Review Over Natural Convection Heat Transfer Coefficient of Various Fins

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***Abstract* - The main purpose of extended surfaces called fins to increase the heat transfer rate. Many types of fins investigated and different result comes. Both experimentally work or numerically work done by researcher to conclude the results with different types of fins such as rectangular, v-type, notched, unnotched fins with different medium such as water and air to increase the heat transfer coefficient.**

Keywords: - Fin, Natural convection, Heat transfer

INTRODUCTION

Convection is the process of heat transfer seen in fluids or gases when it flows over the surface. When the gas or any fluid flows over the surfaces, it carries away the heat or gives its heat to the surface depending upon the difference in temperature. If the convection occurs itself without any external force medium it is said to be natural convection. Fins are the mechanism used to enhance the convective heat transfer in various engineering applications. They provide the practical means to achieve a large total heat transfer surface area without the use of excessive amount of primary surface area. They are used in electrical appliances, transformers, internal combustion engines, machines, heat exchangers etc. Various studies have been done to enhance the heat transfer either experimentally or analytically. However there is still need for more studies in this field so as to get maximum heat transfer from one surface to other using fins. Some applications are there where natural convection is the only method applied using fins for heat transfer. So, the system must be designed to get maximum heat transfer from the system so that it can perform its function well. This paper is presented in order to study some of the work done in this area.

LITERATURE SURVEY

Misummi and Kitamura [1] studied the methods of natural convection heat transfer from vertical plat having horizontal partition and v-shape plates in water circumference. It has been reported that heat transfer in the downstream regions of partition plate is remarkably enhanced when the plate height exceeds certain values due inflow of the low temperature fluid in to the separation region.
Parishwad et al. [2] reported the enhancement of the heat transfer in downstream region in the horizontal partition plate and vertical shape fin with air as the circumference. The various methods have been studied to enhance the heat transfer in case of plate with fins.

Bhavnani and Bergles [3] with the help of interferometry technique try to investigate local heat transfer coefficient for surface with repeated ribs and steps. The cross section for ribbed surface has rib height of 6.35 and 3.18 mm spaced at 25.4 mm intervals. The ribs have been fabricated for the aluminum. The maximum increase in heat transfer reported has been 23.2% with step pitch to height ratio of 16.

Heya et al. [4] reported that the height of roughness element less than the boundary layer thickness have no appreciable influence on the heat transfer of natural convection and it reported that these element work as flow retarder that the heat transfer promoter.

Naserian et al. [5] studied the laminar natural convection condition of v-type fin configuration for the shape, number of pieces and gap between the pieces. These studies were done experimentally and numerically. It has been tried to analyze the effect of different conditions like fin height, spacing, length on heat transfer rate, heat transfer coefficient rate, thermal boundary layer. The optimum shape & spacing for the analysis purpose was given Row spacing has also been studied and found that initially with increase the rows, natural heat transfer coefficient increases but affect a certain point it decreases due to interference of boundary layer. The correlations relating Nusselt Number with Rayleigh number has also been suggested.

Senol Baskaya & Murtaj Ozek [6] parametrically studied of fins of aluminum and analyzed that the length, height, spacing and temperature difference produces an effect on the overall heat transfer over each variables of fin. It has also been founded that with increase in overall heat transfer with increases of height of fin and decreases in the length.

Sane et al. [7] studied the aluminum fin array for the heat transfer characteristics without notched and with notched. The parameter taken for the experimental purpose was fin asm150 mm and height of fin as 75 mm. Number of fins were 9 to 15 and notched portion from 10% to 40%. The voltage was applied from 50 to 200 w. From the experiments it has been observed that the total heat flux as well as the heat transfer coefficient increases as the notch depth increases.

S.D. Suryavanshi and N.K. Sane [8] studied the natural heat transfer through rectangular inverted notched fin arrays and observed that increasing the notched area increases the heat transfer coefficient.

Barhatte et al. [9] studied heat transfer rate by using different types of notches in the fin and observed more heat transfer in the triangular notch fin than rectangular, circular, trapezoidal notch.

Shivdas S. Kharche and Hemant S. Farkade [10] studied over the different notched and unnotched fins and found that notched fins have more heat transfer rate than unnotched fins an average heat transfer rate coefficient for without notched has been 8.3887 w/m^2k and for 20% notched fins 9.8139 w/m^2k.

Starner and McManus [11] conducted one of the earliest studies about the heat transfer performance of rectangular fin arrays. In their experiments, four sets of fin arrays have been tested to investigate free convection heat transfer performances. The fin arrays have been positioned with three base types, vertical, 45^0 and horizontal. Besides the main heater, guard heaters have been employed to reduce side heat losses. From experimental data, it has been found that heat transfer rates obtained from the tests with vertical arrays fell 10 to 30 percent below those of similarly spaced parallel plates. For the 45^0 base positions, heat transfer rates have been 5 to 20 percent below from the values taken at vertical position. With the use of smoke filaments, the flow patterns have been observed for each base position. The effect of fin height has also been studied and it has been realized that fin height, fin spacing and base orientation affected the heat transfer performance significantly.

Leung and Probert [12] performed another experimental study to investigate steady-state rates of heat dissipation under natural convective conditions from either vertically based or horizontally based vertical rectangular fins. It has been to figure out the effect of fins height on optimum fin spacing, and hence, two fin lengths have been employed, namely 10 mm and 17 mm. The tests have been carried out with the base of the fin array at either 20 °C or 40 °C above the mean temperature of the environmental air in the laboratory. As a result of limited number of experiments, it has been concluded that for 150 mm length of fins, the optimum fin spacing values have been 9.0 ± 0.5 mm to 9.5 ± 0.5 mm for the vertical fins protruding outwards from the vertical base and upwards from the horizontal base, respectively. It has also been reported that the change of fin height and base-to-ambient temperature difference did not affect optimum fin spacing values for the orientations considered in the study.

An experimental investigation of the heat transfer rate from an array of vertical rectangular fins on vertical rectangular base has been studied by Leung et al. [13]. The fins have been manufactured from light aluminum alloy. The space bars made of the same material has been produced to adjust the separation between adjacent fins by predetermined amounts. The wooden case has been located at the rear of the test section to cover thermal insulation and heater plate. For various fin configurations, the experiments have been conducted at base temperatures of 20 °C, 40 °C, 60 °C and 80 °C above the mean temperature of ambient air. It has been determined that the optimum fin spacing, corresponding to the maximum rate of heat transfer, is about 10 ± 1 mm.

Welling and Wooldridge [14] performed experimental study to compare actual rectangular fin experiments with those of vertical plate, enclosed duct and parallel plate data from previous studies. During the tests, guard heater plate has been utilized to minimize the heat losses from the sides and rear of the set-up. Data obtained from experiments showed that with closely spaced fins, the heat transfer coefficients have been smaller compared to wider fin spacing because of boundary layer interference, which prevents air inflow. It has been observed that the heat transfer coefficients of finned arrays have been smaller than those of vertical plate and greater than either those of enclosed ducts or those of parallel plates. For a given base-to-ambient temperature difference, an optimum H/s (fin height to fin spacing) ratio at which heat transfer coefficient is maximum has been determined from the considered fin configurations.

Harahap and McManus [15] observed the flow field of horizontal rectangular fin arrays for natural convection heat transfer to determine average heat transfer coefficients. In the experimental unit, guard heaters and guard fins have been located near the end fins to eliminate the end effects. To visualize the flow field, schlieren-shadowgraph techniques and smoke injection have been used. Several types of chimney flow have been observed. For equal fin spacing and fin height, two series of rectangular fin arrays differing in length has been compared. The result of comparison indicated that the array having shorter fin length (by half) had higher average heat transfer coefficient because of its effective utilization caused by single chimney flow. This result revealed that single chimney flow pattern has been favorable to high rates of heat transfer.

An experimental study to predict optimum fin spacing in terms of fin height and base-to-ambient temperature difference for natural convection heat transfer from rectangular fins on horizontal surfaces has been reported by Jones and Smith [16]. Determination of local heat transfer coefficients have been achieved by measuring local temperature gradients with interferometer. Integrating the measured local heat transfer coefficients, the average heat transfer coefficient for the array has been studied. Since the determined heat transfer coefficients have been for convection only and is independent of the radiation, the interferometric technique has been used directly. The results have shown that fin spacing, is the primary geometric parameter that affects the heat transfer coefficient.

Filtzroy [17] performed a study to determine the optimum spacing of a set of parallel vertical fins cooled by free convection heat transfer in the laminar flow regime.

Bar-Cohen [18] analytically investigated the effect of fin thickness on free convection heat transfer performances of rectangular fin arrays. The results of analysis have shown that for each distinct combination of environmental, geometric and material constraints, an optimum fin thickness that maximizes the thermal performance of an array exists. It has been suggested that in air, the optimum fin thickness value of an array can be taken approximately equal to optimum fin spacing value for the best thermal performance.

Leung et al. [19] studied the thermal performances of rectangular fins on vertical and horizontal rectangular bases experimentally. Experiments have been performed for three different cases; horizontally based vertical fins, vertically based vertical fins and vertically based horizontal fins. Optimum fin spacing values have been predicted for each case. For constant base temperatures of 40°C, 60°C and 80°C, the experiments have been conducted to reveal the effect of base position on heat transfer performances of fin arrays. For three different fin heights, i.e. 32 mm, 60 mm and 90 mm, and for a base temperature of 60°C, the experiments have also been performed. The results show that for vertical fins on a vertical base, fin spacing is the most effective parameter influencing the heat transfer rate. It has also been determined that unlike fin spacing, the variation in fin height did not cause an effective change in heat transfer rate for vertical fins on both vertical base and horizontal base. It has been concluded that among the all considered base positions vertical fins on a vertical base has best solution for better heat transfer performance.

The effects of changing fin length from 250 to 375 mm on the rate of heat transfer and the optimum fin spacing of vertical rectangular fins protruding from a horizontal or a vertical rectangular base have been investigated by Leung et al. [20], experimentally. Except fin length, other geometric parameters of several fin configurations have been kept fixed for considered orientations. Experiments have been conducted at a constant base temperature, 40°C above that of the ambient environment. The experimental measurements for vertical base showed that the increase in fin length caused reduction in the rate of heat dissipation per unit base area from the fin array. In addition, the optimal fin spacing rose from 10 ± 1 mm to 11 ± 1 mm as a result of fin length increase. On the other hand, with horizontal base, large reduction in the rate of heat transfer per unit area occurred when the fin length has been increased. The optimal fin spacing of horizontally based fin array increases from 11 ± 1 mm to 14 ± 1 mm as the fin length has been increased from 250 mm to 375 mm. All these consequences revealed that the effect of fin length on heat transfer performance of fin arrays is significant.

Leung and Probert [21] investigated effects of varying fin thickness on the rate of heat transfer from vertical duralumin fins protruding perpendicularly outwards from a vertical rectangular base, experimentally for free convection conditions. The experiments have been performed with five different fin thicknesses, namely 1, 3, 6, 9 and 19 mm, for base temperatures of 20°C and 40°C above that of the ambient environment, which has been maintained at 20°C. It

has been observed that the average optimal uniform fin thickness 3 ± 0.5 mm, for maximum rates of heat transfer, when the uniform separations between the adjacent fins exceeded 20 mm and for 20 mm $\leq s \leq$ 50 mm, the optimal fin thickness decreased slightly as either the fin separation or the base temperature has been reduced.
Yüncü and Anbar [22] performed an experimental study of free convection heat transfer from rectangular fin arrays on a horizontal base. 15 different fin arrays and a base plate have been tested. The effects of fin height, fin spacing and base-to-ambient temperature difference on heat transfer performance have been investigated. It has been found that the rate of convective heat transfer from the fin array mainly depends on these parameters. The experimental results indicated that optimum fin spacing, for maximum heat transfer rate from fin array, decreased as the fin height increased. The effect of base-to-ambient temperature on the optimum fin spacing has been also discussed and it has been concluded that it has no any significant affect.

Yüncü and Güvenc [23] investigated the performance of rectangular fins on a vertical base in free convection heat transfer, experimentally. During experiments, the length, width and thickness of fins on arrays have been kept fixed, but other parameters such as fin spacing and fin height have been varied. The effects of fin height, fin spacing and base-to-ambient temperature difference on the heat transfer performance of fin arrays has been observed for several heat inputs. According to the experimental results, it has been deduced that fin spacing is the most important parameter in the thermal performance of fin arrays and an optimum fin spacing can be found for every fin height, for a given base-to-ambient temperature difference. This result revealed that optimum fin spacing depends on two main parameters, fin height and base-to-ambient temperature difference. The experimental results have been compared with those of obtained from horizontally based fin arrays. It has been concluded that for vertically based fin arrays, higher heat transfer enhancement can be achieved.

Yüncü and Mobedi [24] performed a three dimensional numerical study on natural convection heat transfer from longitudinally short horizontal rectangular fin arrays. The governing equations i.e. momentum and energy, have been tried to solve by using a finite difference code based on vorticity-vector potential approach. For various geometric parameters i.e. fin length, fin height and fin spacing, flow configurations occurring in the channel of the fin arrays has been analyzed. Two types of flows have been defined as a result of observations. In first type flow configurations; with small fin spacing, air enters from the ends of the channel moves along the fin length and flows out at the center of the channel. On the other hand, in the second case, with large fin spacing, fresh air can also enter into the channel from the middle part since the space between two fins is sufficiently large. Then, it turns 180^0 at the base and flows up along the fin height while it moves to the central part of the channel. The effects of fin length and fin height on the heat transfer rate of horizontal fin array have also been examined and it has been concluded that an increase in these geometric parameters causes reduction in the rate of heat transfer from array. This is due to more boundary layer interference along the channels which lowers the amount of intake cold air in the channel.

Natural convective heat transfer from annular fins has been investigated by Yüncü and Yildiz [25] experimentally. 18 sets of annular fin arrays have been tested to observe their heat transfer performances. The fin arrays have been heated with several heat inputs and corresponding base and ambient temperature differences have been recorded. Using the measured data, total heat transfer rates from fin configurations have been evaluated. A radiation analysis has been applied to estimate the rates of radiation heat transfer. Then, radiation contributions have been subtracted from total heat dissipations to obtain essential convection heat transfer rates. It has been concluded that the convection heat transfer rate from the fin arrays depends on fin diameter, fin spacing and base-to-ambient temperature difference.

CONCLUSION

From the studies it has been found that enchantment of heat transfer rate is one of the major concerns in this area. Fins are used to enhance the heat transfer rate. Optimum temperature differences fin spacing, fin height and fin length are the most important factor affecting the performance of any device. The performances of the fins were also affected by the boundary layer formed over them. Various experiments were performed and relations were given in order to calculate these parameters. Most of the testes have been performed in aluminum fins and relations were developed for this. Different parametric studies have also been performed in order to understand the factors affecting the heat transfer process in a fin arrays.

FUTURE SCOPE

In the coming future more advance materials can be used in order to enhance the heat transfer rate. There is much need to enhance the property in order to maximize the performance of the system. There has been work in this regard but still there is much need to do in this field. Some new co-relations can be developed and tested. New materials can be used to develop fins in order to enhance the heat transfer rate.

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