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An Effect of Different Copper Fins and Internal Grooving of Air Cooled Counter to Cross Flow Heat Exchanger

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Abstract— The objective of this study is to provide modern analytical and empirical tools for evaluation of the thermal-flow performance or design of air-cooled heat exchangers (ACHE) with copper material of rectangular fin shape and cooling towers. This review consists various factors which effect the performance of ACHE. A fan will be fitted perpendicular to the tube which expand cold air through the fan on tube. When the hot fluid will be flow in tube then internally groove shaped of tube due to high turbulence in fluid. The performance of the various types of fins is presented with respect to the parameters: (1) Reynolds number, (2) fin pitch, (3) fin height, (4) fin thickness, (5) tube diameter, (6) tube pitch, (7) tube type, (8) number of tube rows, and (9) effect of dehumidifying conditions. The total cost of cycle can be reduced by increasing the effectiveness of heat exchanger. In this Section the conclusions and the recommendations for the future work have been given.

Keywords: Internal Grooving, Rectangular Fin, Pressure Drop, Annular Tube, Heat Transfer Coefficient, Turbulent Flow

I. INTRODUCTION

A heat exchanger is a device that is used to transfer thermal energy (enthalpy) between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact. In heat exchangers, there are usually no external heat and work interactions. Typical applications involve heating or cooling of a fluid stream of concern and evaporation or condensation of single- or multicomponent fluid streams. In other applications, the objective may be to recover or reject heat, or sterilize, pasteurize, fractionate, distill, concentrate, crystallize, or control a process fluid. In most heat exchangers, heat transfer between fluids takes place through a separating wall or into and out of a wall in a transient manner. In many heat exchangers, the fluids are separated by a heat transfer surface, and ideally, they do not mix or leak. Such exchangers are referred to as direct transfer type, or simply recuperators. In contrast, exchangers in which there is intermittent heat exchange between the hot and cold fluids—via thermal energy storage and release through the exchanger surface or matrix— are referred to as indirect transfer type, or simply regenerators.

A heat exchanger consists of heat transfer elements such as a core or matrix containing the heat transfer surface, and fluid distribution elements such as headers, manifolds, tanks, inlet and outlet nozzles or pipes, or seals. Usually, there are no moving parts in a heat exchanger; however, there are exceptions, such as a rotary regenerative exchanger (in which the matrix is mechanically driven to rotate at some design speed) or a scraped surface heat exchanger. To increase the heat transfer area, appendages may be intimately connected to the primary surface to provide an extended, secondary, or indirect surface. These extended surface elements are referred to as fins. Thus, heat is conducted through the fin and convected (and/or radiated) from the fin (through the surface area) to the surrounding fluid, or vice versa, depending on whether the fin is being cooled or heated. As a result, the addition of fins to the primary surface reduces the thermal resistance on that side and thereby increases the total heat transfer from the surface for the same temperature difference. Fins may form flow passages for the individual fluids but do not separate the two (or more) fluids of the exchanger. These secondary surfaces or fins may also be introduced primarily for structural strength purposes or to provide thorough mixing of a highly viscous liquid.

Heat exchangers are manufactured in a variety of types, and thus we start this chapter with the classification of heat exchangers. We then discuss the determination of the overall heat transfer coefficient in heat exchangers, and the log mean temperature difference (LMTD) for some configurations. We then introduce the correction factor F to account for the deviation of the mean temperature difference from the LMTD in complex configurations. Next we discuss the effectiveness–NTU method, which enables us to analyze heat exchangers when the outlet temperatures of the fluids are not known. Finally, we discuss the selection of heat exchangers.

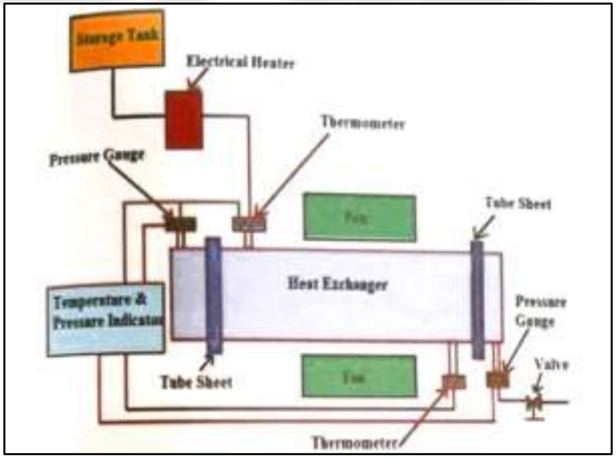

Fig. 1: Schematic diagram of basic experimental set-up

Now a days, heat exchanger are obtainable in many configurations. Classification of heat exchangers depands upon their application, process fluids, and mode of heat transfer and flow. The most standard method to improve the heat transfer rate is the use of turbulence promoters or roughness components, like groove, wire, rib or wounded on the face of it. To get better performance of heat exchangers a general method can be used which is by putting up regular interval disturbance promoters along with the stream wise manner. Because of flow of mixing and periodic disruptions of thermal boundary layers, arrangement of the channels may take to the increment of the heat transfer, but regularly causes an increase of pressure drop. More competent heat transfer can be supported by grooved tubes than smooth tubes. The basic set-up shown in fig.1

The rest of the paper is organized in four sections. Section 2 is used to describe all the proposed design with its dimension. Section 3 presents the various performance parameters such as heat transfer rate, overall fin efficiency, effectiveness of cross flow ACHE, number of transfer unit (NTU) and the capacity ratio (C) and as final point a conclusion is presented in section 4 with best proposed design.

II. DESGIN

In this section, we present the proposed design with two different size with rectangular fin of thickness of mm, height = 6 cm, and characteristic length = 11 cm, calculated using standard formulas is shown in fig.2

Here we use internal grooving with radius of 3 mm and pitch length 6 mm on aluminium material for the proposed heat exchanger. 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 figure 3. The overall length of proposed tube is again 1 meter standard dimension.

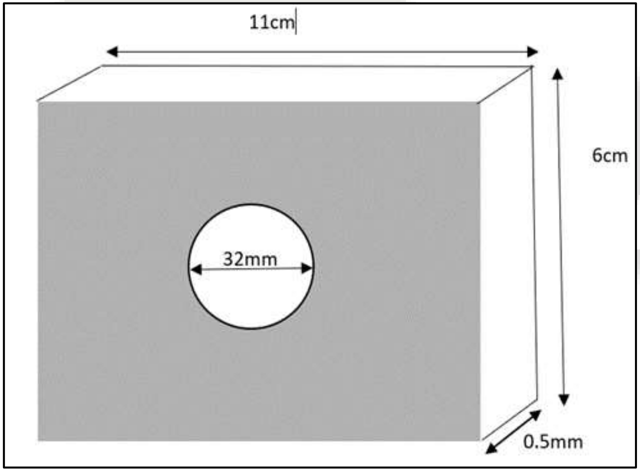

Fig. 2: layout of fin of proposed heat exchanger

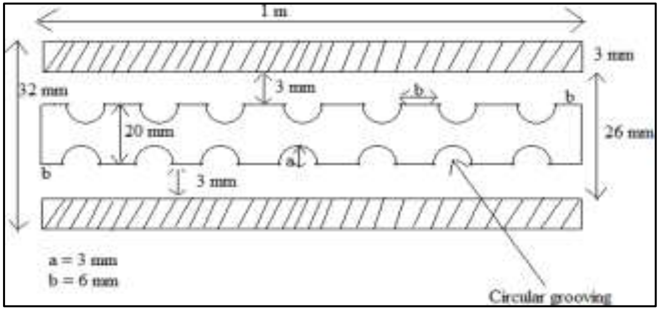

Fig. 3: Heat exchanger with internal grooving with rectangular fin

We are also changing the difference between the fins in order to optimized design in terms of performance as well as cost, for that we are taking six variation in successive rectangular fin to evaluate the performance of heat transfer efficiency of proposed heat exchanger by changing the distance of fins. the proposed distance between the fins are 5 mm 10 mm 15 mm and 20 mm in six proposed setup.

Fig. 4: physical set up for heat exchanger with internal grooving with rectangular fin.

III. RESULTS AND DISCUSSION

This section is dedicated to the result calculated for the proposed setup of four variations with different fin size of Air-Cooled Heat Exchanger (ACHE) design with internal grooving; all of them are having variable fin distance. The calculation of various parameters starts with the calculation of discharge through the internally grooved tube.

Discharge through the pipe = 0.002m3/s

$$\text{Area of cross section} = \pi/4(Do^2 - D1^2)$$
$$= \pi/4(262-202) = 216.77\text{mm}^2$$
$$= 216.77\times10\text{-}6 \text{ m}^2$$

$$\text{Velocity of hot fluid} = Q/A_o = 0.0002/216.77\times10^{-6} = 0.92\text{m/s}$$

For the different values obtained in the above setup we will now calculate the effectiveness of ourproposed heat exchanger.

$$\epsilon = \frac{Q_{actual}}{Q_{max}} = 1\text{- e}\left(\frac{e^{-c(NTU)^{0.78}}-1}{C(NTU)^{-0.22}}\right)$$

Where C = Heat capacity ratio = C_{max}/C_{min}, and NTU is number transfer unit = UA_s

	Distance between fins (mm)	Without fan heat transfer rate (Watt)	With fan heat transfer rate (Watt)
Proposed setup, Internal circular grooving with rectangular fins at different distance (in mm)	Internal grooving tube	285.87	289.41
	5	6488.42	6526.26
	10	3589.65	3614.63
	15	2579.70	2599.30
	20	1923.41	1935.37

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

Graph 1 Comparative Variation of Heat Transfer Rate with Hot Fluid Inlet Temperatures of Internal Circular Grooved Tube with Rectangular Fins Air Cooled Heat Exchanger

The below table shows the average value of heat transfer rate of simple concentric tube air cooled heat exchanger, Internal circular grooved tube air cooled heat exchanger and internal circular grooved tube with rectangular fins air cooled heat exchanger. In internal circular grooved tube with rectangular fins there are four cases with different fin size i.e at the distance between two consecutive fins are 5 mm, 10 mm, 15 mm, 20 mm The heat transfer rate that is mentioned in above table is natural convection (without fan) and forced convection (with fan).

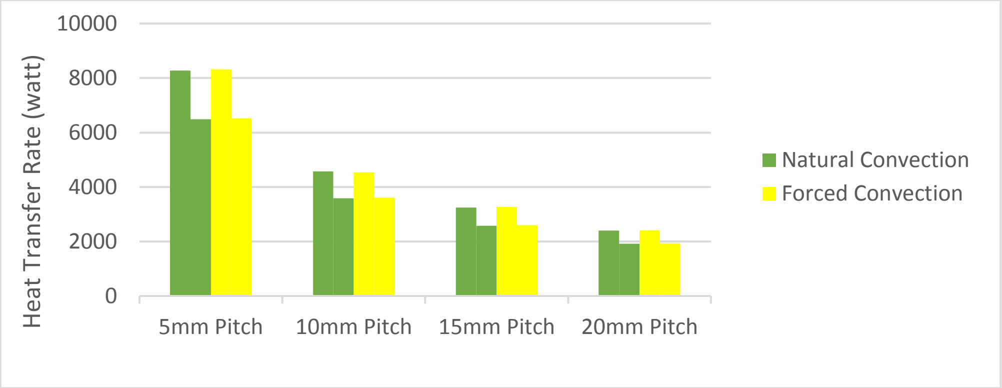

Fig. 5: Comparative variation of heat transfer rate with natural and forced convection, Internal circular grooved tube air cooled heat exchanger and internal circular grooved tube with different rectangular fins air cooledheat exchanger.

Distance between two consecutive fins (in mm)	5	10	15	20
NTU	0.134	0.069	0.0504	0.0374
$C=C_{min}/C_{max}$	0.62	0.62	0.62	0.62
$\epsilon_{\text{cross flow ACHE}}$ (in percentage)	12.79	6.64	4.8	3.57

Table II: Calculation table of heat exchanger effectiveness for proposed setup.

Graph 2 Comparative variation of heat exchanger effectiveness with NTU of Internal Circular Grooved Tube with Rectangular Fins Air Cooled Heat Exchanger

We have also calculated the effectiveness of counter to cross flow air cooled heat exchanger which is a function of number of transfer unit (NTU) and the capacity ratio(C).

Graph 3 Comparative Variation of overall fin effectiveness with distance between two consecutive fins

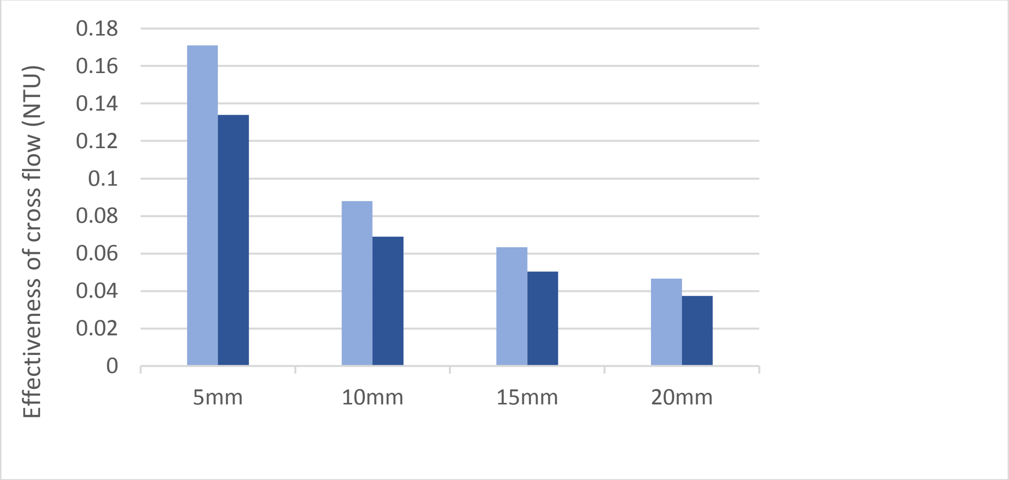

Fig. 6: Variation of heat exchanger effectiveness with NTU with different rectangular fins air cooled heat exchanger

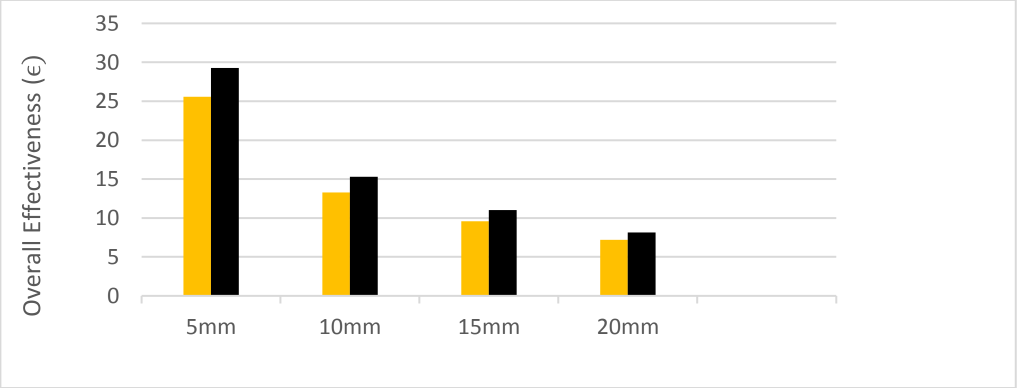

Fig. 7: Variation of overall fin effectiveness with distance between two consecutive fins with different rectangular fins air cooled heat exchanger.

IV. CONCLUSION

In this paper, A exhaustive examination is displayed on various spiral grooved concentric tune heat exchanger with rectangular copper fins at different fin pitch and variable number of fins. From the result analysis we found that the heat transfer rate is maximum in internal spiral grooving in concentric tube with rectangular copper fins for distance between two consecutive fins are 5 mm, a total of 100 fins are used for the proposed setup. For all proposed design we find that forced convection outperform as compared to natural convection so far is heat transfer rate is concerned in case of forced convection. we found that the heat transfer rate is maximum in internal spiral grooving in concentric tube with rectangular copper fins for distance between two consecutive fins are 5 mm as well. We can conclude that the heat exchanger with in internal spiral grooving in concentric tube with rectangular copper fins for distance between two consecutive fins are 5 mm is more desirable from heat transfer rate, efficiency of fins, effeteness of fins and effectiveness of cross flow ACHE point of view.

There is a large scope to modify in this field. We can 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 and fins.

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