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An Analysis Of Counter To Cross Flow Air-Cooled Heat Exchanger Using Different Fins Pitch With Internal Circular Grooving

Satyaprakash[1] and Sachin Baraskar[2]
M.Tech. Scholar, Department of Mechanical Engineering, SSSUTMS, Sehore, M.P./466001, India[1]
Assistant Professor, Department of Mechanical Engineering, SSSUTMS, Sehore, M.P./466001, India[2]

Abstract: *The presented dissertation is an experimental setup for heat exchangers designs first one is a simple tube air cooled heat exchanger without grooving, second one is air cooled heat exchanger with internal circular grooving and third one is internally curricular grooved air cooled heat exchanger with rectangular fins. In case of third design we are taking seven variations in successive rectangular fins to evaluate the performance of the heat transfer efficiency of the proposed heat exchangers by changing the distance of fins and hence the number of fins used in the proposed heat exchanger. We are changing the distance between the fins and its number until we get a constant or almost constant temperature drops. The proposed distance between the fins are 0.5 cm, 1.0 cm, 1.5 cm, 2.0 cm, 2.5 cm, 3.0 cm and 3.5 cm in seven proposed setup for the air cooled heat exchanger with 200, 102, 68, 52, 42, 35 and 29 fins respectively. From the proposed analysis we establish that the heat transfer rate is highest in internal circular grooving with rectangular fins at the distance between two fin is 0.5 cm. The heat exchanger effectiveness is also higher in internal circular grooving with rectangular fins at the distance between two consecutive fins 0.5 cm than other arrangements. We can conclude that the heat exchanger with fins which is placed at 0.5 cm is more advantageous from heat transfer viewpoint. But on the basis of economical point of view, the heat exchanger with rectangular fins which is placed 3.5 cm is more desirable because the number of fins required is very less compared to other arrangement. The overall better performance i.e. more desirable from heat transfer as well economical point of view of heat exchanger is the heat exchanger with rectangular fins which is placed at 10 mm because less number of fins are required and better heat transfer compared to others. The effectiveness of the exchanger is also not large. The overall fin effectiveness have obtained for internal circular grooving with rectangular fins setup are 27.59, 14.56, 10.04, 7.91, 6.58, 5.56, and 4.86 at the distance between two consecutive fins are 0.5 cm, 1.0 cm, 1.5 cm, 2.0 cm, 2.5 cm, 3.0 cm, 3.5 cm respectively. The efficiency of rectangular fin is 96.87 %..*

Keywords: *Heat exchangers, Air Cooled, Fins, Transfer rate, Forced Convention.*

1. Introduction

Heat exchangers are one of the generally utilized supplies in the process enterprises. Heat exchangers are utilized to move heat involving two cycle stream. One can understand their utilization to any cycle which includes cooling, warming, build up, bubbling or dissipation will involve a heat exchanger for these reasons. Cycle liquids, normally are warmed or cooled prior to the cycle or go through stage change. Distinctive heat exchanger is named by their application. Pro instance, heat exchanger being utilized to consolidate is known as condenser, likewise heat exchangers used for bubbling objects are called boiler. Execution and productivity of heat exchanger is estimated throughout the measure of heat transfered utilizing slightest region of heat move and weight drop. An all the more healthier introduction of its proficiency is finished by ascertaining generally heat move coefficient. Weight slump and zone required for a specific measure of heat move, gives knowledge concerning the capital expense and force prerequisites (successively expense) of heat exchangers. Normally, there is loads of writing as well as speculations to plan a heat exchangers as indicated by the necessities. A decent plan is all used to heat exchangers by means of slightest conceivable region and compel go down to satisfy the heat transfer requirement.

As we probably aware it is a modern test to improving the effectiveness of heat exchanger and the heat move. Air-cooled heat exchanger is broadly utilized in an assortment of ventures, for example, warm force plants Chemical treatment facilities, ORC Plant, Oil and Gas, Steel Industry and numerous different applications. In this arrangement hot liquid is streaming inside the cylinder, and encompassing air ignores the external facade of the cylinder as cooling liquids. The cooling wind currents over the outside of inside scored balance tube with a fan to upgrade the heat move region. As we know that the rate of the heat transfers are the function of surface area of fins and air velocity passing over that surfaces. ACHEs are unremarkably used wherever a method system generates heat that should be removed, that there's no native use. They are a "green" answers as compare to shell and tube heat exchanger along with cooling towers as a result of they are doing not need an auxiliary water system (water lost tanks to float and evaporation, and there are no chemicals required for water treatment). Wherever there's a no utility like water offered as a cooling medium. They are typically used when outlet temperature is more than the maximum expected surrounding temperature. They will be used with closer room temperatures, however, they usually become pricey as compared to an assortment of a cooling towers and a water cooled heat exchanger. The fig.1.1 describes the functioning principle of ACHEs.

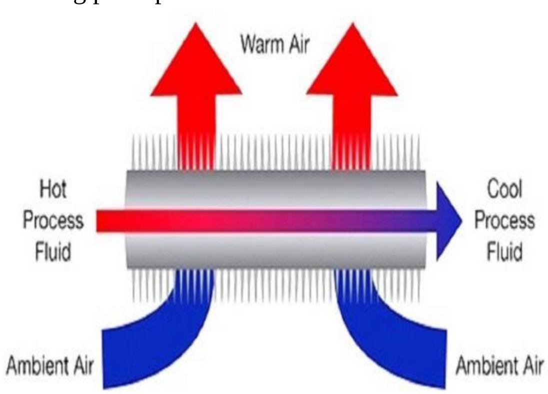

Fig.1 Operating Principle of ACHE

2. Type of Air-Cooled Heat Exchangers (ACHE)

The basic motive for choosing air because the effective fluid in situ water are its straight out great quantity. But, water is barely chosen as cooling fluids mainly within desiccated region like the center East. And since of the high setting cost of water transfer equipment (including pipes, pumps, filters, etc.), Air are chosen because the cooling fluids in spite of its low cooling properties. Ever since air's heat transfer coefficient has low, tube is mounted with fins so as to extend the heat transfers rate. The main suitable materials for fin is aluminum because it has high thermal conductivity little weight, and good formability. There are mostly three mode for heat transfers conduction, convection, and radiation. Convection is split into two subgroups natural convection and made convection. Forced convection heat transfers are that the most frequent mode for heat transfer in heat exchanger or in several chemical plants. There are basically three sorts of air cooled heat exchanger:

- Forces Draft ACHE
- Induced Draft ACHE
- Natural Draft ACHE

The employ of turbulence promoter or roughness components, like rib, groove or wires wounded on the face of it, is that the hottest technique to reinforce the heat transfer rate. A generally used method for recuperating performances of heat exchanger devices are to place up regular interval disturbance promote along sides the stream wise manner. Such appointment of the channel might cause the increment of the heat transfers caused by flow mixing and periodic disruptions of thermal boundary layer, but frequently causes a rise of pressure drops.Grooved tubes assist more competent heat transfer than smooth tubes. Small diameter tubes have superior heat transfer rate than usual-sized tubes with round aluminum tubes and aluminum fin. Artificial groove or fluted tubes are extensively used in recent heat exchanger since they are more useful in amplification of heat transfers. Different type of grooving profile like spiral, circular, triangular, etc. are present. All grooving profiles help out to get better the heat transfer rates throughout the turbulence.

Forces Draft ACHE

In this type of heat exchangers, the fan is placed below the tubes bundle and the air is forced throughout the tubes by an external source of power.

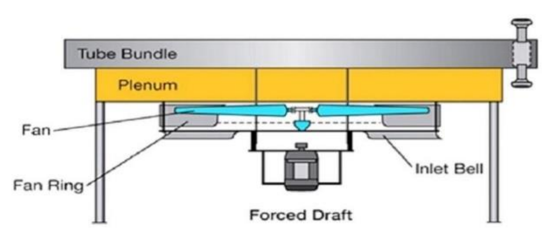

Fig.2 Forced Draft ACHE

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Induced Draft ACHE

This type of heat exchangers, the fan is placed above the tubes bundle and the air is pulled through the tubes by an external source of power.

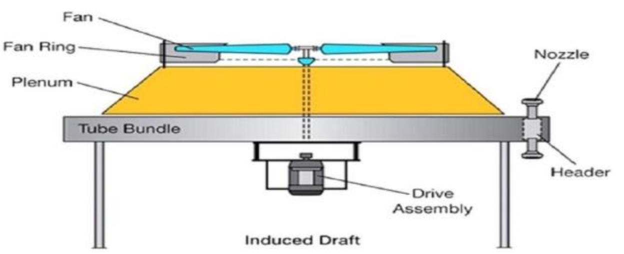

Fig.3 Induced Draft ACHE

Natural Draft ACHE

In this type of heat exchanger, the fan or other source is not used to induce or force the air through the tubes. It’s application in transformer oil cooling.

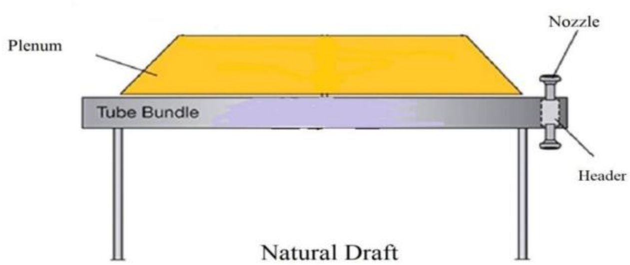

Fig.4 Natural Draft ACHE

3. Proposed Work

3.1 Design

In this design we imitate our research with a very basic heat exchanger fabricated using aluminum as material, this design have neither any external grooving nor having any fin attached with the heat exchanger. Dimension of the proposed design is a simple aluminum annular tube with thickness of outer wall is 3 mm with internal diameter of 26 mm and outer diameter of 32 mm as exposed in fig 5. The overall length of the proposed tube is 1 meter.

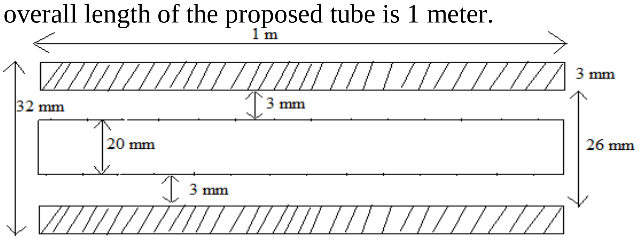

Fig.5 Layout of simple heat exchanger without grooving

3.1 Heat Exchanger with Internal circular Grooving

Second design in basically a modified version of first design with internal circular grooving with radius of grooving of 3 mm and pitch length of 6 mm here also we are using aluminum as our fabrication material for the proposed heat exchanger. Dimension of the proposed design has outer wall thickness of 3 mm with internal diameter of 26 mm and outer diameter of 32 mm respectively as shown in fig 5.2. The overall length of the proposed tube is again 1 meter standard dimension of circular grooving is selected in such a way that an internal symmetry is maintained throughout the design. Due to the introduction of internal grooving the heat transfer characteristic of the proposed design improved as compare to that of the first proposed design (i.e simple tube ACHE), details of the results achieved is explained in chapter 6. In this design we are taking various reading for different temperature of hot water, the experimental setup also gives the results of heat exchange in two scenario one with fan and other without fan.

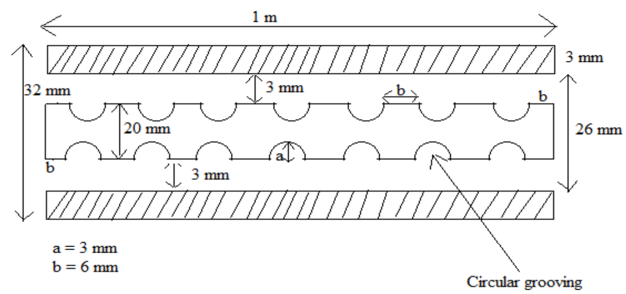

Fig.6 Layout of heat exchanger with internal grooving.

3.2 Internally circular Grooved Heat Exchanger with Rectangular Fins

Third design is again a modified version of second design with rectangular fin of thickness 0.5 mm, height = 6.4 cm and characteristic length = 11.2 cm, calculated using standard formulas as shown in fig 5.3. In this design the internal circular grooving having same dimension as that of mention in section 5.2, with radius of grooving of 3 mm and pitch length of 6 mm here also we are using aluminum as our fabrication material for the proposed heat exchanger. Dimension of the proposed design has outer wall thickness of 3 mm with internal diameter of 26 mm and outer diameter of 32 mm. The overall length of the proposed tube is again 1 meter standard dimension. Dimension of circular grooving is selected in such a way that an internal symmetry is maintained throughout the design. Due to the introduction of internal grooving as well as rectangular fin the heat transfer characteristic of the third design is much improved as compare to that of the first and second proposed design, details of the results achieved is explained in chapter 6. In this design we are taking various reading for different temperature of hot water, the experimental setup also gives

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the results of heat exchange in two scenario one with fan (i.e. forced convection) and other without fan (i.e. natural convection).

We are also changing the distance between fins in order to get the most optimized design in terms of performance as well as cost, for that we are taking seven variation in successive rectangular fin to evaluate the performance of heat transfers efficiency of the proposed heat exchangers by changing the distance of fins and hence number of fins used in the proposed heat exchanger. We are keep changing the distance between the fins and its number until we get a constant or almost constant performance. The proposed distance between the fins are 0.5 cm, 1.0 cm, 1.5 cm, 2.0 cm, 2.5 cm, 3.0 cm and 3.5 cm in 7 proposed setup for the ACHE with 200, 102, 68, 52, 42, 35 and 29 fins respectively.

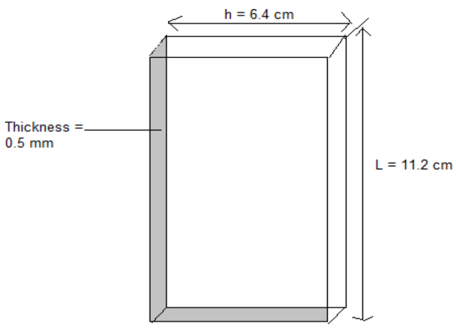


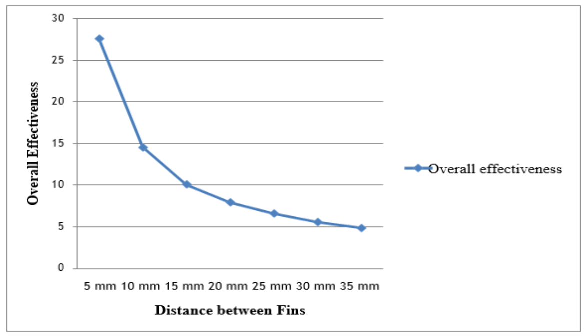
Fig.7 Layout of rectangular fin of proposed heat exchanger

4. Results

From the previous chapter analysis we found that the overall fin effectiveness have obtained for internal circular grooving with rectangular fins setup are 27.59, 14.56, 10.04, 7.91, 6.58, 5.56, and 4.86 at the distance between two consecutive fins are 0.5 cm, 1.0 cm, 1.5 cm, 2.0cm, 2.5 cm, 3.0 cm, 3.5 cm respectively.

- The effectiveness of fin ∈fin = 1, indicates that the addition of fins to the surface does not affect the heat transfer. The effectiveness of fin ∈fin <1, indicates that the fin acts as insulation. The effectiveness of fin ∈fin >1, indicates that the fins are increasing heat transfer rate from the surface. So finned surfaces are designed on the basis of maximizing effectiveness for a specified cost or minimizing cost for a preferred effectiveness. When we are calculating performance of proposed heat exchanger with internal grooving and fin we get the fin efficiency (ηfin) is 96.87% as calculated.
- The overall effectiveness for a finned surfaces is defined as the ratio of the total heat transfer from the finned surface to the heat transfer from the without finned surfaces.

It depends on the fin density i.e. number of fins per unit length as well as effectiveness of individual fins. Its measure the performance of finned surface.
The variation of overall fin effectiveness with distance between two consecutive fin is shown in graph below. From this graph, it shows that the values of overall effectiveness of fins are decreases when the distance between two consecutive fins increases.



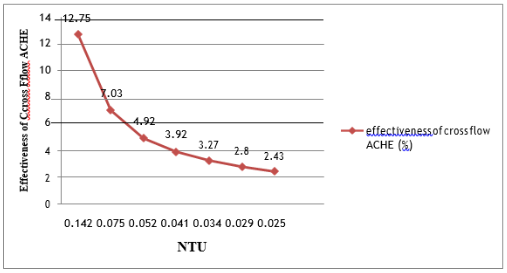
Graph 1 Variation of overall fin effectiveness with distance between two consecutive fins.

Heat Exchanger Effectiveness

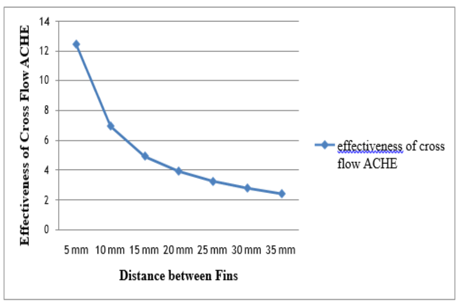
The heat exchanger effectiveness when using internal circular grooving with rectangular aluminum fins are shown in graph 6.2. The heat exchanger effectiveness with a very high effectiveness might be advantageous from a heat transfer viewpoint but disagreeable from an economical viewpoint a heat exchanger with a large NTU, a large size of heat exchangers cannot be reasonable economically. The variation of heat exchanger effectiveness with NTU and distance between two consecutive fins is shown in graph 6.2 & 6.3. It represent the value of cross flow air cooled heat exchanger with the distance between two consecutive fins as well as NTU. When the distance between two consecutive fins increases the value of heat exchanger effectiveness decreases. The same relation is in NTU and heat exchanger effectiveness.

Table 6.1 Calculation table of heat exchanger effectiveness and NTU for ACHE with internal circular grooving and rectangular fins.

Distance between two consecutive fins (in mm)	5	10	15	20	25	30	35
NTU	0.144	0.076	0.052	0.041	0.034	0.029	0.025
C= Cmin/Cmax	0.6	0.62	0.6	0.63	0.63	0.6	0.63
Ɛcross flow ACHE (in percentage)	12.75	7.03	4.9	3.92	3.27	2.8	2.43



Graph 2 Variation of heat exchanger effectiveness with NTU



Graph 3 Variation of heat exchanger effectiveness with distance between two consecutive fins.

5. Conclusion

From the previous section analysis we conclude the following:

- The heat transfer rate is maximum in internal circular grooving with rectangular fins air cooled heat exchanger at the distance between two consecutive fin is 5 mm.
- The heat exchanger effectiveness of internal circular grooving with rectangular fins air cooled heat exchanger at the distance between two fin 5 mm is higher than other arrangements.
- We can conclude that the heat exchanger with fins which is placed at 5 mm is more desirable from heat transfer point of view. But on the basis of economical point of view, the heat exchanger with rectangular fins which is placed 35 mm is more desirable because the number of fins required is very less compared to other arrangement.
- The overall better performance i.e more desirable from heat transfer as well economical point of view the heat exchanger which is the internally circular grooved with rectangular fins air cooled heat exchanger at fin pitch 10 mm because less number of fins are required and better heat transfer compared to others. The effectiveness of the exchanger is also not large.
- The efficiency of rectangular fin is 96.87%.

This research is done experimentally. This can be done on software like CFD. 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. It can also be done on different fins profile with different grooving profiles.

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