A Review Paper On Design And Analysing Of Different Types Of Fin Configurations

[1]Mubashshir Shaikh, [2]Yusuf Shaikh, [3]Fatru Shaikh,[4]Danish Shaikh, [5]Rizwan Shaikh
(Mechanical Engineering Department)
Anjuman-I-Islam Kalsekar Technical Campus,New Panvel,Maharashtra, India

Abstract : This paper investigates the work done on various types of fins effect of perforation shape or geometry on the heat transfer of perforated fins.The type of heat ex-changer used is heat sink with the perforated fins under the forced convection heat transfer to determine the performance for each perforation shape between straight, slanting, transverse,circular, rectangular, triangular,cylindrical,square and also with the non-perforated fins. The experimental result compared between the types of fins perforation shape and the heat transfer coefficient to clarify the best perforation shape for the plate heat sink. The fluid and heat transfer properties of various fins were studied which found out were using CFD,ANSYS,CATIA .The difference between experimental and numerical results was reported for temperature distributions when the power supplied are respectively.The overall conclusion shows various paper analysed and their results and tabulated and also shown in the graphical format.

Keywords:Fins analysis, Heat transfer, Perforations, shapes, Plate fins, heat ex-changers

I. Introduction

Abhishek Mote[1] Fins are the extended surfaces purposely provided at a place from where heat is to be removed. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature gradient between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Fins are widely used for cooling of IC engines. The different types of fin geometries that can be used for an IC engine are-

1) Rectangular fins: The cross section of fins is rectangular in shape.
2) Triangular fins: The cross section of fins is triangular in shape.
3) Trapezoidal fins: The cross section is trapezoidal in this case providing greater surface area for heat transfer.
4) Pin fins: The area for heat transfer is in the form of small pin shaped fins called as Pin fins.

Heat transfer through extended surfaces is mainly focused on convectional heat transfer. The condition of cooling medium that surrounds those surfaces is responsible for conventional heat transfer. The movement of air across the fins and its pattern of movement over the periphery of extended surfaces greatly affect the heat transfer rate. Optimum length of fins: Since we are purposely increasing the surface area for getting maximum heat transfer, but it does not mean that we can go on increasing the length (and thereby the surface area) beyond a certain limit. If the length of fins is increased too much, the convective thermal resistance would increase thus reducing the heat transfer rate, fin efficiency and also; it adds unnecessary material and costs also. Conversely, if the length of fins is too short, the heat transfer rate and fin efficiency would decrease again. Hence the length of fin needs to be optimum in value

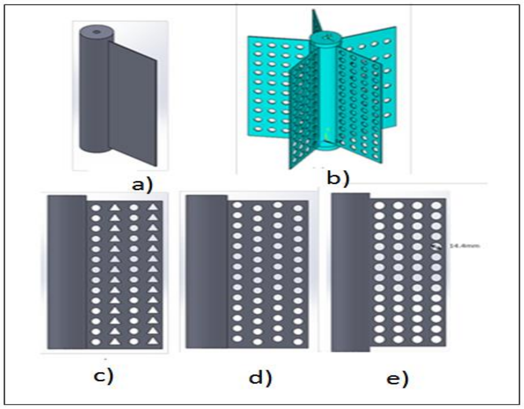


Figure 1:Different types of perforations

I. LITERATURE SURVEY

Thamir K. Ibrahim.[2] Heat sink with perforated and non-perforated fins were investigated.Perforated fins increase the heat coefficient of the heat sink by 35.82–51.29%.The difference between experimental and numerical results was about 8% and 9% for temperature distributions when the power supplied are 150 W and 100 W respectively.The fluid and heat transfer properties of heat sink were studied experimentally and numerically using CFD.Heat sink with perforated fins showed significant effect on the performance of forced convection heat transfer.

L.Prabhu[3].Heat transfer performance of fin is analysed by ANSYS workbench for the design of fin with various design configuration such as cylindrical , square and rectangular configuration. The heat transfer performance of fin with same base temperature is compared. In this thermal analysis, Aluminium was used as the base metal for the fin material. Fins are design with the help of CATIA V5R16. Analysis of fin performance done through the software ANSYS 15.0.

M. Sabri Sidik[4].An analysis was conducted to study the heat transfer of in-wheel electric motor cooling fin for light electric vehicle application. This study focuses on motor housing design and heat transfer analysis of different cooling fins arrangement for motor housing.Three types of cooling fin arrangement on the motor housing has been selected and modelled in CATIA software. There were straight fin, slanting fin and transverse fin. Then, all models were exported to ANSYS for heat transfer analysis purpose. This suggests that the straight fin arrangement has the highest efficiency of heat dissipation and distribution compare to the slanting and transverse fin arrangement.

Zan WU[5]. Natural convection heat transfer enhancement of perforated fin array with different perforation diameter 4-12mm and a different Angles of inclination (0-90) increase in the heat transfer coefficient was achieved with perforated fins of 12mm perforation diameter of the Angle of orientation 45 degree which shows about 32% enhanced heat transfer coefficient

with saving 30% material.

Pardeep Singh[6] In this research, the heat transfer performance of fin is analysed by design of fin with various extensions such as rectangular extension, trapezium extension, triangular extensions and circular segmental extensions. The heat transfer performance of fin with same geometry having various extensions and without extensions is compared. Near about ranging 5% to 13% more heat transfer can be achieved with these various extensions on fin as compare to same geometry of fin without these extensions. Fin with various extensions design with the help of software AutoCAD. Analysis of fin performance done through the software Autodesk® Simulation Multiphysics. In this thermal analysis, temperature variations w.r.t. distance at which heat flow occur through the fin is analysed. Extensions on the finned surfaces is used to increases the surface area of the fin in contact with the fluid flowing around it.So, as the surface area increase the more fluid contact to increase the rate of heat transfers from the base surface as compare to fin without the extensions provided to it. On comparison, rectangular extensions provide on fin gives the greatest heat transfer than that of other extensions having the same length and width attached to finned surface.

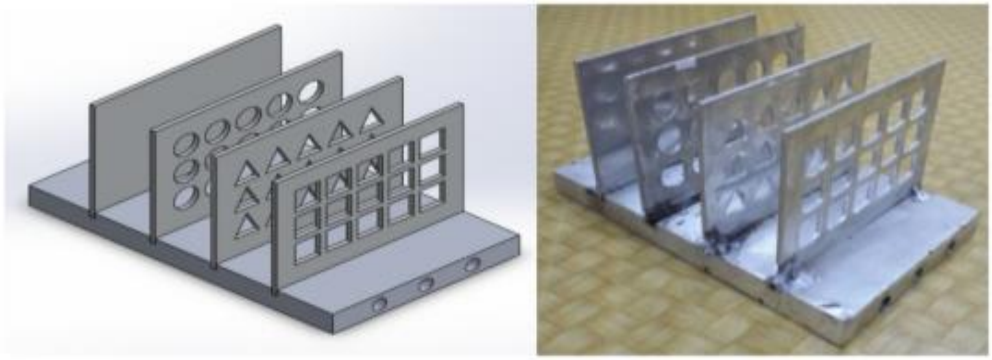


Figure 2: From left Non-perforated, Circular perforated ,Triangular perforated ,Square perforated fins.

II. ANALYSIS

[2]Thamir K. Ibrahim.The comparison between triangular perforation shapes with the rectangular show that the increment 5.099% which is a show that the triangular shape is better than rectangular in term of heat transfer coefficient. As the result, the heat transfer coefficient for triangular perforation shape is better compared to the non-perforation and also to the other perforation shape. In the same way, when comparing the circular perforation shape with the non-perforation and with the other perforation shape, the heat transfer coefficient has increased simultaneously by 5.239–7.194% compared to non-perforated and with the rectangular perforation fins. In comparison, the heat transfer coefficient of circular perforation with the triangular perforation shape has decreased significantly by 0.14%. As a result, the circular perforation shape is better in term of performance compared to non-perforated and rectangular shape but it not as good as the triangular perforation shape. Also, when comparing the rectangular shape with the non-perforated and another perforation shape, the rectangular perforation shape has increment of 2.25% compared to the non perforated but when doing comparison between rectangular perforations with the circular perforation the heat transfer coefficient of rectangular shape has decrement about 5.099% which is can be stated that the circular perforation shape is better than the rectangular perforation shape. This trend also can be seen when comparing the rectangular shape with the triangular shape which has decrement about 5.239%. This result will be stated that the rectangular perforation shape is the on the third place when comparing the rectangular perforation shape with non-perforation and also with the other perforation shape.

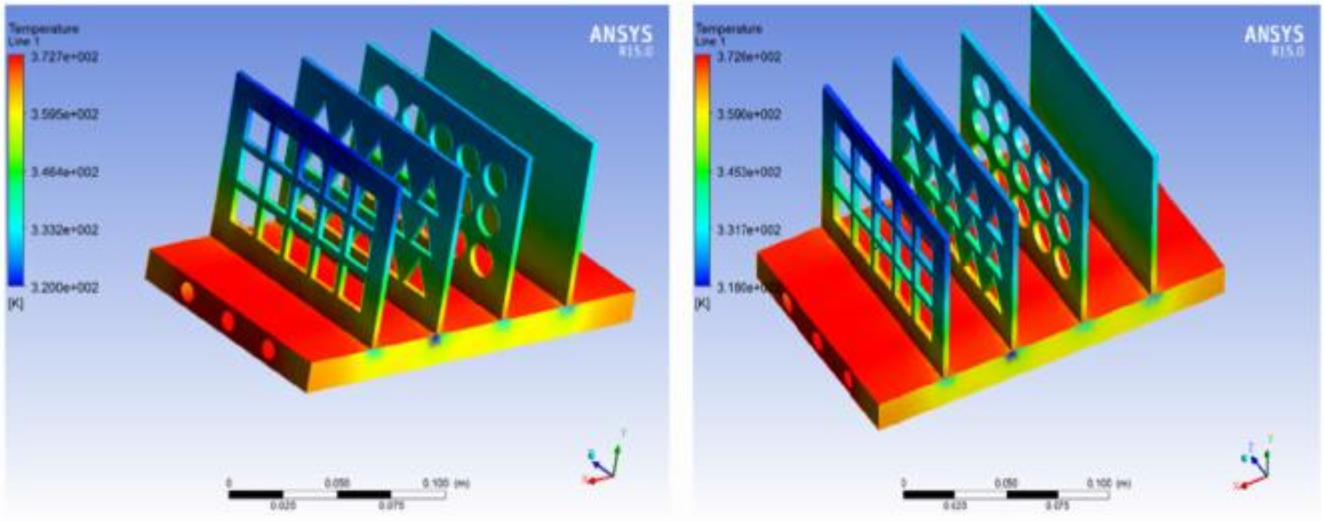


Figure 3. Analysis on software (ANSYS)

Table 1

Calculated data for *h* with 150 W.

Shape	$1.8\ ms^{-1}$	$2.0\ ms^{-1}$	$2.3\ ms^{-1}$	$2.5\ ms^{-1}$	$2.8\ ms^{-1}$
Triangular	809.641	811.787	812.707	813.988	816.693
Circular	808.768	809.297	811.260	811.872	812.208
Non-Perforated	802.962	805.586	806.011	807.391	808.649
Rectangular	804.792	805.359	806.820	807.555	807.837

Table 2

Calculated data for *h* with 100 W.

Shape	$1.8\ ms^{-1}$	$2.0\ ms^{-1}$	$2.3\ ms^{-1}$	$2.5\ ms^{-1}$	$2.8\ ms^{-1}$
Triangular	813.9321	814.8369	815.6178	819.6847	818.1489
Circular	813.5966	813.4903	812.9027	813.3169	811.8548
Non-Perforated	782.7495	791.9992	787.4329	787.5146	787.2344
Rectangular	805.9596	806.6728	806.7859	806.9838	807.1534

L.Prabhu[3].All the 3D models of the different fin configurations (circular, rectangular, square) are imported to ANSYS WORKBENCH 15.0 for meshing and steady state thermal analysis. ANSYS Mechanical is a Workbench application that can perform a variety of engineering simulations, including stress, thermal, vibration, thermoelectric, and magneto static simulations. A typical simulation consists of setting up the model and the loads applied to it, solving for the model's responses to the loads, then examining the details of the response with a variety of tools. The Mechanical application has "objects" arranged in a tree structure that guide you through the different steps of a simulation. By expanding the objects, you expose the details associated with the object, and you can use the corresponding tools and specification tables to perform that part of the simulation.

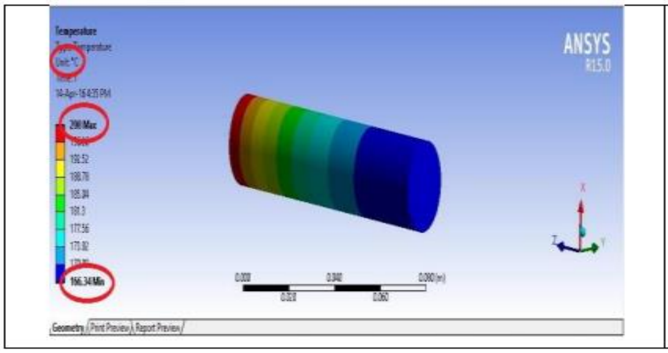


Fig 4.Steady State Thermal Analysis of Circular

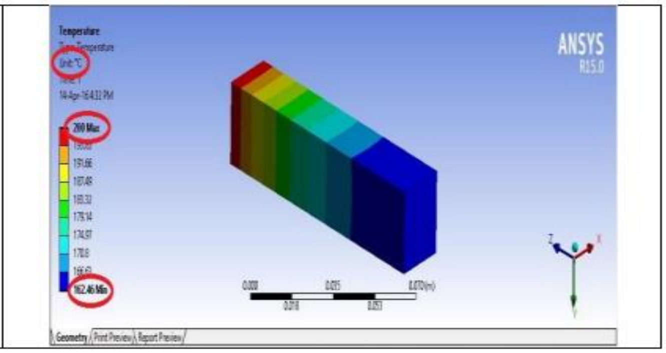


Fig 5. Steady State Thermal Analysis of Square

Table 3 Maximum and Minimum temperatures

FIN CONFIGURATION	MAXIMUM TEMPRATURE	MINIMUM TEMPRATURE
CIRCULAR	200	166.34
SQUARE	200	162.46
RECTANGULAR	200	155.62

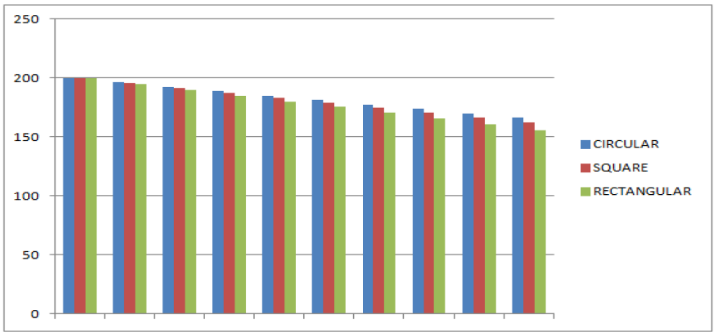


Fig 6: Graph showing temperature variations

M. Sabri Sidik[4]Total Heat Transfer Rate and Maximum Temperature. Fig. 8 shows bar graph of the total heat transfer rate and maximum temperature for all the three fin arrangement. It shows the lowest total heat transfer rate and the lowest maximum temperature achieved was the straight fin with value of 2056.91 W and 407.71 K. These results reflect due to the efficiency of the temperature distribution and the velocity fluid flow through this fin. The highest total heat transfer rate and highest maximum temperature is the transverse fin suggests that this fin has the lowest efficiency of cooling fin arrangement as shown in Fig 7.

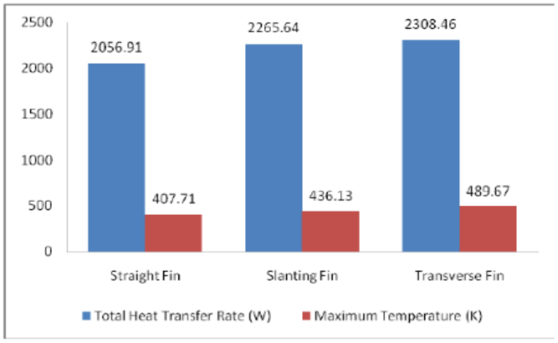
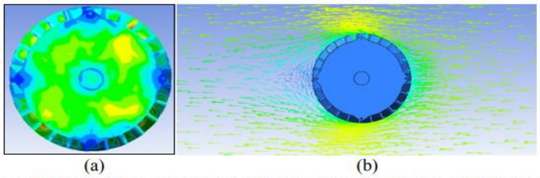
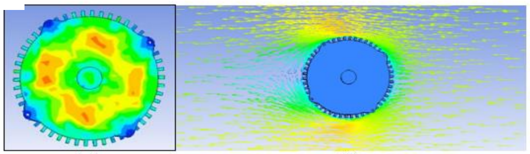


Figure 8: Total heat transfer rate and maximum temperature for the straight, slanting and tranverse fin arrangement



(a) (b)

: Slanting fin arrangement; (a) Temperature distribution, (b) Velocity vector



(a) (b)

Figure 7: Transverse fin arrangement; (a) Temperature distribution, (b) Velocity vector

Zan WU[5] The present study examined the extent of heat transfer enhancement from isolated isothermal perforated plates with staggered patterns, vertical parallel Isothermal perforated plates, and vertical Fig. 10 Vertical rectangular isothermal perforated fins on vertical surfaces s W H qh/qs Fig. 9 Ratio of heat transfer rate of high (a) and low (b) H/s ratios perforated to non-perforated vertical parallel plates with the same weight vs wall-to-wall spacing for different ratios of open area, t=0.002 rectangular isothermal perforated fins compared with their non-perforated counterparts with the same weight by using existing correlations, under natural convection conditions. Most of the correlations were adopted for calculating hs under different conditions. However, the qh/qs ratio is almost unaffected by the uncertainties of these correlations, because the hs value is also present in qh term and accounts for a large amount of qh. The qh/qs ratio has a similar level of uncertainty with Eq. (2) resulting from the term (1+0.75ε), the heat transfer augmentation ratio of the interrupted surface which should be experimentally and numerically investigated comprehensively in the future.

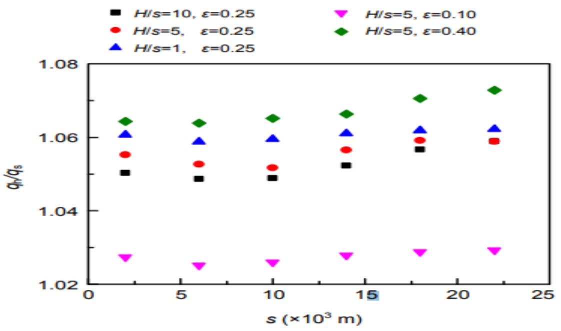


Fig 9. Ratio of heat transfer rate of perforated to non-perforated vertical rectangular isothermal fins with the same weight vs wall-to-wall spacing at various H/s and ratios of open area, t=0.002m

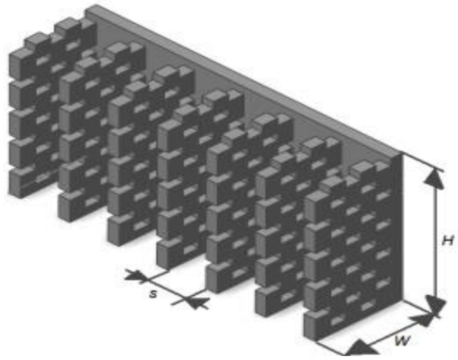


Fig 10. Vertical rectangular isothermal perforated fins on vertical surfaces.

Pardeep Singh[6]Heat transfer calculated by using the heat transfer governing differential equation for the fin of finite length and loses heat by convection ,

$$Q_{\mathrm{fin}} = \sqrt{hPkA_{cs}}(t_o - t_a)\left[\frac{\tanh[ml] + \frac{h}{km}}{\left(1 + \frac{h}{km}\tanh(ml)\right)}\right]$$

for which the given length of fin (l in m), thickness of fin (y in m), width of fin (b in m),thermal conductivity of fin (k in W/m °C), coefficient of convective heat transfer (h in W/m2 °C) , temperature at base of fin (to in °C),temperature of the ambient fluid (ta in °C). After the calculations of heat transfer rate of various fin geometry now it is the time to compare the increase in heat transfer rate for the given geometry of fin which is shown in Table-4. The fin without extensions having 21.7665 W heat transfer

TABLE-4
PERCENTAGE INCREASE IN HEAT TRANSFER FIN WITH EXTENSIONS

Type of extensions	Percentage increase in heat transfer fin with extensions					
	28 °C	26 °C	24 °C	22 °C	20 °C	18 °C
Rectangular	12.796	12.797	12.793	12.794	12.798	12.795
Trapezium	5.232	5.232	5.232	5.231	5.231	5.227
Triangular	3.139	3.137	3.134	3.139	3.137	3.135
Circular segmental	4.373	4.380	4.372	4.371	4.374	4.371

Table-5 shows that the effectiveness of fin with rectangular extensions, trapezium extensions, triangular extensions and circular segmental extensions.

TABLE-5
EFFECTIVENESS OF FIN WITH EXTENSIONS

Type of extensions	Effectiveness					
	28 °C	26 °C	24 °C	22 °C	20 °C	18 °C
Rectangular	5.846	5.846	5.846	5.846	5.846	5.846
Trapezium	5.656	5.656	5.656	5.656	5.656	5.655
Triangular	5.756	5.756	5.756	5.756	5.756	5.756
Circular segmental	5.408	5.408	5.408	5.408	5.408	5.408

III. CONCLUSION

By giving perforation to the fin will resulting the higher temperature different compared to the non-perforated fins that will affect the temperature distribution of the heat generated at the heat source along the fins. By giving perforation to the fins will increase the heat coefficient of the heat sink by 35.82–51.29% regarding to the perforation shape or geometry.Data collected from the experiment can be used for analysing the heat transfer coefficient and also the temperature distribution for each of the perforation shape or geometry conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.[2]

The use of fin (extended surface), provide efficient heat transfer. Heat transfer through fin of rectangular configuration is higher than that of other fin configurations. Temperature at the end of fin with rectangular configuration is minimum, as compare to fin with other types of configurations. The effectiveness of fin with rectangular configuration is greater than other configurations. Choosing the optimum size fin of rectangular configuration will reduce the cost for heat transfer process and also increase the rate of heat transfer.[3]

The heat transfer analysis on cooling fin arrangement of in-wheel electric motor housing has suggest the straight fin has the highest efficiency in temperature distribution and the lowest total heat transfer rate compare to the others fin arrangement. In future, the optimum fin size in term of height, width and spacing will be determined using the similar method of heat transfer analysis to get a better efficiency of heat dissipation and cooling of the motor.[4]

The perforated fins can enhance heat transfer the magnitude of heat transfer enhancement depends upon Angle of orientation, diameter of perforations and heater input. The optimum perforation diameter depends upon the Angle of inclination. The increase in the heat transfer coefficient was achieved with perforated fins of 12mm perforation diameter[5]

The use of fin (extended surface) with extensions, provide efficient heat transfer: Fin with extensions provide near about 5 % to 13% more enhancement of heat transfer as compare to fin without extensions.Heat transfer through fin with rectangular extensions higher than that of fin with other types of extensions. Temperature at the end of fin with rectangular extensions is minimum as compare to fin with other types of extensions. The effectiveness of fin with rectangular extensions is greater than other extensions. Choosing the minimum value of ambient fluid temperature provide the greater heat transfer rate enhancement. [6]

REFERENCES

[1]. Abhishek Mote-Analysis of Heat transfer through fins of an IC Engine using CFD- IRJET April 2016

[2].Thamir K. Ibrahim Experimental study on the effect of perforations shapes on vertical heated fins performance under forced convection heat transfer.IJHMT 2017

[3].L.Prabhu Design and analysis of different types of fin configurations using Ansys- IJPAM 2018

[4].M. Sabri, Heat Transfer Analysis of In-Wheel Electric Motor Housing with Different Cooling Fin Arrangement using ANSYS Research Gate October 2014

[5].Zan WU Modeling natural convection heat transfer from perforated plates,Feb 2012

[6].Pardeep Singh Design and Analysis for Heat Transfer through Fin with Extensions -IJIRSET May 2014