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Numerical and Experimental Investigation Plane Fin with the Help of Passive Augmentation Method

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Abstract: *As we know that fins are basically a extended surface which is use to increase the heat transfer rate, this is basically a secondary surface mounted on primary surface to augment heat transfer from it . To dissipate heat at faster rate, different heat transfer enhancement methods have been suggested in literature. Active and passive heat transfer techniques are commonly employed for heat transfer augmentation in fluids.*
Recent development in technology has led to demand for high performance lightweight, and compact heat transfer equipment. To provide accommodation with this demand, finned surface are usually used to increase rate of heat transfer. The excessive heat must be dissipated to the surrounding for smooth functioning of system. This is more important in cooling of gas turbine blade, thermal power plants, air conditioning equipment and electrical / electronic component. This component is getting more compacting size, which generates heat continuously. This excessive heat will reduce the life of component. To overcome this problem there is need of effective cooling system. Therefore now a day's industries are utilizing thermal system such as ribs, fins, baffles etc. The turbulence occurred due to these passive techniques are good enough to increase rate of heat transfer. Our project is an extension in this direction to analysis the heat augmentation capacity of rectangular heat fin array.
Keywords: *Extended surfaces, heat exchangers, passive techniques, heat transfer enhancement, free and forced convection.*

I. Introduction

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.

1.1. Types Of Augmentation Techniques: -

They are broadly classified into three different categories:

(i) Passive Techniques
(ii) Active Techniques
(iii) Compound Techniques

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.

B. Active Techniques: - In comparison to the passive techniques, these techniques have not shown 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 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.

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. Heat Fin

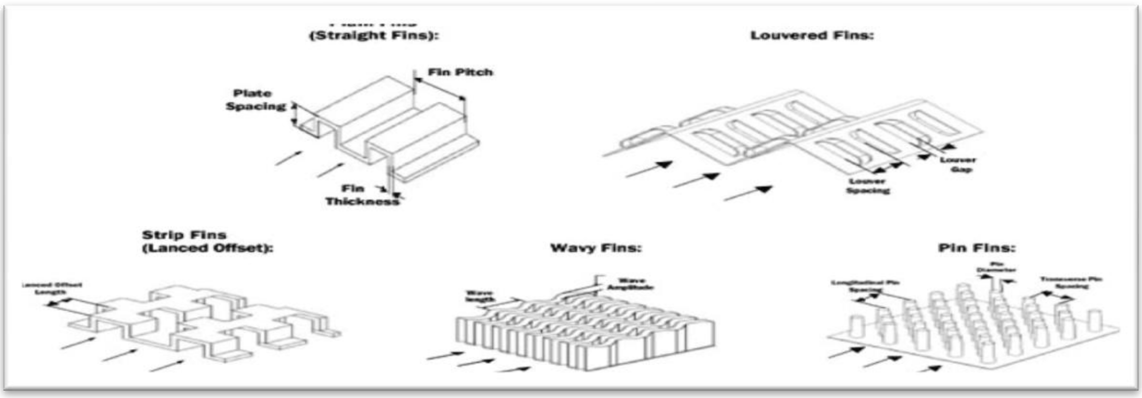
Many engineering systems during their operation generate heat. If this generated heat is not dissipated rapidly to its surrounding atmosphere, this may cause rise in temperature of the system components. This by-product cause serious overheating problems in system and leads to system failure, so the generated heat within the system must be rejected to its surrounding to maintain the system at recommended temperature for its efficient working. The techniques used in the cooling of high power density electronic devices vary widely, depending on the application and the required cooling capacity. The heat generated by the electronic components has to pass through a complex network of thermal resistances to the environment. Passive cooling techniques found more efficient and economic for electronics component. Using fins is one of the most inexpensive and common ways to dissipate unwanted heat and it has been successfully used for many engineering applications. Fins come in various shapes; such as rectangular, circular, pin fin rectangular, pin fin triangular etc. Rectangular fins are the most popular fin type because of their low production costs and high thermal effectiveness. Study of influence of geometric parameters viz. fin length, fin height, fin spacing over heat dissipation found important.

A heat fin transfers thermal energy from a higher temperature device to a lower temperature fluid medium. The fluid medium is frequently air, but can also be water, refrigerants or oil. If the fluid medium is water, the heat fin is frequently called a cold plate. In thermodynamics a heat fin is a heat reservoir that can absorb an arbitrary amount of heat without significantly changing temperature. Practical heat fins for electronic devices must have a temperature higher than the surroundings to transfer heat by convection, radiation, and conduction. The power supplies of electronics are not 100% efficient, so extra heat is produced that may be detrimental to the function of the device. As such, a heat fin is included in the design to disperse heat to improve efficient energy use.

To understand the principle of a heat sink, consider Fourier's law of heat conduction. Fourier's law of heat conduction, simplified to a one-dimensional form in the x-direction, shows that when there is a temperature gradient in a body, heat will be transferred from the higher temperature region to the lower temperature region. The rate at which heat is transferred by conduction, $\mathbf{q_k}$, is proportional to the product of the temperature gradient and the cross-sectional area through which heat is transferred.

$$\mathbf{qk = -kA\frac{dT}{dx}}$$

A variety of extended surfaces like the plain trapezoidal, plain rectangular can perform such function, and we have included the offset strip fin geometry in our present work.



2.1 Types Of Plate Fins

2.1 Plain Fins: -

Plain fins are by far the most common of all compact cores or surfaces used in compact heat exchangers. The plain- fin surfaces are characterized by long uninterrupted flow passages, with performance similar to that obtained inside long circular tubes (Kays and London, 1984).

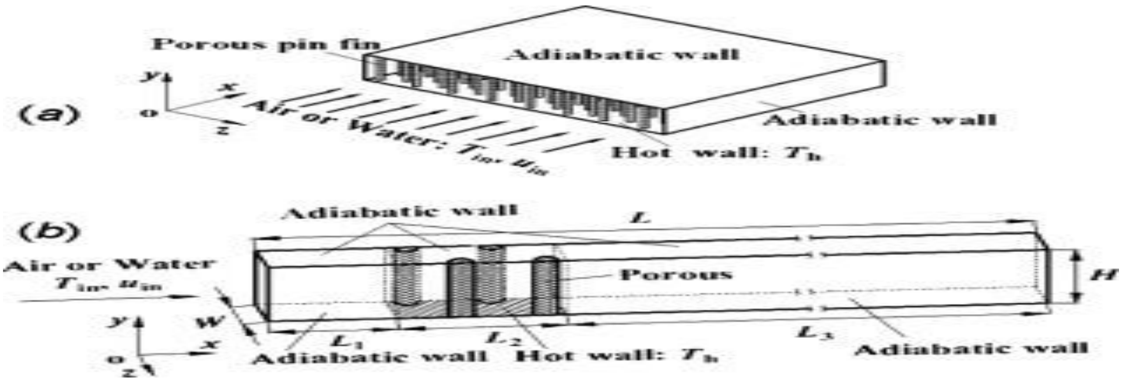
Plain fins are used in those applications where core pressure drop is critical. Their application range from aerospace air conditioning duties to oil refining (Hesselgreaves 2001), among many others. An heat exchanger with plain fins requires a smaller flow frontal area than that with interrupted fins for specified pressure drop, heat transfer and mass flow rate. Of course, the required passage length is higher leading to a larger overall volume. The heat transfer enhancement achieved with plain fins results mainly from increased area density, rather than any substantial rise in the heat transfer coefficient (Brockmeier, et al. 1993).

III. Passive Heat Transfer Techniques Omproved By The Different Researchers

3.1 Jian Yang Min Zeng Qiuwang Wang, Akira Nakayama

The forced convective heat transfer in three-dimensional porous pin fin channels is numerically studied in this paper. The Forchheimer–Brinkman extended Darcy model and two-equation energy model are adopted to describe the flow and heat transfer in porous media. Air and water are employed as the cold fluids and the effects of Reynolds number (Re), pore density (PPI) and pin fin form are studied in detail. The results show that, with proper selection of physical parameters, significant heat transfer enhancements and pressure drop reductions can be achieved simultaneously with porous pin fins and the overall heat transfer performances in porous pin fin channels are much better than those in traditional solid pin fin channels. The effects of pore density are significant. As PPI increases, the pressure drops and heat fluxes in porous pin fin channels increase while the overall heat transfer efficiencies decrease and the maximal overall heat transfer efficiencies are obtained at PPI_20 for both air and water cases. Furthermore, the effects of pin fin form are also remarkable.

With the same physical parameters, the overall heat transfer efficiencies in the long elliptic porous pin fin channels are the highest while they are the lowest in the short elliptic porous pin fin channels.



3.1.1 Physical model: „(a) porous pin fin heat sink and „(b) Representative computational domain
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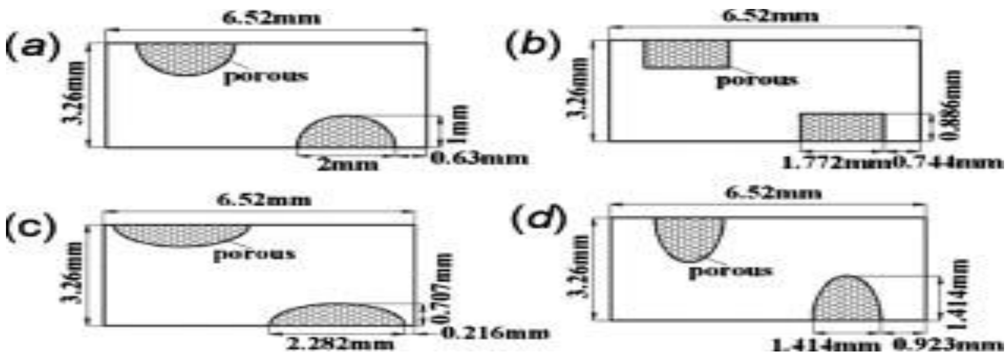


3.1.2 Different forms of porous pin fin cross-section: (a) circular Form (b) cubic form(c) long elliptic form, and (d) short elliptic form

3.2 Markus R¨utten and Lars Krenkel

The main physical mechanisms causing the enhancement of heat transfer is the generation and amplification of sufficiently strong longitudinal vortices which are interacting with the thermal boundary layer.

The stratification of the thermal boundary layer near the heated walls is disturbed by these vortices. The convection of warmer fluid perpendicular to the heated wall and the mixing with colder fluid is intensified, and, additionally, further external momentum is transported into the inner boundary layer region.

3.3 K.S Dhanawade, H. S. Dhanawade

The present paper reports, an experimental study to investigate the heat transfer enhancement in rectangular fin arrays with circular perforation equipped on horizontal flat surface in horizontal rectangular duct. The data used in performance analyses were obtained experimentally by varying flow, different heat inputs and geometrical conditions. The experiment covered Reynolds number range from 3000-6000, based on the flow average inlet velocity and hydraulic diameter. Clearance ratio (C/H) 0.45, inter-fin spacing ratio (S/H) 0.22, duct width 150mm, height100mm and fin size of both solid and perforated (weight reduction) were 100mm x 55mm x 3mm. For various heat inputs and flow rates values of Reynolds and Nusselt number were obtained. The results of perforated fin arrays have been compared with its external dimensionally equivalent solid fin arrays. It shows that enhancement in heat transfer of perforated fin arrays than solid fin arrays.

IV. Experimental Analysis Of Heat Fins

5.1 parallel fin: -

5.1 Parallel Fin

Dimension

Length – 100 mm Breadth – 60 mm Thickness – 05 mm Convective heat transfer area – 6784 mm^2

Material used – Aluminium

Thermal conductivity – 200 W/m-k

Time (min)	Voltage (V)	Current (mA)	Fin Temperature (^{0}c)	Air Temperature (^{0}c)	Air Velocity (m/sec)
0	230	10	40.0	33.5	105
2	230	10	42.5	35.7	105
4	230	10	46.3	36.7	105
6	230	10	50.4	37.2	105
8	230	10	54.6	38.2	105
10	230	10	58.7	38.2	105
12	230	10	58.9	38.3	105

5.1.1 Observation Of Parallel Fin:

Heat Analysis of fin: -

Properties of air

T_s = 331 K,

T_∞ = 311 K

Mean Temperature = $\frac{Ts+T\infty}{2}$

$= \frac{331+311}{2}$

= 321 K

Properties of air at 321 K

ρ = 1.1614 Kg/m^3 Cp = 1.007 KJ/Kg-K $\mu = 184.6 \times 10^{-7}$ NS/m^2 $\upsilon = 15.89 \times 10^{-6}$ m^2/s

$K_{air} = 26.3 \times 10^{-3}$ W/m-K P_r = 0.707 d = 4A/p = 0.1125 m

Reynolds Number $R_e = \frac{\rho vd}{\mu} = 7.455\times 10^5$

Prandtl Number Pr = $\frac{\mu Cp}{Kair} = \frac{184.6 \times 10{-}7{\times}1.007}{26.3 \times 10{-}3}$

= 0.707

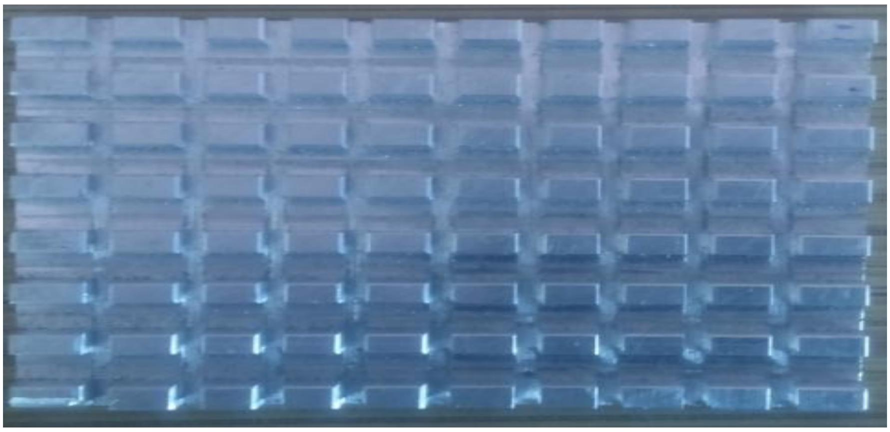
The empirical relation for heat convective coefficient in forced convection is given by-

$\frac{hd}{Kair} = 0.023(R_e)^{0.8}(Pr)^{0.4}$

By the above relation the heat convective coefficient (h) can be calculate

h=233.3 W/m^2-K

5.2 Cross Fin: -



5.2 Cross Fin

Dimensions: -

Length – 100 mm Breadth – 60 mm Thickness – 05 mm Convective heat transfer area – 11,824 mm^2 Material used – Aluminium

Thermal conductivity – 200 W/m-K

5.2.1 Observation Of Cross Fin: -

Time (min)	Voltage (V)	Current (mA)	Fin Temperature (^{0}c)	Air Temperature (^{0}c)	Air Velocity (m/sec)
0	230	10	31.7	31.9	105
2	230	10	40.0	35.1	105
4	230	10	42.8	36.0	105
6	230	10	43.8	37.1	105
8	230	10	44.3	38.2	105
10	230	10	45.5	39.3	105
12	230	10	46.1	40.3	105

5.1.2 Table Of Observation Of Cross Fin

Heat Analysis of fin: -

Properties of air

T_s = 319.1 K, T_∞ = 313.1 K

Mean Temperature = $\frac{Ts+T\infty}{2}$

$= \frac{319.1+313.1}{2} = 316.1$ K

Properties of air at 316.1 K

ρ = 1.2780 Kg/m^3 Cp = 1.0065 KJ/Kg-K $\mu = 172.1 \times 10^{-7}$ NS/m^2 $\upsilon = 13.665 \times 10^{-6}$ m^2/s

$K_{air} = 24.3 \times 10^{-3}$ W/m-K $P_r = 0.707$ d = 4A/p = 0.1125 m

Reynolds Number $R_e = \frac{\rho v d}{\mu}$

$= \frac{1.2780 \times 105 \times 0.1125}{172.1 \times 10-7}$

$= 8.6 \times 10^5$

Prandtl Number Pr = $\frac{\mu Cp}{Kair} = \frac{172.1 \times 10-7 \times 1.0065}{24.3 \times 10-3}$

= 0.71

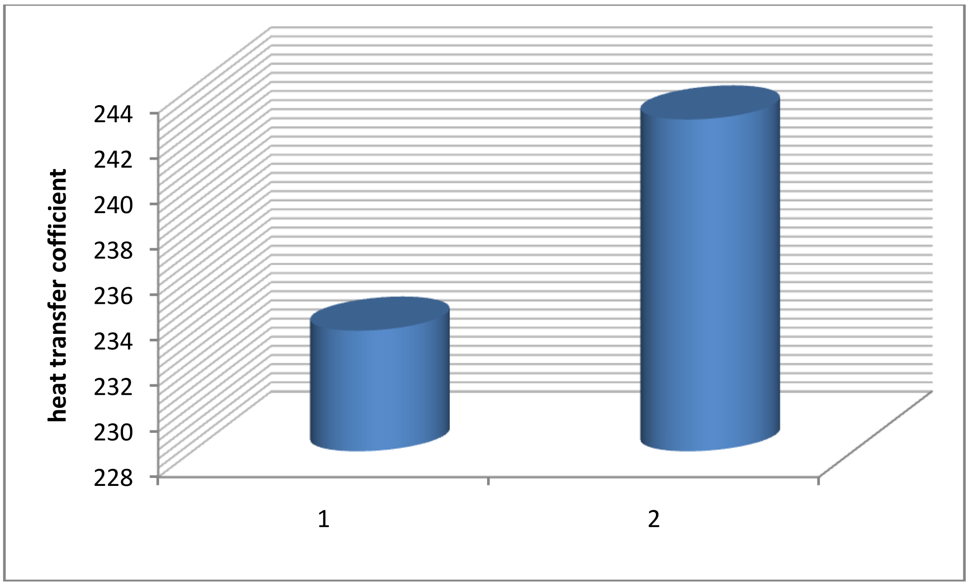
The empirical relation for heat convective coefficient in forced convection is given by-

$\frac{hd}{Kair} = 0.023(R_e)^{0.8}(Pr)^{0.4}$

By the above relation the heat convective coefficient (h) can be calculate

h=242.58 w/ m2-k

V. Result



Fin	Single cut	Double cut
Heat transfer coefficient	**233.30**	**242.58**

Double cut roughness is better than single cut fin. Disturbance in flow help to more increase the rate of heat transfer.so using passive methods help to increase the rate of heat transfer with little change in geometry.

VI. Conclusion:

Many researchers are taking interest to enhance heat transfer rate with passive methods. dimple, protrude and rough surfaces etc passive methods are used in heat exchangers, air heaters and heat sinks to enhance heat transfer. Passive methods can easily manufacture and applicable too. We need to work on compound technique, surly it will augment more heat transfer than other methods.

References

[1] Jian Yang Min Zeng Qiuwang Wang, Akira Nakayama “Forced Convection Heat Transfer Enhancement by Porous Pin Fins in Rectangular Channels” IEEE transactions on components and packaging technologies , vol. 27, no. 4, December 2004
[2] “Heat Transfer Enhancement by Using Vortex Generators” 5th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008) June 30 –July 5, 2008 Venice, Italy
[3] K. H. Dhanawade, H. S. Dhanawade“Enhancement of Forced Convection Heat Transfer from Fin Arrays with Circular Perforation” IEEE 2010.
[4] M.J. Sable, S.J. Jagtap , P.S. Patil , P.R. Baviskar & S.B. Barve“enhancement of natural convection heat transfer on vertical heated plate by multiple v-fin array” IJRRAS 5 (2) ● November 2010.
[5] Abdullah H. AlEssa and Mohammed Q. Al-Odat “enhancement of natural convection heat transfer from a fin by triangular perforations of bases parallel and toward its base” The Arabian Journal for Science and Engineering, Volume 34, Number 2B, October 2009.
[6] Kai-Shing Yang, Kuo-Liang Wun, Ing Youn Chen, Chi-Chuan Wang “Experimental Investigation of High Performance Thermal Module with Dimple Vortex Generators” Department of Mechanical Engineering, National Chiao Tung University, Hsinchu Taiwan 300.
[7] Sandeep S. Kore, Satishchandra V. Joshi, Narayan K.Sane “experimental investigations of heat transfer enhancement from dimpled surface in a channel” ISSN : 0975-5462 Vol. 3 No. 8 August 2011
[8] S. V. Iyer and K. Vafai, , “passive heat transfer augmentation in a cylindrical annulus utilizing a porous perturbation” 18th Avenue, 1999,Columbus, OH 43210-1107,USA.
[9] A. Vikrant Katekar B. Ankur VithalKar C. Bhojraj Kale “enhancement of convective heat transfer coefficient in solar air heater of roughened absorber plate” Second International Conference on Emerging Trends in Engineering and Technology, ICETET-09