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To Study the Heat Transfer Phenomena in Parallel Plate Heat Exchanger

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ABSTRACT

Heat exchangers are devices whose primary responsibility is the transfer (exchange) of heat, typically from one fluid to another. However, they are not only used in heating applications, such as space heaters, but are also used in cooling applications, such as refrigerators and air conditioners. The main objective of the study is to study the heat transfer phenomena in plate Heat Exchanger. And to calculate the rate of heat transfer, LMTD and overall heat transfer coefficient for plate heat exchanger and also compare the performance of plate heat exchanger for diff plate material (SS316 and TITANIUM).

Keywords : LMTD, overall heat transfer coefficient, heat transfer rate.

2. INTRODUCTON

Heat Exchanger is a device in which heat is transferred from one fluid to another. The necessity for doing this arises in a multitude of industrial applications. Common examples of heat exchangers are the radiator of a car, the condenser at the back of a domestic refrigerator and the steam boiler of a thermal power plant.

The plate heat exchanger (PHE) was invented by Dr. Richards Seligman in 1923. Plate heat exchangers (PHE) have been widely used in different industrial applications. The traditional concept, plate-and-frame heat exchanger, consists of plates, gaskets, frames and some additional devices, such as carrying and guiding bars, support column, etc. The two streams flow into alternate channels between plates, entering and leaving via ports at the corner of the plates. Heat is exchanged between adjacent channels through plates. This type of compact heat exchangers provides a number of advantages over shell-and-tube heat exchangers, such as compactness, high effectiveness, easy cleaning, cost competitiveness, etc. In performance, more than 60 different plate patterns have been developed to promote heat transfer with minimum pressure drop.

One of the inherent features of PHEs is their flexibility. The heat transfer surface area can be changed discretely with a step equal to heat transfer area of one plate. All major producers of PHEs manufacture a range of plates with different sizes, heat transfer

Surface areas and geometrical forms of corrugations. This enables the PHE to closely satisfy required heat loads and pressure losses of the hot and cold streams.

2. LITERATURE REVIEW

The plate heat exchangers are widely used in warming, heating, cooling applications, food, and cosmetic and chemistry industry. The plate type heat exchangers are initially developed for the pasteurized liquid food domain which mostly requires hygienic application. But, these heat exchangers have a large application area in chemistry and food sector because of being compact and having the quality to be easily cleaned [5].

The augmentation techniques of heat exchanger efficiency can be classified as active and passive methods. In active method, heat transfer can be improved by giving extra energy to system. In passive

Method, however, the improvement can be performed without giving extra energy.

Some examples to active method include the use of mechanical auxiliary elements, turning of surface, mixing of fluid with mechanical parts, constituting of electro-static areas in flow area, vibration of system, etc., Some examples to passive method include covering of surface, changing of surface, forming of the same projection parts of the rough surface, locating of the tabulators in flow area, etc., [5].

In the passive methods, usually a turbulence effect is given to the flow by the shapes having different geometries for this purpose; rugged surfaces are used, in a study made to improve the heat transfer

In the most of the studies made on the plate surface heat exchangers, it is observed that the configuration is symmetrical; the cold and hot fluid pass by the same number of canals and the favorite flow shape is based on "parallel-counter flow". Kandlikar and Shah [12] investigated multi pass plate heat exchanger effectiveness.

The main object of this experimental set up is to compare the performance of PHE for different plate material. And find out LMTD and overall heat transfer coefficient,

$$\Delta T_m = \frac{\Delta T_1 - \Delta T_2}{\ln \frac{\Delta T_1}{\Delta T_2}}$$

$$Q_h = M_h C_p \left(T_1 - T_2\right)$$

$$Q_c = M_c C_p \left(T_4 - T_3\right)$$

$$U_i = \frac{Q}{A_i \Delta T_m}$$

$$U_o = \frac{Q}{A_o \Delta T_m}$$

3. EXPERIMENTAL SET-UP

Heat exchanges are the devices used to transfer the heat from one end fluid to other. Transfer of heat is needed for many applications, commonly used are transfer type, storage and direct contact type. In transfer both heat and cold fluids passing simultaneously through the heat exchanger and heat is being transferred through the separating wall between them.

In transfer type heat exchanger different types of flow arrangements are used viz. parallel counter or cross flow. The latest type being the plate type heat exchanger. The apparatus plate type heat exchanger consists of parallel plates stacked together.

The hot fluid is water obtained from water heater. The cold fluid is tap water. Hot water enters to top flow through the alternate plates in stack and comes to diagonally opposite end of plates. It enters reverse the direction during the flow cold water enters lower part of plates pass through alternate pair through and water out the stack through output at upper diagonally opposite end of plates.

CALCULATION:-

Mass flow rate

Cold water, mc = _____ kg/sec

Hot water, mh = ______ kg/sec

$Qc = m_c\ (t_{co} - t_{ci})$ kw

$Qh = m_c\ (t_{hi} - t_{ho})$ KW

$\theta_1 = T_{hi} - T_{co}$ °C

$\theta_2 = T_{ho} - T_{ci}$ °C

LMTD = $\theta_1 - \theta_2 / \ln(\theta_1/\theta_2)$ °C

$S = T_{co} - T_{ci} / T_{hi} - T_{ho}$

$R = T_{hi} - T_{ho} / T_{hi} - T_{ci}$

Take correction factor F from respective graph

F = ____

Corrected LMTD, θc = F × LMTD

$Q_h = U_h\ A\ \theta c$

U_h =W/m² °C

$Q_c = U_c\ A\ \theta_c$

U_c =W/m²°C

Effectiveness = $T_{hi} - T_{ho} / T_{hi} - T_{ci}$ %

4. Experimental procedure:

Connect the water supply and start water flow for hot water keep flow rate about 4-5 lit/min(maximum flow rate is 12 lit/min).

Keep cold water flow rate between 5-10 lit/min.

- Connect the main electric supply.
- Switch 'ON' on the water heater.
- "Never switch on" heater before starting water supply.
- Observe water inlet and outlet temperature.
- Wait till steady state reached and note down the observation.
- Repeat the procedure by changing the water flow rate.

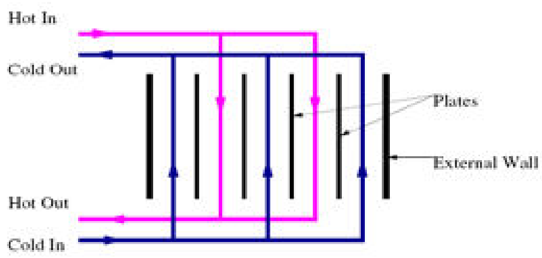


Fig.1 Block diagram of apparatus

Fig.2 Plate Heat Exchanger apparatus

5. OBSERVATIONS & CALCULATIONS:

DATA:

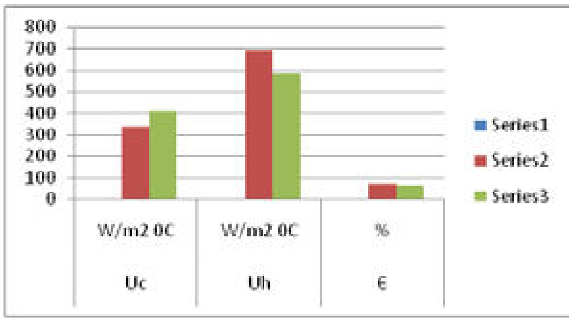
- Heat exchanges (Alfa-level main) no. of plates 10 with passage of hot and cold fluids between the alternate plates.
  - o Plate size = 180 × 460 mm
  - o Effective heat transfer area = 0.7m2
  - o Plate Pack Length = 29 mm
  - o Max. Working Temp = 110 °C

Observation table

Temperature (°C)				Mass flow rate (kg/s)	
T_{ci}	T_{co}	T_{hi}	T_{ho}	Mc	mh
32	34	42	35	0.125	0.071
32	34	38	34	0.0833	0.0588

Result table

No	Heat transfer		LMTD W/m² ⁰C	U_c W/m² ⁰C	U_h %	Є
	Q_c kW	Q_h kW				
Titanium	1.045	2.077	4.44	340	696	70
Titanium	0.696	0.98	2.42	410	588	66.66

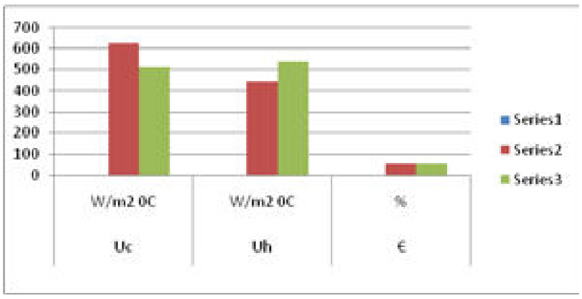


Observation table

Temperature (°C)				Mass flow rate Kg/s	
T_{ci}	T_{co}	T_{hi}	T_{ho}	mc	Mh
32	36	42	37	0.125	0.071
32	34	38	35	0.0833	0.0588

Result table

No	Heat transfer		LMTD W/m² ⁰C	Uc	Uh	Є
				W/m² ⁰C	%	
	Q_c kW	Q_h kW				
S.S.316	2.09	1.49	4.77	626	447	50
S.S.316	0.696	0.737	1.947	510	540	50



6. RESULT AND DISCUSSION

We saw from the experimental set up values of plate heat exchanger using fluid as water in case of hot and cold fluid. Heat transfer more effective in case of titanium material compare to SS316

7. CONCLUSION

PHE are most widely used in liquid to liquid application. In this study various literatures have been reviewed, and from those it is concluded that, chevron plate configuration is most efficient, and best plate material is TITANIUM as compared to Stainless. Steel Alloy(316)

NOMENCLATURE:

Ai = Inside heat transfer area, m2
Ao = Outside heat transfer area, m2
Cph = Specific heat of hot fluid at mean tem perature, kJ/kg oC
Cpc = Specific heat of cold fluid at mean tem perature, kJ/kg oC
Mh = Mass flow rate of the hot water, kg/s
Mc = Mass flow rate of the cold water, kg/s
Q = Average heat transfer from the system, W
Qc = Heat gained by the cold water, W
Qh = Heat loss by the hot water, W
Thi = Inlet temperature of the hot water, oC
Tho = Outlet temperature of the hot water, oC
Tci = Inlet temperature of the cold water, oC
Tco = Outlet temperature of the cold water oC
ΔTm = Log mean temperature difference, oC
Ui = Inside overall heat transfer coefficient, W/ m2 oC
Uo = Outside overall heat transfer coefficient, W/ m2 oC

REFERENCES

1. Holman, J.P., "Heat Transfer", 9th ed., McGraw Hill, NY, 2008, Page 525-526, 528-531. | 2. McCabe, Smith, J.C., Harriott, P., "Unit Operations of Chemical Engineering", 7th ed. McGraw Hill, NY, 2005, Page 327-329, 331-333. | 3. Arora.Domkundwar, "A Course in Heat & Mass Transfer", 6th ed., Dhanpat Rai & CO.(P) LTD.,NY, 2003, Page A.6 | 4. T. Zaleski, K. Klepacke, A plate heat-exchanger-method of calculation, chart and guidelines for selecting plate heat-exchangers configuration, Chem. Engg Process. 31 (1) (1992) 45–56 | 5. Aydın Durmus, Hüseyin Benli ,Irfan Kurtbas, Hasan Gül "Investigation of heat transfer and pressure drop in plate heat exchangers having different surface profiles, "International Journal of Heat and Mass Transfer 52 (2009) 1451–1457