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Experimental and Investigation of Double Pipe Heat Exchanger Using Fins

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***Abstract*—*Heat exchangers are employed in nuclear and thermal power plants for the heat transfer. Heat exchangers are the major equipments which influence the effective working and overall efficiency of the power plant. So it is necessary to design the heat exchangers with the capacity to transfer maximum amount of heat. The heat transfer mostly depends on the heat transfer surface area and flow direction of the fluids being used for exchange of heat, flow velocity, etc. In this project an attempt is made to enhance the transfer of heat from hot fluid to cold fluid of the double pipe heat exchanger. Here we design a heat exchanger with internal fin which can eliminate more heat. And the comparison was taken with previously designed double pipe heat exchangers. The calculation has been performed as per the standard procedures employed for the design of heat exchangers.*

***Keywords*— *Double pipe heat exchanger, Internal fins.*

I. INTRODUCTION

A heat exchanger is a device built for efficient heat transfer from one medium to another, whether the media are separated by a solid wall so they never mix, or the media are in direct contact. They are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries and natural gas processing. One common example of a heat exchanger is the radiator in a car, in which a hot engine-cooling fluid, like antifreeze, transfers heat to air flowing through the radiator. Here we design and fabricated the double pipe heat exchanger with three various model. And compare their performance and effectiveness. We selected steel as material for producing double pipe heat exchanger. The thermal conductivity of steel is 20-45 w/mk. In this project the pin fin is selected. The main advantage with Pin fin is that they perform in a better manner when they are placed in a tilted position. When compared to other heat sinks, they show a better performance as well. The fins are fixed inside the internal cylinder. Some of the fins lengths are extended outside the internal cylinder and some of the fins length are extended inside the internal cylinder. Fins are used in a large number of applications to increase the heat transfer from surfaces. The fin is exposed to a flowing fluid, which cools or heats it, with the high thermal conductivity allowing increased heat being conducted from the wall through the fin. The water is selected as working fluid. It consists of two cylinder (i.e) inner cylinder and outer cylinder. The hot stream of water is allowed to flows through inner cylinder and normal water is allowed to flows through outer cylinder. The experiment is carried out in three various designed double pipe heat exchanger to eliminate more heat from hot fluids to cold fluid

II. EXPERIMENTAL SETUP

Here we compare three various design of double pipe heat exchanger. The comparison was take on performance and overall effective through calculations.

A. Plane surfaced double pipe heat exchanger

In its simplest form, the double pipe heat exchanger, (also known as a concentric pipe, hairpin, jacked pipe and jacketed U-tube heat exchangers), consists of a single tube mounted inside another. One fluid flows in the inner pipe, while a second fluid flows in the outer pipe annuals.

Fig. 1. plane surface double pipe heat exchanger.

B. External finned double pipe heat exchanger

It is similar to plane surface DPHE as the hot water enters in inner tube and cold water enters in outer tube. Here additionally the longitudinal fins are attached in its external surface. It can eliminate the more heat than the plane surface heat exchanger with the help of longitudinal fin.

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Fig. 2. External finned double pipe heat exchanger.

C. Internal finned double pipe heat exchanger

It is also similar to plane surface DPHE as the hot water enters in inner tube and cold water enters in outer tube. Here additionally the numbers of pin fins are attached in its outer and inner surface of internal tube. It can eliminate the more heat than the plane surface heat exchanger with the help of pin fins. Its structure was given in below diagram.

Fig. 3. Internal finned double pipe heat exchanger.

Fig. 4. Pin fin arrangement in internal cylinder

III. Readings and Calculations

A. *Calculate Logarithmic Mean Temperature Difference (LMTD)* Internal finned pipe

Parallel flow:

ΔT_{lm} = [(T_{hi}-T_{ci}) - (T_{ho} -T_{co})] / ln[(T_{hi}-T_{ci}) / (T_{ho}-T_{co})]
= [(58.6-29.5) - (43.4 -35.6)] / ln[(58.6-29.5) / (43.4-35.6)]
= (29.1-7.8) / ln [(29.1 / 7.8)]
= 21.3 / ln [(3.730)]
= 21.3 / 1.316
ΔT_{lm} = 16.18°C

Counter flow:

ΔT_{lm} = [(T_{hi}-T_{co})-(T_{ho}-T_{ci})]/ ln[(T_{hi}-T_{co}) / ($T_{ho}T_{ci}$)]
= [(54.4-34.2) - (41.1-29.5)] / [(54.4-34.2) / (41.1-29.5)]
= (20.2-11.9) / [(20 / 11.5)]
= (20.2-11.9) / ln [(1.697)]
= 8.3 / 0.528
ΔT_{lm} = 15.71°C

B. *Calculations for effectiveness*

Heat transfer
Q_h=m_h .Cp_h [T_{hi}-T_{ho}]
Mass flow rate of hot fluid
m_h = [1000/sec]*10^{-2}
m_h = (1000/48.69)*10^{-3}
m_h =0.02
Heat transfer in hot fluid
Q_h=0.102*4.187(54.4-14.1)
Q_h=1.114
Mass flow rate of cold fluid
m_c = (1000/sec)*10^{-3}
m_c = (1000/9.79)*10^{-3}
m_c =0.102
Heat transfer in cold fluid
Q_c=m_c* C $_{pc}$ (T_{co}-T_{ci})
Q_c =0.102*4.187*(34.2-29.5)
Q_c =2.007
Overall heat transfer
Q = (Q_h+Q_c)/2
Q = (2.007+1.114)/2
Q =1.56
Area of heat exchanger
A=Л D L
A=л *0.72*0.012
A=0.027 m²
Q= U A $(\Delta T)_{lm}$
Heat transfer coefficient
U=Q/A*$(\Delta T)_{lm}$
U=1.56/ (0.027*15.71)
U=3.67 w/m² k
C_h=C_{ph}*m_h
C_h=4.187*0.02
C_h=0.083
C_C=C_{pc}*m_C
C_C=4.187*0.102
C_C=0.427
Effectiveness
ε =1- exp ((-UA/C_{min})*(1+ (C_{min} /C_{max})/ (1+ (C_{min} /C_{max})))
ε =1-exp (((-3.67*0.027)/(0.083))*(1+(0.125/0.293)/(1+(0.125/0.293)))
ε =0.69
ε = 69%

Counter flow:
Heat transfer
Q_h=m_h .Cp_h [T_{hi}-T_{ho}]
Mass flow rate of hot fluid
m_h = [1000/sec]*10^{-3}
m_h = (1000/41.16)*10^{-3}
m_h =0.024
Heat transfer in hot fluid
Q_h =0.024*4.187(58.5-43.4)
Q_h =0.1.52
Mass flow rate of cold fluid
m_c = (1000/sec)*10^{-3}
m_c = (1000/9.49)*10^{-3}
m_c =0.105
Heat transfer in cold fluid
Q_c=m_c* C $_{pc}$ (T_{co}-T_{ci})
Q_c =0.105*4.187*(35.6-29.5)
Q_c =2.68
Overall heat transfer
Q = (Q_h+Q_c)/2
Q = (2.68+1.52)/2
Q =2.1
Area of heat exchanger
A=Л D L
A=л *0.72*0.012
A=0.027 m²
Q= U A $(\Delta T)_{lm}$
Heat transfer coefficient
U =Q/A*$(\Delta T)_{lm}$
U=2.1/ (0.027*16.18)

$U=4.80\ w/m^2k$
$C_h=C_{ph}*m_h$
$C_h=4.187*0.024$
$C_h=0.100$
$C_c=C_{pc}*m_c$
$C_c=4.187*0.105$
$C_c=0.439$

Effectiveness

$\varepsilon=1-\exp((-UA/C_{min})*(1+(C_{min}/C_{max})/(1+(C_{min}/C_{max})))$
$\varepsilon=1-\exp(((-4.80*0.027)(0.100)*(1+(0.100/0.439)/(1+(0.100/0.439)))$
$\varepsilon=0.72$
$\varepsilon=72\ \%$

TABLE I. Readings of internal finned DPHE.

Flow type	Hot water			Cold water			LM TD	ε
	Vol. flow rate	Inlet temp ^0c	Outlet temp ^0c	Vol. flow rate	Inlet temp ^0c	Outlet temp ^0c		
Parallel flow	44.2	58.6	43.4	9.49	29.5	35.6	16.18	69%
Counter flow	48.6	54.4	41.1	9.79	29.5	34.2	15.71	71.6%

TABLE II. Comparison table.

Sl.No	Type of heat exchanger	Type of flow	LMTD	HEAT transfer coefficient (U) w/m²k	Effectiveness ε (%)
1	Plane surface DPHE	Parallel flow	15.37	1.179	23
2	Plane surface DPHE	Counter flow	18.53	1.37	34.7
3	External finned DPHE	Parallel flow	24.5	1.99	34.8
4	External finned DPHE	Counter flow	18.42	1.79	37.1
5	Internal finned DPHE	Parallel flow	16.18	3.67	69
6	Internal finned DPHE	Counter flow	15.71	4.80	72.1

IV. CONCLUSION

Experimental investigations of heat transfer and performance characteristics of double pipe heat exchanger fitted with inserted pin fin with spacing of 10mm and 30 mm long and 3mm dia carried out for both parallel and counter flow. The following conclusion could be made:

The heat transfer coefficient and friction factor increases by using pin fin arrangements.

- The effectiveness of 69 % can be obtained by using internal fin double pipe heat exchanger through parallel flow.
- The effectiveness of 72.1 % can be obtained by using internal fin double pipe heat exchanger through counter flow.
- The performance ratio for pin fin heat exchanger is greater than unity, therefore improvement in the energy saving lead to validate the capacity of the proposed expressions to predict the behavior for practical applications.

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