A Review on Poly Phenylene Sulphide Material for Spiral Coil in Shell Heat Exchanger

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Abstract- Heat exchangers used in medical applications require special non-reactive materials for the tubes through blood fluids or plasma fluids flow so that there is no contamination. Especially in process of plasma, platelet separation process from blood such heat exchangers are required. The PPS material is an ideal material for such applications, so also due nature of adhesion property of fluid under consideration the geometry of the tubes plays a significant part in design and development of the heat exchanger. Paper discusses the development of such heat exchanger where in the PP tube is wound in a helical shape and fluid is always passed from top to bottom. This Spiral tube is then fitted in a cylindrical shell which circulate the cooling fluid (water) in either parallel or counter flow configuration. The paper discusses the analysis of the spiral tube. Also the performance of heat exchanger in counter flow is discussed

Keywords: PS (Poly Phynelene Sulphide) , Spiral tube , Counter flow.

I. INTRODUCTION

Heat exchanger is an equipment used to transfer heat between one or more working fluids and fluid separated by a solid wall to prevent mixing. They are widely used in space heating, refrigeration, air conditioning power stations, chemical plants, petroleum plants, refineries, natural-gas processing, and sewage treatment. The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the incoming air.

A spiral heat exchanger (SHE), may refer to a helical (coiled) tube configuration, more generally, the term refers to a pair of flat surfaces that are coiled to form the two channels in a counter-flow arrangement. Each of the two channels has one long curved path. A pair of fluid ports are connected tangentially to the outer arms of the spiral, and axial ports are common, but optional**.**

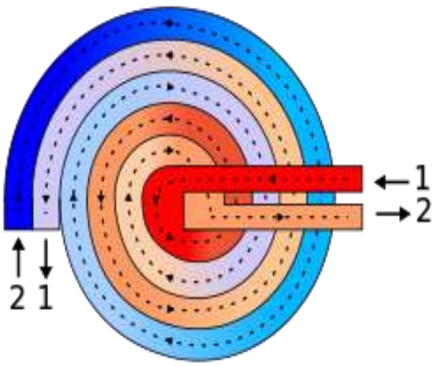

Fig. 1: Schematic drawing of a spiral heat exchanger

A spiral tube heat exchanger is a coil assembly fitted in a compact shell that optimizes heat transfer efficiency and space. Spiral coil assembly has PPS material requirement for durability and strength. The coil assembly is fitted in a compact shell. . The spiral shape of the flow for the tube side and shell side fluids creates centrifugal force and secondary circulating flow that enhances the heat transfer on both sides in a true counter flow arrangement. You get the advantage of tube side enhancement without the associated potential for plugging on both the shell and tube side of the heat exchanger. Since there are no baffles or dead spots to lower velocities and coefficients, heat transfer performance is optimized. The profile of a spiral is very compact and fits in a smaller footprint than a shell and tube design. Since the tube bundle is coiled, space requirements for tube bundle removal are virtually eliminated. When exotic material is required, a spiral tube heat exchanger minimizes the material used since manifolds replace the channels, heads and tube sheets of a conventional shell and tube design.

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II. LITERATURE REVIEW

Spiral flow heat exchangers are known as excellent heat exchanger because of far compact and high heat transfer efficiency. SFHE is a unique design where it consists of single fluid as working fluid for heat exchange. Here heat transfer takes place between solid and fluid, and hence can be called as conjugate heat transfer. Heat transfer characteristics of SFHE are observed at various Reynolds number and base temperature. SFHE is designed and fabricated with new arrangement for measuring the heat transfer is employed for obtaining the experimental results. The concept of thermoelectric effect is used which is direct conversion of temperature difference to electric voltage, to measure temperature at various points in the heat exchanger. For steady state analysis, the pressure drop for calorimeter along the length of the flow is found to be uniform except at the mid length and found to be increasing with the mass flow rate. At the centre of the plate there is sharp decline in pressure due to change in the cross sectional area of flow. The pressure recovery takes place in a short distance. It is observed that temperature of water gradually increased along the flow length because it picks up heat during the course of the flow. There is a clear evidence of the heat transfer cross the vertical strip separating the adjacent counter flow hot and cold steams. For constant inlet and base temperatures, the outlet temperature of the water decreases with mass flow rate. Velocity suddenly increases at mid length due to change in cross section area of SFHE, velocity recovers in a short distance in the downstream and remains almost constant till the outlet.[1]

Spiral tube heat exchangers are known as excellent heat exchanger because of far compact and high heat transfer efficiency. An innovative spiral tube heat exchanger is designed for particular process engineering. A new arrangement for flow of hot and cold fluids is employed for design, hot fluid flows in axial path while the cold fluid flows in a spiral path. To measure the performance of the spiral tube heat exchanger, its model is suitably designed and fabricated so as to perform experimental tests. The spiral tube heat exchanger is compact in size and more heat transfer can be carried out. [2]

In this paper the possible replacement of conventional metallic heat exchangers with plastic components is investigated with reference to low size Organic Rankine Cycles, aiming at a reduction of the plant investment cost. A thermodynamic optimization of a 20 kW regenerative ORC plant, representative of a low temperature (<140 _C) heat recovery application, has been carried out according to the presently available data for plastic shell and tubes heat exchangers offered on the market. With the aim to study the introduction of plastic heat exchangers, a fluid selection process has been carried out, complying with temperature and pressure limits imposed by the plastic material resistance. N-heptane turned out as the most appropriate fluid for this case: the selection of a non-common ORC working fluid is a remarkable aspect of plastic heat exchanger adoption. [3]

In this paper, a general review on polymer compact heat exchangers (PCHEs). Types of polymers used and their respective characteristics and the relative merits and the current PCHEs available in process industries. Their future applications are discussed. The relative merits of using polymers over metals are shown through a quantitative comparison, between PVDF and other heat exchangers. When incorporating the same tube dimensions, thickness and fluid film coefficients, significant cost savings can be achieved using the PVDF exchanger. Result is.the ratio of the overall heat transfer coefficients is 6:1, the ratio of the Weight of 1m 2of Ni–Cr–Mo to Weight of 1m 2of PVDF is 5:1 and a tube bundle of Ni–Cr–Mo alloy will cost 2.5 times as much as a PVDF bundle. Alternative for a wide range of industrial applications by metallic heat exchangers. Their energy saving benefits and resistance to fouling and corrosion are likely to be at the forefront of a new technology that will uncover new market opportunities in the various sectors of the chemical industry [4]

In this paper single salt deposition of $CaSO_4$ and $CaCO_3$ is studied on various polymeric heat transfer surfaces to gain a sound basis for novel polymer film heat exchanger (PFHX) design. Even at high overall heat transfer conditions (possible due to small wall thickness) the scaling quantity was found to be very low compared to a stainless steel surface and strongly dependent on the interfacial energy difference between polymer surface and deposit. $CaSO_4$-scaling is very low on polymer heat transfer surfaces compared to stainless steel at same initial wall temperature. The comparatively smaller heat transfer losses (<5% vs. 48%) are promising for efficient novel heat exchangers with low necessary excess area. For the model salts $CaSO_4$ and $CaCO_3$ scaling quantity is very low in comparison to stainless steel. Through an identification of scaling kinetics the activation energy of $CaCO_3$-scaling on a surface was found to be of 40% larger compared to the stainless steel surface. [5]

III. EXPERIMENTAL SETUP

Following figure shows the schematic diagram of experimental set up.

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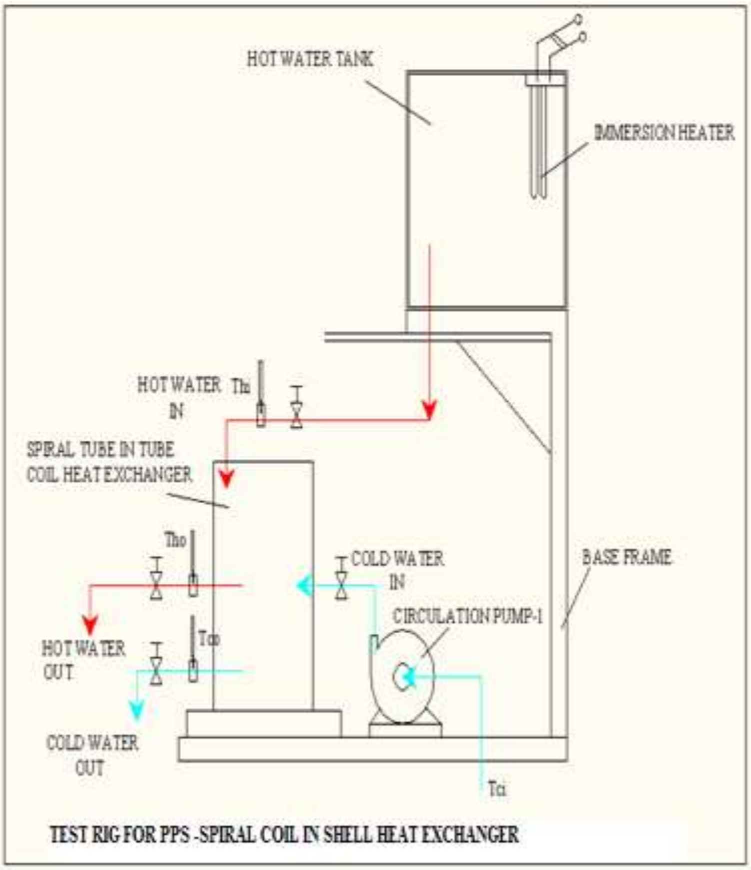

Fig.2 Experimental Setup

The hot water enters through the inlet header by effect of gravity from the tank with heater. The circulation pump is connected to the shell side with help of flow control valve. The sell side water flows in either directions thereby parallel and counter flow configurations are possible. Experiments will be conducted by changing both the hot water and the cooling water flow rates and taking the temperature readings at steady state. Repeat the experiment for several combinations of water flow rates. Values of LMTD, Effectiveness, and overall heat transfer coefficient are calculated by experimental and theoretical method.

IV. CALCULATION OF HEAT TRANSFER COEFFICIENT THEORETICALLY

If we neglect heat losses to the surroundings and assume the hotter fluid to flow in the tube,
Heat lost by the hot fluid=m c (C_P hot) [T $_{(\text{tube inlet})}$-T $_{(\text{tube outlet})}$]
Heat gained by the cold fluid= m c (C_P cold) [T ($_{\text{shell inlet}}$)-T ($_{\text{shell outlet}}$)]
Total heat transfer in the exchanger=U× A×θm

Whereθm=logarithmic mean temperature difference (LMTD)

Logarithmic mean temperature difference (LMTD) can be defined as that temperature difference which, if constant, would give the same rate of heat transfer as actually occurs under variable conditions of temperature difference.

1. LMTD for a shell and heat tube exchanger, when calculated, comes out to be

$$\text{LMTD}\ (\theta m) = \frac{(\theta 1 - \theta 2)}{\ln(\theta 1 / \theta 2)}$$

Where $\theta_1 = T_{hi} - Tco$
$\theta_2 = T_{ho} - Tci$

2. Capacity ratio (C):

$$C = \frac{(m\ Cp\ )\ small}{(m\ Cp\ )large}$$

3. Effectiveness (ε)

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$\varepsilon = \frac{(Tco - Tci)}{(Thi - Tci)}$ …..assuming (m C_p) c< (m Cp) h

4. Calculation of Heat Transfer Coefficient Experimentally

The overall heat transfer coefficient can also be experimentally obtained from the heat duty as follows:

$Q = F \times U \times A \times \theta m = m \times Cp \times \Delta T$

For a counter-current spiral heat exchanger, the F-correction factor equals 1.0.

IV. RESULTS AND DISCUSSION

Fig 2, 3, 4 shows the variation of mass flow rate for calculate overall heat transfer coefficient, effectiveness and LMTD. It is observed that mass flow rate inside tube increases the overall heat transfer coefficient also increases. LMTD decreases with increase in flow rate. The effectiveness increases with increase in flow rate.

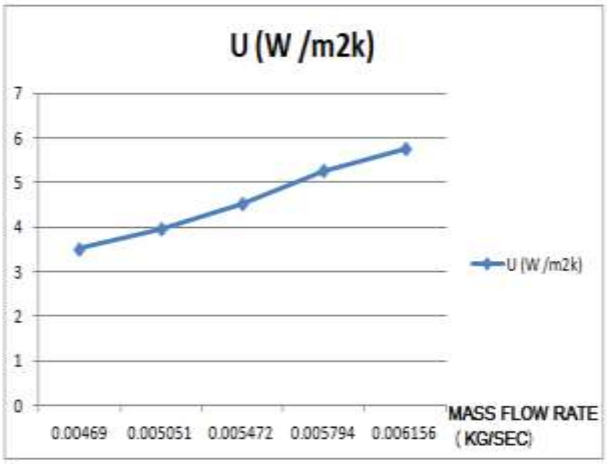

Fig 3 graph between mass flow vs overall heat transfer coefficient

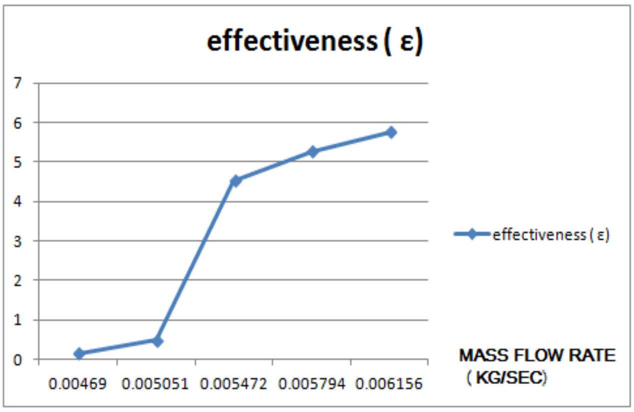

Fig.4 graph between mass flow rate vs effectiveness

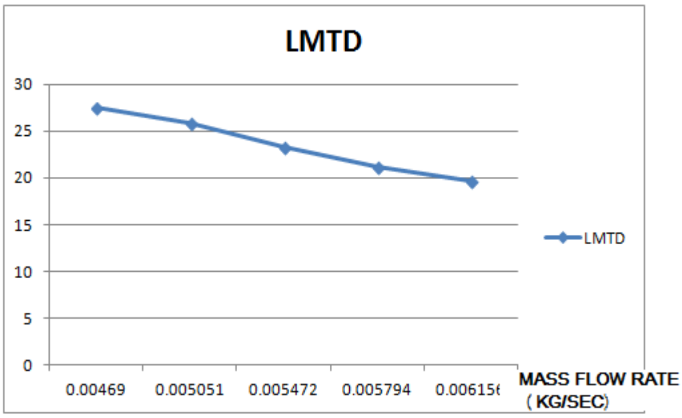

Fig .5 graph between mass flow rate vs LMTD

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V. CONCLUSION

Their energy saving benefits and resistance to fouling and corrosion are likely to be at the forefront of anew technology that will uncover new market opportunities in the various sectors of the chemical industry. LMTD decreases with increase in flow rate. The Overall heat transfer coefficient increases with increase in flow rate. The effectiveness increases with increase in flow rate.

VI. APPLICATION

The use of spiral tube in tube coil heat exchanger is possible in following areas apart from medical field.
1. Applications include liquid heating/cooling,
2. Vent condensing.

Listed below are the details for standard services in which spiral exchangers warrant consideration.
1 Sample Cooling
2 Analyzer Pre-cooling
3 Seal Coolers
4 Condensers
5 Cryogenic Vaporizers
6 Compressor Inter- and After-Coolers
7 General Applications

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