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PERFORMANCE ANALYSIS OF COUNTER TO CROSS FLOW HEAT EXCHANGER WITH DIFFERENT FAN ANGLES

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ABSTRACT

A heat exchanger is device which heat exchangers among two or more fluids. Heat exchanger are using for the heating and cooling systems in domestic and industrial operations. When heat exchanger devices are used in any operation than some heat losses in atmosphere. We studied different research paper and analysed the performance parameter of heat exchangers. After studied of different research paper, I found new idea to get better the thermal performances of counter to cross flow by using air cooled heat exchanger [ACHE] process. Constrained geometry structures are counter to cross flow using air cooled heat exchangers process. In air cooled heat exchanger [ACHE] process is using internal grooved aluminium concentric tube and aluminium fins. Hot water will be flow in spiral grooved aluminium tube and rectangular fins will be fitted on tube. A fan will be fitted perpendicular to the tube which expand cold air through the fan on tube. In this study, time-domain simulations are performed for the National Advisory Committee for Aeronautics Air foil 6512 propeller. NACA 0015 was used for blade inner fan with a variety of inner fan blade angles 15^0, 30^0, 45^0 and 60^0 and varied wind speed to turbine ventilator 1.5, 3, 4.5 and 6 m/s**.** The fans will blow the air on tube due to hot fluid will be decreases the temperature outlet of tube. We will be temperature difference found input and output of the hot fluid.

Keywords: Air Cooled Heat Exchanger, Internal grooved tubes, Rectangular Aluminium fins, Rectangluar Copper fins.

1. 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. 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.

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.

The term axial flow fan indicates that the air flows through the fan in an approximately axial direction. On the inlet side, as the flow approaches the fan blades, the direction of the flow is axial, in other words, parallel to the axis of rotation, provided there are no inlet vanes or other restrictions ahead of the fan wheel. The fan blade then deflects the airflow

A propeller is a mechanism designed to produce a tractive force or push, when submerged in a fluid medium. The propellers are aerodynamic elements, that are composed of a hub or central core and a number of blades.

The operating principle of axial-flow fans is simply deflection of airflow. Past the blade, therefore, the pattern of the deflected airflow is of helical shape, like a spiral staircase. This is true for all three types of axial-flow fans: propeller fans, tube axial fans, and vene axial fans. Accordingly, the design procedures and the design calculations are similar for all three types**.**

The helical pattern of the airflow past the blade of an axial flow fan the air velocity the can be resolved into two components: an axial velocity and a tangential velocity. The axial velocity is the useful component. It moves the air to the location where we need it.

Turbulence and noise are mostly produced by the edges, both leading and trailing edges and not by the blade surface. Therefore, fewer and wider blades will result in a better fan efficiency and a lower noise level. But if the number of blades becomes too small and the blade width, too large, the fan cub becomes too wide axially and thus heavy, bulky, expensive, and hard to balance. .

Heat transfer in a heat exchanger usually involves convection in each fluid and conduction through the wall separating the two fluids. In the analysis of heat exchangers, it is convenient to work with an overall heat transfer coefficient U that accounts for the contribution of all these effects on heat transfer. The rate of heat transfer between the two fluids at a location in a heat exchanger depends on the magnitude of the temperature difference at that location, which varies along the heat exchanger.

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.

Types of flows and working point of the fan

We can have a sucking or a blowing flow.

The sucking one requires a smaller distance between the axial fan and the core surface.

The operating point of the cooling system is obtained by matching the cooling performance curve with the characteristic fan curve.

We get the ideal working point of the fan when there are:

- Higher air flow
- Higher pressure head
- Lower noise
- Lower consumption

Features & Benefits**:**

Efficient operation. More air with less power or reduced power for same air. Optimal operational cost. Economical initial cost. Impellers are dynamically balanced to ISO – 1940 Grade 6.3 or 2.6. Fans available with or without seal disk to suit Induced Draft or Forced Draft applications. Blade airfoil with high lift and low drag.

Standard Material of Construction

Blades**:** Fibre-Glass Reinforced Plastic using fire retardant resins

Figure1.11 - Different fan blade angle

1. DESIGN

In this design is basically a modified version of 45^0 and 55^0 fan blade angle on simple tube and internal spiral grooving with radius of grooving of 3mm and pitch length of 5mm, 10mm, 15mm, 20mm here also we are aluminum tube as our fabrication material for the proposed heat exchanger. Dimension of the proposed design has outer wall thickness of 3mm while inner wall thickness of 3mm with internal diameter of 26 mm and other diameter of 32 mm respectively as shown in fig. The overall length of the proposed tube is again 1-meter standard dimension of spiral grooving is selection in such a way that an internal symmetry is maintain 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 design details of the results achieved is explained. In this design we are taking various reading for different temperature for hot water the experimental setup also gives the results of heat exchanger in two scenario one with fan forced convection and other without fan natural convection. In this design we are using constant number of 200 aluminum and copper fins are used in first design of dimension thickness 0.5 mm height 6cm, 7cm and characteristic length 11cm, 12cm.

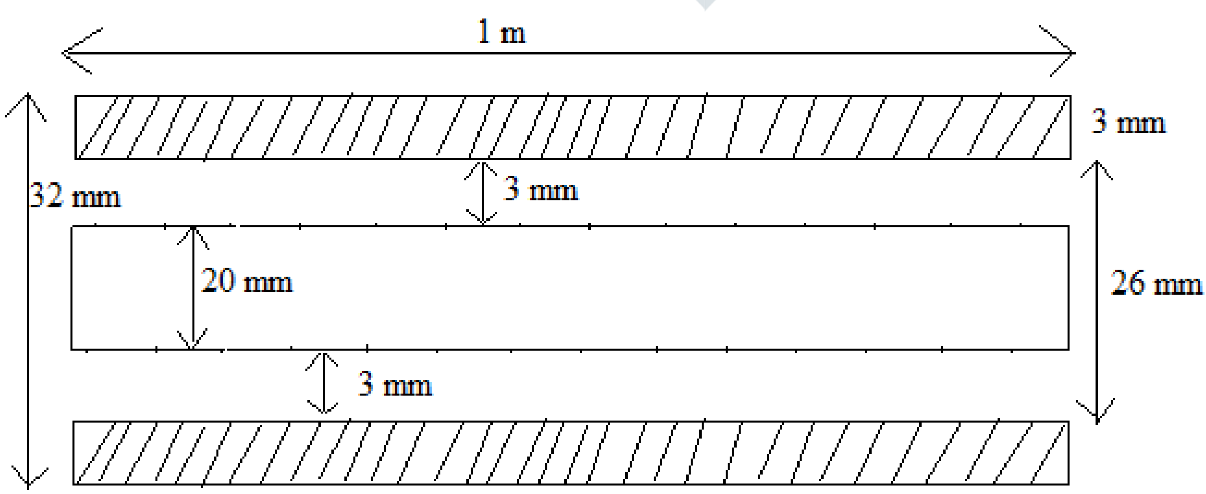


Figure 2.1 Layout of Simple Tube Heat Exchanger Without Grooving

1. Rectangular fin

The proposed dimension of the rectangular fins used are of thickness 0.5 mm, height = 6 cm and characteristic length = 11 cm, calculated using standard formula as shown in figure.

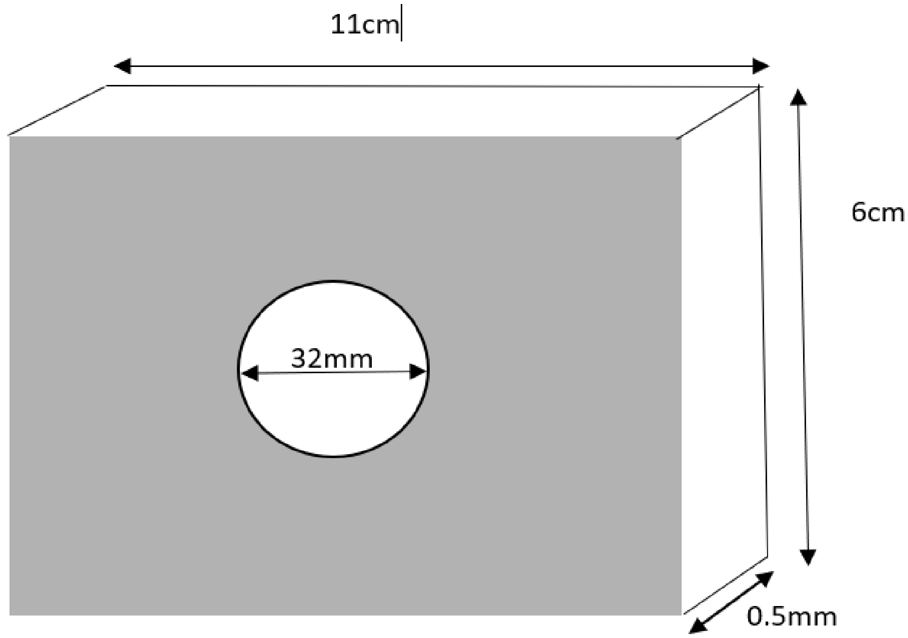


Figure 2.2 Layout of rectangular Aluminium Fin of Proposed Heat Exchanger

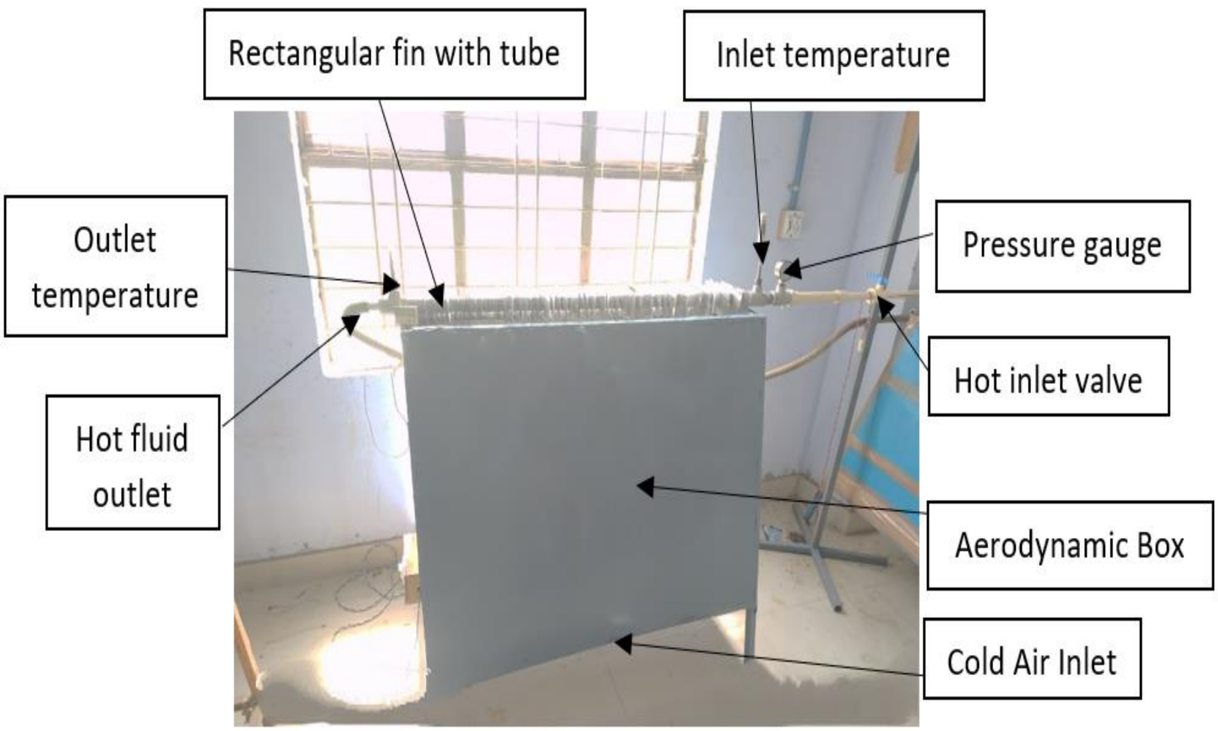


Figure 2.3 Physical Experimental setup of Rectangular Fin Based on Heat Exchanger.

In simple words, the Angle of a Blade is known as PITCH. Blade pitch play an important role in the flow of air circulation. Pitch may differ from one fan to another. In general. The manufacturers tilt 5 - 10 degree for an ordinary fan and 30 – 55 degrees for a premium fan. A higher pitch such as maintaining > 55 degree may show poor performance of air circulation. Maintaining high pitch may causes air restriction.

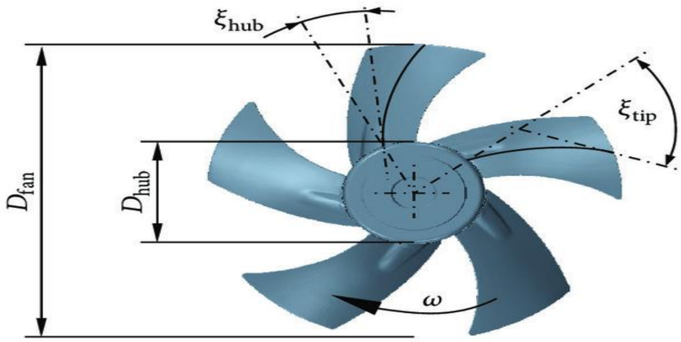


Fig2.4 Layout of fan blade angle

3. RESULT AND DISCUSSION

The experiment was conducted on six different setups at different temperature for both free and forced air convection. One with simple air-cooled heat exchanger (ACHE) without grooving, second with internal spiral grooving pitch of 5 mm, third with internally spiral grooving pitches, forth another different size of rectangular and parallelogram fin with simple tube heat exchanger and internally grooved tube the characteristic length of the fin is 11cm, 12cm, height= 6cm, 7cm and thickness= 0.5mm respectively.

3. Analysis of Fluid Temperature on heat Transfer Rate at Different pitch for air cooled heat exchanger

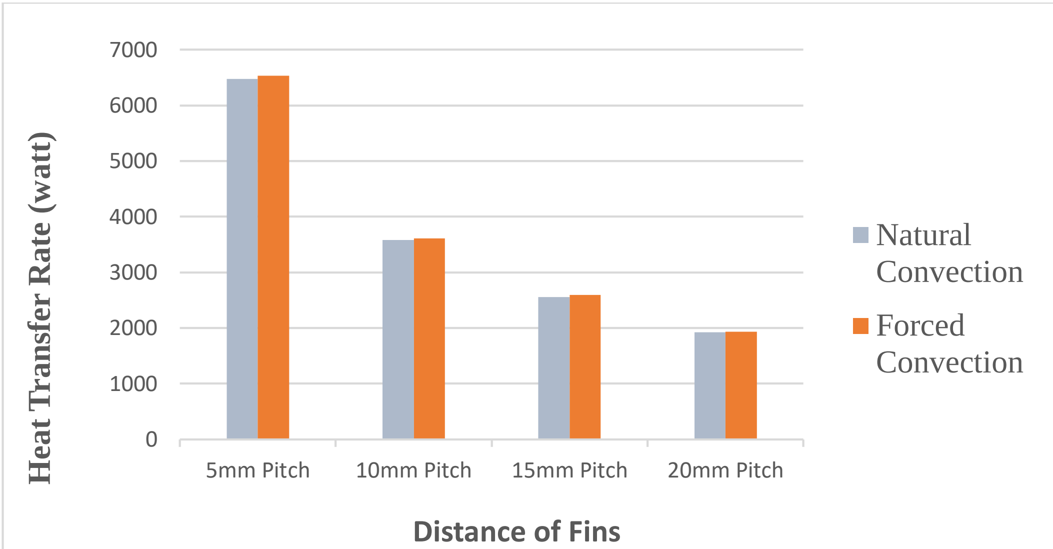
The analysis of fluid temperature on heat transfer rate at different pitch for air cooled heat exchanger (ACHE) is explained below. six different setups at different temperature for both free and forced air convection is analysed. One with simple tube air cooled heat exchanger (ACHE) without grooving, second with internal spiral grooving pitch of 5mm third with internally spiral grooving pitch of 5mm fourth, fifth and six is repeated with air cooled heat exchanger with different size of rectangular fins respectively.

1. 45 Degree fan blade angle on rectangular fins calculation

	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	6474.91	6535.20
	10	3585.88	3610.18
	15	2557.87	2597.84
	20	1924.14	1935.37

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

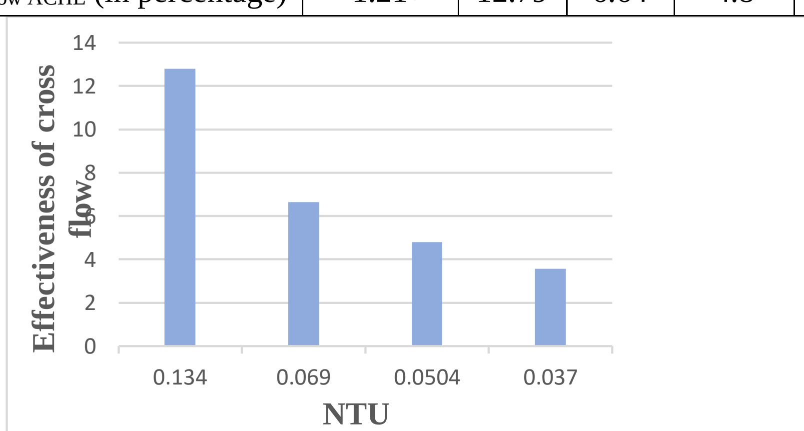
The below table shows the average value of heat transfer rate of simple concentric tube air cooled heat exchanger, Internal circular grooved tube air cooled heat exchanger and internal circular grooved tube with rectangular fins air cooled heat exchanger. In internal circular grooved tube with rectangular fins there are seven cases 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).



Graph 3.1 Comparative variation of heat transfer rate with natural and forced convection of simple 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.

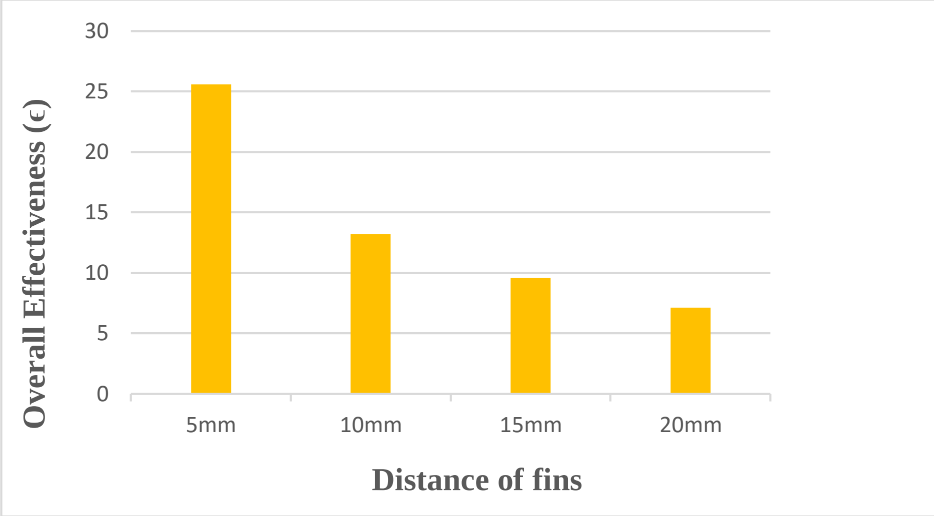
3.2 Comparative Variation of heat exchanger two different fin size effectiveness with NTU

Distance between two consecutive fins (in mm)	Internal grooving tube	5	10	15	20
NTU	0.005	0.134	0.069	0.0504	0.0374
$C=C_{min}/C_{max}$	0.63	0.62	0.62	0.62	0.62
$\epsilon_{cross\ flow\ ACHE}$ (in percentage)	1.21	12.79	6.64	4.8	3.57



Graph 3.2 Variation of effectiveness with NTU rectangular fins air cooled heat exchanger.

3.3 Variation of overall fin effectiveness with different fin size between two consecutive fins



Graph 3.3 Variation of overall fin effectiveness between two consecutive fins with rectangular fins air cooled heat exchanger.

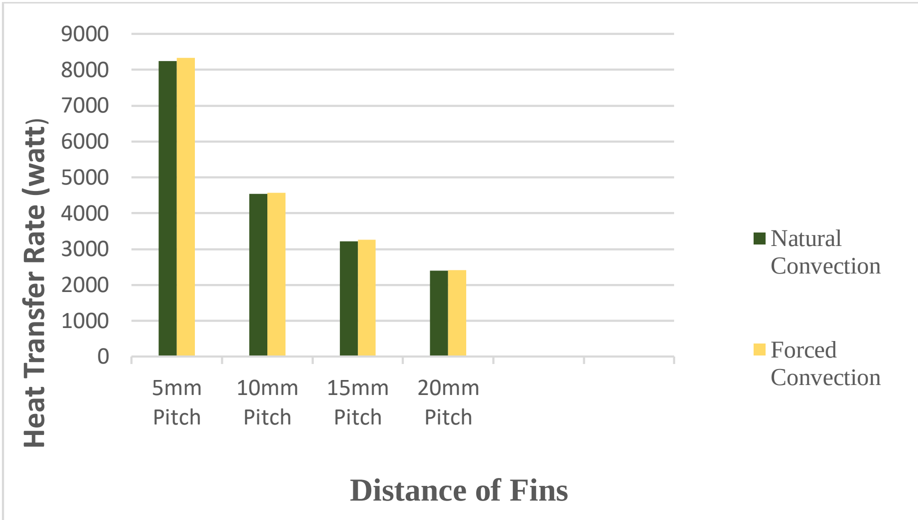
Distance between two consecutive fins (in mm)	5	10	15	20
NTU	0.171	0.088	0.063	0.046
$C=C_{min}/C_{max}$	0.62	0.62	0.62	0.62
$\epsilon_{cross\ flow\ ACHE}$ (in percentage)	8.77	6.04	5.01	4.2

2. 60^0 Degree fan blade angle on rectangular fins calculation

	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)	5	8251.84	8328.68
	10	4533.37	4564.08
	15	3212.82	3263.02
	20	2397.49	2411.49

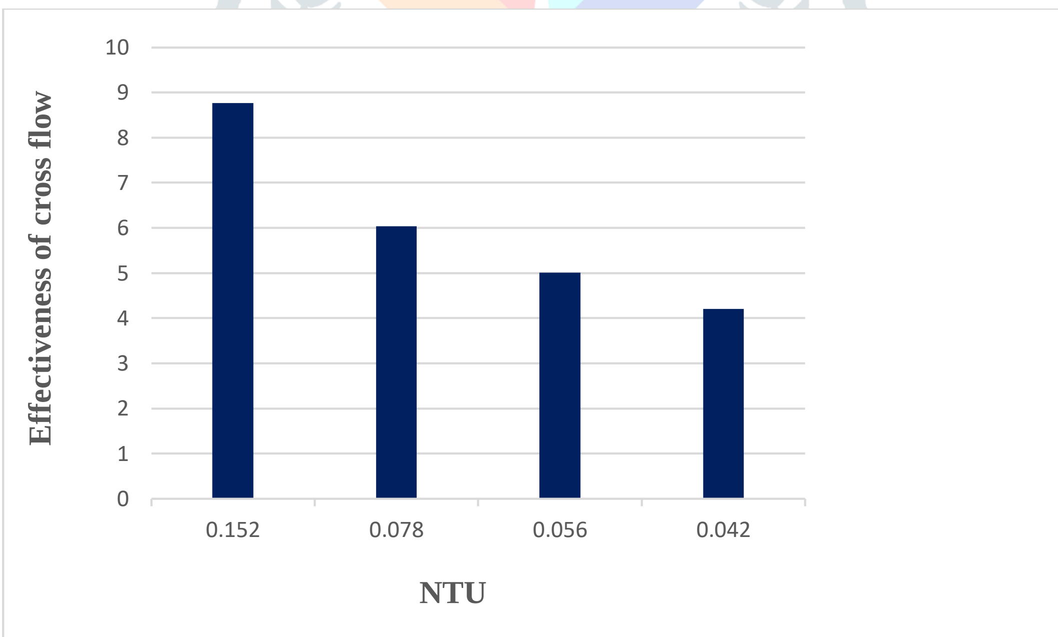
3.4 Comparative Variation of Heat Transfer Rate with Hot Fluid Inlet Temperatures of Internal Circular Grooved Tube with Rectangular Fins Air Cooled Heat Exchanger

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 parallelogram fins there are seven cases 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).



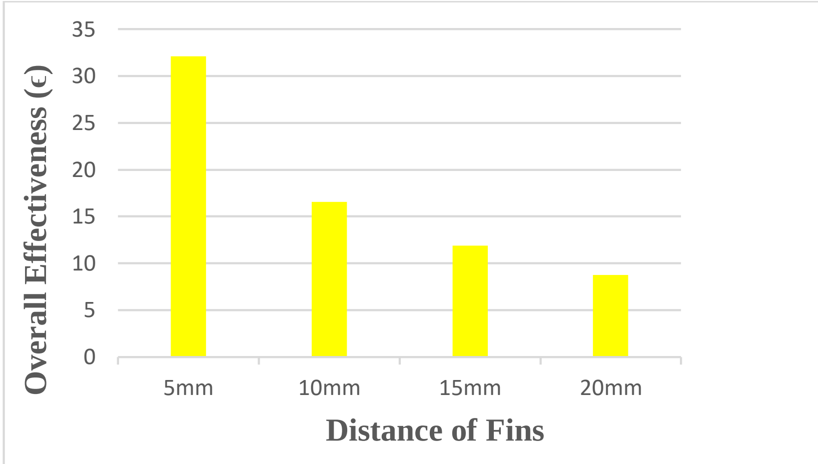
Graph 3.4 Comparative variation of heat transfer rate with natural and forced convection of simple tube air cooled heat exchanger, Internal circular grooved tube air cooled heat exchanger and internal circular grooved tube with rectangular fins air cooled heat exchanger.

3.5 Comparative Variation of heat exchanger two different fin size effectiveness with NTU



Graph 3.5 Variation of effectiveness with NTU Rectangular fins air cooled heat exchanger.

3.6 Variation of overall fin effectiveness with different fin size between two consecutive fins



Graph 3.6 Variation of overall fin effectiveness two consecutive rectangular fins air cooled heat exchanger.

4. CONCLUSION

This experimental study examined and analysed the various internal circular grooving heat exchanger at different pitches with rectangular fins at the distance between two fin is 5mm. Heat exchanger effectiveness is also higher as compare to another arrangement. We can conclude that the heat exchanger with in internal spiral grooving in concentric tube with rectangular Fins different size 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. But on the basis of economical point of view, the heat exchanger with rectangular fins which is placed 20 mm is more desirable because the number of fins required is very less compared to other arrangement. It was observed that increased heat transfer rate was obtained for forced convection as compare to free convection.

REFERENCES

[1] Afzal, A., Mohammed Samee, A.D., Abdul Razak, R.K "Optimum spacing between grooved tubes: An experimental study', Journal of Mechanical Science and Technology, Vol 34, No. 1, January 2020.

[2] Nithiyesh Kumar, C., Ilangkumaran, M., "Experimental study on thermal performance and exergy analysis in an internally grooved tube integrated with triangular cut twisted tapes consisting of alternate wings", Heat and Mass Transfer, Vol 55, April 2019.

[3] ZhisongLi. "Design and preliminary experiments of a novel heat pipe using a spiral coil as capillary wick". International Journal of Heat and Mass Transfer Volume 125, November 2018.

[4] Pengxiao Li, Peng Liu, Zhichun Liu, Wei Liu "Experimental and numerical study on the heat transfer and flow performance for the circular tube fitted with drainage inserts". International Journal of Heat and Mass Transfer Volume 107, April 2017.

[5] Pankaj N. Shrirao, Rajeshkumar U.Sambhe, Pradip R.Bodade, "Convective Heat Transfer Analysis in a Circular Tube with Different Types of Internal Threads of Constant Pitch". International Journal of Engineering and Advanced Technology (IJEAT), Volume2, Issue-3, February 2013.

[6] Kadir Bilen, Murat Cetin, Hasan Gul, Tuba Balta, "The investigation of groove geometry effect on heat transfer for internally grooved tubes". Applied Thermal Engineering, Volume 29, Issue 4, March 2009.

[7] P. Bharadwaj, A.D. Khondge, A.W. Date, "Heat transfer and pressure drop in a spirally grooved tube with twisted tape insert" International Journal of Heat and Mass Transfer, Volume 52, Issues 7–8, March 2009.

[8] M. Siddique, A.-R. A. Khaled, N. I. Abdulhafiz, and A. Y. Boukhary, "Recent Advances in Heat Transfer Enhancements: A Review Report", Hindawi Publishing Corporation, International Journal of Chemical Engineering, Volume 2010, September 2010.

[9] S Basavarajappa, G Manavendra and S B Prakash, "A review on performance study of finned tube heat exchanger", Journal of Physics: Conference Series, Vol. 1473, No. 1, February 2020.

[10] M Goto, N Inoue, N Ishiwatari, "Condensation and evaporation heat transfer of R410A inside internally grooved horizontal tubes, Vol. 24, Issue 7, July 2001.

[11] M. Goto, N. Inoue, R. Yonemoto, "Condensation heat transfer of R410A inside internally grooved horizontal tubes", Int. J. Refrig. 26 (2003) 410–416.

[12] V. Zimparov, "Enhancement of heat transfer by a combination of three-start spirally corrugated tubes with a twisted tape", Int. J. Heat Mass Transfer 44 (3) (2001) 551–574.

[13] P.G. Vicente, A. Garcia, A. Viedma, "Experimental investigation on heat transfer and frictional characteristics of spirally corrugated tubes in turbulent flow at different Prandtl numbers", Int. J. Heat Mass Transfer 47 (4) (2004) 671– 681.

[14] P. Naphon, M. Nuchjapo, J. Kurujareon, "Tube side heat transfer coefficient and friction factor characteristics of horizontal tubes with helical rib", Energy Convers. Manag. 47 (18–19) (2006) 3031–3044.

[15] AGS Roll Groove Specifications for 14-72"/DN350-DN1800 roll groove dimensions, © 2019 Victaulic Company.