COMPARATIVE ANALYSIS OF HEAT EXCHANGER FOR DIFFERENT MATERIALS

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ABSTRACT

Double pipe heat exchanger is simplest type's concentric pipes of different diameter. In this paper parallel and counter both flow arrangements will do. Selecting different materials copper, aluminum and steel for heat exchangers and producing tubes of heat exchangers have been studied and the discus effects of thermal conductivity on them. Operations on the different tubes with different materials are having the same dimensions (diameter and length) and the factors affecting heat exchangers. Further, selection of the most appropriate tube material and obtained with regard results to these factors. By analysis and experimentation of systematic data degradation leads to the conclusion that the maximum heat transfer rates is obtained in case of the inward counter flow configuration compared to all other factors, except these we observe to vary with small difference in each section.

Keywords: Circulartube heat exchangers, Parallel and counter flow, Effectiveness, Reynolds Number and Nusselt Number.

1. INTRODUCTION

A device which is used to transfer heat energy 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 is heat exchanger. There are no external heat and work interactions in a heat exchanger. An application of heat exchanger involves heating or cooling of a fluid stream of concern and evaporation or condensation of single- or multi component fluid streams. Except these other applications, may be to recover or reject heat, or sterilize, pasteurize, fractionate, distil, concentrate, crystallize, or control a process fluid. In a few heat exchangers, the fluids exchanging heat are in direct contact. In a transient manner, heat transfer between fluids takes place through a separating wall or into and out of a wall in a heat exchanger. Fluids are separated by a heat transfer surface in many heat exchangers, and ideally they do not mix or leak is direct transfer type, or simply recuperators heat exchangers are referred to as. In an indirect type of heat exchanger there is intermittent between the hot and cold fluids—via thermal energy storage and release through the exchanger surface or matrix, or simply regenerators. Due to pressure difference and matrix or valve switching usually having fluid leakage from one fluid stream to the other.

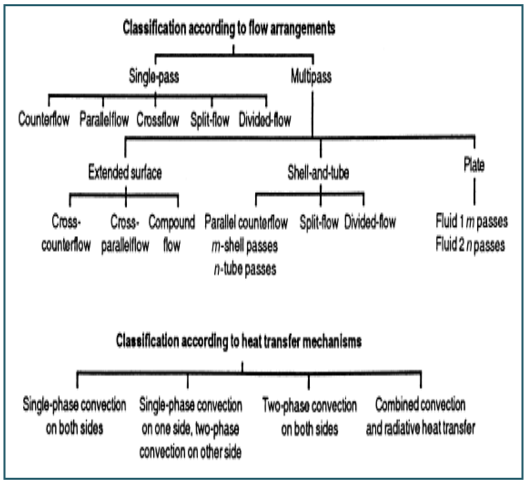

Figure 1 Classification of heat exchanger

1.2General criteria for materials selection

A general procedure that could be used for identifying the most appropriate material for a specific heat exchanger application would consist of the following steps.

- Define the heat exchanger requirements
- Establish a strategy for evaluating candidate materials
- Identify candidate materials
- Evaluate materials in depth

Special considerations which affect materials selection include:

Physical Properties

- High heat transfer coefficient (requiring high thermal conductivity for tube material)
- Thermal expansion coefficient to be low and as compatible as possible with those of the materials used for tube sheet, tube support and shell to provide resistance to thermal cycling.

Mechanical Properties

- Good tensile and creep properties (High creep rupture strength at the highest temperature of operation and adequate creep ductility to accommodate localised strain at notches are important).
- Good fatigue, corrosion fatigue and creep-fatigue behaviour.
- High fracture toughness and impact strength to avoid fast fracture.

Corrosion Resistance

- Low corrosion rate to minimise the corrosion allowance (and also radioactivity control in heat exchangers for nuclear industry)
- Resistance to corrosion from off normal chemistry resulting from leak in upstream heat exchanger or failure in the chemistry control
- Tolerance to chemistry resulting from mix up of shell and tube fluids.

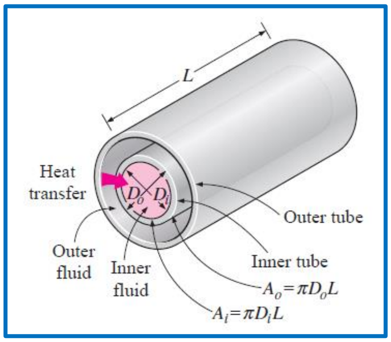

Figure 2. Double pipe heat exchanger

2. LITERATURE SURVEY

Shah and London, 1978 -to study heat exchangers there are several different approaches have been devised. Early attempts include analytical solutions of the Nusselt number for a large collection of duct shapes under laminar flow with either constant wall temperature or constant wall heat flux boundary conditions, using different techniques such as conformal mapping

Sastry 1964, 1965 or Galerkin integral methods (Haji-heikh et al 1983) are given many simplified models for heat exchangers have also been proposed. Single-phase heat exchanger with louvered fins was developed an analytical approach for predicting the air-side performance of a heat exchanger.

Sahnoun and Webb 1992 - Their predicted model of heat transfer coefficients with errors of as much as 25%. For calculating the air-side heat transfer in heat exchangers under condensing conditions an analytical method has been described (Ramadhyani 1998). Srinivasan and Shah (1997) recently examined in condensation phenomena occurring in compact heat exchangers. To analyze transport phenomena in the air-side, within the fin-tube passages that was other attempts.

(Kushida et al 1986; Bastani et al 1992; Torikoshi et al 1994), have been carried out with CFD techniques assuming isothermal fins and in the water-side, inside the tube bends (Goering et al 1997), Ranganayakulu and Seetharamu (1999) a single-phase heat exchanger using finite elements had been performed in a steady state simulation. Their analysis included the effect of one-dimensional heat conduction at the wall, no uniformity in the inlet fluid flow, and a few different models of temperature distributions Due to the fact that no analytical or accurate numerical solutions are available; the information has been usually derived experimentally. A large amount of experimental information about transport phenomena in and evaporator heat exchangers are reported in the open literature.

(Webb 1980; Kakac et al 1981; Kays and London 1984; Shah et al 1990). For instance, Beecher and Fagan (1987) determined performance data for single-phase finned-tube heat exchangers; Jacobi and Goldschmidt (1990) characterized, experimentally, heat and mass transfer performance of a Condensing heat exchanger. Similar studies were also examined by McQuiston (1976 and 1978), Mirth and Ramadhyani (1995), and Yan and Sheen (2000). Thermal performance data for evaporators have been developed by Panchal and Rabas (1993). These findings are all based on the experimentally determined overall, air-side and water-side heat transfer coefficients.

A few studies have been carried out to find correlations for the performance of compact heat exchangers. The most representative examples are those for single phase

operating conditions (Gray and Webb 1986), for heat exchangers operating under wet conditions (McQuiston 1978), and for evaporators (Kandlikar 1991).
Shell and Tube heat exchangers by changing different parameters to meet the industry requirements an extensive research work has been done till date. Lunsford (1998) provided some methods for increasing shell and-tube exchanger performance. The methods considered whether the exchanger is performing correctly to begin with, excess pressure drop capacity in existing exchangers, the re-evaluation of fouling factors and their effect on exchanger calculations, and the use of augmented surfaces and enhanced heat transfer. Sparrow and Reifschneider (1986) conducted experiments on the effect of inter baffle spacing on heat transfer.
Huadong Li and Volker Kott Ke (1998) on experiments getting the effect of leakage on pressure drop and local heat transfer in shell and tube heat exchangers for staggered has slight contribution to the local heat transfer at the surfaces of the external tubes of the tube bundle, but reduces greatly the per-compartment average heat transfer.

3. Methodology

3.1 Tube types heat exchanger

It's like a pipe heat exchanger generally known as double pipe heat transfer which is named by its construction because two pipes are fitted in such way that one pipe is fitted into other inside space. By cross section they look concentric by coaxial view. It can be extend as requires length and bend like hair pin shape at the edges to make it fit in particular area. Hot fluid is flow into the inner tube and cold fluid is flow into the space between inner and outer pipes.

Applications:

1. Refrigerators,
2. Domestic heating systems and
3. Car radiators etc

General equation of heat transfer rate across a heat exchanger is usually expressed in the form

$$Q = UA\,\Delta T_m \qquad \ldots\ldots\ldots\ldots\ (1)$$

.The following assumptions are applicable using this equation:
1. Overall heat coefficient U is constant,
2. Specific heats of the hot and cold fluids are constant,
3. Heat exchange with the ambient is negligible, and 4. The flow is steady and either parallel or counter flow.
Where:

Q = heat transfer rate, Watts
U = overall heat transfer coefficient, W/m^2 K
A = heat exchanger area, m^2
ΔT_m= average temperature difference between the fluids, K

$$Q = -(mC_p)_h\,(T_{h1} - T_{h2}) = (mC_p)_c\,(T_{c2} - T_{c1}) \ldots.(2)$$

$$Re = (\rho V d)/\mu \qquad \ldots.(3)$$

$$\text{Effectiveness } (\epsilon) = \frac{\text{Actual heat transfer}}{\text{Maximum possible heat transfer}} \ldots.(4)$$

S.No	Types of Heat Exchanger	U, W/m^2 °C
1	Water to Water	850-1700
2	Water to Oil	100-350
3	Water to Gasoline	300-1000
4	Feedwater heaters	1000-8500
5	Steam to light fuel oil	200-400
6	Steam to heavy fuel oil	50-200
7	Steam Condenser	1000-6000
8.	Ammonia condenser (Water Cooled)	800-1400
9	Gas to Gas	10-40
10	Water to Air in Finned tube (Water in tubes)	30-60 400-850

Table-1 Values of heat transfer coefficient

Table-2 Thermal conductivity of some materials

Materials	Thermal Conductivity W/m°C
Aluminum	200-250
Aluminum brass (76 Cu-22Zn-2Al)	100-110
Brass (70 Cu-30Zn)	98
Carbon Steel	45

Copper	386
Cupro-nickel (90 Cu - 10 Ni)	70
Nickel	62
Stainless Steel, type 316 (17 Cr-12 Ni - 2 Mo)	16
Stainless Steel, type 304 (18 Cr-8 Ni)	16

Materials	Effectiveness	Heat transfer 'Q' (W)	Overall heat transfer 'U' (w/ m^2 K)	Reynolds Number	Nusselt Number	LMTD
Copper	0.713	265.46	1326	28830	137	9.10
Aluminium	0.713	264.53	1321.33	28830	137	9.10
Steel	0.713	256.05	1279	28830	137	9.10

S.No	Hot Water Parallel flow			Hot Water Counter flow		
	Mass Flow rate (kg/s)	T_{ci} (ºC)	T_{co} (ºC)	Mass Flow rate (kg/s)	T_{ci} (ºC)	T_{co} (ºC)
1	0.02	38	49	0.02	37	46
2	0.02	37	45	0.02	36	44
3	0.02	38	46	0.02	36	45
4	0.02	38	45	0.02	37	46
Avg	0.02	37.75	45.5	0.02	36.5	45.25

4. RESULT AND ANALYSIS

Figure 3 Experimental Setup

Table-3 Specifications of heat exchanger pipes

Particulars	Inner diameter (mm)	Outer diameter (mm)	Length (mm)
Cu pipe	25	28	250
Al pipe	25	28	250
Steel pipe	25	28	250

Table-4Observation of Parallel and Counter flow hot water

Table-5 Observation of Parallel and Counter flow Cold water

S.No	Cold Water Parallel flow			Cold Water Counter flow		
	Mass Flow rate (kg/s)	T_{hi} (^oC)	T_{ho} (^oC)	Mass Flow rate (kg/s)	T_{hi} (^oC)	T_{ho} (^oC)
1	0.03	59	49	0.03	65	51
2	0.03	58	48	0.03	63	49
3	0.03	59	49	0.03	64	50
4	0.03	57	48	0.03	65	50
Avg	0.03	58.25	48.5	0.03	64.3	50

Table-6 Parallel Flow Observation

Similarly we calculate all the parameter for counter low heat exchanger.

Table-7 Counter Flow Observation

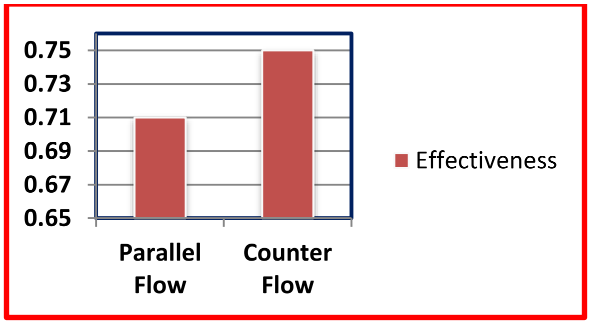

Figure-4 Comparisons of Effectiveness

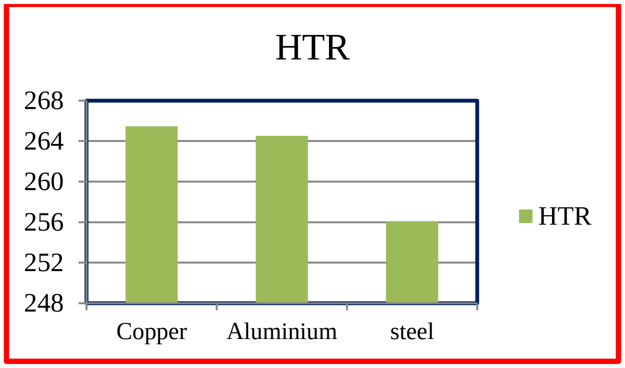

Figure.5 heat transfer rate (HTR) for Parallel Flow

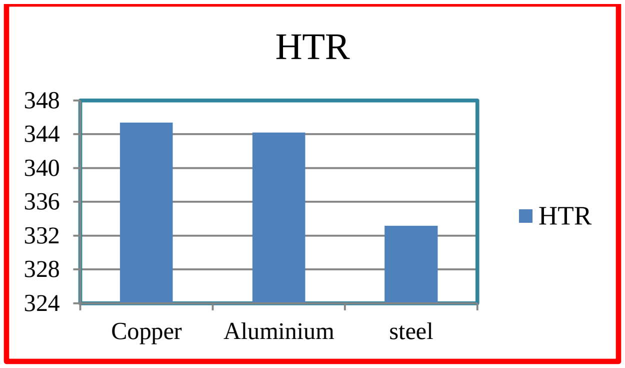

Figure.5 heat transfer rate (HTR) for Counter Flow

Materials	Effectiveness	Heat transfer 'Q' (W)	Overall heat transfer 'U' (w/ m^2 K)	Reynolds Number	Nusselt Number	LMTD
Copper	0.75	345.39	1346	31306	142	11.84
Aluminium	0.75	344.18	1338	31306	142	11.84
Steel	0.75	333.15	1286	31306	142	11.84

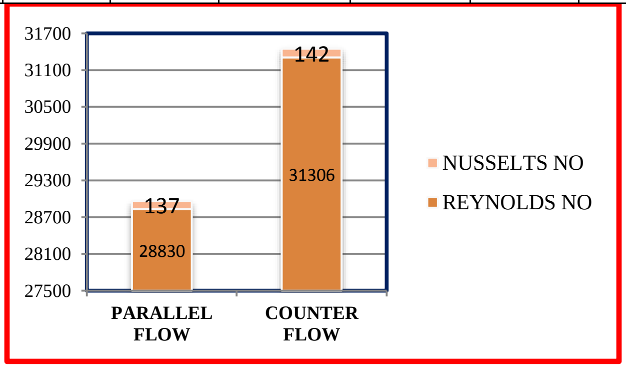

Figure 6 Reynolds & Nusselts no for Parallel and Counter flow

6. CONCLUSION

An Experiment shows that effectiveness of counter flow heat exchanger is maximum compare to parallel flow. In a setup we used three different types of materials copper, aluminium and steel. Analyses of setup we find that copper have higher thermal conductivity then aluminium after steel. Variation of thermal conductivity depends on temperature as the increases of temperature thermal conductivity increases but I analyses at constant temperature 42ºC for all three material. As same temperature and same length and diameter of circular tube heat transfer rate and overall heat transfer rate is maximum for copper tube in both the cases either parallel flow or counter flow.

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