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HEAT TRANSFER ENHANCEMENT USING FINS WITH PERFORATION: A REVIEW

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ABSTRACT

Extended surfaces called as fins a passive technique is used for enhancing heat transfer between surface and surrounding fluid. They find applications not only in electronic equipments but also in important areas like electrical transformers, heat exchanger, chemical processing system etc. As proper heat dissipation results in saving of power and reduces chances of overheating problems, perforation are made on the fins. Perforated fin improves heat transfer rate compared to solid fin by varying the different parameter like shape of perforation, diameter of perforation and number of perforation. This paper focuses on studies which deal with heat transfer enhancement by using perforated fin.

KEYWORDS: Heat transfer rate, Perforated fin, solid fin.

INTRODUCTION

Fins are used as a powerful tool for dissipating heat from primary surface to surrounding fluid to avoid the burning or overheating of the system. Various types of fins such as rectangular fins, square fins, tapered or pin fins are used for both natural and forced convection heat transfer. These fins protrude from either a rectangular or cylindrical base. Many attempts have been made to design optimized fins. To dissipate more heat from these fins slots, grooves, interruptions or perforation are made to the body of fins. Due to this, heat transfer surface area is increased, weight is reduced and hence greater thermal performance is achieved.

LITERATURE REVIEW

Many engineering systems during their operation generate heat. If this generated heat is not dissipated to surrounding, may cause overheating problems and leads to system failure. So the generated heat within the system must be dissipated to surrounding atmosphere to maintain the system at recommended temperature for its efficient working [1].Due to demand of lightweight, compact, and to achieve the required heat dissipation rate, with the least amount of material, perforations are made to the fins [2, 3]. S. H. Barhatte et al.[4] investigated heat transfer through horizontal base fins experimentally by cutting a notch at center of fin. By computational analysis using ANSYS CFX different geometrical shapes such as circular, rectangular, triangular and trapezoidal are studied. They concluded that heat transfer coefficient is highest for triangular notch followed by trapezoidal, circular and rectangular respectively.

One of the popular technique involves the use of interrupted surfaces of different configurations. Interruptions aim at promoting surface turbulence so the heat transfer rate increases by resetting the thermal and hydrodynamic boundary layer. Detailed work in this area was carried out by M. Ahmadi et.al [5] experimentally and numerically investigated the natural convection heat transfer from vertically mounted inline interrupted fins. They performed parametric study to investigate the effects of fin spacing and interruptions made to the vertical fin. It was also observed that the heat flux from heat sink increased when interruptions were added. Many circular perforation in the range of 24 to 56 on rectangular fin was reported in the literature of W. Hussein [6] experimentally studied the natural convection heat transfer from a rectangular fin plate by circular perforations fitted to aluminium cylinder heat sink. The patterns of perforations including 24 for the first fin and the number of perforations were increased by 8 for every fin until reached to 56 for the fifth fins. It was found that the temperature drop between the fin base and fin tip increases as the perforation diameter increased due to decrease in temperature resistance. They also observed that the temperatures drop along the solid fin was less than perforated fin. Other researchers reported the similar results with same heat sink geometry and dimensions. C. S. Muthuraja et. al. [7] studied the temperature distribution along the height of perforated fin with circular perforation. They observed that temperature drop along height of perforated fins was consistently higher than compared to equivalent solid fin. R. R. Jassem [8] used aluminum cylinder heat sink with first fin non-perforated and others fins perforated by different shape such as circle, square and hexagon keeping constant cross section area of perforation. The results shown that temperature drop is higher for perforated fins than that of solid fins and fins with triangular perforation gives higher heat transfer.

G. D. Gosavi et. al. [9] studied and investigated the concept of heat transfer through perforated material is one of the methods of improving the heat transfer characteristic in the natural convection. A perforated and solid material of brass, aluminum and copper was selected for the experimentation. As the review was concerned it was found that, the heat transfer through perforated fins was much greater than 50-60% than the solid one. U. V. Awasarmol and A. T. Pise [10] studied experimentally natural convective heat transfer enhancement of perforated fin array with perforation diameter ranging from 4 mm to 12 mm inline. They tested the four configurations from 0^0C to 90^0C inclination angle from which they found optimum perforation diameter as 12mm at 45^0. A. H. M. AIEssa and N. S. Gharaibeh [11] experimentally examined natural convective heat transfer enhancement from a horizontal rectangular fin with triangular perforation. They observed that perforation increased surface area of fin, so heat dissipations for given range of perforation dimension increases and magnitude of heat transfer enhancement is proportional to the fin thickness. A. H. AlEssa and M. Q. Al-odat [12] used several methods to increase the effective heat transfer surface area of fin specified. They investigated the natural heat transfer enhancement from a horizontal rectangular fin embedded with equilateral triangular perforations numerically and concluded that magnitude of enhancement is directly proportional to fin thickness and thermal conductivity of material. According to A. B. Ganorkar and V. M. Kriplani [13] due to perforation laminar boundary layer is broken and more turbulence is produced which in turn increases the convective heat transfer coefficient. They studied the effect of rectangular fin with circular perforation having diameter, 6-10mm for different Reynolds number. They came to conclusion that enhancement of $Nu_{perforated}/Nu_{solid}$ is significant with increase in number of holes as well as diameter of holes with increase in Reynolds number but weight of fin is reduced and hence it is advantageous. G. Chaudhari and I. Wankhede [14] experimentally showed that for certain percentage of perforation, the perforated fin enhanced the heat transfer. Total heat transfer rate from fin arrays depends on base-to-ambient temperature difference and percentage of perforation. The total heat transfer was maximum for 30% perforated fin array. Their results revealed that the experimental data were in a good agreement with the correlations with average relative errors of less than 20 % for Churchill and Chu's and Mc Adam's correlations. Heat transfer augmentation with perforated fins with square cross section attached to flat surfaces was carried out by B. Sahin and A. Demir [15] numerically. They kept clearance ratio constant (C/H=0) and varied the pin-fin spacing ratio in stream wise direction (Sy/D=1.208, 1.944 and 3.4) and the Reynolds number (Re=13.500, 27.500 and 42.000).The height of fin was taken as 100 mm .All fins were perforated at a distance of 17 mm from the bottom of base plate with 8 mm diameter. They have observed that the lowest pin-fin spacing ratio of Sy/D=1.208 with clearance ratio of C/H=0 gives better cooling performance.

There have been many studies on forced convection heat transfer on fins. K. Dhanawade et.al [16] investigated experimentally, the effect of the various parameters like geometry, Reynolds number and friction factor on the heat transfer for the rectangular fins with square and circular perforation. They found that the most important parameter affecting the heat transfer is Reynolds number and geometry of perforation. They found that the Nusselt numbers of square and circular perforated fin arrays as well as solid fin arrays increased with increase in Reynolds number. Among three cases, circular perforated fin shows greater increase in Nusselt numbers with increase in Reynolds number. A. Khosnevis et. al. [17] investigated numerically the effect of lateral surface perforation on thermal enhancement of a 3-D channel with a ground attached heater. Hole and slot were the two types of perforations made to the rectangular ribs and equations were solved with FLUENT 6.3.The result showed significant enhancement in heat transfer and pressure drop by increasing the perforation area due to disorganizing the thermal traps between the ribs. Also observed that for same open area ratio for slot and hole perforation, more over all thermal performance was achieved for hole perforation case. F. Ismail et al. [18] numerically studied the turbulent convection heat transfer on a rectangular plate mounted over a horizontal flat surface. The fins used were of lateral perforated rectangular, circular, hexagonal cross sections. They found that shape of lateral perforation significantly effects on the heat transfer behavior of heat sinks below turbulent flow conditions. Perforated fins found the heat transfer enhancement with triangular, square, circular and hexagonal in increasing manner respectively. M. Shaeri and T. Jen [19] reported highest heat transfer rate in a laminar flow for a perforated fin with the greater porosity, regardless of investigation on the effects of perforation sizes. In their study, the effects of size and number of perforations on laminar heat transfer characteristics of an array of perforated fins at the highest porosity have been numerically investigated. K. Rajput and A. Kulkarni [20] examined heat transfer augmentation from a rectangular fin with circular perforation under natural convection using ANSYS 10. Study showed that as perforations increased heat transfer rate also increased upto certain dimension and then started decreasing. Heat transfer enhancement of the perforated fin increased with increase in diameter and number of perforation with optimum dimension as 16 mm diameter and 32 numbers of holes. N. Patil and S. Bhosale [21] carried out experimental investigation of a horizontal fin array with circular perforations for free convection. They determined that heat transfer was optimum in case of 5 mm diameter as compare to 4 mm because as hole size is decreased there caused restriction for pass through it so heat transfer decreased. M. Al-Widyan and A. Al-sharrawi [22] numerically investigated that heat transfer from perforated fin increased with Grashof number upto $1x10^6$ and decreasing spacing between the holes, where a maximum value of heat transfer enhancement is reached and then started to decrease with increase in diameter. So, hole diameter and spacing between holes is carefully controlled and maintained in the desirable ranges. Finite element analysis of convective heat transfer augmentation from horizontal rectangular fin with circular perforation is examined by R. V. Dhanadya and A. S. Nilawar [23].They studied the fins with different thickness keeping length constant which showed that heat transfer increased with increase in fin thickness.

CONCLUSION

1. Nusselt number increases with increasing number of perforations on rectangular fin array.
2. The perforated fins have high heat transfer coefficient than solid fin.
3. The perforated fin is light in weight, saves material and extracts heat quickly from heated surface compared to solid fin.
4. Heat transfer enhancement depend on number of perforation, size and shape of perforation, thickness of perforated fin and thermal conductivity of fin material.

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