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A Review on Effect of Perforation and Carbon Nanotubes Coating on Heat Transfer Augmentation

K.A.Rajput[1], A.V.Kulkarni[2]

P.G. Student, Department of mechanical Engineering, Shreeyash college of engineering & Technology, Aurangabad, Maharashtra, India[1]

HOD, Department of mechanical Engineering, Shreeyash college of engineering & Technology, Aurangabad, Maharashtra, India[2]

Abstract: It is very important to dissipate unwanted heat generated in mechanical devices such as IC engines, radiators, electronic IC's etc. to the atmosphere. Extended surfaces are widely use in many engineering application because of easy in construction, require less space, light weight. Many new techniques are adopted to improve its effectiveness by reducing the thermal boundary layer thickness and increasing the heat transfer surface area. One of this is perforation through fin body. Limitations of active techniques overcome by passive techniques and researchers find compound techniques is new emerging technique to enhance heat transfer. Now day's nanotechnology is used in typical cooling applications in many industries by nanostructured coatings, nano porous and nano fin over the surface. It has high thermal conductivity (2000 w/m-k).This article provides a detailed review of heat transfer enhancement by perforation and CNT coating.

Keywords: Heat transfer augmentation, Passive technique, Extended surfaces, perforation, CNT coating.

I. INTRODUCTION

The removal of excessive heat from system components is essential to avoid the damaging effects of burning or overheating. Therefore, the enhancement of heat transfer is an important subject in thermal engineering. The heat transfer from surfaces may in general be enhanced by increasing the heat transfer coefficient between a surface and its surroundings, by increasing the heat transfer area of the surface, or by both. In most cases, the area of heat transfer is increased by utilizing the extended surfaces in the form of fins attached to walls and surfaces. Extended surfaces are used to enhance heat transfer in a wide range of engineering applications and offer a practical means for achieving a large total heat transfer surface area. Fins are commonly applied for heat management in electrical appliances such as computer power supplied, or other applications include IC engine cooling such as fins in a car radiator [1], [2].

Heat transfer inside flow passages can be enhanced by using passive surface modifications such as rib tabulators, protrusions, pin fins, and dimples. These heat transfer enhancement techniques have practical. Application for internal cooling of turbine airfoils, combustion chamber liners and electronics cooling devices, biomedical devices and heat exchangers. The heat transfer can be increased by the following different Augmentation Techniques. They are broadly classified into three different categories: (i) Passive Techniques (ii) Active Techniques (iii) Compound Techniques [3], [4].

A. Passive techniques

These techniques generally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices. They promote higher heat transfer coefficients by disturbing or altering the existing flow behavior (except for extended surfaces) which also leads to increase in the pressure drop.

In case of extended surfaces, effective heat transfer area on the side of the extended surface is increased. Passive techniques hold the advantage over the active techniques as they do not require any direct input of external power. These techniques do not require any direct input of external power; rather they use it from the system itself which ultimately leads to an increase in fluid pressure drop. They generally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices. They promote higher heat transfer coefficients by disturbing or altering the existing flow behavior except for extended surfaces. Heat transfer augmentation by these techniques can be achieved by using;

1) Treated Surfaces: Such surfaces have a fine scale alteration to their finish or coating which may be continuous or discontinuous. They are primarily used for Boiling and condensing duties.

2) Rough surfaces: These are the surface modifications that promote turbulence in the flow field in the wall region, primarily in single phase flows, without increase in heat transfer surface area.

3) Extended surfaces: They provide effective heat transfer enlargement. The newer developments have led to modified finned surfaces that also tend to improve the heat transfer coefficients by disturbing the flow field in addition to increasing the surface area.

4) Displaced enhancement devices: These are the inserts that are used primarily in confined forced convection, and they improve energy transport indirectly at the heat exchange surface by displacing the fluid from the heated or cooled surface of the duct with bulk fluid from the core flow.

5) Swirl flow devices: They produce and superimpose swirl flow or secondary recirculation on the axial flow in a channel. These include helical strip or cored screw type tube inserts, twisted tapes. They can be used for single phase and two-phase flows.

6) Coiled tubes: These lead to relatively more compact heat exchangers. It produces secondary flows and vortices which promote higher heat transfer coefficients in single phase flows as well as in most regions of boiling.

7) Surface tension devices: These consist of wicking or grooved surfaces, which direct and improve the flow of liquid to boiling surfaces and from condensing surfaces.

8) Additives for liquids: These include the addition of solid particles, soluble trace additives and gas bubbles in single phase flows and trace additives which usually depress the surface tension of the liquid for boiling systems.

9) Additives for gases: These include liquid droplets or solid particles, which are introduced in single- phase gas flows either as dilute phase (gas-solid suspensions) or as dense phase (fluidized beds).

B. Active techniques

These techniques are more complex from the use and design point of view as the method requires some external power input to cause the desired flow modification and improvement in the rate of heat transfer. It finds limited application because of the need of external power in many practical applications. In comparison to the passive techniques, these techniques have not shown much potential as it is difficult to provide external power input in many cases.

In these cases, external power is used to facilitate the desired flow modification and the concomitant improvement in the rate of heat transfer. Augmentation of heat transfer by this method can be achieved by:

1) Mechanical Aids: Such instruments stir the fluid by mechanical means or by rotating the surface. These include rotating tube heat exchangers and scrapped surface heat and mass exchangers.

2) Surface vibration: They have been applied in single phase flows to obtain higher heat transfer coefficients.

3) Fluid vibration: These are primarily used in single phase flows and are considered to be perhaps the most practical type of vibration enhancement technique.

4) Electrostatic fields: It can be in the form of electric or magnetic fields or a combination of the two from dc or ac sources, which can be applied in heat exchange systems involving dielectric fluids. Depending on the application, it can also produce greater bulk mixing and induce forced convection or electromagnetic pumping to enhance heat transfer.

5) Injection: Such a technique is used in single phase flow and pertains to the method of injecting the same or a different fluid into the main bulk fluid either through a porous heat transfer interface or upstream of the heat transfer section.

6) Suction: It involves either vapor removal through a porous heated surface in nucleate or film boiling, or fluid withdrawal through a porous heated surface in single-phase flow.

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7) Jet impingement: It involves the direction of heating or cooling fluid perpendicularly or obliquely to the heat transfer surface.

C. Compound techniques

A compound augmentation technique is the one where more than one of the above mentioned techniques is used in combination with the purpose of further improving the thermo-hydraulic performance of a heat exchanger.

When any two or more of these techniques are employed simultaneously to obtain enhancement in heat transfer that is greater than that produced by either of them when used individually, is termed as compound enhancement. This technique involves complex design and hence has limited applications.

II. LITERATURE SURVEY

A.B.Ganorkar et al. [3], has review different types of arrangements of extended surfaces. Extended surface heat exchangers are simple in construction and extensively used in many of the industries. Continuous Research is going on to improve its effectiveness by increasing fluid turbulence, generating secondary fluid flow patterns, reducing the thermal boundary layer thickness and increasing the heat transfer surface area. In this review paper they explain different types of arrangements of extended surface.

Abdullah H. Al Essa et al. [5], has study and examine the heat transfer enhancement from a horizontal rectangular fin embedded with triangular perforations (their bases parallel and toward the fin tip) under natural convection. They considered geometrical dimensions and thermal properties as parameter of the fin and the perforations. The temperature drop is studied for perforation dimension and space between them. The experimentation results shows that gain in heat transfer enhancement for certain values of triangular dimensions is increase with its dimensions and is proportional to the fin thickness and its thermal conductivity. They state that the gain in the heat dissipation rate for the perforated fin is a strong function of both the perforation diameter and lateral spacing which attain maximum at optimum perforation dimension and spacing respectively. With perforation it reduces the fin expenditure of material.

Dr. Aziz M. Mhamuad et al. [6], has Study the problem of heat transfer for perforated fins under natural convection. They take 15 fins with different perforation dimension with uniform cross-sectional area of 100x270mm and constant fin thickness. The patterns of perforations include 18 circular perforations (holes). Experiments were carried out in an experimental facility that was specifically design and constructed for this purpose. The results show that decreasing the perforation dimension decrease heat transfer rate.

Abdullah H. Al Essa et al. [7], has study the enhancement of natural convection heat transfer from rectangular perforation in fin body of aspect ratio of two by using finite element techniques. The study investigated the gain in fin area and of heat transfer coefficients due to perforations. The study shows that for certain values of perforation dimension, heat transfer rate increases. Enhancement in heat transfer is proportional to fin thickness and its thermal conductivity and it is function of the fin dimension. Geometrical analysis preferred for calculation of heat transfer rate.

Wadhah Hussein Abdul Razzaq Al- Doori et al. [8], has study and investigate heat transfer rate from rectangular fin with circular perforation. The pattern of perforation including 24 circular perforations with increment of 8 from first fin until 56 no of perforation which is distributed in 14 Columns and 4 rows. Experiments were carried through in an experimental facility that was specifically design and constructed for this purpose. The study shows that temperature along the perforated fin length higher than that for the equivalent non perforated fin. The gain in heat dissipation rate for the perforated fin is a strong function of the perforation dimension and lateral spacing. Decreasing the perforation dimension reduces the rate of temperature drop along the perforated fin.

Raaid R. Jassem [9], has investigated natural convection heat transfer rate in rectangular perforated fin plates. Five fins used with one non perforated and each of different shape perforation which includes circle, square, triangle, and hexagon while keeping cross-section same of each perforation. Experiments produced through in an experimental facility that was specifically design and constructed for this purpose. The study results show that temperature drop takes place along fin length higher in perforated fin than non perforated. The gain in heat dissipation rate for the perforated fin is a strong function of the perforation dimension and lateral spacing. The largest value of RAF at triangular perforation and the smaller value occurred in circular perforation. Also, triangular perforation gives best values of heat transfer coefficient and then the circular, square, hexagonal, and non-perforation respectively. Decreasing the perforation dimension reduces the rate of temperature drop along the perforated fin. Heat transfer coefficient for perforated fin that contained a larger number of perforations higher than the perforated fin that contained a small number of perforations.

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Sujith Kumar C. S et al. [10], has study and investigate heat transfer rate and pressure drop characteristics of CNT coated stainless steel substrate in a rectangular macro channel with water as the working fluid. The convective heat transfer rate with laminar and turbulent flow was calculated with Reynolds number varying from 500-2600. The temperature drop was compare with non coated counterpart. The results show that CNT coated surface enhances the heat flux when compared to an uncoated surface due to surface roughness which causes surface turbulence. The pressure drop not much affected by coating.

R. Senthilkumar et al. [11], used a rectangular aluminium fin for experiment to find out convective heat transfer rate. The fin was coated with Carbon nanotube using PVD process. The heat transfer rate with and without coating were investigated and compare each other. The temperature and heat transfer characteristics were investigated using Nusselt, Grashof, Prandtl and Rayleigh numbers and also optimized by Taguchi method and ANOVA analysis. The average percentage of increase in fin efficiency is 5 %.

III. CONCLUSION

The present review paper brings about effect of perforation and CNT coating on heat transfer enhancement. It is found that for certain amount of perforation and its spacing increase the heat transfer rate with reduction in weight of material but it is not surely given that how much amount perforation required for given size and thickness. It also found from review CNT coating increase heat transfer rate in some extent so it is useful to researcher to find out heat transfer enhancement by using compound technique i.e. combination of perforation and CNT coating which will definitely increase heat transfer rate much more than today.

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