REVIEW ON CIRCULAR PIN FINS IN FORCED CONVECTION

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ABSTRACT

Heat transfer is a discipline of thermal engineering that concerns the generation, use, conversion, and exchange of thermal energy (heat) between physical systems. Heat transfer is classified into various mechanisms, such as thermal conduction, thermal convection, thermal radiation, transfer of energy by phase changes. Engineers also consider the transfer of mass of differing chemical species, either cold or hot, to achieve heat transfer. While these mechanisms have distinct characteristics, they often occur simultaneously in the same system. Pin fins are used to increase heat transfer from heated surfaces to air. Industrial experience has shown that for the same surface area, pin fins can transfer considerably more energy than straight fins. The analysis of a single pin fin is well known. However, when fins are placed in an array, the convective patterns become interrelated, and the resulting heat transfer coefficient has not been predicted. This investigation suggests that the most important geometric parameter influencing the heat transfer from pin fin arrays is the ratio of the fin diameter to the center-to-center spacing

Keyword : - *Aluminum, Circular, CFD, Dropped, Iron Stainless-Steel.*

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1. INTRODUCTION

In present analysis, it is important to know which turbulence model should be used to get accurate flow pattern inside the cyclone. In cyclone the flow pattern has high turbulence; K-epsilon and K-omega model are good for backflow and linear flow problem where the chances of small backflow are expected. However, in case of cyclone the flow is highly swirl and for such a case Reynolds Stress turbulence model is preferred. Reynolds stress turbulence model include the fluctuated velocity term with constant velocity term. The shear stress in fluid is given by Newton law of viscosity, which include the velocity term. This is replaced by the Reynolds fluctuating velocity, the shear stress obtained by this is not an isotropic and hence varies for various flow direction. Fluent solve seven equations in RST model in which three for momentum equation three for shear stress and one for mass balance.

For generation of mesh or number of nodes first we go to the MESH modelled and MESH option which is located at fluent tree press the GENERATE MESH button. It will create the automatic number of grids. Then we require modify the grid for accurate results will be come but we are not make so fine mesh because it increase computational time. For generating mesh go to the sizing option then select the edge for making the division and then specify the number of division. In the numerical analysis problem the grid independent test is important test. This test is useful to examine the number of grid in dependent or independent of the number of grids. In the numerical problem the results and the computational time are always depends up on the number of grid generated. So if we modification the quantity of grid the results is altered. While fluctuating the number grids a time may come when the results are independent of the number of grids. The least number of grids after which there is no alteration in results is observed is known as optimum grid size and the results were independent of grids.

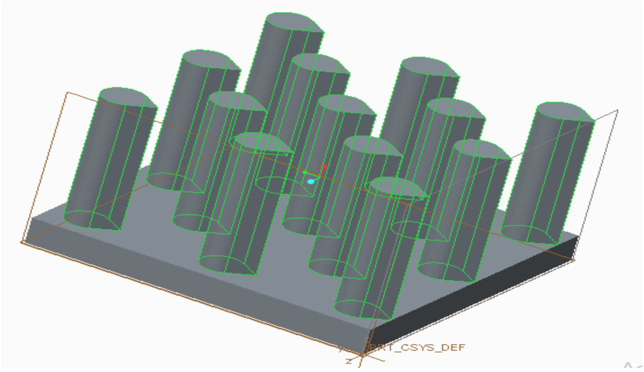

Figure -1: dropped shaped fins by using PTC Creo 3.0

2. PROBLEM IDENTIFICATION

In modern engineering applications like air conditioning, cooling of nuclear reactor fuels, internal combustion engines as well as in electronic devices & solar energy applications, heat dissipation has been a major problem & a challenge to thermal engineers. In this paper, performance of pin fin of three different materials (Aluminium, Brass & stainless steel) is studied. The influence of design parameters like the pin fin length, diameter & fin material on thermal efficiency of the natural convection heat sink is evaluated using the experimental setup prepared by graphical programming language with Lab VIEW (Laboratory Virtual Instruments for Engineering Workbench). The result show efficiency of Aluminium is highest followed by Brass and steel respectively

1.The heat transfer rate is less in 1-directional heat flow model as well as in natural convection.

2.The surface area of circular pin fin is less comparing to dropped shape of pin fin.

3.Heat Transfer rate is not uniform in 1-directional flow of fluid.

4.Due to circular shape of pin fins more materials are required which result in more cost.

Before designing and developing new types of heat sinks, it is important to study and understand the work which has been done in this field. This paper reviews previous work done on heat sinks. Various parameters such as effect of interruptions, arrangement, geometry and material are considered. Important findings from these works are presented. The results from these studies show that perforations on fins do enhance the heat transfer rate. The material with highest thermal conductivity has highest heat transfer rate when used as heat sink. Arrangement of fins is an important factor as heat transfer rate is different for different arrangements.

4. LITERATURE REVIEW

1. Dr.A.T.Autee et al**,** This paper gives the experimental analysis of heat transfer over a flat surface equipped with Square perforated pin fins in staggered arrangement in a rectangular channel. The Fin dimensions are 100mm in height & 25mm in width. The range of Reynolds number is fixed & about 13,500– 42,000, the clearance ratio (C/H) 0, 0.33 and 1, the inter-fin spacing ratio (Sy /D) 1.208, 1.524, 1.944 and 3.417. Sy i.e. stream wise distance is varies and Sx i.e. span wise distance is constant. The friction factor, enhancement efficiency and heat transfer correlate in equations with each other. Here we are comparing Square pin fins with cylindrical pin fins. Staggered arrangement and perforation will enhance the heat transfer rate. Clearance ratio and inter-fin spacing ratio effect on enhancement efficiency. Both lower clearance ratio and lower inter-fin spacing ratio and comparatively lower Reynolds number give higher thermal performance. Friction factor & Nusselt number are key parameter which relates with efficiency enhancement and heat transfer rate.

2.Amol B. Dhumne et al**,** the present paper gives the experimental analysis of on heat transfer enhancement and the corresponding pressure drop over a flat surface equipped with cylindrical cross-sectional perforated pin fins in a rectangular channel. The channel had a cross-sectional area of 250-100 mm2. The experiments covered the following range: Reynolds number 13,500–42,000, the clearance ratio (C/H) 0, 0.33 and 1, the inter-fin spacing ratio (Sy/D) 1.208, 1.524, 1.944 and 3.417. Nusselt number and Reynolds number were considered as performance parameters. Correlation equations were developed for the heat transfer, friction factor and enhancement efficiency

3. Ganesha T et al, in this paper, Experimental Investigation on Tapered Cylindrical with and without Perforated Pin Fins with Inline and Staggered Fins Array using Natural and Forced Convection, for a constant heat flux of 85 Watts over all the arrangements at varying air velocity from 1m/s to 5m/s. The taper pin fin is made out of Aluminium 6061 having dimensions of base diameter 20mm, top diameter 10mm and length 80mm. The number of pin fin used in inline and staggered arrangement are 9 and 8 respectively Constant clearance ratios (C/H) and inter fin distance ratio (Sy/D) 1.25 were used. The heat transfer takes place through a rectangular base plate with fins held in a rectangular tunnel. The Nusselt number and Reynolds number were considered as performance parameters. Correlated standard equations are used for finding the values of heat transfer coefficient, Reynolds number, Nusselt number and Effectiveness. By concluding all the result perforated taper cylindrical inline pin fins have higher heat transfer capability.

4.Manikandan C. et al. presented a CFD-based simulation study using ANSYS 15.0 to evaluate temperature and pressure drop in a perforated drop-shaped pin fin heat sink. Heat transfer increased by converting circular fins into staggered perforated drop shapes under constant heat flux. These drop fins, having the same cross-sectional area, caused delayed airflow through the fins, leading to greater thermal dissipation. Transient flow conditions were applied to ensure better simulation accuracy. The drop- shaped fins were found to outperform circular and rectangular fins in thermal performance.

5. DESIGN AND ANALYSIS

The design modeled pin fins for experimentation are shown in In this experimentation three materials are chosen i.e. stainless-steel ,Aluminum and Iron with dropped and circular shaped geometries respectively,

		
Aluminium circular	Aluminium Dropped	Stainless-steel circular
		
Stainless-Steel Dropped	Iron circular	Iron dropped shaped

Figure -2: different geometries of fins

5. DATA DEDUCTIONS

5.1:Heat transfer rate (Q) calculation

$Q=h^{*}A_s^{*}(\Delta T)$ (1)

Where,

Q - Heat transfer rate, KJ/s or watt

hs – Convective heat transfer coefficient, W/m^2 ^{0}c A - Area m^2

ΔT - Temperature difference, K Cp -Specific heat, KJ/Kg * K

m - Mass flow rate, Kg/s

5.2 :Surface Area (As) Calculation

As= (b*L) + (π*r^2*h) * N (For circular shape pin fin)

= (0.15*0.25) + (π*0.01*0.07) * 20

= 0.0376 m^2

As=(b*L) + ((π*d*H/2) +(L*b*H/2)) *N (For drop shaped pin fin)

= (015*0.25) + ((π*0.1*0.07/2) +(0.010*0.010*0.07/2))*20

= 0.0592 m^2

Where,

b= Width of base plate=150mm=0.15m d= diameter of pin fin = 10mm=0.1m

L= Length of base plate = 250mm=0.25m H=Height of pin fin =70mm=0.07m

N= Number of pin fins = 20 From Equation number (4) h=85.641 W/m^2k

5.3 Nusselt Number Calculation (Nu)

Nu= h.L/K

= 85.41*0.1875/0.025

= 642.30

Where,

h= Convective heat transfer coefficient (W/m^{20}c) L= Characteristic length (m)

= For Rectangular Duct L=4(a*b)/2(a+b)=0.1875m K= Thermal conductivity (W/m^0c)=0.025(W/m^0c)

6. CONCLUSION

Extended surface heat exchangers are easy in construction and extensively use in many of the industries. Continuous research is going on to improve its effectiveness by reducing the thermal boundary layer thickness and increasing the heat transfer surface area. Perforations in the fins one way that used to improve its effectiveness. An experimental study submitted to investigate the heat transfer by natural convection in a rectangular perforated fin plate. Five fins used in this work first fin non-perforated and others fins perforated by different shapes these fins perforation by different shapes (circle, square, triangle, and hexagon) but these perforations have the same cross section area (113 mm^2). These perforations distributed on 3 columns and 6 rows. Experiments produced through in an experimental facility that was specifically design and constructed for this purpose. The results show that the drop in the temperature of the non-perforated fin from 72 to 57^0C while the temperature drop in perforated fins, at the same power supplied (126 W) was (72-52^0C), (72-51.5^0C), (72-50^0C) and (72 -48^0C) for shapes (hexagonal, square, circular and triangular) respectively. 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.

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