Scientific Journal of Impact Factor(SJIF): 3.134

e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2, Issue 5, May -2015

PERFORMANCE ANALYSIS OF HEAT EXCHANGER BY REPLACING COPPER TUBES WITH POLYMER TUBE OR COMPOSITES MATERIAL

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Abstract — *In this thesis the polymer heat exchangers to the current technology in metallic heat exchangers. A review of state of the art of polymer heat exchangers is presented and technological problems are identified. In a current metallic heat exchangers copper tube is used for transferring the heat exchangers, copper tube is used for transferring the heat. Since the thermal conductivity of the copper tube is high so when the copper tube transfers the heat there are some heat losses. The thermal expansion coefficient of the copper tube is high so when the high temperature is achieved into the copper tube than the shape and size of the copper tube also changes. Copper is a reactive metal so when the chemical treatment process is done for removing the chocking defect, copper metal react with the chemical so strength of the copper tube will be decrease. In this simulation models were developed and used to explore the thermal-hydraulic, packaging and weight tradeoffs associated with polymer heat exchangers.*

***Keywords –** Heat Exchanger , Polymer*

I INTRODUCTION

HEAT EXCHANGER

A heat exchanger is a device built for efficient heat transfer from one medium to another. The media may be separated by a solid wall, so that they never mix, or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries, natural gas processing, cryogenics applications and sewage treatment. One common example of a heat exchanger is the radiator in a car, in which the heat source, being a hot engine-cooling fluid, water, transfers heat to air flowing through the radiator (i.e. the heat transfer medium).

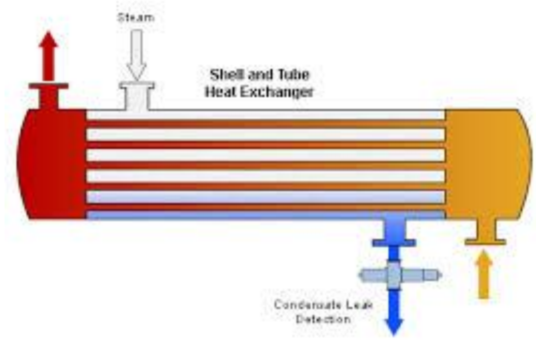


Figure Tube and shell type heat exchanger

Polymers are substances made up of recurring structural units, each of which can be regarded as derived from a specific compound called a **moanomer.** The number of monomeric units usually is large and variable, each sample of a given polymer being characteristically a mixture of molecules with different molecular weights. The range of molecular weights is sometimes quite narrow, but is more often very broad. The concept of polymers being mixtures of molecules with long chains of atoms connected to one another seems simple and logical today, but was not accepted until the 1930's when the results of the extensive work of **I-I**

II LITERATURE REVIEW

[1] Younggil Park ,Anthony M. Jacobi A polymer-tube-bundle heat exchanger was conceptualized as a potential replacement to a conventional metallicplate-fin-and-tube heat exchanger for water-to-air applications. The lower thermal conductivity and mechanical strength of polymers were systematically overcome by employing a larger number of thin-walled small-diametertubes. Major benefits of polymers as heat exchanger materials are: (1) reduced weight and cost, (2) manufacturingflexibility for complex designs, and (3) chemical stability.

[2] Ye.P.Mamunga, V.V.Davydenko, P.Pissis, E.V.Lebedev In this paper The electrical and thermal conductivity of systems based on epoxy resin (ER) and poly(vinyl chloride) (PVC) filled with metal powders have been studied. The composite preparation conditions allow the formation of a random distribution of metallic particles in the polymer matrix volume for the systems ER–Cu, ER–Ni, PVC–Cu and to create ordered shell structure in the PVC–Ni system.

[3] A.Elkhaoulani , F.Z.Arrakhiz , K.Benmoussa , R.Bauhfid , A.Qaiss In this paper the torsion tests were carried out for hemp fibers polypropylene composite and the compatibilized composite at different fiber content.

[4] Suzhu Yu, Peter Hing, Xiao Hu The thermal conductivity of polymer composites having a matrix of polystyrene (PS) containing aluminum nitride (AlN) reinforcement has been investigated under a special dispersion state of filler in the composites: aluminum nitride filler particles surrounding polystyrene matrix particles: aluminum nitride filler particles surrounding polystyrene matrix particles .The thermal conductivity of the composite is five times that of pure polystyrene at about 20% volume fraction of AlN for the composite containing 2 mm polystyrene particle size.

III METHODOLOGY

A. SELECTION OF TUBE MATERIAL

From the review of the literature and companies observation, it is found that the benefits of polymers as heat exchanger materials are: (1) reduced weight and cost, (2) manufacturing flexibility for complex designs, and (3) chemical stability.

Table 1 Properties of polymer

Property	Value
Density (×1000 kg/m3)	1.5
Poisson's Ratio	0.21
Thermal Conductivity(W/m-K)	0.46-0.50
Specific Heat (J/kg-K)	312

B. DETAIL OF HEAT EXCHANGER.

Table 2 Heat Exchanger

Parameter	Dimension
Shell Diameter(mm)	207
Tube outside Diameter(mm)	19
Tube Pitch	50
Length of Tube (mm)	1500
Number of Tubes	7
Tube to Tube Clearance	31
Shell Length	1500
No of Baffles	5
No of Passes	1
Hot Fluid inlet Temp. (T1)	63^{o}**C**
Cold Fluid Inlet Temp. (t1)	33^{o}**C**

Table 3 Properties of Fluid

Parameter	**Symbol**	**Unit**	**Cold Water (Shell)**	**Hot Water (Tube)**
Fluid			Water	Water
Specific Heat	CP	KJ/Kg.K	4.178	4.178
Thermal Cond	K	W/m.K	0.615	0.615
Viscosity	μ	Kg/m.s	0.0013	0.0013
Prandtl 's No.	Pr		5.42	5.42
Density	ρ	Kg/m3	998.2	998.2

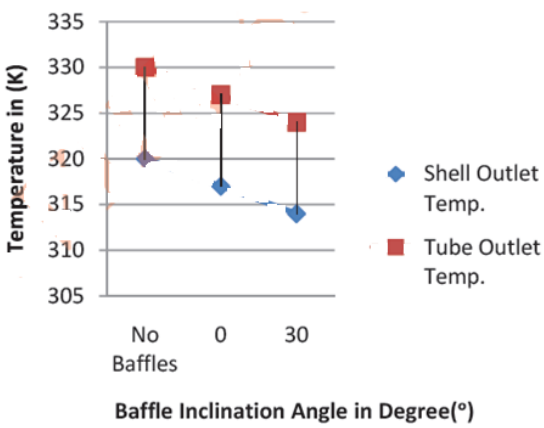
IV EXPERIMENTAL RESULT AND DISCUSSION

The performance of polymer tube heat exchanger at the various inclination angle of baffles and effct of temperature and velocity with different type of baffles.

A. For the Outlet Temperature of the Shell Side and Tube Side

Table 4 The Outlet Temperature of the Shell Side and Tube Side

Baffle Inclination Angle in (Degree)	**Outlet Temperature Of Shell side in (k).**	**Outlet Temperature Of Tube side in (k).**
Without Baffles	320	330
0^{o}	317	327
30^{o}	314	324



It has been found that there is much effect of outlet temperature of shell side & tube side with increasing the baffle inclination angle from 0^{o} to 30^{o} & without having baffles.

B. For Heat Transfer Rate across Tube side

Baffle Inclination Angle in (Degree)	Heat Transfer Rate Across Tube side (KW)
Without Baffles	4.41
0°	6.39
30°	8.52

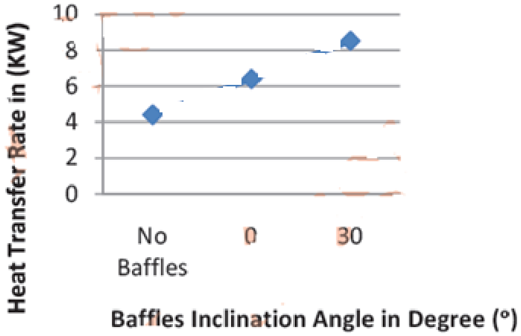
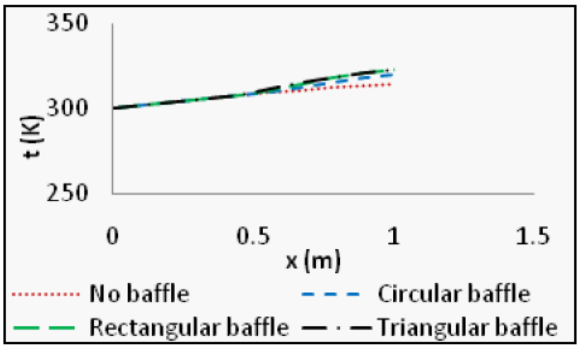


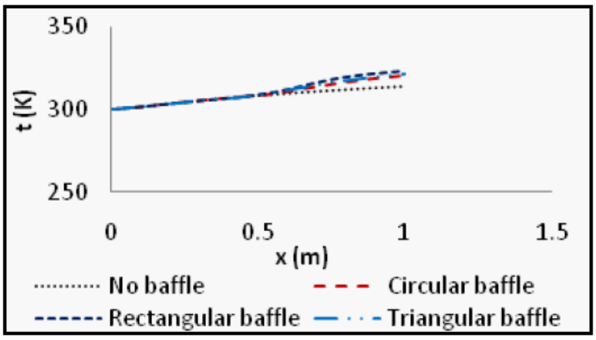
Fig shows that the heat transfer rate is increase when the baffle inclination is increase.

C. Temperature Variation Along the Center Line

Fig. provides a temperature variation along the center line of the tube. Here the baffle is placed at 0.048 m. At inlet, the temperature in all the cases is 300 K. As we proceed along the baffle, the temperature of air increases slightly. At x=0.05m, the temperature of air in case of no baffle is 309.21 K and 309.09 K, 309.20 K and 309.33 K in case of circular baffle, 310.65 K and 310.36 K in case of rectangular baffle, and 311.11 K and 310.48 K in case of triangular baffle. Beyond the baffle, the temperature of air goes on increasing. At x=0.1 m, the temperature in case of no baffle is 314.10 K and 313.87 K, 320.33 K and 320.21 K in case of circular baffle, 323.06 K and 323.14 K in case of rectangular baffle, and 322.62 K and 321.66 K in case of triangular baffle.



(a)



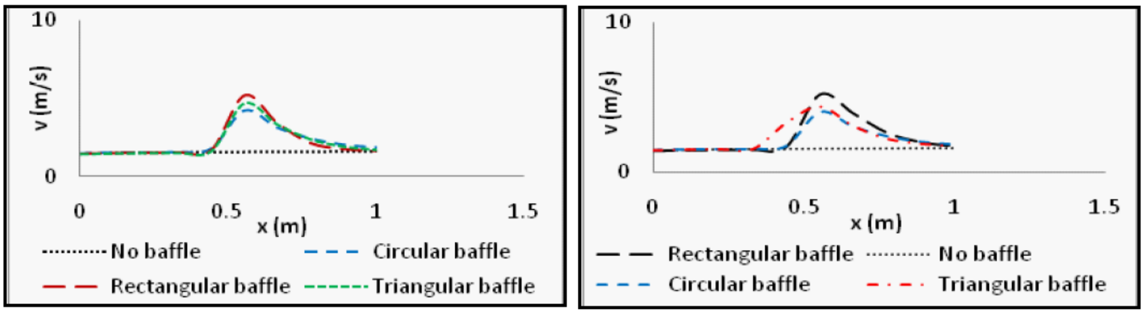
(b)

Figure Temperature Variations Along the Center Line in Case of Single Baffle Used W.R.T No Baffle (a) Polymer, (b) Cu

D. Velocity Variation Along the Center Line

Velocity variation plots give an idea of flow separation at the places where baffles are being placed along the centerline of the heat exchanger tube as shown in fig. This is because at the places along the length of the tube where baffles are being placed, there is more turbulence created by the vortex generators (baffles) which results in more mixing of the fluid layers.

Due to this, the temperature drops where a baffle is placed which results in decrease of viscosity and hence decrease in pressure. Since the flowing fluid here follows Bernoulli's equation. So in pressure results in sharp increase in velocity and hence flow separation occurs.



(a) (b)

Figure Velocity Variations Along the Center Line in Case of Single Baffle Used W.R.T no Baffle (a)polymer, (b) Cu

E. Simulation

Table 5 Input variables for typical heat exchanger simulation

Variable	Value	Notes
Qevap	3.5 kW	1-ton
UAcond	0.86 kW/K	Assumed value
Dout	4 mm	Initial guess
SDR (Dout/ttube)	15	Initial guess
RatioSTDout	2	Initial guess
Aface	0.4 m^2	Typical of air cooled cond
ΔTapproach,hx	2 C	Initial guess
Vw	0.00015m^3/s (2.5gpm)	Initial guess
Vface,air	1.0 m/s	Typical of air cooled cond.
Tair,in	35 C	Rating condition
ΔTsup	5 C	TXV or EEV
ΔTsub	5 C	Typical at rating condition
ηpump/fan	0.2	Assumed pump/fan efficiency
Hisen	0.7	Assumed isentropic efficiency
K tube	0.31 W/mK	Nylon conductivity

Table 6 Output variables for typical heat exchanger simulation

Output	~Value
tube	0.26 mm
Core width	0.63 m
Core height	0.63 m
Core depth	0.30 m
N rows	38
N modules	79
N total	3010
Tw,,in,hx	45.8 C
Tw,out,hx	39.6 C
Tair,out	43.8 C
UAhx	1.3 kW/K
COPcyc	4.28
COPsys	4.06

V CONCLUSION

From this study, it has been following result found that

1. Effect of outlet temperature of shell side & tube side with increasing the baffle inclination angle from 0^o to 30^o.
2. The pressure drop decreases with increase in baffle inclination.
3. The heat transfer rate is increase when the baffle inclination is increase.
4. Chemical stability of heat exchanger tube is increased.

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