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A COMPARATIVE ANALYSIS AND PERFORMANCE OF FIN TO ENHANCE HEAT TRANSFER RATE AND COST EFFECTIVE OPERATIONS BY VARYING FIN GEOMETRY

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HIGHLIGHT

To analysis different fins profile

To investigate the heat transfer rate of various fins

To find out the effect of geometrical parameters of fins.

To perform Finite Element based heat transfer analysis on the fin structures

To calculate heat transfer parameters

ABSTRACT

In many engineering applications extended surfaces known as fins, are used to enhance convective heat transfer. The problem of natural convection heat transfer for perforated fins was investigated in this work. An experimental study was conducted to investigate the natural convection heat transfer in a rectangular fin plate with no perforations ,square perforations, triangular perforation and circular perforations. The investigation is conducted to compare heat transfer rate of different fins embedded with different types of perforations. Experimental results shows the temperatures distribution and heat transfer coefficient calculated using Ansys Workbench 19.2 and Furthermore, for different perforation , the heat transfer rate and the coefficient of heat transfer also varied giving better results. The work done on various types of fins, effect of perforation shape or geometry on the heat transfer was simulated in ANSYS to determine best type of fin to be used.The comparison between experimental result and software result between the types of fins perforation was analysed for the heat transfer coefficient to clarify the best perforation shape for the required application.The experimental was reported for temperature distributions when the heat supplied are respectively. The overall conclusion shows different perforations analysed and their results are tabulated.

Keywords – perforations, Ansys workbench, Temperature distribution, Natural convection etc.

INTRODUCTION

In the study of heat transfer, a fin is a surface that extends from an object to increase the rate of heat transfer to or from the environment by increasing convection.. Increasing the temperature difference between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Sometimes it is not economical or it is not feasible to change the first two options. Adding a fin to an object, however, increases the surface area and can sometimes be an economical solution to heat transfer problems. Typically fin material has highthermal conductivity and so they are made up of materials like copper, aluminum and iron. The fin isexposed to flowing fluid which cools or heats with high thermal conductivity allowing the heat being conducted from the wall through surface. Thus fins are used to enhance convective heat transfer in a wide range of engineering applications, and offer a practical means for achieving a large total heat transfer surface area without the use of an excessive amount of primary surface area. Fins are commonly appliedfor heat management in electrical appliances such as computer power supplies or substation transformers. Other applications include IC engine cooling, such as fins in a car radiator and compressors. Fins are alsoused in newer technology such as hydrogen fuel cells.

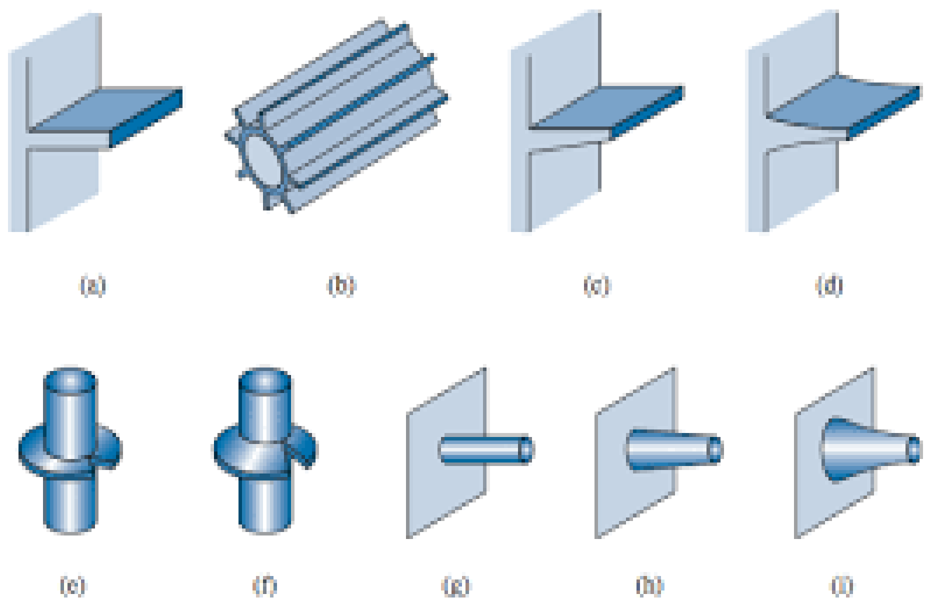
A fin for the circular, Square and rectangular surface that extends from a pin configuration to increase the rate of heat transfer from the environment by increasing convection. For this principle of Conduction, convection, radiation of a fin configuration determines the amount of heat and its transfers. Increasing the temperature difference between the fin configuration and the Depends on the environment, slightly increasing the convection heat transfer coefficient, or slightly increasing the surface area of the pin configuration of the object increases the heat transfer. Sometimes it is not economical or it is not feasible to change the first two options. Adding a fin configuration, however, increases the surface area of circular, square and Rectangular can sometimes be economical solution to heat transfer problems.

Extended surfaces that are well known as a fin are commonly used to enhance heat transfer in many applications. Therefore, various types of fins like rectangular plate fins, square pin-fins and circular pin-fins are commonly used for both natural and forced convection heat transfers. Extended surface heat transfer plays a very important role in heat exchangers involving a gas as one of the fluids. A heat exchanger is a device which is used to transfer thermal energy between two or more fluid, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact. Not only are heat exchangers often used in the process, power, petroleum, air-conditioning, refrigeration, cryogenic, heat recovery, alternative fuel, and manufacturing industries, they also serve as key components of many industrial products available in the market. The heat exchangers can be classified in several ways such as, according to the transfer process, number of fluids and heat transfer mechanism. Plate type extended surface heat exchangers have corrugated fins mostly of triangular or rectangular cross-sections sandwiched between the parallel plates. These are widely used in automobile, aerospace, cryogenic and chemical industries, electric power plants, propulsive power plants, systems with thermodynamic cycles i.e. heat pump, refrigeration etc. and in electronic, gas-liquefaction, air-conditioning, waste heat recovery systems etc. They are characterized by high effectiveness, compactness (high surface area density), low weight and moderate cost. The next category is Tube-Fin Heat Exchangers, These heat exchangers may further be classified as (a) conventional and (b) specialized tube-fin exchangers. Tube-fin exchangers are employed when one fluid stream is at a high pressure and or has a significantly higher heat transfer coefficient than that of the other fluid stream. In a conventional tube-fin heat exchanger, the transfer of heat takes place by conduction through the tube surface.

Various types of extended surfaces are commonly used to remove the heat from the engineering systems. Variety of fins like plate fins, circular pin-fins and square pin-fins are used for the purpose of removal of heat under both natural and forced convection mode. Heat transfer rate can be increased by increasing the fin surface area, increasing the velocity of fluid and using the good quality or better fluid. Practically increasing the area and usage of better fluid is not economical in many cases. Because increasing the area of fins leads increase in total weight of the system also usage of better fluid increase overall cost of the system. In many cases, increase of temperature difference between working fluid and fin surface, also increase of heat transfer coefficient on fin surfaces using better working fluids are not economical. In such situations using of fins are preferred.Pin-fin arrays are often used in heat exchanger systemto enhance the heat transfer rate. The performance ofmany engineering devices from power electronics togas turbines is limited by thermal management. Heatsinks with pin-fins are commonly used to augmentheat transfer as the pin-fins increase the surface areaand turbulence [1]. A pin fin is a cylinder or othershaped element attached perpendicular to a wall withthe transfer fluid passing in cross-flow over theelement. Pin fins having a height-to-diameter ratio,H/d, between 0.5 and 4 are accepted as short fins,whereas long pin fins have a pin height-to-diameterratio, H/d, exceeding 4 [7]. Many researchersinvestigate the performance parameters of pin-fin andcompared it with different profiles of the fins andsuggested that, pin-fin elements are best suited forenhancement of heat transfer. Also investigated heattransfer enhancement methods, forced convectiveheat transfer and friction factor for air flowing insiderectangular horizontal duct over a set of pin–finsunder uniform heat flux and studied the effects offlow and geometrical parameters on the heat transferand friction factors characteristics [1-15]. In existingstudies, all the parameters affecting the heat transferand friction factor have not been investigated; still there is some lack of knowledge of influencingparameters because it requires a large number ofexperiments. Therefore, the purpose of this study is toperform experiments on pin-fin system withadditional influencing parameters in combination ofexisting parameters which affects on the performance of pin fins and geometrical

Types of Fins There are following types of fin generally used

(1) Rectangular fin
(2) Triangular fin
(3) Pin fin
(4) Parabolic fin
(5) Cylindrical fin



GENERAL CASE

1. Steady state
2. Constant material properties (independent of temperature)
3. No internal heat generation
4. One-dimensional conduction
5. Uniform cross-sectional area
6. Uniform convection across the surface area

Fins are generally used to enhance the heat transfer from a given surface • Addition of fins can increase the heat transfer from the surface by several folds • In many engineering situation, means are often sought to improve heat dissipation from a surface to its surrounding • Whenever the available surface is found inadequate transfer the required quantity of heat with available temperature drop and convective heat transfer coefficient, extended surfaces or fins are used. • By increasing the surface area in contact with air or providing fins • By increasing the heat transfer coefficient the surface • By increasing the temperature difference between hot and cold bodies

. **WORKING PRINCIPLE** • In many engineering application, large quantities of heat have to be dissipated from small areas. • The fins increases the effective area of the surface thereby increasing the heat transfer by convection. • In other words, the shape of fins must be optimized such that the heat transfer density is maximized when the space and the materials used for the finned surfaces are constraints.

METHODS TO INCREASE HEAT TRANSFER RATE • By increasing the surface area in contact with air or providing fins. • By increasing the heat transfer coefficient for the surface. • By increasing the temp of the hot surface or by increasing the temperature difference between hot and cold bodies

TYPES BY DESIGN • The fins are designed and manufactured in many shapes and forms. • They manufactured in different geometries, depending upon the practical applications. • The ribs attached along the length of a tubes are called longitudinal fins. • The concentric annular disc around a tube are termed as circular or annular fins • Pin fins or spines are rods protrading from a surface.

Theory of Heat Transfer From Finned Surfaces:-

According to Newton's Law Of Cooling, the rate of heat transfer from a surface at a temperature T_s to the surrounding medium at T_∞ is given by Newton's law of cooling as,

$$Q_{conv}=hA(T_S-T_a)\text{..................................}(1)$$

Where

h = heat transfer coefficient

A = heat transfer surface area

T_S =surface temperature

T_a =ambient temperature

LITERATURE SURVEY

Literature survey has been done in order to study the research done by various researchers on the heattransfer analysis of heated plates by using fin .The few of the articles chosen for review work are stated below

.**Baskaya S, Sivrioglu M., and Ozek M. [1]** carried out parametric study of natural convection heat transferfrom the horizontal rectangular fin arrays. They investigated the effects of a wide range of geometricalparameters like fin spacing, fin height, fin length and temperature difference between fin and surroundings; to the heat transfer from horizontal fin arrays.

However, no clear conclusions were drawndue to the various parameters involved**. M.J. Sable, S. J. Jagtap, P.S.Patil, P. R. Baviskar, and S.B.Barve[2]** investigated heat transfer enhancing technique for natural convection adjacent to a vertical heatedplate with a multiple V- type partition plates (fins) in ambient air surrounding. They concluded that ascompared to conventional vertical fins, the V-type partition plates work not only as extended surface butalso as flow turbulator.

The work by **R.S.Prasolov , Heya, Fujii , Bhavnani and Bergles [3]** suggest thatthe roughness elements whose height is less than the boundary layer thickness will have no appreciableinfluence on the heat transfer of natural convection and these elements will work as flow retarder rather than the heat transfer promoter.

Misumi and Kitamura [4] have reported an experimental work on enhancement of natural convection heat transfer from vertical plate having a horizontal partition plateand V-plates in the water ambience.

An extensive review and discussion of work done on the convective heat transfer in electronic equipment cooling was presented **by Incropera [5**], summarizing various convection cooling options..

Jones and Smith [6] studied the variations of the local heat transfer coefficient for isothermal vertical fin arrays on a horizontal base over a wide range of fin spacing. For awide range of temperatures

Rammohan and Venkateshan [7] made an interferometric study of heattransfer by free convection and radiation from a horizontal fin array.

Correlations useful for the rmaldesign were presented **.S.S.Sane, N.K.Sane,** and **G.V. Parishwad [8]** established a match between the experimental results and the results obtained by using CFD software for a horizontal rectangular notched fin arrays dissipating heat by natural convection. Both the flow patterns as well as the trend of heat transfer coefficient are found to be within 5% range

.Kharche and Farkade ,[9] used fin with notch andwith-out notch of copper as a fin material on vertical heated plate for the experimental work.

B. Ramdas Pradip et. al. [10] studied many industries are utilizing thermal systems wherein overheating can damage the system components and which may lead to failure of the system. To overcome this problem, thermal systems with heat exchanger effective emitters such as ribs, fins, baffles etc. are desirable. The need to increase the thermal performance of the systems, there by affecting energy, material and cost savings has led to development and use of many techniques known as “Heat transfer Augmentation”. This technique is additionally termed as “Heat transfer Enhancement”. Augmentation techniques increase the convective heat transfer by reducing the thermal resistance in a heat exchanger. Many heat augmentation techniques has been reviewed, these are (a) surface roughness, (b) plate baffles and wave baffles, (c) perforated baffles, (d) inclined baffles, (e) porous baffles, (f) channel, Crossed Ribs and Grooves. Most of these techniques are based on the baffle arrangement. The Heat transfer enhancement techniques lead to increase in heat transfer coefficient but at the cost of increase in pressure drop.

Compared the effect of heat transfer coefficient for notch and without notch fins. From the experimental study it was found that the heat transfer rate in notched fins was more than the unnotched fins..**Matthew Christensen [11]** does his investigation on the Static Heat Transfer analysis of Fins,

Pardeep Singh, Harvinder lal, Baljit Singh Ubhi et al (2014).[12] In this paper, the heat transfer performance and effectiveness of fin is analyzed 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 with various extensions and without extensions is compared. The ranging 5% to 12% increase in heat transfer can be achieved with these various extensions on fin as compare to same geometry of fin without these extensions.

Kumbhar D.G, Dr. N.K. Sane, Chavan S. T., et al (2009) [13] in this paper, the effect of triangular perforations on rectangular fin is investigates the comparison of perforated fin with solid fin for temperature distribution along the fin and heat transfer rate. The analysis is done using software ANSYS and also by experimentation. The investigation observed that heat transfer rate increases with perforations as compared to fins of similar dimensions without perforations.

Umesh Vandeorao Awasarmol et. al (2010).[14] Researcher the first engine blocks were taken for experimentation work. Modifying the solid rectangular fins as permeable fins by drilling three holes per fins inline in one half of the length of the fin of a cylinder block. The investigation observed heat transfer rates, heat transfer coefficients and percentage saving of material for solid and permeable fins are compared. The experiment shows that heat transfer rate improves with the use of permeable fins. The base temperatures profiles of solid fins are more elevated as compared to permeable fins and the tip temperatures of solid fins are more elevated as compared to permeable fins. It means that for the same heat flux the cylinder with permeable fins runs cool which shows that heat transfer rate is more in permeable fins as compared to solid fins. Also there is a net increase in heat transfer rate with permeable fins as compared to that of the cylinder block with solid fins.

N. Nagarani et al. [2012] [15] The study of this paper presents numerical and experimental comparative study of elliptical and circular fins which are made up of same kind of metal with same surface area and fed with constant heat inputs under free convection. The numerical result show a lot of distribution of isotherms and elevated rate of temperature distribution on the axis of elliptical fin than those of circular fin. In this research work, the heat transfer of elliptical and circular fins which are made up of same kind of metal with same surface area has been analyzed experimentally by feeding constant heat inputs below free convection. In elliptical fin, the surface temperature goes on decreasing gradually and continuously. The experimental results show that the performances of elliptical fins are better in respect of isotherms, temperature distribution, formed tube potency and effectiveness when put next to those of circular fins

V List of Abbreviations

l =length of fin (m)

w =width of fin (m)

t =thickness of fin (m)

d =Diameter of circular fin (m)

q =Heat Flux (w/m^2)

h =Convective heat transfer coefficient (W/m^2K)

μ =Poisson's ratio

τ =shear stress (N/m^2)

E =young's modulas (N/m^2)

ρ =Density of material (kg/m^3)

Q_{conv} =Heat transfer by convection (W)

A =area of convective surface (m^2)

η_f =fin efficiency

θ_b =temperature difference (degreeC)

θ_f =fin effectiveness

VI Availability of data and materials

In this section we have to show the availability of data and which type of material we are used.

(A) ***Material selection-***

The material which is selected for fabrication of fins plates is aluminum (6061) .It is an hardened aluminum alloy ,containing magnesium and silicon as its major alloying elements.It is used commonly for manufacturing fins materials.

(B) In this paper we have used different types of fins profile .we have used specific shape and size of different types of fins.

VII. METHODOLOGY

1) *Material selection*

- The material which is selected for fabrication of fins plates is aluminum (6061) .It is an hardened aluminum alloy ,containing magnesium and silicon as its major alloying elements.It is used commonly for manufacturing fins materials.

2) *Machine tool used*

- We have used different types of machine tools such as Hand cutting machine to cut aluminum plate into required size
- Then we have used drilling machine to drill holes of 8.5mm/9.5mm/10mm on the plate.
- Then we used hand Grinding machine to polish the surface of the material.

3) *Design*

We have Designed 4 types of plates which are

- **Non perforated plate**:-The cross sectional area of fin is (100 x 55mm).
- **square perforated plate**:-The cross sectional area of fin is (100 x 55mm).There are 10 square holes is drilled at the surface of the plate with equidistance(45mm) between two holes vertical and the horizontal distance. And the bottom space is left for the heater arrangement.

circular perforated plate:-The cross sectional area of fin is (100x 55mm).There are 10 circle holes is drilled at the surface of the plate with equidistance(45mm) between two holes vertical and the horizontal distance

- **Triangular perforated plate**:-The cross sectional area of fin is (100x 55mm).There is 10 Triangular hole is drilled at the surface of the plate with equidistance vertical and the horizontal distance. we have design the fin plates model by CATIA V5 R21

4) *Analysis*

- we have analyze on cases of fins in ansys software .we had got different results through which we get which one has better heat coefficient rate.

VI. FEM OF A HEAT SINK

In the present work, the software ANSYS 15.0 has been used to model and simulate Heat transfer and CFD analysis of heat sink with different perforations in the fins.

A. Preparation of the Design model

The design s of heat Sink with perforated fins is done in CATIA V5 R21 in STEP format. The 3D

Model are shown in Figures respectively.

A flat platform of 100 X 100 X 5 mm is common in all designs. Fin height for all models is 50 mm. There are a total number 10 fins in line arrangement with fin spacing of 10 mm between them. And thickness of each fin is 3mm.

- Non perforated plate:-The cross sectional area of fin is (100 x 50mm).

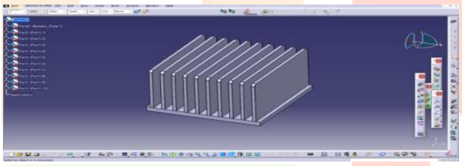


Fig 2. Non perforated plate.

- square perforated plate:-The cross sectional area of fin is (100 x 50mm).

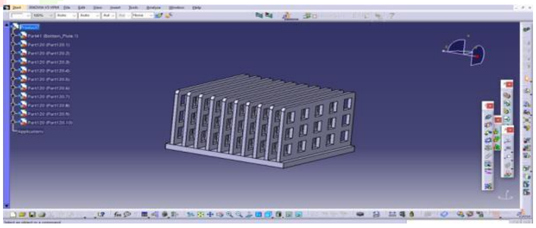


Fig 3. Square perforated plate

- circular perforated plate:-The cross sectional area of fin is (100 x 50mm).

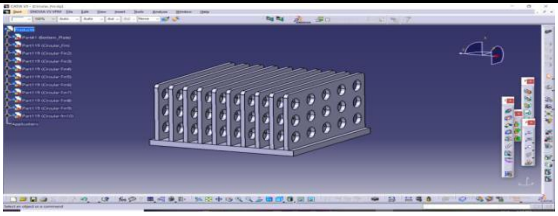


Fig 4. Circular perforated plate

• Triangular perforated plate:-The cross sectional area of fin is (100 x 50mm)

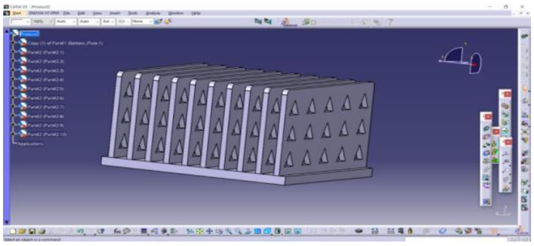


Fig 5. Triangular perforated plate

B. Geometry

The detailed specifications of the heat sink design are shown in the below table 3.1. The material properties for modeling of the heat sink with perforated fin are shown in the Table and properties of air are tabulated

- Material: Aluminum
- Material Properties required for Analysis
  - **Density:** 2.7 g/cc
  - **Young Modulus** : 68.3 GPa
  - **Poisson's Ratio**: 0.3
  - **Shear Modulus**: 30 GPa

	A	B	C
1	Property	Value	Unit
2	Density	2770	kg m^-3
3	Isotropic Secant Coefficient of Thermal Expansion		
4	Coefficient of Thermal Expansion	2.3E-05	C^-1
5	Isotropic Elasticity		
6	Derive from	Young's Modulus and Poisson's Ratio	
7	Young's Modulus	7.1E+10	Pa
8	Poisson's Ratio	0.33	
9	Bulk Modulus	6.9608E+10	Pa
10	Shear Modulus	2.6692E+10	Pa
11	S-N Curve	Tabular	
15	Tensile Yield Strength	2.8E+08	Pa
16	Compressive Yield Strength	2.8E+08	Pa
17	Tensile Ultimate Strength	3.1E+08	Pa
18	Compressive Ultimate Strength	0	Pa
19	Isotropic Thermal Conductivity	Tabular	
20	Scale	1	
21	Offset	0	W m^-1 C^-1
22	Specific Heat, C_p	875	J kg^-1 C^-1
23	Isotropic Relative Permeability	1	
24	Isotropic Resistivity	Tabular	

Fig 6. Material properties for analysis

*C. **Mesh Generation & Simulation***

The heat sink model is imported in to the work bench design modeler and meshed with a four node three dimensional tetrahedron element SOLID72the meshed model of the heat sink is as shown in the below figure-3.4 and the mechanical APDL (ANSYS Parametric Design Language) solver is used to mesh the heat sink.

- Meshing Properties
  - Type of Element: **Tetrahedrons**
  - Minimum Element Size**: 3mm**
  - Software Used: **Ansys**

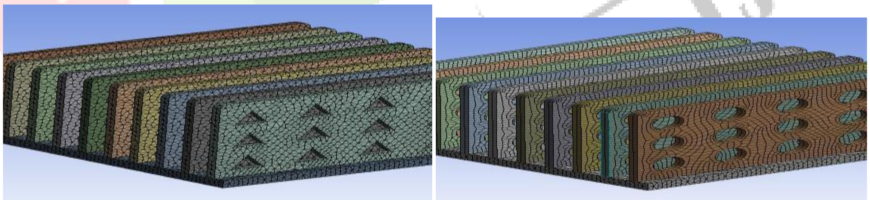


Fig 7. Mesh generation

***D. Finite Element Model – Thermal Boundary Conditions*• Analysis Settings**

- **Temperature Load of 450 degrees Celsius.**

- Convective Boundary condition of 5 W/m^2 heat transfer coefficient.

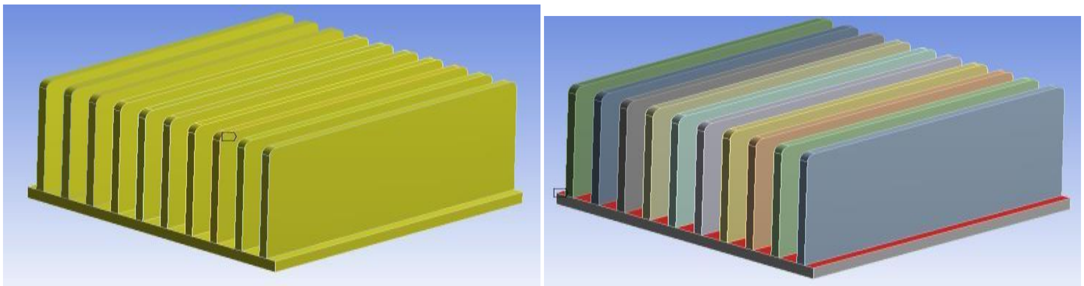


Fig 8. Finite element model

VII. RESULT AND DISCUSSION

1) Normal Fin

- Results – Temperature Gradient – Normal Fin

The temperature gradient is observed to be between 251 degrees and 450 degrees Celsius.

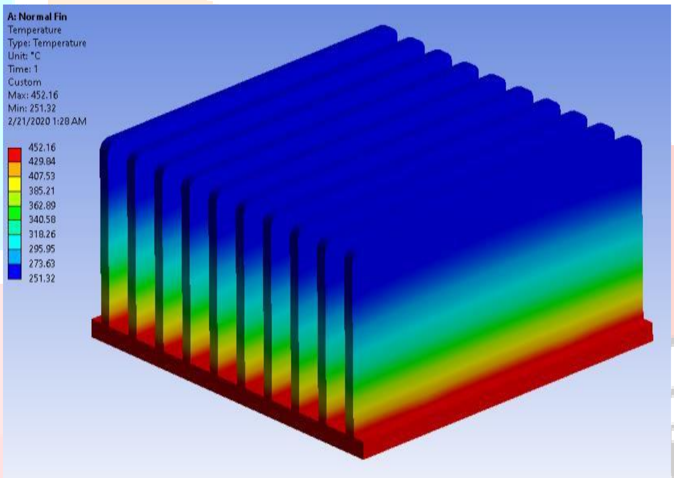


Fig 9. Temperature gradient of normal fin

- Results – Heat Flux Dissipation – Normal Fin

The heat flux dissipation through the structure is observed to be 1.34 W/mm^2.

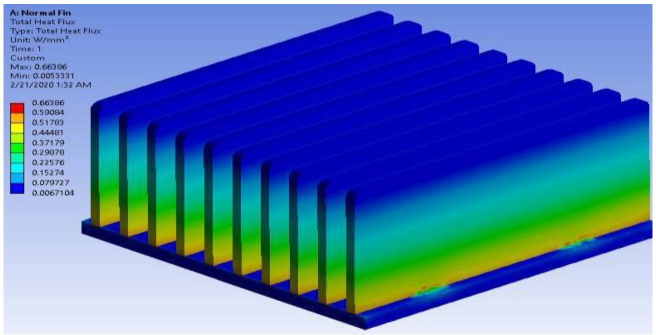


Fig 10. Heat flux dissipation of normal fin

2) Circular Fin

- Results – Temperature Gradient – Circular Fin

The temperature gradient is observed to be between 327.06 degrees and 450 degrees Celsius.

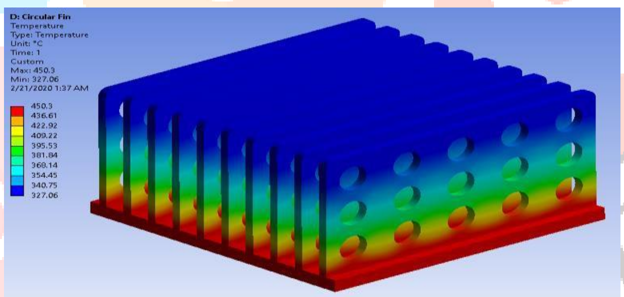


Fig 11. Temperature gradient of circular perforated fin

- Results **– Heat Flux Dissipation – Circular Fin**

The heat flux dissipation through the structure is observed to be 1.14 W/mm^2.

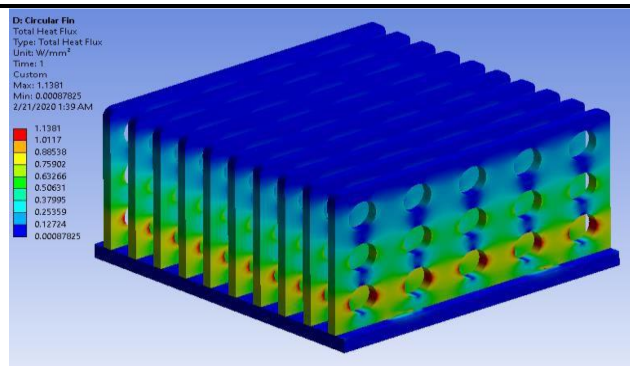


Fig 13. Heat flux dissipation of circular perforated fin

3) Square Fin

- Results – Temperature Gradient – Square Fin

The temperature gradient is observed to be between 315.01 degrees and 450 degrees Celsius.

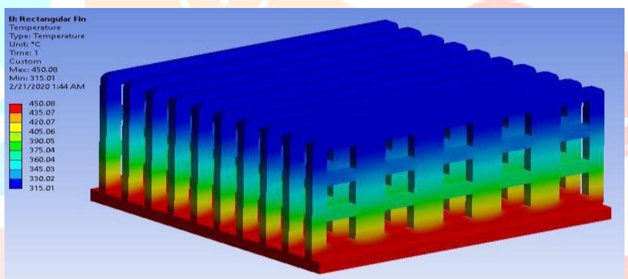


Fig 14. Temperature gradient of square perforated fin

- Results – Heat Flux Dissipation – Square Fin

The heat flux dissipation through the structure is observed to be 1.34 W/mm^2

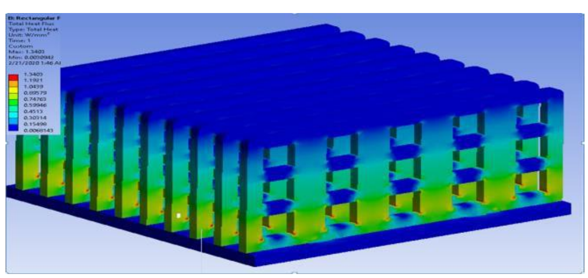


Fig 15. Heat flux dissipation of square perforated fin

4) *4. **Triangular Fin***

- Results – Temperature Gradient – Triangular Fin

The temperature gradient is observed to be between 328.5 degrees and 450 degrees Celsius.

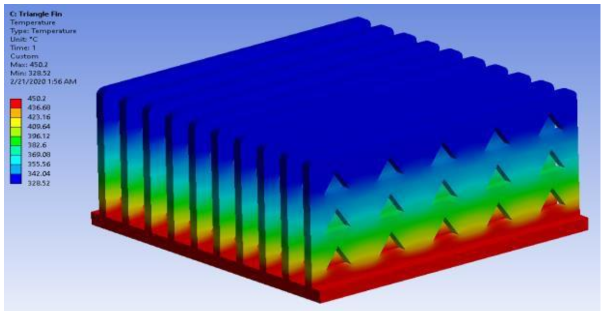


Fig 16. Temperature gradient of triangular perforated fin

- Results – Heat Flux Dissipation – Triangular Fin

The heat flux dissipation through the structure is observed to be 1.68 W/mm^2.

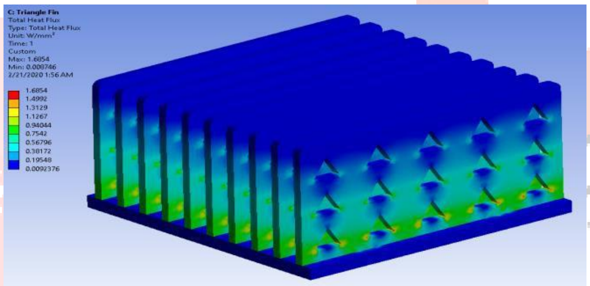


Fig 17. Heat flux dissipation of triangular perforated fin

VIII. ADVANTAGE

- without intermediate impedance, thermal conductivity is good because the cutting tooth density is big, so the unit volume heat dissipation area is bigger.
- Standard in size, and can be put into mass production.
- Light in weight.
- Solder able
- Customize relative easy in vary of shapes

IX. DISADVANTAGES

- more bad rate, and low production efficiency
- the distance between FINS is smaller and the flow resistance is relatively larger
- Negative in cooling, if not accompany installed DC Fan.
- Tooling and tooling fee, it's hard to satisfy small quantity order

X. APPLICATIONS

- Economizers of steam power plants
- Heat exchangers of a wide variety, used in different industries
- cooling of electric motors, transformers
- Cooling of electronic equipments, chips,I.C boards etc.
- Radiators for automobiles
- Air-cooling of cylinder heads of Internal
- Combustion engines (e.g. scooters, motor cycles, aircraft engines etc.), air compressors

XI. COMPARISON

- The overall heat flux is generated more in triangular cross section fins. Hence, it is expected to be dissipating more heat from the surface.
- Hence, the best case scenario for the design of fins are either the triangular or rectangular cut-outs and the least case scenario is the solid normal fins
- 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.

XII. CONCLUSION

The presence of perforation and especially many perforations cause an increase in heat transfer area and also temperature difference dropped more between fin base and fin tip. The larger value of surface area and smaller temperature difference between fin and ambient air have not increased heat transfer considerably. The perforation holes act like cavities and the flow is confined inside the perforations. The use of perforated fins causes reduction of fin's weight significantly. reduction of weight due to use of new perforations. Certainly reduction of weight leads to saving material in manufacturing fins as well as lighter assembly. This explains cost and energy benefit of utilization of the new perforated fins. However the increase of heat transfer by use of these kinds of perforated fins in comparison with solid fin is not considerable

XIII Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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XV Authors contribution

In this work authors collect all the information releted to fins which are used in different areas and research work .apart from this author also study latest work on fins which is very useful for our work .

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