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Experimental investigations on different surface geometries of finned tube air cooled heat exchanger

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Abstract:

Heat exchanger is a device which transfers the energy from hot fluid to the cold fluid. The present study was performed on the finned tubes having fines of different pitch sizes. The objective of the present work was for evaluate the rate of heat transfer and the finned tube performance when water flowing in the tube is cooled by the air supplied with some velocity.

The performance was evaluated for the different air flow rates for the two finned tubes having different pitches. The performance of the tube is evaluated and compared .The different plots obtained from the data collected shows the variation of temperature, velocity and heat flow rates. The temperature of the air flowing over the tubes is also varied and the effect is observed which is shown in the graphical form in the report.

1. Introduction

1.1.Heat Transfer

Transfer of energy due to the temperature difference is known as heat transfer. The science of thermodynamics deals with the amount of heat transfer as a system undergoes a process from one equilibrium state to another, and makes no reference to how long the process will take. But in engineering, we are often interested in the rate of heat transfer, which is the topic of the science of heat transfer.

2. Extended Surface Heat Exchangers

2.1.Air cooled heat exchanger

The Air-cooled heat exchanger, also known as dry cooler, air-cooler or fin-fan cooler is a device which rejects heat from a fluid or gas directly to ambient air. When cooling both fluids and gases, there are two sources readily available, with a relatively low cost, to transfer heat the .air and water. The obvious advantage of an air cooler is that it does not require water as a cooling medium, which means that equipment require cooling need not to be near a cooling water reservoir. In addition, the problems associated with treatment and disposal of water have become more complex with government regulations and environmental concerns. The air-cooled heat exchanger provides a means of transferring the heat from the fluid or gas into ambient air, without environmental concerns, or without great ongoing cost.

2.2.Fin geometry

There are two type of test section. The first type is made of crimped finned tube heat exchanger, having dimensions of (40cm) overall length, which contains (32cm) copper tube of (16mm) outer diameter & inner diameter(13.5) with fin pitch (10 fin/in), fin outer diameter(34.5mm) and fins thickness (0.1mm).. and the tubes material ad braas. Fin type crimp root soldered.

The second type is made of crimped finned tube heat exchanger, having dimensions of (40cm) overall length, which contains (32cm) copper tube of (16mm) outer diameter(14mm) inner diameter with fin pitch (11 fin/in), fin outer diameter(38mm) and fins thickness (0.1mm). and the tubes material ad brass. Fin type crimp root soldered

Figure 1

2. Expperimental Set-Up

The experiment in lnct college mechanical department I.C. engine lab

The setup which contain

- 120 cm long duct 32×32 cm^2 cross section area
- A 3 thousand watt instant water electric geyser
- Room heater rod for supplying hot air
- Thermocouple with indicator
- Fan
- 7 pointer speed controller for fan
- Regulator for controlling heater.
- U tube manometer for pressure drop(mercury)

3. Theoretical Analysis:-

A heat exchanger is a component that allows the transfer of heat from one fluid (liquid or gas) to another fluid. In a heat exchanger there is no direct contact between the two fluids. The heat is transferred from the hot fluid to the metal isolating the two fluids and then to the cooler fluid in this study the performance parameter such as air velocity ,pressure drop ,discharge of air and water , temperature of air and water , we provide heating coil in the duct for increasing the temperature of air

For the heat balance,

$q = m_h C_p (T_4 - T_3)$ = Heat given , C_p of water 4.187 KJ/Kg-degree

$q = m_c C_p (T_2 - T_1)$ =Heat taken , C_p of air 1.007 KJ/Kg-degree

$Q = A_1 V_1$= discharge of air, Area of duct = 0.32 m×0.32 m=0.1024 m^2

Mass flow rate of air

$\dot{m} = Q \times \rho_{AIR}$ m^3/sec

Mass flow rate water

$Q = \frac{(\text{volume of flask})}{(\text{time taken to fill})}$ { m^3/sec }

volume of water =1 litter (10^{-3} m^3)

$\dot{m} = Q \times \rho_{water}$ m^3/sec $\rho_{water} = 1000$ kg/m^3

The pressure drop in the tube can be calculated by eq^n

$\Delta p = g \times \Delta h(\rho_m - \rho_w)$

$\rho_m = 13600$ kg/m^3, $\rho_w = 1000$ kg/m^3, h= 0.002 m

g=9.81 N/sec^2 Δ h=(h1-h2), h1=78mm, h2=75 mm

$\Delta p = 370.818$ N/M^2

LMTD (log mean temperature difference), $\Delta T = (\Delta T_2 - \Delta T_1) / \log((\Delta T_2) / \Delta T_1)$ (°F)

4. Experimental Work

The constructed test rig. It consists of a test section which is a model of a crimped finned tube heat exchanger, water heater, natural flow of water system, control panel and measuring instrumentation. The rig is made of steel structure on which the testing component is fixed.

There are two type of test section. The first type is made of crimped finned tube heat exchanger, having dimensions of (40cm) overall length, which contains (32cm) copper tube of (16mm) outer diameter & inner diameter(13.5) with fin pitch (10 fin/in), fin outer diameter(34.5mm) and fins thickness (0.1mm).. and the tubes material ad braas. Fin type crimp root soldered.

The second type is made of crimped finned tube heat exchanger, having dimensions of (40cm) overall length, which contains (32cm) copper tube of (16mm) outer diameter(14mm) inner diameter with fin pitch (11 fin/in), fin outer diameter(38mm) and fins thickness (0.1mm). and the tubes material ad brass. Fin type crimp root soldered

5.Procedure Adopted For Experiment

First of all we calculate the velocity of air at different point on the duct and take the average speed of the air .The following table gives the information of the velocity: Then the change the change the air inlet temperature of the air and mass flow rate of water and calculate the heat supplied by water and transfer by air

5.1.When mass flow rate of water is = 0.010274kg/ sec

5.1.1.<u>When the air flowing over the tube is atmospheric air</u>

Test were performed at following conditions

Water flow rate of water = $\dot{m} = Q \times \rho_{\text{water}}$ kg/sec , $\rho_{\text{water}} =$ 1000 kg/m^3

Time taken to fill one Littre cylindrical flask= 1:37.33 second

volume of water =1 litter (10^{-3} m^3)

Q= $\frac{\text{(volume of flask)}}{\text{(time taken to fill)}}$ { m^3/sec }

Q* ρ = (10^{-3} m^3/1:37.33 second) *1000 kg /m^3 = 0.010274 kg/ sec

$\dot{m} = Q \times \rho_{\text{AIR}}$ m^3/sec $\rho_{\text{AIR}=}$ 1.1647 kg/m^3 at 30 degree

Temperature of the water flowing in the tube=44 degree centigrade

Speed of the air : There are seven speed of air which is given in the above table

T_4 =water inlet T_1 = air inlet , T_3 = water outlet T_2 = air outlet

The following calculation is given below:-

		AIR TEMP.		**air temp difference**	**WATER TEMP.**		**water**
S.No.	**fan**	**outlet**	**inlet**		**outlet**	**inlet**	
		T1	T2	T1-T2	T3	T4	T3-T4
1	1	36	30	6	21	54	33
2	2	34	30	4	22	54	32
3	3	34	30	4	22	54	32
4	4	33	30	3	23	54	31
5	5	34	30	3	24	54	30
6	6	33	30	3	22	54	32
7	7	33	30	3	22	54	32

Table 1

S.No.	mass flow rate water	cp=4.187	Heat supplied by water	mass flow rate air	cp of air 1.007	Heat transfer by air
	M=Q*ρ		MCp(T4-T3)	M=Q*A*ρ	ρ=1.1647	MCp(T2-T1)
1	0.01027	4.187	1.419613621	0.207521587	1.007	1.25384543
2	0.01027	4.187	1.376595027	0.250457088	1.007	1.00884115
3	0.01027	4.187	1.376595027	0.291007283	1.007	1.172177337
4	0.01027	4.187	1.333576432	0.310089728	1.007	0.936781068
5	0.01027	4.187	1.290557838	0.322016256	1.007	0.972811109
6	0.01027	4.187	1.376595027	0.33632809	1.007	1.016047159
7	0.01027	4.187	1.376595027	0.355410534	1.007	1.073695224

Table 2

5.1.2.<u>When the air flowing over the tube is heated at various temperatures</u>

Test were performed at following conditions

Water flow rate of water = $\dot{m} = Q \times \rho_{\text{water}}$ kg/sec , $\rho_{\text{water}} =$ 1000 kg/m^3

Time taken to fill one Litter cylindrical flask= 1:37.33 second

volume of water =1 litter (10^{-3} m^3)

Q= $\frac{\text{(volume of flask)}}{\text{(time taken to fill)}}$ { m^3/sec }

Q* ρ = (10^{-3} m^3/1:37.33 second) *1000 kg /m^3 = 0.010274 kg/ sec

$\dot{m} = Q \times \rho_{\text{AIR}}$ m^3/sec , $\rho_{\text{AIR}} =$ 1.1385 kg/m^3 at 37 degree

Temperature of the water flowing in the tube=44 degree centigrade

Speed of the air : There are seven speed of air which is given in the above table

T_4 =water inlet T_1 = air inlet , T_3 = water outlet T_2 = air outlet

The following calculation is given below:-

		AIR TEMP.		air temp difference	WATER		water difference
S.No.	fan	outlet	inlet		outlet	inlet	
		T1	T2	T1-T2	T3	T4	T3-T4
1	1	42	39	3	27	54	27
2	2	42	39	3	23	54	31
3	3	41	38	3	26	54	28
4	4	39	37	2	24	54	30
5	5	39	37	2	25	54	29
6	6	39	37	2	26	54	28
7	7	39	37	2	26	54	28

Table 3

S.No.	mass flow rate water	cp=4.187	Heat supplied by water	mass flow rate air	cp of air 1.007	Heat transfer by air
	M=Q*ρ		MCp(T4-T3)	M=Q*A*ρ	ρ=1.1385	MCp(T2-T1)
1	0.01027	4.187	1.161502054	0.165547008	1.007	0.500117511
2	0.01027	4.187	1.333576432	0.223838208	1.007	0.676215226
3	0.01027	4.187	1.204520648	0.258812928	1.007	0.781873855
4	0.01027	4.187	1.290557838	0.282129408	1.007	0.568208628
5	0.01027	4.187	1.247539243	0.305445888	1.007	0.615168018
6	0.01027	4.187	1.204520648	0.310109184	1.007	0.624559897
7	0.01027	4.187	1.204520648	0.324099072	1.007	0.652735531

Table 4

5.2.When mass flow rate of water is = 0.010274324 kg/ sec

5.2.1.When the air flowing over the tube is atmospheric air

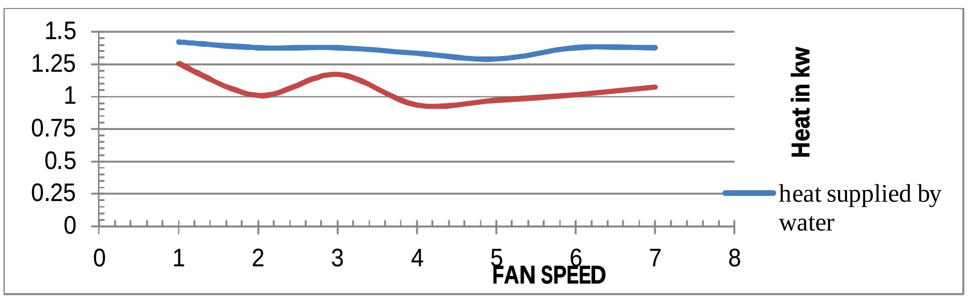

Figure 1

*5.2.2.*When the air flowing over the tube is heated at various temperatures

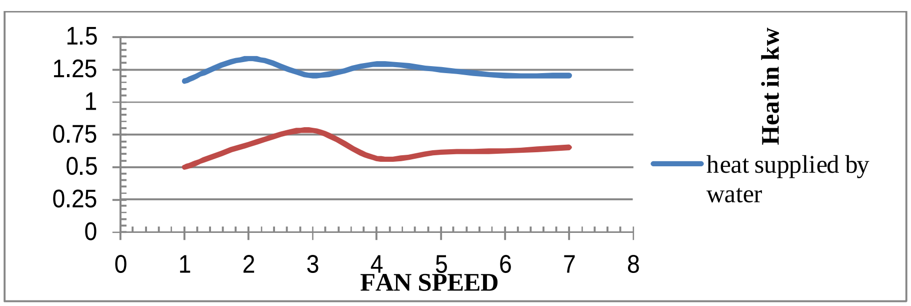

Figure 2

6. Nomenclature

m_h = mass flow rate of hot fluid

m_c = mass flow rate of cold fluid

ΔT_1= T_4 -T_1 ΔT_2 =T_3–T_2

T_1 = air outlet T_2 = air inlet

T_3 = water outlet T_4 =water inlet

A_1= area of duct V_1= velocity of air

ρ_{AIR}= 1.1647 kg/m^3 at 30 degree ,

ρ_{AIR}= 1.1609 kg/m^3 at 31 degree

ρ_{AIR}= 1.1458 kg/m^3 at 35degree

ρ_{AIR}= 1.1421 kg/m^3 at 36 degree

ρ_{AIR}= 1.1385 kg/m^3 at 37 degree

7. Result And Conclusion

In this present experimental work, the performance of two fined tube at difference mass flow rate and difference air velocity have been evaluated. Different performance curves for crimped fin tube air to water heat exchanger have been plotted.

The plots show the variation of the mass flow rate of water on the difference in temperature of water and air which is found almost constant for high mass flow rate. If the mass flow rate of water is less the effect of velocity is seen uniform. At high velocity of air the heat transfer is more due to turbulence of air.

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