Fem Analysis of Fins with Varying Shapes and Material for Their Thermal Behaviour and Applications: A Literature Review

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Abstract— 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. Extensions on the finned surfaces is used to increases the surface area of the fin in contact with the fluid flowing around it. In the study of heat transfer, fins are surfaces that extend from an object to increase the rate of heat transfer to or from the environment by increasing convection. 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. Sometimes it is not feasible or economical to change the first two options. Thus, adding a fin to an object, increases the surface area and can sometimes be an economical solution to heat transfer problems.
There are two ways to increase the rate of heat transfer:
1) To increase the convection heat transfer coefficient h.
2) To increase the surface area A_s.

It is noted that: Increasing h may require the installation of a pump or fan, or replacing the existing one with a large one. The alternative is to increase the surface area by attaching to the surface extended surfaces called fins made of highly conductive material such as aluminium.

Key words: Fins, Shapes and Material

I. INTRODUCTION

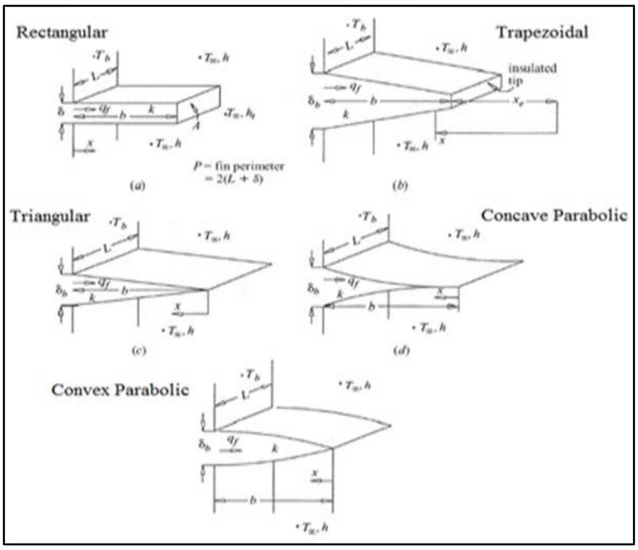

Fig. 1: Various Longitudinal Fins

A. The two main requirements of an efficient cooling system are:

1) It must be capable of removing only about 30% of the heat generated in the combustion chamber. Too much removal of heat lowers the thermal efficiency of the engine.
2) It should remove heat at a fast rate when the engine is hot. During the starting of the engine, the cooling should be very slow so that the different working parts reach their operating temperatures in a short time.

Fin performance is assessed by two factors [11]: Fin Effectiveness, ε_f, and the Fin Efficiency, η_f. Fin effectiveness is defined as the ratio of the fin heat transfer rate to the heat transfer rate that would exist without the fin.

$$\varepsilon_f = \frac{q_f}{hA_c\theta_b}$$

Fin efficiency is defined as the ratio of the actual amount of heat transferred to the amount of heat that would be transferred if the entire fin was at the base temperature.

$$\eta_f = \frac{q_f}{hA_f\theta_b}$$

Fins are the most effective instrument for increasing the rate of heat transfer. As we know, they increase the area of heat transfer and cause an increase in the transferred heat amount. Based upon the cross sectional area type, straight fins are of different types such as rectangular fin, triangular fin, trapezoidal fin parabolic fin or cylindrical fin. Fin performance can be measured by using the effectiveness of fin, thermal resistance and efficiency. Triangular fins have applications on cylinders of air cooled cylinders and compressors, outer space radiators and air conditioned systems in space craft.

The shape of triangular and rectangular fins around the cylinder are shown in figure 2. As the heat developed inside a two stroke engine cylinder is more, the heat has to be dissipated to surroundings by fins. These fins fitted are having an appropriate surface area to take away the heat to surroundings.

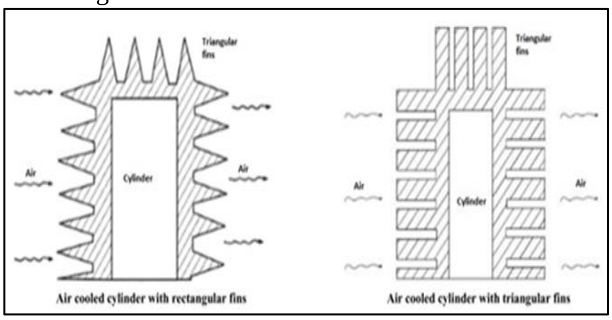

Fig. 2: Triangular and Rectangular fins around the cylinder

Discussed for ordinary fins problem, the thermal conductivity assumes to be constant, but when temperature difference between the tip and base of the fin is large, the effect of the temperature on thermal conductivity must be considered. Also, it is very realistic that to consider the heat generation in the fin (due to electric current or etc.) as a

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function of temperature. The problem is solved for two main cases.In the first case, heat generation is assumed variable by fin temperature and in these condcase, boththermal conductivity and heat generation vary with temperature. Results are presented for the temperature distribution for arange of values of parameters appeared in the mathematical formulation (e.g. N, εG, and G). Results reveal that DTM is very effective and convenient. Also, it is found that this method can achieve more suitable results compared to numerical methods.

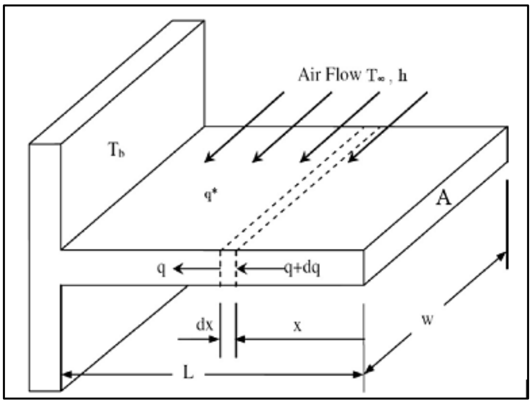

Fig. 3: Considered fin geometry with the heat generation source

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Many engineering devices generate heat during their operation. If this generated heat is not dissipated rapidly to its surrounding atmosphere, this may cause rise in temperature of the system components. This cause overheating problems in device and may lead to the failure of component. To avoid overheating, and the consequent ill effects, the heat transferred to an engine component (after a certain level) must be removed as quickly as possible and be conveyed to the atmosphere. It will be proper to say the cooling system as a temperature regulation system. It should be remembered that abstraction of heat from the working medium by way of cooling the engine components is a direct thermodynamic loss.

It is very important to predict the magnitude of heat transfer in designing engine, hence it is the objective in this analysis to study the dissipation of heat as well as temp distribution on the cylinder for the engine model. Fins must be designed to achieve maximum heat removal with minimum material expenditure, taking into account, however, the ease of manufacturing of the fin shape. Large number of studies has been conducted on optimizing fin shapes.

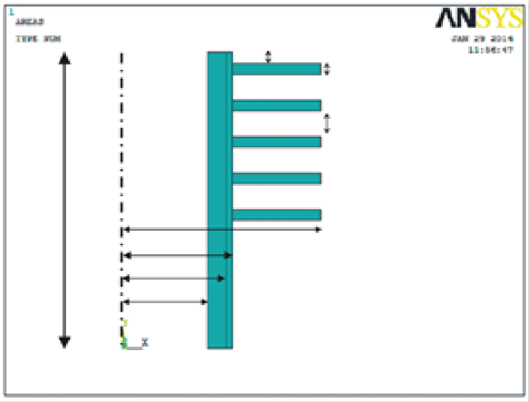

Fig 4: Cylinder and Fin Model Considered for Analysis (5)

Paper introduced shape modifications by cutting some material from fins to make cavities, holes, slots, grooves, or channels through the fin body to increase the heat transfer area and/or the heat transfer coefficient Raaid. [8] Fins or extended surfaces are known for enhancing the heat transfer in a system. Liquid-cooling system enhances better heat transfer than air-cooling system, the construction of air cooling system is very simpler. Therefore it is imperative for an air-cooled engine to make use of the fins effectively to obtain uniform temperature in the cylinder periphery.

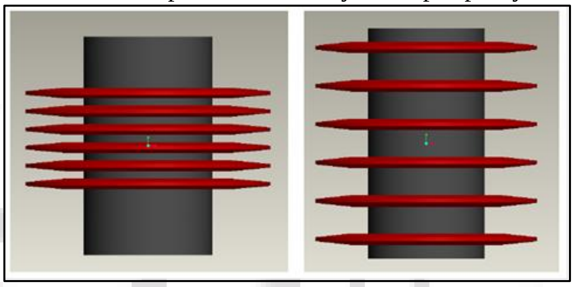

Fig 5: Assembly of the fins (6nos) with a pitch of 10mm and 20mm respectively along with the cylinder (8)

[9]The major heat transfer takes by two modes that is by conduction or by convection. Heat transfer through fin to the surface of the fin takes place through conduction where as from surface of the fin to the surroundings, it takes place by convection. Further heat transfer may be by natural convection or by forced convection.

Paper used the least squares method for predicting the performance of a longitudinal fin with temperature-dependent internal heat generation and thermal conductivity and they compared their results by Homotopy Perturbation Method (HPM), Variational Iteration Method (VIM) and double series regular perturbation method and found that the least squares method is simpler than other applied methods. [12] Fins are widely used in many industrial applications such as air conditioning, refrigeration, automobile, chemical processing equipment and electrical chips. Although there are various types of the fins, but the rectangular fin is widely used among them, probably, due to simplicity of its design and its easy manufacturing process. [13]Paper considered circular fins with an arbitrary heat source distribution and a nonlinear temperature-dependent thermal conductivity and obtained the results for the optimum fin design. [14] Research conducted an analytical study of a rectangular and longitudinal fin with temperature dependent internal heat generation and temperature-dependent heat transfer coefficient.

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II. Discussion and Conclusion

Traditionally concept of fin is applied using rectangular fins only. With the time and development of technologies it is seen in literature that various shapes and materials were tested for their performance. The selection of shape material depends purely on application area and scope. As literature review highlights, circular fins entered into use instead of rectangular fins where the fitment and use of rectangular fins was difficult. As researches go on shapes like triangular and trapezoidal were tested with different fin materials. Some researchers proves cylindrical fins as a better fins in special cases and some suggested to use rectangular fins to use as these fins are cost effective and also performs better in most of the cases. It can be finally concluded that triangular fins and trapezium fins may be designed and tested against regular shape rectangular or cylindrical fins for their performance and durability.

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