Analysis of Perforated Fins through Convective Heat Transfer: A Review

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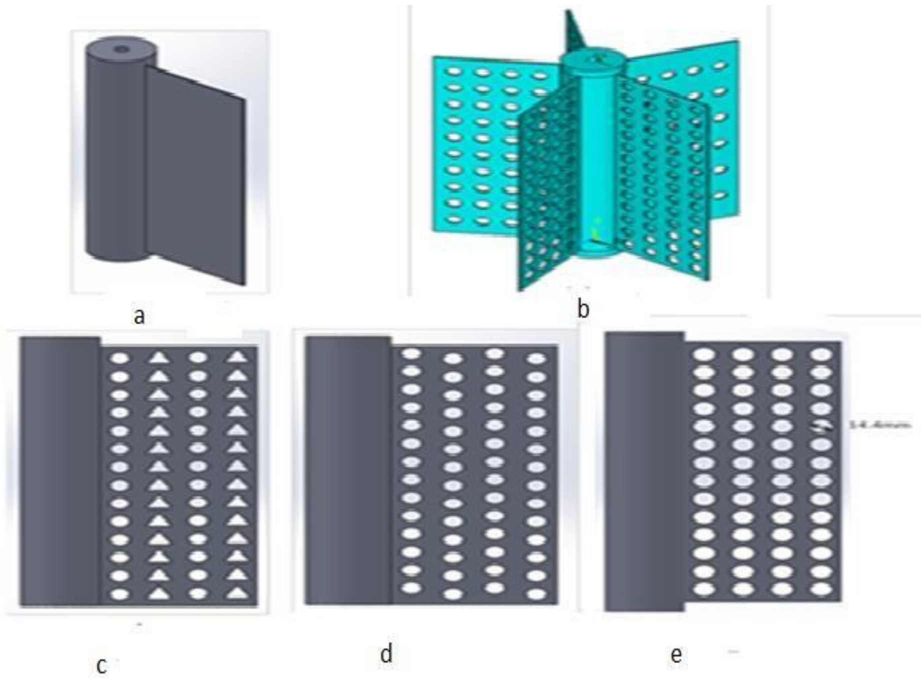
Abstract
It is essential to remove the heat from the system to avoid the overheating because overheating could damage the systems. Hence heat transfer enhancement plays an important role to safe the systems. The heat transfers mainly by conduction and convection. The conduction heat transfer depends upon thermal conductivity of material so to increase heat transfer take the material which have more thermal conductivity. The convective heat transfer is in ways natural and force convection, extended surfaces are used to increase the heat transfer rate by natural/free convection because extended surfaces/fins provide more surface area to transfer the heat between surface of system and surrounding fluid.
Keywords: *Heat transfer, extended surfaces,Rayleigh number*

1. Introduction

The electronic, aerospace, automobile, power plants and nuclear industries are focusing on energy efficiency and need higher cooling rates.



(a) Fin without perforation (b) fin with circular perforations, (c) Mixed perforations (d) fin with elliptical perforation (e) Increasing the size of perforation

This has encouraged to optimize the performance of cooling technologies. Fins or extend surfaces are used to increase the heat dissipation rate from surface which are convectively cooled by gases (air) under free or forced convection. Extended surface provides more surface area to contact the surrounding fluid so that the surrounding fluid takes more heat. If the perforation is create in extended surfaces it give more surface area to contact the surrounding fluid so fin has been perforated to improve the performance of fin extended surface. Perforation may be in the form of slots, notches or circular holes in the fin. Following are the advantages of perforation like Increase in the rate of heat transfer, reduce the size of wake region behind the fins, chance of flow separation decreases and the fin weight also reduces.

2. Literature Review

M.R. Shaeri et al. [10] in 2008 accomplished study of heat conversion from arrangement of rectangular fins consists square perforation windows which are arranged in extendedsurface. For analysis, they usedRNG based k -e turbulent model and Navier–Stokes equations. They done Computations for Reynolds numbers of 2000– 5000 based on the fin thickness and Pr = 0.71. They conclude that if perforation is increased, the lighter fins and more cost-effective fins will be attained. The main benefit of these type of fins with perforation is that they have, lower drag force, considerable lower weight and slight more heat dissipation rate with relative to unperforated fin.

Yinhai Zhu [11] in 2008 modelled and simulated 4 basic extended fins of the heat augmenters 1stisstrip offset fin 2nd is perforated fin 3rdis rectangular plain fin, and last one wavy fin, by considering thermal entry effect, end effect and fin thickness as parameter,. And they also investigated 3D numerical simulations on the heat transfer and flow in the four fins.Theydid CFD simulations for the four basic fins of PFHE at Reynolds number ranges of 132.3–1323.They found that the thermal entry length of the four fins might be represented in the format of $L_e=c_1 Re^{c2} Pr\ Dh$.

Abdullah H. AlEssa et al. [1] in 2009 has examined and studied using finite element technique the enhancement of heat dissipation rate through convection from a horizontal fin having shape rectangularfixed with rectangular holes of aspect ratio of two..The author did parametric study for thermal properties andshape and size of the fin and the perforations was done on the basis of this. This study revealed that for some specific values of dimension of rectangular perforation, the fin with perforation have higher rate of heat dissipation. It is find thedegree of enhancement is proportionate to its thermal conductivity and the fin thickness. Also, it is established that the heat dissipation rate for perforated fins depends on the thermophysical properties of fin, fin dimensions and the perforation geometry or shape.

Abdullah H. AlEssa and Mohammed Q. Al-Odat [2] in 2009 investigated the augmentation of heat dissipation rate through convection from a horizontal fin with rectangular shape fitted with equilateral triangular perforations.in this study the author compared The results offin having perforation with unperforated simple solid fins. The author did parametric study for thermal properties and shape and size of the fin and the perforations was done on the basis of this. And by examining the result it is found that the fin with perforation results increase in heat dissipation rate. The degree of enhancement is proportionate to the fin width and its thermal conductivity. The fins having perforationincreases the rate of heat transferand also lower the perforation of fins of triangular shape improves heat conversion rates and simultaneously lower the weight and spending of the material of fin.

Kumbhar D.G et al. [9] in 2009 examined and studied the heat conversionenhancing from a horizontal fin having rectangular shape with triangular perforations whose bases is parallel & towards the fin base under free convection using ANSYS Version 9. It is found that heat conversion is augmented using perforations as compared to fins having same size without perforations. Also result showed that when the triangular perforation is used in case of perforations having triangular shapebest heat dissipation is attained. It is also determined that heat dissipation rate depends on material to material and on thermal conductivity. The perforation of extended surface of fins improves the heat transfer rates and simultaneouslymaterial of fins is also lighten.

Wadhah Hussein Abdul Razzaq Al- Doori [7] in 2011 conducted experimental study to determine heat dissipation by free convection in a fin plate having shape rectangular with heat sinksascircular perforations. The result showed that the reduction in temperaturealongside the perforation was comparatively higher than for the equivalent fin having no perforation. The author got that the enhancement in the heat transfer rate for the fin having perforation was strongly in relation with the perforation dimensions and lateral spacing in a way that with increase in perforation size and adjacent spacing, heat transfer also increases anddecreasing the perforation dimensions reduces the temperaturealongside the fin with extended using perforation. It is found that coefficient of heat transfer for large number of perforation is greater than the fin having no perforation or less perforation.

Dhanawade Hanamant S et al. [6] in 2013 examined results of the fluid flow and characteristics of heat dissipation of an extended surface fin arrangementsby modelling and simulation in CFD by experiment with lateral perforation having circular holes in which external solid fin arrays embedded on regular flat surface is a problem of heat transfer rate.The author used fluid flow (CFX) workbench of ANSYS 12.0 to conduct experimental analysis and the CFD simulation on anunperforated and perforated fin arrangements. The result showed that there is an enhancement of heat transfer as we increase the size of perforated holes because more free convection is achieved.

Amol B. Dhumne and Hemant S. Farkade [5] in 2013 investigated experimentally changes in heat dissipation and friction factor considering the certain design parameters for the heat exchanger embedded with perforated pin fins having square cross-sectional. The result shows that the bestsignificant parameters affecting heat dissipation rate are fin height, fin spaces and Reynolds number. Heat dissipation rate can be enhanced by changes in these parameters.The heat dissipation rate which was witnessed maximum is at Reynolds number 42,000, 50 mm fin height and 3.417 Sy/D

Kavita H. DhanawadeȦ et al. [8] in 2014 had studied on a horizontal flat surface in which number of fin array put in vertically and perforation creates in rectangular and circular shape.The cross sectional area of the rectangular duct was 200 mm x 80 mm. The data used in investigation were obtained experimentally for fin arrays of material aluminium, by varying geometry and size of perforation as well as by varying Reynolds number from 21 104to 8.7 104. The conclusion obtained that Reynolds number and perforation geometry are the most important parameter to improve the heat transfer. Due to perforation created in fin array the weight of the fin reduces and also decrease the expenditure of the related material. Low weight and cost give extra advantage in air conditioning and many other industrial applications.

Amer. Al-Damook et al. [4] in 2015 conducted an experimental study on the effects and changes due to using of pin heat sinks with different dimension and shape with multiple perforation using Computational Fluid Dynamics (CFD) methods. The outcome showed that the use of more pin will increase heat dissipation rate and simultaneously the pressure is reducedthrough the heat sink and also fan power is reduced to pump the air through them. The result shown that to ensure that perforation are aligned and manufactured with a good surface finish perforation care must be taken.

Amer Al-Damook et al. [3] in 2016 examined the effects and changes due to using of pin heat sinks with different dimension and shape they used single perforation, rectangular perforation and notched perforations in fins.These experiment or study emphasizes on the benefits of considering pins with notch perforation or rectangular slot. Result shows that both type perforation results increased rates of heat dissipationat the same time fan power essential to motion of air over the fins is lower compared to equivalent simple fins. The result showed monotonically increase in heat transfer when perforation increases and heat transfer rate increase by over 10%, simultaneously reducing fan power consumption and pin weight by over 30% and 40% respectively.

3. Equations

Heat transfer can be calculated mainly by conduction and convection

Convection heat transfer $Q = hA\Delta T$

Where h is the heat transfer coefficient

Conduction heat transfer $Q = -KA\frac{dT}{dx}$

Where K is thermal conductivity

Rayleigh number $Ra = \frac{g\beta L_c^3 \Delta T}{\vartheta^2}$

Where $\beta = \frac{1}{T_m}$ and $T_m \frac{T_a+T_s}{2}$

Nusselt number $Nu = \frac{hL_c}{K}$

4. Conclusion

From the above review papers, it is observing that the heat dissipation rate can be increase by different ways. When the extended surfaces are used the heat transfer rate increases and depends upon number of fins, fin spacing and fin thickness. When the Extended surfaces are perforated in different shape i.e. circular, triangular, rectangular the heat dissipation increase because more convection heat transfer. It is also observe that when the perforation is in elliptical shape the heat dissipation is more compare to triangular, rectangular or circular because the chance of flow separation is less in elliptical perforation.

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