Review on Heat Transfer from Fins

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Abstract: All the electronic components release heat during their operation which must be transferred to the surrounding for its proper and intended operation and to avoid the damage of the equipment. The main aim of extended surfaces is to limit the maximum temperature in the metallic walls. Hence increase the possibility of using the least refractory material and minimizing the material and processing cost. Generally, the extended surfaces (fins) are made up of the materials having high conductivity like aluminum. The heat transfer will depend on the geometry of the fin like length, thickness, cross sectional area, width, spacing between the fins and the operating parameters such as heat supplied to the device, material of the fin, orientation of the fins, temperature difference between the fin and surrounding, number of fins, fin array orientation etc. as the electronic devices and engines developed, heat generated from them increases and while the surface area of the electronic equipment decreases continuously.

Keywords: active devices, effectiveness, passive devices, pressure loss.

1. INTRODUCTION

Many techniques have been searched for increasing the heat transfer rate. Bergles classified these techniques into three main categories

1) Passive techniques 2) Active technique 3) Combination of these two

As passive technique, does not require any external heat source. Passive method generally uses the geometrical modification to the flow by using inserts, artificial roughness or material removal from the surface. Generally, the thermal performance of the device improves by the use of the passive techniques. In active method, heat transfer rate is increased by the help of the external power. Effects pulsating by camps, reciprocating pump-piston are various specimens of active techniques. Chyu et al. [1] investigated the effect of the circular and oval shape dimples on the heat transfer for laminar air flow. He placed dimples on the both sides of the aluminum plate. Results shows that for laminar flow heat transfer rate increases while the pressure drop was lesser than or equivalent to that of the flat surfaces. Nada [2] experimentally determined fluid flow characteristics and natural convection heat transfer in horizontal and vertical narrow enclosures at wide range of Rayleigh number (Ra) for different fin spacing’s and lengths. Inserting fins improves heat transfer rate as compared to bare base plate. Optimum fin spacing’s for which Nusselt number (Nu) and finned surface effectiveness ( ) are maximum is obtained. They found that with increasing fin length, Nusselt number and effectiveness ( ) increases. As Rayleigh number Increases Nusselt number also increases and for any fin array geometry as Rayleigh number increases, effectiveness ( ) reduces for Ra>10,000. Dogan and Sivrioglu [3] investigated the effect of the fin spacing, fin height and heat flux on mixed convection heat transfer from the horizontal rectangular fin array and also determined the fin spacing for the maximum heat transfer. The results show that for the maximum heat transfer rate the fin spacing is 8-9 mm and it depends on Rayleigh number. Lawsonet al. [4] investigated the variation of the heat transfer and pressure loss with the fin spacing through the pin fin rectangular array for the Reynolds number varying from 5,000 to 30,000. Experiments were conducted on the wide range of pin fin geometries of copper arrays with varied stream wise and span wise spacing. The results show that as
the spanwise and streamwise spacing decreases, rate of heat transfer increases. Heat transfer is more
dependent on the streamwise spacing than the spanwise spacing while pressure loss is more
dependent on the spanwise spacing than the streamwise spacing. Karabacak and yakar [5] studied
experimentally the convective heat transfer through the holes of a perforated finned heat exchanger.
They concluded that below the critical Reynolds number heat transfer rate from the imperforated fin
is higher than the perforated fin while above the critical Reynolds number perforated fin has higher
heat transfer rate. Iqbal et al. [6] used the finite element method for the maximum heat transfer to
find out the configuration of fin annulas with the parabolic fins. And they found that no single fin is
suitable in all criteria and for allsituation.Turkyilmazozlu [7] numerically investigated the heat
transfer through a straight fin varying exponential shape when thermal conductivity and heat transfer
coefficient depends on temperature. And considering exponential the general shape. The result shows
that the efficiency of the exponential profile is higher than the rectangular profile.Kundu and lee [8]
analytically determines the different fin geometries performances under the temperature dependent
thermal conductivity and variable heat transfer coefficient with wet surface condition. Results shows that
the fin with the exponential profile has maximum efficiency.Islam et al. [9] studies the straight and the inclined fins flow behavior and the flow characteristics along with their effect on the heat
transfer. For air flow (Reynolds number= 3824 - 12747) heat transfer and flow characteristics of the
finned surface was determined in a tall duct with the 200mm height. In this experiment, the heating
surface with the short rectangular fins exposed to the air flow. To measure wall temperature and the
heat transfer coefficient over end wall and fin base T-type thermocouple and infra-red camera were
installed. The heat transfer enhancement shown by the Nusselt number is more than the 3 times than
the finless duct for the inclined fins while in case of the straight fins the enhancement is more than
the 2 times. Shaeri and jen [10] investigated the Shaeri and Yaghoubi study for the highest heat
transfer rate in the laminar flow for pin fin. The Navier-Stokes equation and energy equations are
solved by finite volume method using simple algorithm. The results show that in a laminar flow and
at a constant porosity, a fin with fewer perforations is more efficient to enhance the heat transfer rate
compared with a fin with more perforations. Ndao et al. [11] studies experimentally the heat transfer
enhancement due to the jet impingement on the smooth and micro fin structure with the water and R-
134a. The experiment were carried out over a wide range of the Reynolds number for a single jet (jet
diameter=2mm) impinging on a micro heater (2mm×2mm). A significant increase in the single phase
heat transfer coefficient is observed due to the presence of micro fins on the impingement surface.
When the area enhancement ratio is 2.44, the increase in the heat transfer rate is 200%. Ismail et al.
[12]studied the three-dimensional fluid flow and heat transfer from an array of solid and perforated
fins that are mounted on the flat plate using N-S equation and k- model of turbulent flow to predict
the turbulent flow parameters. Their result shows that perforated fin has higher effectiveness than the
solid fins. Circular & rectangular perforated fins have almost same heat transfer rate but circular fins
have lower pressure drop.Fernández-Seara et al. [13] experimentally investigated Pressure drop and
heat transfer characteristics of a titanium brazed plate-fin heat exchanger with offset strip fins, firstly
using water on both of the sidesthe heat exchanger and secondly 10-30 wt.% ethylene glycol aqueous
solutions as working fluids.Calamas& Baker [14]investigated computationally the effect of
bifurcation angle, thermal conductivity, mass density, scale, material, width to thickness ratio and
heat flux on the performance of tree like fin’s. The results show that the tree like fins have lower base temperature and more effective than the rectangular fins. With increase in the bifurcation angle,
Fin effectiveness increases while base temperature and fin efficiency decreases. Fin effectiveness is
found to be highly dependent on the material density and less dependent on the thermal conductivity.
Venare et al. [15] investigated experimentally the effect of dimples (circular and elliptical) on the
heat transfer rate. Dimples were placed on both sides of an aluminum plate with a relative pitch of
S/D=1.21 and relative depth of /D=0.16.the heat transfer rate, friction factor and nusselt number are
higher for the elliptical plate as compared to the plane and plate with circular dimples and the pressure drop is equivalent or lesser than the plane and circular dimples. Turkyilmazoglu [16] investigated the combined heat and mass transfer mechanisms owing to the temperature and humidity ratio differences and their influence on the efficiency of different exponential type porous fin configurations. The test shows that the fin tip temperature and efficiency of the exponential porous wet fins are much better than those of corresponding to the straight porous wet fins. Kundu and Lee [17] analyzed the minimum shape of porous fins with convection and radiation modes of heat transfer taken place on its surfaces. And variable heat transfer heat transfer coefficient varying with the temperature is considered for the analysis. Results shows that the volume of optimum profile fin monotonically increases with the porosity and the need of the solid material declines rapidly with the porosity. Sheu et al [18] studied the performance of the piezoelectric fins in association with the heat transfer. They used 9 piezoelectric fins bonded with different bonding and piezometric patch are made. They found that for the piezoelectric fin array, a maximum 64% heat transfer augmentation at a supplied power of 5W (refer figure 1). Badescu [19] analytically determines the minimum volume for the given heat flux.

![Fig. 1. Heat transfer enhancement ratio vs power consumption.](image)

It consists of two regions. In the first region, close to the basis, the pin thickness decreases linearly. In the second region, the pin thickness is constant or may decrease, depending on thermal loads and operation. Elshafei [20] investigated experimentally the natural convection heat transfer from circular pin fin heat sinks subject to the influence of its geometry, heat flux and orientation. The result shows that the heat transfer performance for heat sinks with hollow/perforated pin fins was better than that of solid pins. Kundu and Lee [21] analyzed the optimum shape of the fin under the dehumidification. As if the surface temperature of the fin surface is lower than the dew point temperature of the air, then moisture condenses on fin surface and latent heat transfer takes place along with the sensible heat transfer. Kundu and Lee [22] analyzed the annular porous step fin in moving condition considering internal heat transfer and radiation heat transfer. His study was based on the modified Peclet number instead of the conventional Peclet number. The study revealed that the for the same mass porous fins have higher heat transfer rate than the solid fins. Hazarika et al. [23] studied the analytical model based on the Differential Transform Method and Adomian Decomposition Method is established for predicting the performance parameters and optimum design parameters of a wet T-shaped fin by considering temperature dependent thermal conductivity of the fin material and convective heat transfer coefficient. Results shows that fins performance decreases with increases in relative humidity and biot number. Park et al. [24] investigated the heat transfer characteristics and convective heat transfer coefficient of porous metal fin with the velocity varying porosity density and velocity in the range of 20, 40, and 80 pores per inch, and 0.007–0.17 m/s, respectively. The porous
fin material is fabricated with the nickel. The results show that the Dittus–Boelter equation can be used to determine the nusselt number for the porous material. Li and Wu [25] investigated experimentally the heat transfer of pin-fin heat sinks cooled by dual piezoelectric fans through infrared thermography. The experimental results show that the thermal resistance reaches the minimum (3.37 °C/W) when the fin width is 8 mm, the two piezoelectric fans are in edge-to-edge configuration, and the fans vibrate counter phase in a series of nine-fin heat sinks with a fin height of 15 mm. The minimum thermal resistance (2.4 °C/W) is obtained when the fin width is 5.1 mm and the two piezoelectric fans are in edge-to edge configuration and vibrate counter phase in a series of sixteen-fin heat sinks with a fin height of 30 mm. The minimum thermal resistance is obtained when the two piezoelectric fans are in edge-to edge configuration and vibrate counter phase. Micheli et al. [26] compared the plate micro fin and pin micro fin array under natural convection condition in air. The plate and pin fin array geometry with same thermal exchanging surfaces are considered. The investigation show that the pin micro-fins can improve the thermal performance compared to plate micro-fin arrays. Fernandez-Seara et al. [27] studies the industrial refrigeration to decrease the size and charge of refrigerant in the evaporators by increasing the rate of heat transfer using tubes with enhanced surfaces. Titanium tube with integral fins and plain tube with same nominal diameter are compared under pool boiling using ammonia. The results show an enhancement factor of nearly 1.2. Chen et al. [28] investigated the natural convection heat transfer and fluid flow characteristics of single tube vertical plate fin and tube heat exchanger for the different values of the fin spacing and tube diameter using 3-D computational fluid dynamics. Using fluent along with other models they investigated temperature and velocity distribution of air flowing between two fins, heat transfer coefficient and fin temperature. Results show that here RNG k– ε model is more suitable than the laminar flow model.

2. CONCLUSION:

1. The cubic pin fin arrays produce the higher heat transfer rates than the elliptical pin fin arrays. It is also concluded that for the same pressure drop shape pin fin has higher heat transfer rates than circular pin fin for internal flow.

2. The heat transfer rate for the imperforated fin is higher than the perforated fin below the critical value of Reynolds number and heat transfer rate for perforated fin is higher than the imperforated fin above the critical value of Reynolds number.

3. The efficiency and base heat transfer rate of the exponential profile (with positive power) is higher than the rectangular profile.

4. Unsteady solution approaches steady state for Grashoff number up to 10000.
3. FUTURE SCOPE:

1. To improve the thermal performance of fin with the increase in the relative humidity of the ambient air and also with the biot number.

2. To decrease flow blockage experienced in the base region in the presence of the fins, which in turn decreases the heat transfer coefficient, mean velocity and fluctuating velocity.

3. Effect of the fin spacing, fin pitch, array and fin dimension (height & width) on the rate of the heat transfer in case of the perforated fins.

4. For getting more practical temperature distribution, fin performance and optimum heat transfer rate we must get the actual variation of the heat transfer coefficient and the thermal conductivity.

5. Investigation of the serrated fin with the elliptical holes.

6. Inverse design of the fin based on the requirement. This reduces the number of iteration for the design of a fin for a given requirement.

7. Cost reduction analysis with variable parameter.

8. Optimize the rate of heat transfer of air cooled cylinder engine with magnesium fins.

9. Dimples shape can be varied to get the maximum rate of heat transfer also their pitch, and surface texture (rough/smooth) can be varied at the expense of the pressure drop.

10. The correlation can be derived for the friction factor (f) and nusselt number with respect to the Reynolds number and geometric parameter for fin with dimples.

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