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Design, Thermal Analysis and Optimization of Fins by Modifying Geometry – A Review

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Abstract

The main Aim of this paper is to study different papers related to fins geometry and try to find out what changes can be made to increase heat transfer rate. In this paper we are going to study different factor which can be used to increase rate of heat transfer. When surface area increases, fluid contact also increases which result in increase in heat transfer. Fins are Extended Surfaces from a hot surface into surrounding fluid and they are used for increasing heat transfer rate. A fin is a kind of heat exchanger which transfers heat to surrounding fluid. Damage to the devices occur when fins are not sufficient to cool the device.

By increasing different parameters Heat transfer rate can be increased, they are:

1. Surface Area of the Object.
2. Convection Heat Transfer Coefficient.

Surface area of the fin can be easy increased by changing fins geometry and increasing convection heat transfer coefficient is quite costly. The aim of this paper is to study papers to increase heat transfer rate of fin which can be achieved by modifying geometry of the fin.

Keywords: *Heat Transfer Rate; Fins Geometry; Material; Efficiency; Effectiveness.*

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1. Introduction

FINS: Fins are Extended Surfaces from a hot surface into surrounding fluid and they are used for increasing heat transfer rate. A fin is a kind of heat exchanger which transfer heat to surrounding fluid. Damage to the devices occur when fins are not sufficient to cool the device.

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Application of Fins: Fins are used in:

- Air Cooled IC Engine.
- Automobile Radiator.
- Reciprocating Air Compressors.
- Electric Devices.
- Refrigerator and A/C condenser units.
- Economiser for stream power plant.
- Electric Motors and Transformers.
- Dry – Type cooling towers.

Types of Fins:

1. Longitudinal fin.
    i. Constant area straight fin
    ii. Variable area straight fin.
2. Pin fin.
3. Radial fin.

Function of Fins: To increase rate of heat transfer is the main function of fins.

Fin Efficiency: It is defined as the ratio of actual heat transfer rate taking place through the fin to maximum possible heat transfer rate that can occur through the fin.

$$\eta_{fin} = \frac{Q_{actual}}{Q_{maximum\ possible}}$$

Fin Effectiveness: Fin Effectiveness is defined as the ratio of heat transfer rate with fin to heat transfer rate without fin.

$$\epsilon_{fin} = \frac{Q_{with\ fin}}{Q_{without\ fin}}$$

Advantages of Fins:

- To increase Heat transfer rate, it is the cheapest way.
- No need of Maintenance.

Disadvantages of Fins:

- Fins may increase weight of the engine.
- Bending of fins may occur if we increase length of the fins.

2. Literature Review

Mayank Jain, Mahendra Sankhala, Kanhaiya Patidar and Lokesh Aurangabadkar [1] studied Optimization of fins by variation in geometry. They use Aluminium Alloy 6061 for base of fins and fins material. They Analysis five fins with different geometry or shape like rectangular fin, rectangular with rectangular extension, rectangular with trapezoidal extension, circular fin and triangular fin. First they get temperature drop by analysis for rectangular fin. They give the base temperature of rectangular fin with three temperatures separately at 60˚C, 80˚C and 100˚C and then they analysis other fins by giving base temperature at 100℃. They did analysis for different geometry and conclude that triangular fin is better then others since heat transfer rate and temperature drop is more in triangular fin as compare to other fins. Fins for Amplifier of a sound system are analyzed in this paper.

R. Sudheer Kumar Reddy, Dr. K. Govinda Rajulu, Dr. S.M. Jameel Basha, E. Vijay Gowd, P. Veera Prathap and C.N. Vishnu Vandhan.A [2] studied pin fin with different shapes. First in terms of temperature distribution they find best material of fin, to find best material they compare Copper, Aluminium, Brass and Stainless Steel. They get copper in highest sink performance but due to lower cost and lower weight they choose Aluminium heat sink. Then four Aluminium pin fins are analyzed, four pin fins are pure solid, Solid with perpendicular holes, Solid with perpendicular holes and through whole of one by third length and Solid with perpendicular holes and through whole of one by two length. Solid with perpendicular holes and axial hole of one by two length transfer more heat as compare to others is the result they get after the thermal analysis of this four pin fins.

Pradeep Singh, Harvinder Lal and Baljit Singh Ubhi [3] made paper on heat transfer through fin with extensions and said that 5% to 13% of heat transfer is get increased by using fin extensions on fins. They did analysis for four extensions in rectangular fins, extension provided on rectangular fin are rectangular, triangular, trapezium and circular segmental extension. AutoCAD software is used for design of the fins and simulation software is used for analysis. They said that Heat transfer with rectangular extension and effectiveness of rectangular extension fins are more as compare to other extensions.

Mr. Vibhav Sawant, Mr. Suprabhat Mohod, Archana Gaikwad and Parth Shah [4] studied review paper on Optimization of fins by modifying geometry and material used for production. After studying three papers they conclude that heat transfer rate can be increased by modifying geometry of fins.

Ramesh Kumar A. and Nanda Kumar S [5] studied heat transfer analysis of engine cylinder fin by varying extension geometry and motorcycle TVS 50 engine cylinder is chosen to find out temperature at various conditions.

For design they use Solid Works software and for analysis they used ANSYS software. They also compared four extensions of fins on their paper, they are rectangular, triangular, circular and trapezium extension. They conclude that fin with extensions, provide both effective and efficient heat transfer and after analysis of fins they said that fin with rectangular extension provide higher heat transfer and greater effectiveness as compare to others extensions.

L. Prabhu, M. Ganesh Kumar, Prasanth M and Parthasarathy M [6] did paper on different types of fin configurations and analysis it in ANSYS. On their paper they compared circular, square and rectangular fins. Volume of all three fins are kept constant. Steady state thermal analysis is done on fins they get fin of rectangular configuration transfer more heat as compare to others fin configuration.

S. Mayakannan, V. Jeevabharathi, D. Suresh Kumar and N. Ashok Kumar [7] did analysis on engine fins with several different shapes with material optimization heat removal method. In this paper they compared Cylinder with concave shape, square shape, triangular shape, convex shape, half circular and trapezoidal shape fins and that fins are made up of four different material AL6061, AL200, CE17 and CE17M. They conclude that AL200 produce the better thermal behavior and Concave is the best cross section for the fin.

Deepak Tekhre and Jagdeesh Saini [8] they made holes on IC engine fins of different size and number. Two different material are used to make that IC engine. Aluminium 6063 and Aluminium Nitride are two materials they used. Steady state and transient state are used to do analysis. Then four models of IC engine with each material were made with no hole, 2mm hole, 6mm hole and 10mm hole. ANSYS software is used for analysis. After completion of the analysis they conclude that heat transfer get increased on increasing diameter of hole and Aluminium Nitride is a better option as compare to Aluminium Alloy 6063. Fin with holes diameter 10 mm show the best result in this paper.

Thammala Praveen and Dr. P. Sampath Rao [9] studied thermal properties by varying Geometry, Material and Thickness of Cylinder Fins. Cylinder fin body for a 150cc motorcycle is used in this paper. Pro/Engineering and ANSYS are the software used in this paper. Four different materials are used to make fins like Aluminium Alloy 7075, Aluminium Alloy 204, Magnesium and Beryllium. Rectangular and Circular shapes are used to make fins with the material mentioned above. Thermal flux is more for Beryllium and heat transfer rate can be improve by modifying the shape of the fins is the result they found.

Siyaram Shah and Rohit Soni [10] studied CFD Transient Thermal Analysis of Cylinder fins by using different materials like Aluminium Alloy, Aluminium Alloy 6061 and Al metal matrix composition alloys (Al-MMC). ANSYS software is used for analysis. Temperature, directional heat flux and total heat flux analysis is done for these three materials and they come conclusion that the fin which is made up of Aluminium Alloy 6061 transfer more heat and attain maximum heat flux as compare to other materials they used in this paper.

N. Srinivasa Rao, G.V. Subhash, K. Ashok Kumar and B.N. Malleswara Rao [11] study and design the effectiveness of engine cylinder fins with variable geometry and material. Cylinder fins are made up of three materials in this paper Aluminium Alloy 6063, Aluminium Alloy 204 and Aluminium Alloy 7068. Different shapes body fins are made up of this materials. Different shapes used for fin body are trapezoidal fin body, rectangular fin body and circular fin body. AutoCAD 2016 is used to make design. And in ANSYS software Thermal Analysis is done and after analysis they make a conclusion that Aluminium Alloy 6063 of circular geometry is most effective in terms of heat transfer and effectiveness.

3. Scope of Work

- There is no paper which compare many shapes together and find best shape of fins so it is important to compare as many shapes we can to find which shape will give maximum heat transfer rate.
- In Some papers best shape of fins is found for electronic devices and according to their working condition so it is important to find best shape of fins according to IC Engine.
- In some paper's analysis are performed irrelevant to actual conditions so we want to find best fins according to real life conditions.
- In Engine Cylinder space between the fins can be modified so that we can obtain different heat transfer rate, which will also affect no. of fins in cylinder.
- Heat transfer rate of fins can be increased by increasing fins surface area by introducing holes on it.

4. Conclusion

- We should compare as many shapes of fins as possible according to real life situation or condition of IC Engine because in research papers only four five fins are compared together. So there are many Shapes which can be analyze.
- More Comparisons can be done by introducing hole on fins which will increase rate of heat transfer and tell us that holes are efficient to introduce on fins or not.
- Analysis can be done according to working conditions of IC Engine Fins.
- Modifications in fins gap can be made to change heat transfer rate.
- Comparison of different shape of fins can be done in terms of effectiveness, efficiency, total heat flux and heat transfer rate.

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