EXPERIMENTAL ANALYSIS OF HEAT EXCHANGER OF DIFFERENT MATERIAL WITH AND WITHOUT FINS

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ABSTRACT

In this paper, experiments were performed to analysis the heat transfer in double pipe heat exchanger of different tube materials such as copper, aluminum and stainless steel with and without fins of 80mm and 160mm pitch difference in parallel flow arrangements. The experimental setup consist of two concentric tubes with outer annulus of G.I tube and inner annulus of copper, aluminum and stainless steel tubes each time with and without fins. Hot water is flowing across the inner tube and cold water is flowing across the outer tube, thus the heat is transferred from the inner annulus to the outer annulus. Firstly we conducted the experiment without fins and recorded the parameter for plane heat exchanger and then with fins of 160mm and 80mm pitch difference. The observations and calculations are determined on the basis of the thermal performance of the double pipe heat exchanger.

The overall experiment is conducted under steady state condition where mass flow rate of cold water is controlled by the manometer and mass flow rate of hot water is same on both side of the outer tube. The result so obtained after number of experiments states that the effectiveness increases with increase in the mass flow rate of cold water in each case of copper, aluminum and stainless steel tubes.

Keywords: Double pipe heat exchanger, effectiveness, heat transfer rate, overall heat transfer coefficient, parallel flow arrangement.

NOMENCLATURE

T_{hi}	Hot water inlet temperature
T_{ho}	Hot water outlet temperature
T_{ci}	Cold water inlet temperature
T_{co}	Cold water outlet temperature
D_p	Diameter of tube
D_o	Diameter of orifice meter
A_p	Area of tube
A_o	Area of orifice meter
H_m	Head of mercury column
H_w	Head of water column
ρ	Density of mercury
C_{dis}	Coefficient of discharge

Q Discharge of orifice meter

m_{cw} Mass flow rate of cold water

m_{hw} Mass flow rate of hot water

V Volume of bucket

t Time taken to fill the bucket

ΔT_m LMTD

€ Effectiveness

Ů Overall heat transfer coefficient

I. INTRODUCTION

Heat exchanger is a device used to transfer heat from one medium to other medium either by direct contact or by indirect contact. Heat exchanger is widely used in industrial purpose and is present in our refrigerator andairconditioning unit. The transfer of heat occurs in three modes: conduction, convection and radiation. Theindustries where it is generally used are chemical, power plants, nuclear reactors, heavy industries, etc.

In this paper, experiments were conducted to analysis the effect of fins on the effectiveness and overall heat transfer coefficient of the double pipe heat exchanger. The fins of different configurations were attached on the outer surface of the tubes which causes a separate and reattach flow. A number of experiments are carried out using different tube material and different fins configuration, but this paper is investigating the performance of three different tube materials with and without fins of three different configurations.

II. EXPERIMENTAL SETUP

The above setup is used to determine the heat transfer. The setup consist of two concentric tube with outerannulus of G.I with 50.8mm diameter and 2430.5mm length and inner annulus of copper, aluminum and stainless steel pipes each time of 16.67mm diameter and 2438.4mm length. The hot water is flowing across the inner tube and cold water is flowing across the outer tube such that heat transfer takes place from inner to outer annulus of the heat exchanger and flow considered is parallel. A digital temperature indicator is used to record the temperature which is connected to the tubes through thermocouple wires at the inlet and outlet of both the tubes. The hot water coming from the geyser is circulated across the inner annulus with the help of pump. The mass flow rate of hot water is same whereas the mass flow rate of cold water is varied with the help of U-shaped manometer attached at the inlet and outlet of the orifice meter attached at the inlet of the inner tube. Firstly we conducted the experiment with plane copper tube as inner annulus and recorded the performance parameter. We repeated the same procedure to obtain the performance parameter of aluminum and stainless steel each time.

The special feature of this experiment is to use fins on the outer surface of the three tubes of different configurations. The use of fins gives many advantages which include perfect separation of fluid around the annulus, high effectiveness, no moving parts, high reliability, etc. The fins provides the zigzag motion to the cold water at the outer annulus resulting in high heat transfer and increase in effectiveness as more surface is exposed to flowing water.

III. SPECIFICATIONS

Digital temperature indicator: K-Type sensor, 0-400 range, 230V- AC Voltage.

Geyser: 1litre capacity, 3000 watt power and 230V-AC Voltage.

Centrifugal pump: Mini super model, 100 watt input, 500mm head and 230V Voltage/50Hz.

Specification of fins:

Material	copper
Shape	Triangular
Base	4mm
Height	8mm
Thickness	1.5mm

Material	Stainless steel
Shape	Rectangular
Base	5mm
Height	10mm
Thickness	1.5mm

Material	Aluminum
Shape	Circular
Diameter	2.5mm

IV. CALCULATION

1. $Q = C_{dis}*[(A_p A_o \sqrt{2gH}_w)/(A_p - A_o)^{1/2}]$

2. $m_{cw} = \rho * Q$

3. $Q_{act} = m_{cw}*C_{pcw}*(T_{co}-T_{ci})$

4. $Q_{max} = m_{cw}*C_{pcw}*(T_{hi}-T_{ho})$

5. $€ = Q_{act}/Q_{max}$

6. $\mathring{U} = Q_{act}/(A*\Delta T_m)$

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V. OBSERVATION

1. Plane tube:

a. Copper tube

S.No	m_{cw}(kg/s)	€	Ů(W/m^2)
1	0.091	0.316	818.39
2	0.122	0.312	1099.88
3	0.147	0.307	1330.19
4	0.168	0.250	1192.27
5	0.187	0.200	975.84

Q_{act} = 0.091*4.2*(37-31) = 2.2932 KW

Q_{max} = 0.091*4.2*(50-31) = 7.2618 KW

€ = 2.2932/7.2618 = 0.316

Ů=(2.2932*1000)/(0.1914*14.64)= 818.39W/m^2

b. Aluminum tube

S.No	m_{cw}(kg/s)	€	Ů(W/m^2)
1	0.091	0.273	676.90
2	0.122	0.200	636.65
3	0.147	0.158	591.15
4	0.168	0.118	494.50
5	0.187	0.067	610.63

Q_{act} = 0.091*4.2*(34-28) = 2.2932 KW

Q_{max} = 0.091*4.2*(50-28) = 8.4024 KW

€ = 2.2932/8.4084 = 0.273

Ů=(2.2932*1000)/(0.1914*17.70)= 676.90W/m^2

c. Stainless steel

S.No	m_{cw}(kg/s)	€	Ů(W/m^2)
1	0.091	0.227	546.19
2	0.122	0.190	616.14
3	0.147	0.158	591.15
4	0.168	0.111	463.13
5	0.187	0.067	305.32

Q_{act} = 0.091*4.2*(33-28) = 1.911 KW

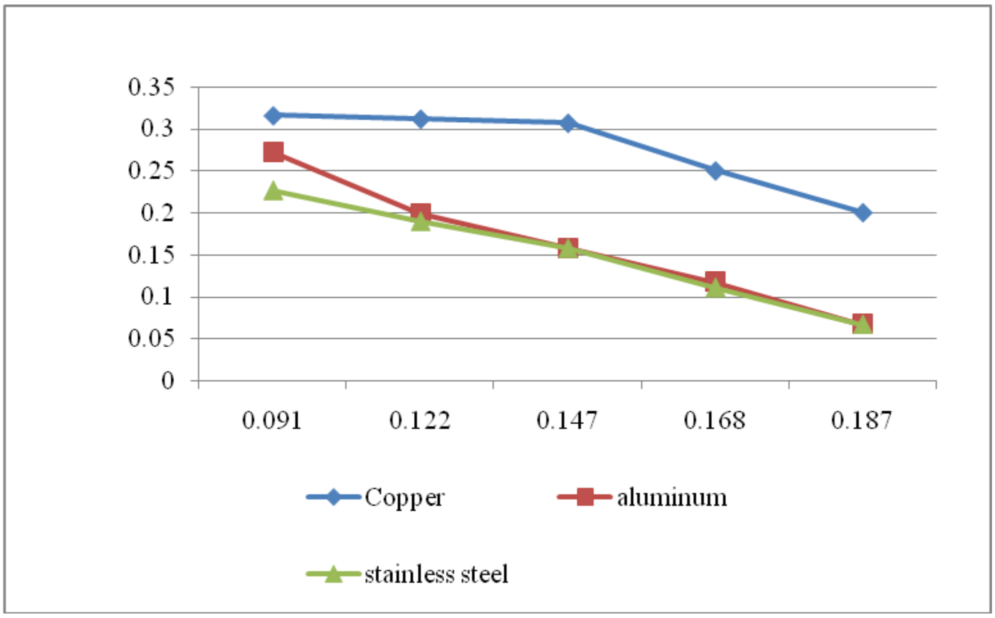
Q_{max} = 0.091*4.2*(50-28) = 8.4084 KW

€ = 1.911/8.4084 = 0.316

Ů=(1.911*1000)/(0.1914*18.28)= 546.188W/m^2

The above equations are used to calculate the heat transfer rate, effectiveness and overall heat transfer coefficient. The same equations are used to calculate the parameters each time the experiment is conducted for tubes with fins of 160mm and 80mm pitch difference.

The following graph is based on the above data for plane tube heat exchanger. The graph is plotted between mass flow rate of cold water and effectiveness. The graph shows the performance of the three materials and alsostates that copper has higher effectiveness than aluminum and stainless steel.



Graph: mass flow rate of cold water Vs effectiveness for plane tubes.

2. Tubes with fins of 160mm pitch difference:

a. Copper tube

S.No	m_{cw}(kg/s)	€	Ů(W/m^2)
1	0.091	0.368	1099.76
2	0.122	0.333	1274.82
3	0.147	0.308	1425.73
4	0.168	0.250	1340.55
5	0.187	0.182	1031.02

b. Aluminum tube

S.No	m_{cw}(kg/s)	€	Ů(W/m^2)
1	0.091	0.364	1006.6
2	0.122	0.300	1067.28
3	0.147	0.278	1185.05
4	0.168	0.187	866.74
5	0.187	0.149	724.99

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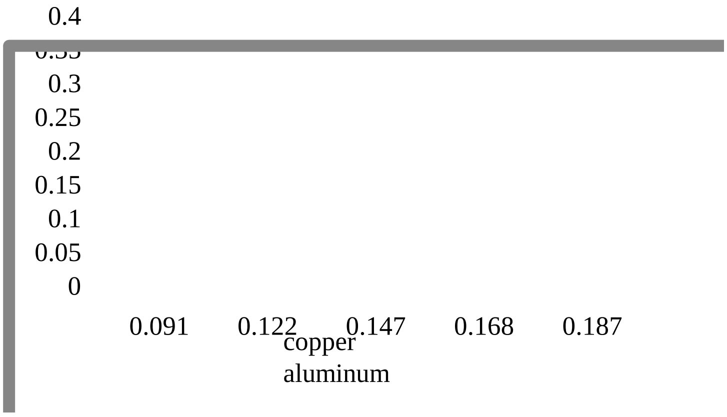
c. Stainless steel

S.No	m_{cw}(kg/s)	€	Ů(W/m^2)
1	0.091	0.318	847.16
2	0.122	0.263	878.90
3	0.147	0.167	542.66
4	0.168	0.125	483.61
5	0.187	0.083	416.18

The following graph states that when fins are mounted over the outer surface of the inner tube, the effectiveness of the heat exchanger increases with the increase in the mass flow rate of cold water. The following graph shows the performance of fins of 160mm pitch difference.



Graph: mass flow rate of cold water Vs effectiveness with fins of 160mm pitch difference.

3. Tubes with fins of 80mm pitch difference

a. Copper tub

S.No	m_{cw}(kg/s)	€	Ů(W/m^2)
1	0.091	0.474	1495.16
2	0.122	0.467	2058.80
3	0.147	0.461	2534.94
4	0.168	0.416	2531.95
5	0.187	0.364	2371.93

b. Aluminum tube

S.No	m_{cw}(kg/s)	€	Ů(W/m^2)
1	0.091	0.409	1236.02
2	0.122	0.388	1519.85
3	0.147	0.375	1897.47
4	0.168	0.308	1761.77
5	0.187	0.273	1998.43

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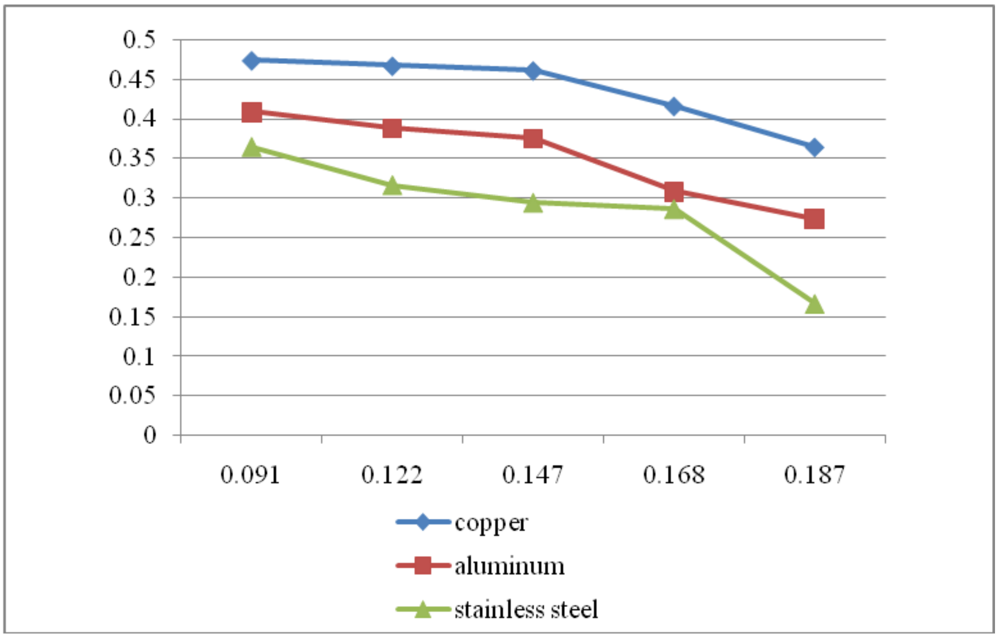
c. Stainless steel

S.No	m_{cw}(kg/s)	€	Ů(W/m^2)
1	0.091	0.364	1049.60
2	0.122	0.316	1200.50
3	0.147	0.294	1350.80
4	0.168	0.286	1562.08
5	0.187	0.167	884.36

The following graph states that when the pitch difference of the fins is decreased to 80mm then the effectiveness increases than the 160mm pitch difference. This is due to more separation of fluid along the tube and more surface of fins exposed to water.



Graph: mass flow rate of cold water Vs effectiveness with fins of 80mm pitch difference.

VI. RESULT AND CONCLUSION

This paper states that when there is increase in mass flow rate of cold water, the effectiveness and overall heat transfer coefficient of heat exchanger also increases. The use of inner tube of different materials also enhances the performance of the heat exchanger giving rises to better efficiency.

Copper tube gives higher effectiveness than aluminum and stainless steel tubes as it has higher thermal conductivity. The insulation on the outer annulus plays a vital importance in the performance of the heat exchanger. Here in many observations it can be noted that heat loss by hot water is higher than the cold water which states that insulation is not enough to resist the losses.

Thus it can be concluded that heat exchanger with fins gives better performance than heat exchanger without fins under the same conditions and parameters, improving the applications of heat exchangers in every field of industries.

VII. REFERENCE

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