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A Review of Extended Surface in Heat Transfer Problems

Sanjay Singh
Mechanical Engineering Department
TIET
Patiala, Punjab, India

Sumeet Sharma
Mechanical Engineering Department
TIET
Patiala, Punjab, India

Dr. D Gangacharyulu
Chemical Engineering Department
TIET
Patiala, Punjab, India

Abstract- **Cooling of electronics component is a major task in today engineering studies. The operation of several engineering system results in generation of heat. This may cause several overheating problems and lead to failure of the system. To overcome this problem and to achieve desired rate of dissipation as when fins or extended surface are utilizing. The main aim of extended surface known as fins to enhance the heat transfer rate. A lot of experimental work or numerical work can be done in this field. The coefficient of heat transfer rate depends upon the specification of fins such as fin length, spacing between fins number of fin, material of fin etc. Generally, the extended are built up of the material have high thermal conductivity. The main goal of review to collect and summarize research work by numerous author in the field of extended surface. So there is need to study the performance of fins under free convection as well as forced convection.**

Keyword – Fins; heat transfer coefficient; optimization; effectiveness

I. INTRODUCTION

Numerous techniques have been found that to enhance the heat transfer rate. Bergles classified these methods into two categories one is active method and other is passive method. Active method is these methods which are required to external power to balance their enhancement. On the flite site of the coin, in passive method they do not need any type of external power to maintain the enhancement effect as fins are placed. The heat dissipation from system to atmosphere can be obtained with help of convection and radiation heat is transferred from system to surrounding due to temperature difference there are three modes to transfer the heat conduction, convection and radiation.

Heat transfer by convection between a hot solid surface and the surrounding colder fluid. Convection heat transfer very typical because it mainly depends on fluid motion and heat conduction. As we know that the heat transfer by convection is expressed as;

$Q = h A_s (T_s – T_a)$

Convection heat transfer can be increase by following ways: -

Firstly, increasing the temperature difference between the surface and fluid.

Secondly, increasing convection heat transfer coefficient by enhancing the flow velocity over body.

Thirdly, increasing the surface area of contact between the surface and the fluid.

Mostly to control the temperature difference is not optimum and increase of heat transfer coefficient also require installation of pump or fan one with new one having higher capacity, the alternative is increase area by extended surface known as fins.

The use of extended surface has been more convenient, trouble free most economical. In today most of the engineering component used increasing surface area by adding fins to the surface in other to achieve the required rate of heat transfer. However, by adding numerous fins increase the surface area and result they may resist air flow and cause the boundary layer interference which greatly affect the heat transfer [1-4]. The main goal of this review paper is to compile the outcomes of various research who have worked on extended surface (fins).

II STUDY OF FINS IN HEAT TRANSFER PROBLEM

Extended surface or fins are used to increases the heat transfer due to increase surface area of cross section in which convection process occur. The fin material should have high thermal conductivity and minimize temperature variation from base to top. There are many type of fin including Pin fin, Straight fin, Annular fin etc. The previous literature suggests under natural convection the use of three or four fin per inches [5]. Length of fin is also one important parameter of fin. We know that the length of fin is directly proportional to the fin length. However, temperature drop along the fin follow exponentially path so that’s why it reaches the surrounding temperature at some length. After beyond this length it does not contribute any heat transfer. Therefore, design extra-long fin is meaningless as a result wastage of material, increase size and excessive weight and also cost increases [6].

Nagarani et al. [7] presented the study of how fin with heat exchangers has been used over the last 20 years in the field of heat transfer. Due to the advancement of technology, most of the industries required effective heat transfer components with less weight, volume and cost. The author was investigated five major type of fins are as: annular fins, elliptical fins and elliptical tube, pin fins, longitudinal fins by experimental and analytical method. It was observed that

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coating on fins increase the heat transfer rate. It was also observed that elliptical fins will be better choice as compared to annular and eccentric fin.

Kang [8] investigated the optimum fin height of a rectangular profile annular fin based by using a variable separation method. According to the results observed by author, the maximum heat loss, minimum fin resistance, and maximum effectiveness is directly proportional to the inside fluid convection characteristic number, fin height, fin base thickness and ambient convection characteristics number and also observed that optimum fin length is between about 1.70mm to 10.6mm. Lastly, the optimum fin length reduce almost linearly with the increase of the base thickness.

Senapati et al. [9] did an investigation of natural convection heat transfer from a vertical cylinder with annular fin have been studied numerically by varying Rayleigh number in both laminar and turbulent flow. His calculation was carried out by varying fin spacing to diameter ratio (S/d) and fin to tube diameter ratio (D/d) in the range of 0.126-5.84mm and 2-5 respectively. According to the author observation, with the addition of fins to the temperature constant cylindrical wall, the heat transfer goes on increasing for laminar flow and for turbulent flow firstly the heat transfer increases to a maximum value and after that decreases with further additions of fins. It also established that the maximum heat transfer takes place in the case of turbulent flow and also predicted that optimum fin spacing lies between 7 and 7.7mm

Senapati et al. [10] performed a numerical investigation of natural convection heat transfer with annular fins over horizontal cylinder. In the present study, author used numerical simulation of full naiver stoke equation along with energy equation has been conducted with annular fins of constant thickness for the laminar range $5 \leq Ra \leq 10^8$. After the result, the author observed that the ideal fin spacing for maximum heat transfer lies between 5 to 6 mm for Ra in the range $5 \leq Ra \leq 10^8$. It also established the correlation for optimum fin spacing as of function of Ra and D/d which can be very helpful to industrial purpose.

Baidya et al. [11] is carried out their investigation of annular fins to learning the heat transfer characteristic under forced convection. He took three variants of fins first, with 11mm diameter without annular fin second, fin with 31mm diameter and last one is annular fin with 31mm diameter under forced convection at different power and Reynold number. In this experiment author taken as fins made of aluminum because aluminum has high thermal conductivity. After experimental results, it was found to be base diameter for annular fin is reduced by one- third as compared to fin with diameter 11mm due to increase in surface area about 40%. It also observed that Reynold number is directly proportional to the heat transfer rate that mean higher Reynold number that will higher heat transfer rate due to large number of air molecules get in contact with hot surface.

Lee et al. [12] performed experimental investigation of natural convection from vertical cylinder with inclined plate fins. In the present paper, author was performed for various fin number, base temperature and inclination angles. After experimental results, it give the correlation and this correlation applicable to certain specific range ($100,000 < Ra < 600,000$, $9 < N < 36$, $30 < \alpha < 90$). The results hence gathered also proved that the thermal resistances of the cylinder with inclined fins is 30% lower than that as compared to radial plate fins. Finally, it observed that inclined plate fins have potential for use in various mechanical components.

Prakash et al. [13] did an experimental investigation the heat transfer performance of V-notched and combination of V-notched and perforated fin arrays under free convection. The main aim to conduct the experiment is to find out the optimum combination of v-notch and perforation to increase the heat transfer rate under natural convection. Results demonstrate that due to combination of V-notch and perforating both surface area and also turbulence rise up as a result fresher air come in contact with fin and vigorously effect the heat transfer. In the nut shell, perforation help to increases turbulence as well as dissipation rate.

Yildiz et al. [14] carried out experiment to study the performance of annular fins on a horizontal cylinder in free convection heat transfer. He took of 18 sets of annular fin arrays climb up on a horizontal cylinder of 24.9mm diameter and constant thickness 1mm, diameter of fin is varied 35mm to 125mm and fin spacing is diverse from 3.6mm to 31.7mm. his investigation revealed that the convection heat transfer rate from the fins arrays mainly depends on fin diameter, fin spacing and base to ambient temperature difference.

Singh et al. [15] studied the performance of heat transfer of fin is investigated with many extensions such as trapezoidal extension, rectangular extension, triangular extension and circular segmental extensions. In this research was to do a comparison test between the heat transfer of fin with same geometry having numerous extension and without extension. He analysis the fin performance with the help of software Auto desk simulation multiphysics. After analysis he observed that heat transfer through fin with rectangular extension is high as compared to other type of extensions. It also observed that fins with extensions to increase heat transfer near about 5 to 13% as compared to fin without extensions, effectiveness of rectangular fins is also high as compared to other type of extensions.

Fadhil et al. [16] investigated the thermal performance of thermosyphon pipe with circumferential fins over condenser section. Thermosyphon pipes have extremely high thermal conductivity. It is manufactured from copper and DI water is used as a working fluid with filling ratio equal to 50% of the evaporator volume. Annular fins are used made up of aluminum. He studied how different input power (2W, 5W, 10W, 15W, 20W, 25W, 40W) and different inclination angle (30^0, 60^0 and 90^0 from horizontal) effect the thermal performance of thermosyphon. The best results were obtained when the pipe is position at inclination angle of 30^0 as compared to other inclination angle. It also suggests the if we increase the input power as a result thermosyphon pipe temperature also rise up.

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Yadav et al. [17] studied the review of fins on heat transfer. In today, mostly electronic component release heat during operation which must be transferred to the environment properly. Otherwise equipment will damage. The main goal of extended surface to limit the maximum temperature. Mostly, extended surface is made of aluminum because of it high thermal conductivity. The heat transfers also depend on the parameter of fins such as length, thickness, spacing, no of fins, inclination of fins, cross sectional area and temperature difference between fins and surrounding. It also suggests that the efficiency and best heat transfer rate of the exponential profile is higher in the case of rectangular profile.

Kumar et al. [18] investigate the heat transfer of heat pipe by comparing experimental data and analytical model. In this research, the evaporator portion of wire screen heat pipe is subjected to forced convection and condenser portion is under free convection air cooling. In this paper analytical model was establish on the basis of thermal network resistance approach. This model determines thermal resistance at the outer surface of the evaporator as well as condenser. The main goal of experiment to evaluate the thermal performance of heat pipe. It also studies the effect of many operating parameters such as heat pipe inclination angle and heating fluid inlet temperature on the evaporator where investigated by experimental. The experiment result compare with analytical model for the validation. It found that the heat transfer coefficient predicted by the model at outer surface a wire screen heat where observed to be in acceptable agreement with experimental result. It also concludes that maximum heat transport rate of heat pipe was found at inclination angle of 25^0 and at 70^0C heating fluid.

Rao et al. [19] investigated the performance of free and forced convection heat transfer from rectangular and trapezoidal fins attached to a heated horizontal base. He took a rectangular fin of dimension 110*50*10mm and trapezoidal fin of dimension 120*30*10mm by aluminum 6063 alloy. It was shown through result that the heat transfer is enhanced for trapezoidal fins in forced convection. It also observed that efficiency of trapezoidal fin was increased by 7.5 % in forced convection.

Hong-Sen et al. [20] have studied about the circumferential fins and divided into numerous circular section. In all circular section heat transfer coefficient and thermal conductivity was considered. In this paper, a recursive formula was used to give the solution of temperature distributions and heat transfer rate on annular fin for both condition.

Naphon et al. [21] investigated the heat transfer coefficient and fin efficiency of circular fins. Circular fin area observed in three condition under dry surface condition, partly wet surface condition and absolutely wet surface condition. The author developed mathematical model with the aid of central finite distinction technique to find temperature distribution on the fin. The results obtained from mathematical model was fair agreement with other researchers'.

Kundu et al. [22] have presented a paper on elliptical fins with the aid of semi analytical technique. In this technique, employed a constraint of fin volume or heat removal, optimization of fin has been recommended. Elliptical fins give better dissipation rate as compared to circular fin and area resist exist on other side of fins. Elliptical fins give better performance on the comparison of eccentric circular fin if the restriction was on one side.

Chen-Nan et al. [23] have analyzed a paper of combined effect of heat and mass transfer in elliptical fins subjected to be dry, absolutely wet and dry wet constraints for different axis ratio, Biot numbers and air humidity. The author found that if the air humidity was spurred up as a result temperature distribution of fin was also increased. It also observed that elliptical fin efficiency is high nearly about 4% as compared to circular fin efficiency having same perimeter for fully dry condition, and efficiency rise up around 8% for fully wet condition.

Abdel- Rehim Zeinab [24] will investigated the impact on overall thermal performance of extended surface such as square, circular, and elliptical pin fins associated with different fin geometries. The authors used EGM to find the combined effect of thermal resistance and pressure drop. The mathematical model was developed on the basis of dimensionless variable such as Reynolds number, Nusselt number and drag coefficient. The result exposed that fin profile was significantly depend on these parameters.

III. CONCLUSIONS

From the cited literature, it has been concluded that enhancement of heat transfer rate is one of the major task in this area. The performance of fin was significantly depending on fin geometries. Optimization and performance of annular fins with elliptical heat exchangers could be directly used for the enhancement of heat transfer. Coating of fins over condenser section also play a vital role to increase heat transfer rate. It also observed that elliptical fins give better heat transfer rate as compared to annular fins and eccentric fins. The performance of fins was also affected on thermal boundary layer.

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