iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 Issue: III Month of publication: March 2015

DOI:

www.ijraset.com
IC Value: 13.98

Volume 3 Issue III, March 2015
ISSN: 2321-9653

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Review on Heat Transfer Enhancement Through Fins Using Surface Modifications

Ashish Dixit
Amity University, Gwalior, Madhya Pradesh

Abstract: Extended surfaces are employed in many engineering applications such as heat exchanger, chemical reactor and micro-electronic devices; hence many techniques have been investigated on enhancement of heat transfer rate. Bergles classified heat transfer intensification methods in to three categories- Active techniques, Passive techniques and combination of these two. But it has been reported that in many cases heat transfer enhancement through passive methods are used as this technique do not require any external power source for this purpose.Passive method generally uses surface or geometrical modifications to the flow channel by incorporating inserts, artificial roughness or material removal from the surface. Passive methods when adopted particularly in Heat exchanger applications proved that the overall thermal performance improved significantly. This paper presents the review on heat transfer enhancement using passive methods and explores how extended surfaces with geometrical modifications like dimples, protrusions, grooves etc., improves heat transfer characteristics.This information is useful for future use of the geometrical modifications of extended surfaces based on the space availability and cost.

Keywords:Heat Transfer Enhancement, Extended Surface, Passive Methods

I. INTRODUCTION

Removal of excessive heat from heated surface at a sufficient rate is essential to avoid overheating and burning effect. Overcoming this sort of problem is only possible by a more effective heat transfer. Heat transfer from heated surface can be enhance either by altering the heat transfer surface area or heat transfer coefficient or by altering the temperature difference. But in most of the cases it has been reported that the most promising technique to intensify the heat transfer rate is increasing surface area by means of extended surfaces called fins.The method of improving the performance of a heat transfer system is referred as the heat transfer enhancement technique. Bergles[1,2] classified these augmentation as (i) Passive Techniques (ii) Active Techniques (iii) Compound Techniques.

A. Passive Techniques

These techniques usually employ surface or geometrical modifications to the flow channel by Incorporating inserts or additional devices. 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 causes high degree of turbulence by disturbing the existing flow behaviour and results in higher heat transfer rates. Treated surfaces, rough surfaces, extended surfaces etc. are very common examples of passive heat transfer enhancement technique.

B. Active techniques

This technique uses some external power input for the enhancement of heat transfer ;examples are mechanical aids, surface vibration, fluid vibration, electrostatic fields, suction and jet impingement.

C. Compound techniques

When any two or more techniques employed simultaneously to obtain enhancement in heat transfer that is greater

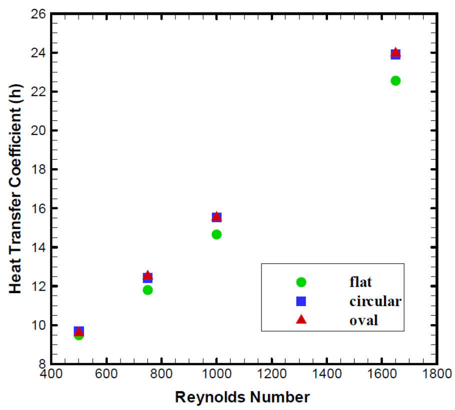
Volume 3 Issue III, March 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

than that produced by either of them when used individually, is termed as compound enhancement. In this paper, an effort has been made to review the heat transfer performance through different turbulators like dimples, perforations, slots and grooves. When air flows over a heated surface an immediate sub viscous layer is formed over the entire heated surface which causes poor heat transfer. In order to get the higher heat transfer rates it is necessary to disturb this sub viscous layer by means of turbulators such as ribs, protrusions, dimples. Numbers of studies have been carried out on optimization of fin geometry by removing the material from fin body in the form of cavities, holes, slots, channels, dimples to increase the heat transfer area and/or the heat transfer coefficient [3-5].Such Turbulence promoters not only break the viscous sub layer but also enable mixing of low velocity air within the viscous sub layer near the surface with the faster flowing air from the outer region of boundary layer which leads to the higher heat transfer.

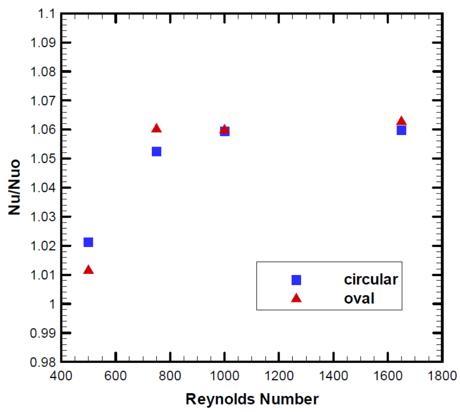
II. REVIEW OF WORK CARRIED OUT

A.B.Ganorkar et al. [6], has review different types of engagements of extended surfaces. Extended surface heat exchangers are simple in construction and broadly used in many of the industries. Continuous efforts is going on to improve its thermal performance 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

D.S.Park[7],has conducted an experimental and numerical investigations to determine whether dimples on a heat sink fin can increase heat transfer for laminar airflows.He has selected two different types of dimples (i) Circular (Spherical) dimples and oval (elliptical) dimples and placed on both sides of a copper plate. For circular dimples he has selected relative pitch of S/D=1.21 and relative depth of δ/D=0.2. For oval dimples For oval dimples, similar ratios with the same total depth and circular-edge-to-edge distance as the circular dimples were used. For these configurations the average heat transfer coefficient and Nusselt number ratio were determined experimentally. For circular and oval dimples, heat transfer enhancements(relative to a flat plate) were observed for Reynolds number range from 500 to 1650 (Reynolds number based on channel height).It has been reported that heat transfer coefficients of the numerical results were very close to the experiment results. Dimples enhanced heat transfer from its surface for laminar air flows while the pressure drop was equivalent or smaller than that of the flat surface.



(a)



(b)

Fig.1

(a) Heat transfer coefficients of the copper plates (b) Heat transfer enhancements on the dimpled plates

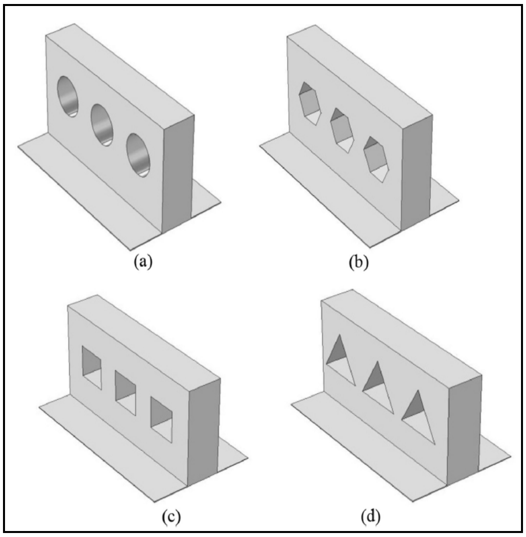
Volume 3 Issue III, March 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Patel et al.[8] has conducted another experimental works on dimpled surface. The objective of his experiment was to find out the heat transfer on dimpled surfaces with inline and staggered arrangements. The results pertaining to dimpled surface was then compared with that of flat surface. Heat transfer coefficients and Nusselt number were measured in a channel with one side dimpled surface. The spherical type dimples of diameter 6 mm and depth 3 mm were fabricated. Keeping channel height constant as 25.4 mm, he has experimented two dimple configurations. The Reynolds number based on the channel hydraulic diameter was varied from 5000 to 15000. He observed significant enhancement in thermal performance of modified surface. With the inline and staggered dimple arrangement, the heat transfercoefficients, Nusselt number and the thermal performance factors were higher for the staggered arrangement.

Ismail et al.[9] performed a numerical study on perforations over the surface to investigate the turbulence behaviour. Thermal and fluid dynamic performances of extended surfaces having various types of lateral perforations with square, circular, triangular and hexagonal cross sections are investigated. RANS (Reynolds averaged NaviereStokes) based modified keu turbulence model is used to calculate the fluid flow and heat transfer parameters. They have taken Flow and heat transfer parameters for Reynolds numbers from 2000 to 5000 based on the fin thickness.They have considered fin dimension as length (L) of 24 mm, height (H) of

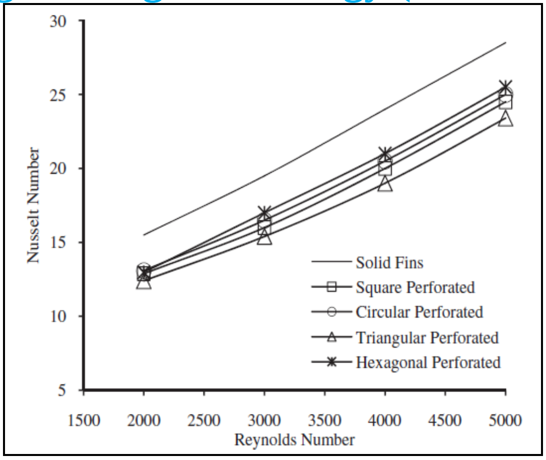
12 mm and thickness (D) of 4 mm. For square perforated fins (two perforation), each square perforation has height (HP) and width (WP) equal to 4 mm and their thickness is equal to fin's thickness.The other types of perforated fin shapes are calculated by keeping the fin volume fixed. The fin's thickness, D is used as the characteristic length to compute the results.

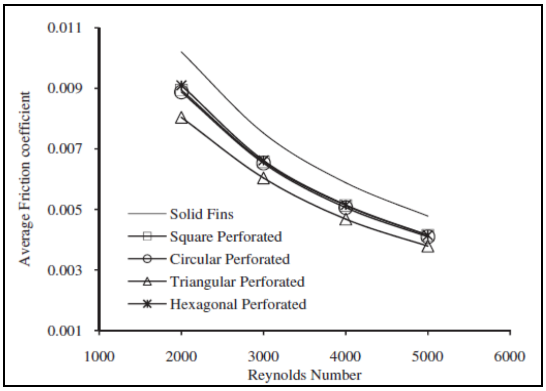
All the results are presented in this study for Reynolds number (Re_D) in the range of $2X10^3$ to $5X10^3$ based on the fin thickness (D). The corresponding Reynolds number based on the fin length is in the range of $1.25X10^4$ to $3X10^4$.



Volume 3 Issue III, March 2015
ISSN: 2321-9653

International Journal for Research in Applied Science & Engineering Technology (IJRASET)





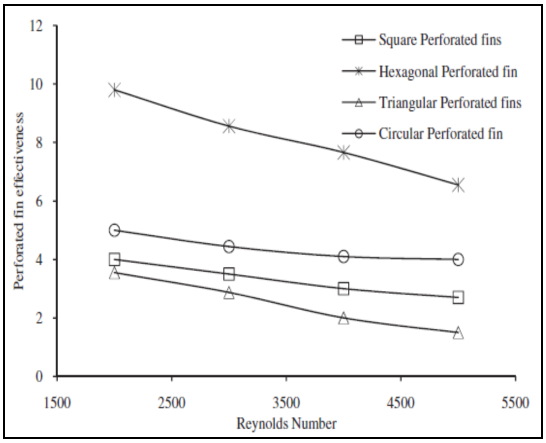


Fig.2

Fig.3
Different types of lateral perforations having same fin variation at Reynolds number

(a)Nusselt Number

International Journal for Research in Applied Science &
Engineering Technology (IJRASET)

Fin volume (a) Circular (b) hexagonal (c) square (b) Variation of skin friction coefficient with Reynolds number
(d) triangular with three perforations (c) Perforated fin effectiveness at different Reynolds number

It has been observed that shape of lateral perforations effects significantly on the thermal performance. Study reveals that fin effectiveness is highest in case of hexagonal perforations where as triangular perforated fins have the lowest and solid fins have the highest Nusselt number values.

III. EXPERIMENTAL INVESTIGATION WITH GROOVED FINS

Number of experimental and numerical studies explores the effect of dimpled,perforated surfaces on thermal performance in the literature. It has been shown experimentally that the heat transfer from extended surface may get affected by the application of grooves of distinct patterns.

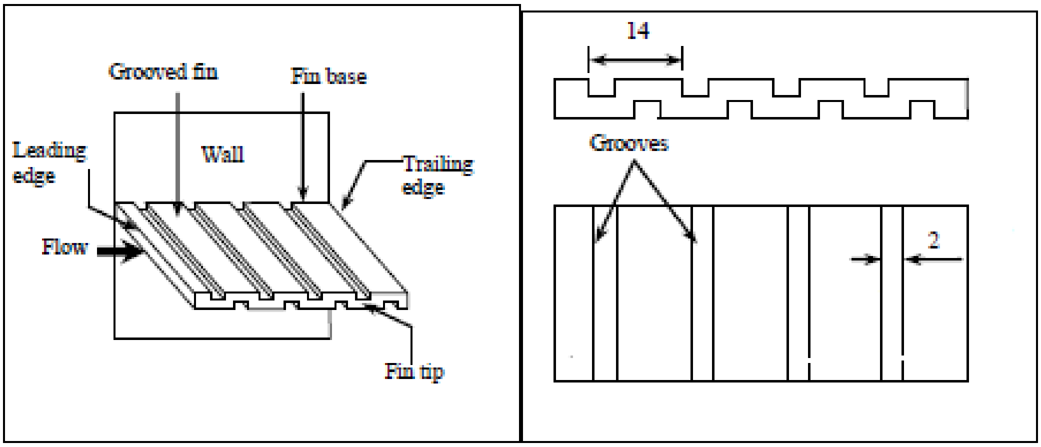
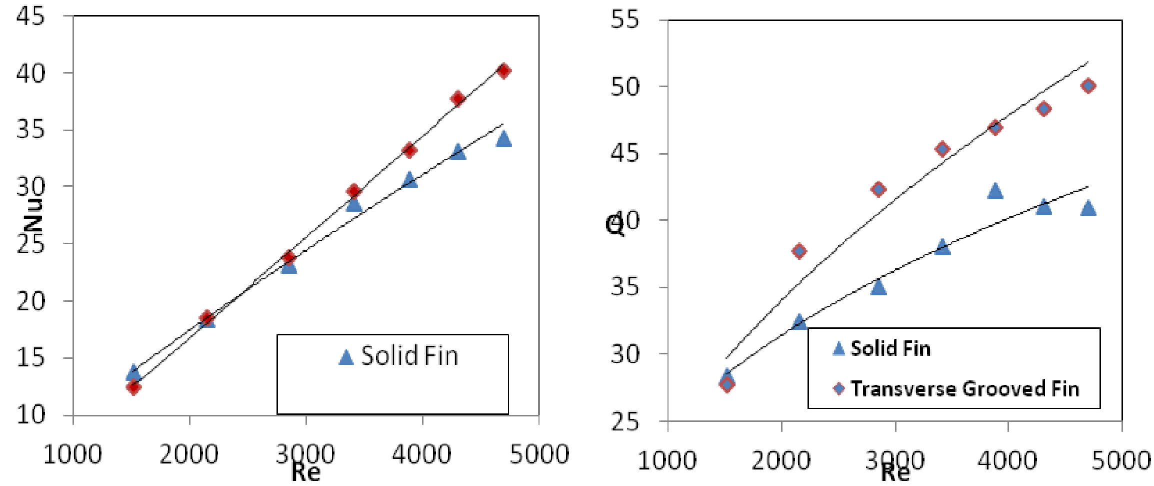


Fig.5
Test fin geometry (250mmx150mm)

In this study transverse grooves are selected and results pertaing to grooved fins are then compared with that of solid fin to get the advantage of this geometrical modification.
Grooved fin effectiveness is also obtained at various fluid flow rates. The results pertaining to heat transfer from grooved fin is discussed in the form of plots. Figure 5(a) shows the variation of Nusselt number with the change in the values of Reynolds number for fin with different groove geometries and a solid fin without grooves. It can be observed that the values of Nusselt number is increased with an increase in the values of Reynolds number for all the fin geometries.
The plots reveals that the presence of grooves brings out considerably higher values of Nusselt numbers at all the values of Reynolds number.In order to understand the effect of grooves on fin surface at different flow rates, the heat transfer rates from the grooved fin is plotted as a function of flow reynolds number in figure.5(b).



(a) (b)

Fig.5

(a) Variation of Nusselt number with flow Reynolds number

(b) Variation of heat transfer with flow Reynolds number

It is observed that the heat transfer rate from the fin and un-finned surface to the surrounding fluid is affected by the geometry of fin and the fluid flow rates. The fin geometry controls the fluid behaviour inside the boundary layer, which is developed over the fin surface.

Plot reveals that the heat transfer rate increases with the increase in reynolds number and attains maximum at about reynolds number of 4560.It is seen that the heat transfer rates from the grooved fin remain highest at all the values of reynolds number while comparing with the solid fin. The maximum heat transfer rate is obtained as 52.5 Watts corresponding to the reynolds number of 4560.

IV. CONCLUSION

Heat transfer data pertaining to grooved fins are obtained and shown in the form of plot and figures.he heat transfer through the plane fin is lesser than that of dimpled, perforated and grooved fins. As the flow passes over the surface of modified fins high degree of turbulence takes place.Sub boundary layer which is formed over the entire heated surface, will get iturrepted due to this turbulence and hence overall average heat transfer coefficient get increased.

REFERENCES

[1] A. E. Bergles, Handbook of Heat Transfer, McGraw-Hill, New York, NY, USA, 3rd edition, 1998.

[2] A. E. Bergles, "The implications and challenges of enhanced heat transfer for the chemical process industries," Chemical Engineering Research and Design, vol. 79, no. 4, pp. 437–444, 2001.

[3] B. V. S. S. S. Prasad and A. V. S. S. K. S. Gupta, "Note on the Performance of an Optimal Straight Rectangular Fin With a Semicircular Cut at the Tip", Heat Transfer Engineering**, 14**(1998).

[4] B. T. F. Chung and J. R. Iyer, "Optimum Design of Longitudinal Rectangular Fins and Cylindrical Spines with Variable Heat Transfer Coefficient", Heat Transfer Engineering, **14**(1993), pp. 31–42.

[5] S. Kakac, A. E. Bergles, and F. Mayinger, Heat Exchangers, Thermal-Hydraulic Fundamentals and Design. Hemisphere Publishing Corporation, 1981.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

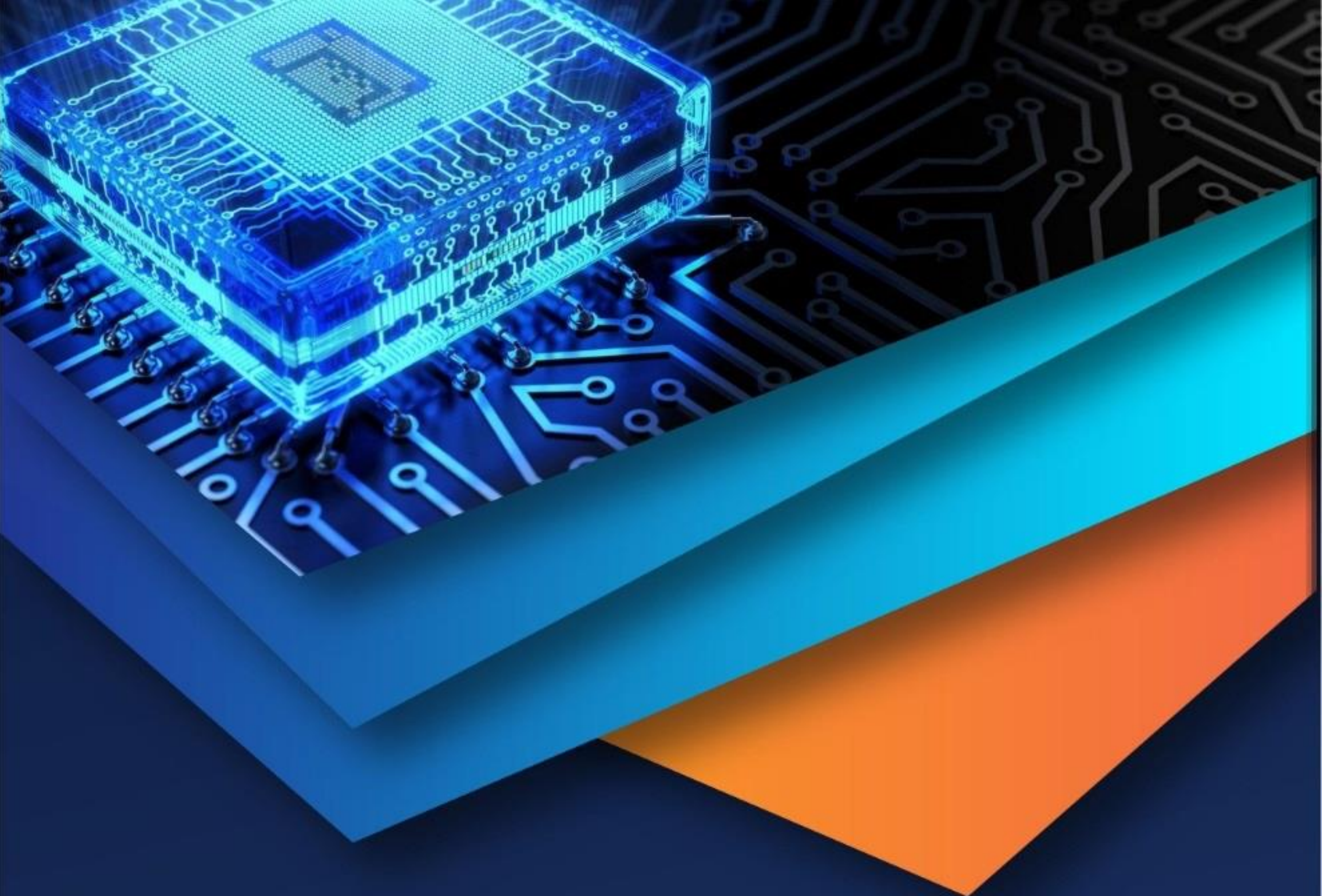
[6] A.B.Ganorkar, V.M.Kriplani, "Review of Heat Transfer Enhancement in Different Types of Extended Surfaces", International Journal of Engineering Science and Technology, Vol. 3 No. 4, pp.3304-3313, 2011.

[7] D.S.Park," Experimental and Numerical Study of Laminar Forced Convection Heat Transfer for a dimpled Heat Sink", A Thesis submitted to the Office of Graduate Studies of Texas A&M University.

[8] Iftikarahamad H. Patel,Sachin L. Borse, "Review Experimental Investigation Of Heat Transfer Enhancement Over The Dimpled Surface", International Journal of Engineering Science and Technology, Vol. 4 No. 8, 2011.

[9]Farhad Ismail,Muhammad Noman Hasan,Suvash C. Saha," Numerical study of turbulent fluid flow and heat transfer in lateral perforated extended surfaces", Energy 64 (2014) 632-639.

[10]*Dixit and Patil,"Heat Transfer Characteristics of Grooved Fin Under Forced Convection",Heat Transfer Engineering,Vol.36,No.13,2015 (In Press)



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY