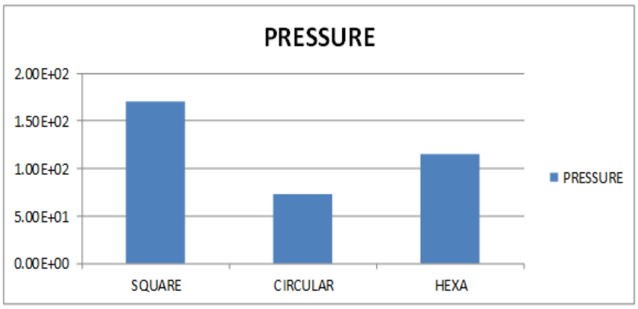
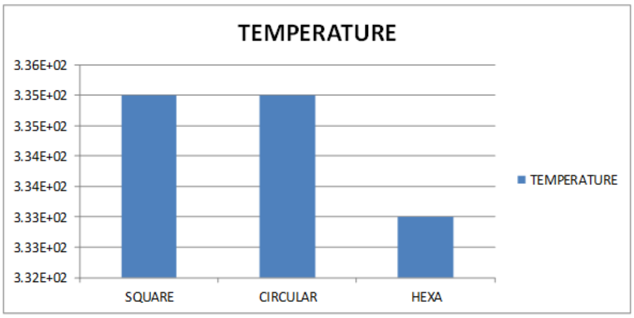
TABULAR RESULTS
CFD ANALYSIS

FINS	PRESSURE	VELOCITY	TEMPERATURE	NUSSELT NUMBER	MASS FLOW RATE	HEAT TRANSFER RATE
SQUARE HOLED FIN	1.70E+02	1.61E+01	3.35E+02	7.38E+03	6.8955621E-08	0.072578249
CIRCULAR HOLED FIN	7.29E+01	1.10E+01	3.35E+02	7.96E+03	8.7224815E-08	0.070926479
HEXA HOLED FIN	1.15E+02	1.29E+01	3.33E+02	4.86E+05	3.9581209E-08	0.074035645

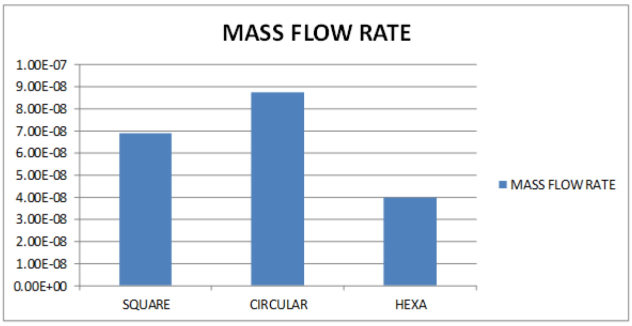
GRAPHS
PRESSURE



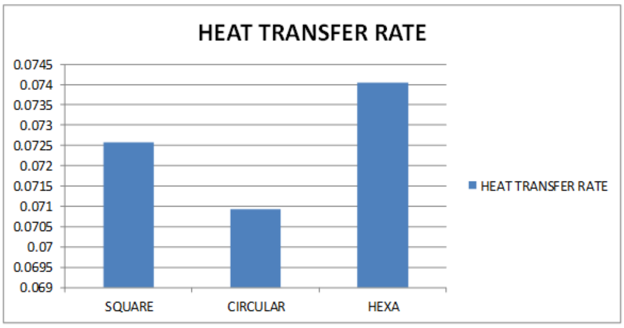
TEMPERATURE



MASS FLOW RATE



HEAT TRASFER RATE



CONCLUSION

In this thesis we have considered three different profiled fins like square, circle and square holed fin using three materials like, al – 7075, brass and cooper. Here we have done cfd analysis and thermal analysis to find out the best output result.

As here in the ansys results we can clearly observe that the nusselt number is the main term for this project, here it is mpre for the square profiled fin and as if we verify the remaining results like pressure, temperature, mass flow rate and the heat transfer rate, here also the square fin profiled has go he best outputs.

As from this results we have done the thermal analysis and here we have verified the heat flux and the thermal error for the different materials with profiles. As here in the comparasion of the graphical results we can clearly observe that the square profile has obtained the best results in all terms of heat flux and the thermal error. But here if we compare with the materials the cooper has obtained the best than the remaining materials like aluminum and brass. So as if we veify according to the cost and life we can even suggest the aluminum material as it also obtained the better output results.

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