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Experimental Study for Counter to Cross Flow Fin- tube Air Cooled Heat Exchanger with internal circular Grooving at different pitches

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ABSTRACT

In this manuscript we have learned four types of Fin-tube Air-Cooled Heat Exchanger (ACHE) design with rounded inner circles in a separate area with rectangular copper wings. In the proposed design we find the average value of the heat transfer counter for crossing the flow rate of the cooling air of the natural convection exchange is 3010.68 watt, 3110.53 watt, 3129.56 watt and 3151.50 watt in a different grooving area at 0 mm [without , 15 mm, 10 mm and 5 mm respectively. similarly for convection compression values the average heat transfer counter for the flow rate of the cooling air tube is 3044.25 watt, 3125.65 watt, 3154.85 watt and 3190 watt in a different grooving area at 0 mm [excluding grooving], 15 mm, 10 mm and 5 mm respectively. The value of the heat transfer function of the test set, using a rotating aluminum inner tube with rectangular brass fins 6.011, 6.484, 6.891, and 7.485 in a separate grooving hole in the 0 mm eg empty tube (excluding grooving), circle grooving pitch by 15 mm, round grooving pitch by 10 mm and circular grooving pitch by 5 mm respectively .In this experimental setting we check that with the circular heat transfer of the grooving concentric aluminum tube with copper wings is the highest in place 15 mm round clipping

Keywords : Fin tube Air-cooled heat exchanger (ACHE), Rate of heat transfer, effectiveness, Circular grooving pitch , capacity ratio, rectangular fin.

I. INTRODUCTION

Heat exchanger are devices that provide the flow of thermal energy between two are more fluids at different temperature heat exchanger are used in wide variety of applications. These includes power production , process chemical and food industries , electronics , environmental engineering , waste heat recovery , manufacturing industries air conditioning and refrigeration and space application [1]. Heat exchanger may be classified according to following main criteria.

- Recuperater / regenrators.
- Transfer process: direct and indirect contact.
- Geometry of construction: tubes, plates and extended surfaces.
- Heat transfer mechanism: single phase and two phase.
- Flow arrangements: parallel ,counter and cross flow.
- Cooling medium: water cooled and air cooled

On the basis of cooling medium heat exchanger may be classified as water cooled heat exchanger and air cooled heat exchanger.Becuase unavailability of water air cooled heat exchanger is commonly used in indusries .In Air cooled Heat Exchanger the cold air flows over the outside of inside scored balance tube with a fan to upgrade the heat move region.

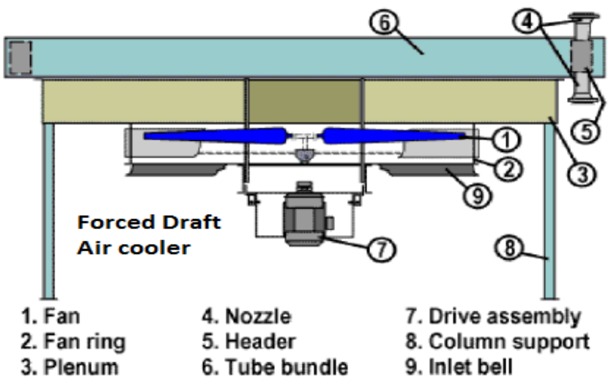


Figure 1. Schematic diagram of basic experimental set-up.

In ACHE hot fluid is flows with constant pressure and constant discharge rate[2]. Air cooled heat exchanger (ACHE) are broadly into three type viz. Forced draft, Induced Draft and Natural Draft The rate of heat transfer is depends on surface area, mass flow rate ,overall heat transfer coefficient and thermal conductivity of fluid.

Materials play very important role in the designing of heat exchanger [3] and defining its performance parameters such as heat transfer rate. There are several material tools used to improve the performance of heat exchangers such as internal and external grooving, shape of grooving profile such as circular grooving, rectangular copper fins etc. [4]Enhancement of heat transfer can also reduce the size of heat exchangers, reducing in pressure drop provide higher heat transfer efficiency, and yield savings of operating costs and materials. The enhancement of heat transfer is critically important in industrial applications such as process cooling, refrigeration, chemical processing, air separation, etc. Fins or extended surfaces play an important role to augment the rate of heat transfer .

The rest of the paper is organized in five sections. Section II literature review . Section III Design Parameter. Section IV consists the results analysis based on performance parameters [5] Section IV it describe the overall conclusion with best proposed design.

II. LITERATURE REVIEW

Among various established techniques of air cooled heat exchanger (ACHE), internal grooving proposed attractive solutions to to improve the heat transfer rate. However, designing a simple internal grooving ACHE has its own limitations hence introduction of fin based grooved heat exchanger becomes very popular among the researchers in resent time, several researcher work on this concept and get remarkable results. However in latest literature available of ACHE a new concept of varying pitches along with the fin based grooved heat exchanger is also introduced but it need further research. Throughout the years, authors have devoted their investigations to making new designs or changes to the basic ACHE to get better heat exchange rate along with controlled value of other parameters. Some of the noteworthy contribution in the field of heat exchanger is presented in this section which gives us the idea of further research by finding a suitable research gap among the latest research work.

1.Asif Afzal, Mohammed Samee et al. [1]Presents an experimental setup for optimal spacing between the external grooved heat exchanger tube. In this work author presents three different grooved tubes with different spacing (pitches) one of the tube is plain in design on the other hand other two of them having pitches of 10 mm and 15 mm after considering all three design for the heat transfer analysis on the basis of result obtained we conclude the with increase of air velocity (Re) the tube surface temperature with grooves and without grooves gets significantly reduced with respect to plain tube. On the other hand the nusselt number in grooved tube is found to either same or lower than the plain tube due to flow velocity reduction at the surface.

2.C. Nithiyesh Kumar1 and M. Ilangkumaranet al. [2]The present study provides the experimental investigation of thermal performance and exergy analysis in an internally grooved(IG) tube fitted with triangular cut twisted tape insert consisting of alternate wings (TCTT). The analysis is carried out with TCTT for different twist ratio, y = 3.5, 5.3 and 6.5 with attack angle, β = 45° and 90°. The investigations were performed in turbulent regime, with Reynolds number ranging from 3000 to 14,000. . The experimental results reveal that, both the thermal efficiency and energy efficiency of the IG tube equipped with TCTT were found to be increased up to 1.12 and 1.85times, respectively, than those that with plain twisted tape (PTT).The integration of IG tube with TCTT creates synergy effect, which increases the overall performance compared to single ones. This is due to the effect of swirl flow induced by TT, along with vortices generated by wings, which results in thinner boundary layer and increased heat transfer .in the study we also find that the Nu increases with increase in Reynolds number and the average value of Nu for IG tube with TCTT is higher than that for plain IG tube by about 46.1%.

3.Zhisong Liet al. [3]In this work authorproposed a new heat pipe structure, replacing the conventional axial-grooved or sinteredwicks with spiral coil and simple piping container. The proposed heat pipe structure is introduced for its design and operational mechanism. With the help of two test articles fabricated preliminary experiments were carried out to investigate the heat transfer performance with different wire diameters and compare with a charged container without coil wick. We also find that the spiral coil successfully functioned as a capillary wick. When talking about the local transverse temperature difference, it existed in the heat pipe due to gravity influence and for evaporation, the coil wick of 0.5 mm wire diameter performed much better than the 0.4 mm wire,

4.Pengxiao Li, Peng Liuet al. [4]In the present study, the heat transfer and flow performance in turbulent flow of the tube fitted with the drainage inserts are investigated. The results show that the new-type insert can lead the fluid at the coreto the tube wall, strengthening the mixing of cold and hot fluid. And the insert also generates the vortex to make perturbation in the fluid domain. The experiment investigates the influence of pitch ratio on the Nusselt number and friction factor. The Nusselt number and friction factor both increase with the decrease of pitch ratio. And the pitch ratio of 3.3 is recommended for the insert. Some numerical results validated by the experimental results are also shown in the study to analyze the influence of slant angle on heat transfer and flow performance. The results indicate that 45° is suggested as the best slant angle for the insert .In the study, the heat transfer and flow performance of the tube fitted with drainage inserts in turbulent flow are investigated by both experimental and numerical methods.

5.Pankaj N. Shrirao, Rajeshkumaret al. [5]This work presents an experimental study on the mean Nusselt number, friction factor and thermal enhancement factor characteristics in a circular tube with different types of internal threads of 120 mm pitch under uniform wall heat flux boundary conditions. In the experiments, measured data are taken at Reynolds number in range of 7,000 to 14,000 with air as the test fluid. The experiments were conducted on circular tube with three different types of internal threads viz. acme, buttress and knuckle threads of constant pitch . The variations of heat transfer and pressure loss in the form of Nusselt number (Nu) and friction factor (f) respectively is determined and depicted graphically. It is observed that at all Reynolds number, the Nusselt number and thermal performance increases for a circular tube with buttress threads as compared with a circular tube with acme and knuckle threads. These are because of increase in strength and intensity of vortices ejected from the buttress threads. Subsequently an empirical correlation is also formulated to match with experimental results with ± 8% and ± 9%, variation respectively for Nusselt number and friction factor.

the thermal analysis which provides total amount of heat absorbed in the cold fluid. The height and width of grooves were kept constant at0.03 cm and 0.1cm respectively. The tube is made up of an aluminum with outer diameter is 2 cm. The LMTD of 2 grooves double pipe heat exchanger was compared with the smooth one since the thermal sectional area has been increased which essentially cause larger heat transfer.

III. DESIGN PARAMETERS

In this section, we present the proposed design of our setup . Here we use internal circular grooving in a concentric tube with radius of 10 mm and having circular grooving at variable pitch length of 5 mm, 10mm and 12 mm on Al material [6] . Dimension of the proposed design has outer wall thickness of 3 mm while inner wall thickness of 3 mm with internal diameter of 26 mm and outer diameter of 32 mm respectively as shown in fig 3. The overall length of the proposed tube is again 1 meter standard dimension. We are taking three variation in internal circular grooving for proposed setup .The pitch of internal circular grooving in first setup we take 0 mm (without grooving),in second setup 5mm pitch and 3mm diameter of circular grooved, in third setup 10 mm pitch and 6 mm diameter of circular grooved, and In fourth setup 15 mm pitch and 9 mm diameter of circular grooved .On these variations we evaluate the performance of proposed ACHE . Total 101 rectangular copper fins are used for the proposed heat exchanger .The thickness of rectangular copper fin is 0.5 mm, height = 6.4 cm and length = 11.2 cm, calculated using standard formulas is shown in fig.1.

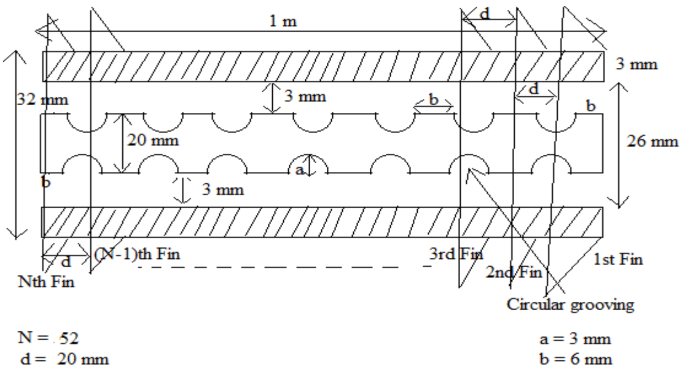


Figure 2 : Layout of propose heat exchanger with internal grooving with rectangular fin.

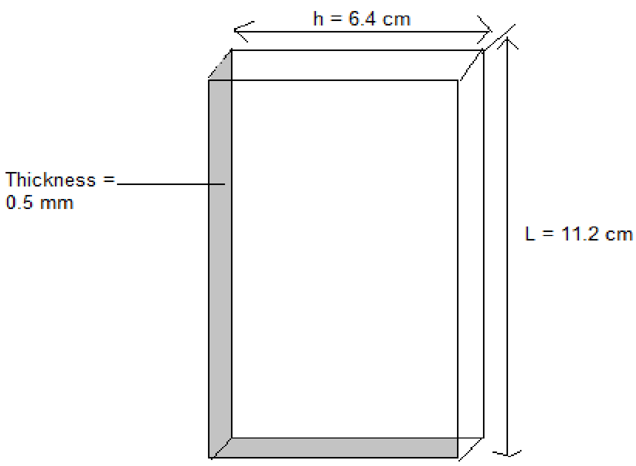


Figure 3: Layout of Fin of heat exchanger

Figure 4: Front view of heat exchanger setup

Figure 4: Side view of heat exchanger setup

Figure 4 : Top view of heat exchanger setup

IV. RESULT AND ANALYSIS

In this section we are approached to the result analysis for setup. The setup consist four variation of fin tube air cooled heat exchanger with internal circular grooving at 0 mm [without grooving], 5 mm, 10 mm and 15 mm pitch . we start our calculation with fin analysis [8,9].

Fin parameters:- fin efficiency(η) and overall fin effectiveness(ε)-

- Fin efficiency (η) = $\frac{\tanh(mLc)}{(mLc)}$ = 98.56%
- Overall fin effectiveness-

$$\epsilon_{Fin}\ \text{overall} = \frac{A_{UN\ fin} + (\eta_{fin} \times A_{fin})}{A_{No\ fin}}$$

$$\epsilon_{Fin}\ \text{overall} = 14.58\ \%$$

Rate of heat transfer of heat exchanger -

$$Q = UAF(\Delta Tlm)_{CF}$$

A comparative analysis of heat transfer rate for counter to cross flow ACHE is presented in table I

s.no.	Setup description	Pitch (mm)	Heat transfer rate in natural convection (watt)	Heat transfer rate in forced convection (watt)
1	Setup- I	0	3010.00	3044.55
2	Setup -II	5	3110.00	3125.85
3	Setup – III	10	3129.00	3154.65
4	Setup - IV	15	3151.00	3190.00

Table I: Heat transfer rate of a counter to cross flow ACHE for proposed setup.

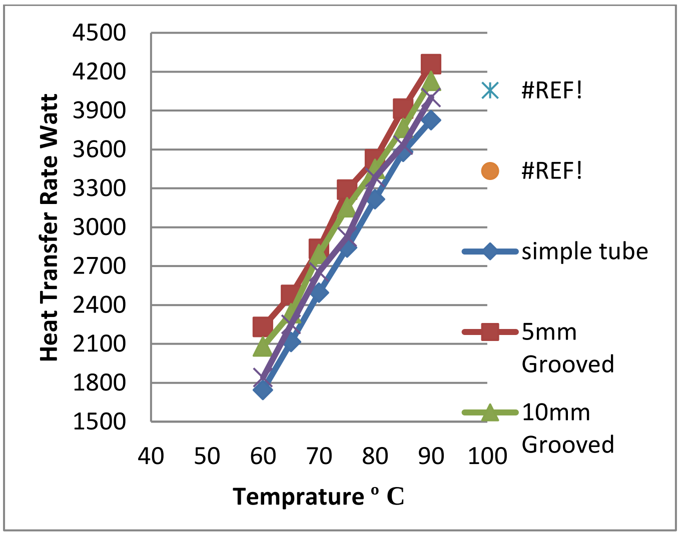
Effectiveness of heat exchanger- the overall effectiveness we have calculated from number of transfer unit (NTU) method ,presented in table II-

S.no.	Setup description	Pitch (mm)	Effectiveness of ACHE in forced convection
1	Setup- I	0	6.011%
2	Setup - II	5	7.048%

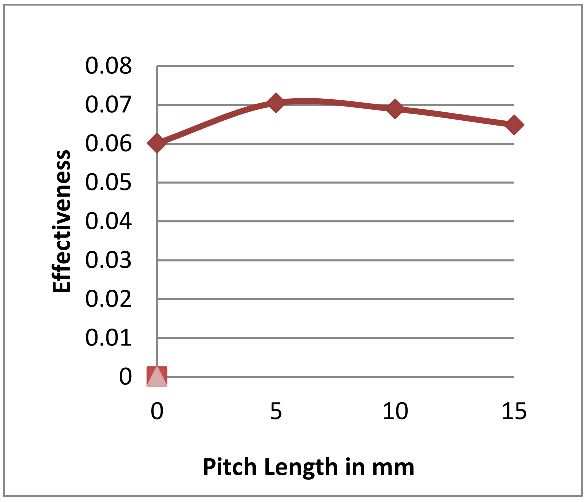
3	Setup – III	10	6.891%
4	Setup - IV	15	6.484%

Table II: Effectiveness of heat exchanger at different pitches of a counter to cross flow ACHE for proposed setup.

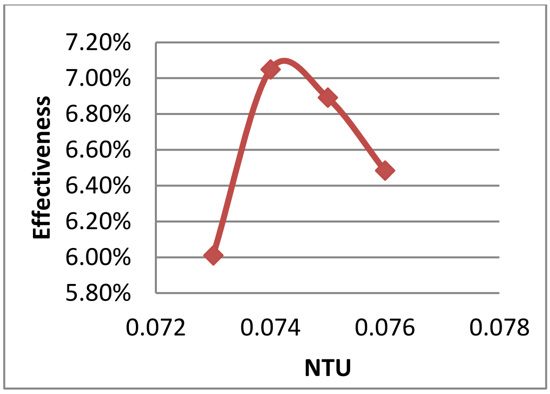
The also work on the size reduction of the proposed heat exchanger designing to obtain optimized performance parameters. Further research can be carried out on different material used for heat exchanger[10] and fins. We have used aluminium tube and copper fin in setup. copper fin have more thermal conductivity then aluminium but cost is very high compared to aluminium .So for higher efficiency at lower cost we used both materials.



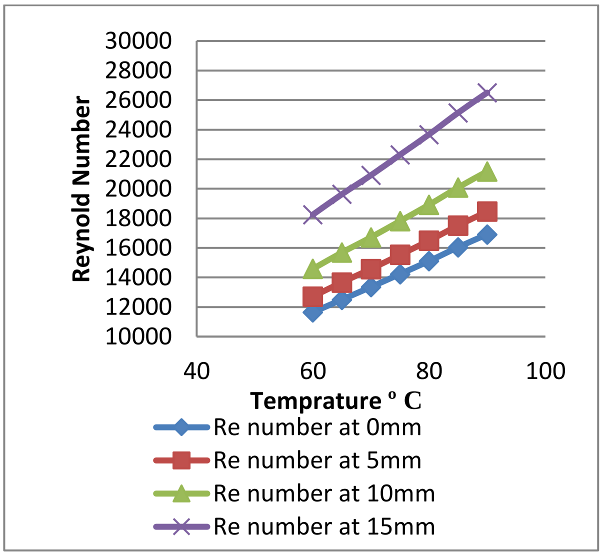
Graph I- Rate of heat transfer of all setup at hot fluid inlet temprature



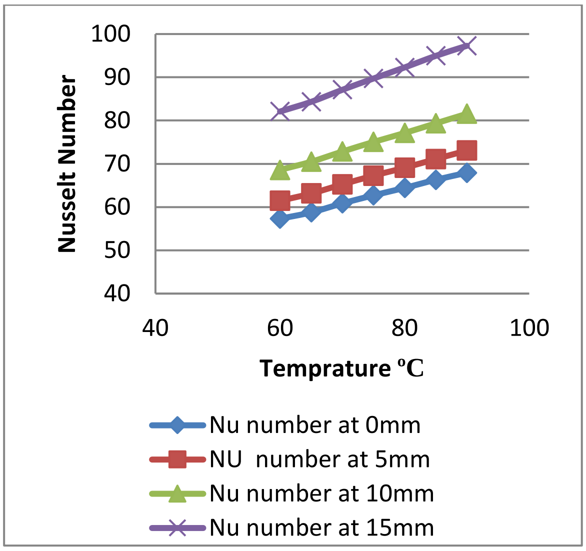
Graph II-Effectiveness vs pitch Length.



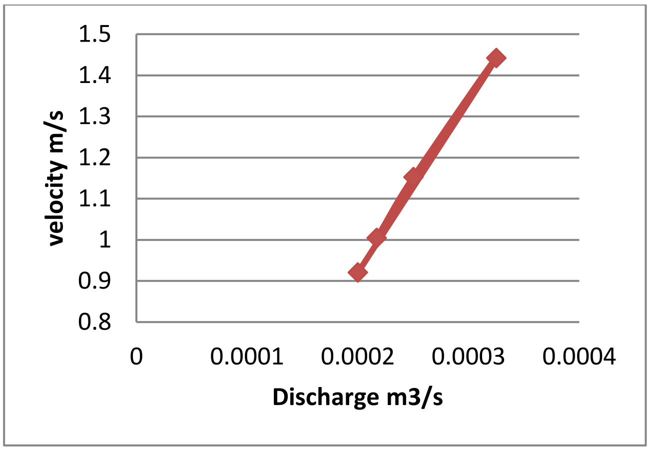
Graph III-Effectiveness vs NTU.



Graph IV-Reynold number variation of all setup at hot fluid inlet temperature.



Graph V-Nusselt number variation of all setup at hot fluid inlet temperature.



Graph VI-Velocity vs Discharge of hot fluid

The above graph shows the variation of results with different pitch of internal circular grooving we have used in setup.

V. CONCLUSION

On concluding the result of this manuscript we can find that the heat transfer rate is maximum in internal circular grooving at 5 mm pitch. The heat exchanger effectiveness is also higher in case of internal circular grooving at 5 mm pitch than other arrangement. We can conclude that in the heat exchanger as we increases pitch of circular grooving from 5 mm to 10 mm and 15mm the effectiveness and rate of heat transfer decreases.

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