Heat Transfer Enhancement by using Twisted Tape Insert

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Abstract- **Heat exchanger as the name indicates it transfers heat from one fluid to another which is at different temperatures. Heat exchangers are devices built for efficient transfer of heat from one fluid to another and are widely used in engineering processes. Some examples are intercoolers, pre-heaters, boilers and condensers in power plants. The heat transfer efficiency depends on both design of heat exchanger and property of working fluid. In this paper, the heat transfer rate is improved by inserting the slotted twisted strip in the heat exchanger & comparison is done for both parallel & counter flow. The result shows that inserting the slotted twisted strip in heat exchanger increases the turbulence in fluid flow, which increases the heat transfer rate.**

Index Terms- twisted tape, twisted tape with slot, heat transfer rate

Nomenclature:
PF- Parallel Flow
PFTS- Parallel Flow Twisted Strip
PFTSWS- Parallel Flow Twisted Strip With Slot
CF- Counter Flow
CFTS- Counter Flow Twisted Strip
CFTSWS- Counter Flow Twisted Strip With Slot

1. INTRODUCTION

A heat exchanger is a device designed to efficiently transfer or "exchange" heat from one matter to another. When a fluid is used to transfer heat, the fluid could be a liquid, such as water or oil, or could be moving air. In heat exchangers the temperature of each fluid changes as it passes through the exchangers, & hence the temperature of dividing wall between the fluids also changes along the length of the exchanger. Heat exchangers are commonly used in practice in a wide range of applications, from heating and air conditioning systems in a household, to chemical processing and power production large plants. The Performance of heat exchanger defines the system efficiency & optimization of operating costs and It is depends on the operating variables, design and specification of Heat Exchanger. The performance of heat exchanger is depends on various parameters like mass flow rates, pressures and temperatures of working fluids, etc. Heat exchanger effectiveness takes into consideration the limitations of heat transfer between two heat exchanging streams due to these parameters.Azher M. Abed et al.[1] investigated experimentally, the heat transfer performance of circular pipe with twisted tape under uniform heat flux condition by forced convection. By modifiying the twisted tape with V cut, they carried out the heat transfer performance & compared with conventional system. The study showed that friction factor, heat transfer rate increased with insertion of twisted tape as compared to plain pipe. NematMashoofi et al.[2] investigated the ways to reduce the pressure drop and subsequently enhance thermal performance improvement factor of a heat exchanger equipped with axial perforated twisted tapes. The results indicated that the use of perforated twisted tape leads to a decrease in pressure drop and heat transfer rate.P.Eiamsa-ard et al. [3] conducted an experimental study to compare the thermal performance of heat exchanger with different twist ratio & space ratio. The full length twisted tapes with two different twist ratios (y¼ P/W¼ 6.0 and 8.0), and the regularly-spaced twisted tape with two different twist ratios (y¼ 6.0 and 8.0) and three free space ratios (s¼ S/P¼ 1.0, 2.0, and 3.0) were employed for comparative study. They suggested that heat transfer rate and friction factor increased with decreasing twist ratio and space ratio.Ranjithet al [4] analysed the performance of a modified double pipe heat exchanger with twisted tape induced swirl flow on both sides. Insertion of twisted tape in double pipe heat exchanger improved the heat transfer coefficient on both tube side and annulus side of heat exchanger. Secondary flows induced by the twisted tape, enhanced cross stream mixing of the fluids, increase in the effective flow length and the fin effect of the twisted tape were the reasons behind improved performance of the heat exchanger.

2. EXPERIMENTAL SETUP & METHODOLOGY

This experimental setup was designed to investigate the effect of turbulence created in the heat exchanger with the help of twisted tape insert. The concentric tube heat exchanger was designed with inner tube (26 mm OD, 23 mm ID) & outer tube (51 mm OD, 48 mm ID). Heat exchanger was insulated with asbestos insulation in order to avoid heat losses to the surroundings. Experimentation have been carried out by varying input parameters like mass flow rate of cold water as well as hot water and input temperature of hot water. The mass flow rates used in experimentation were 0.0167kg/sec, 0.020kg/sec, 0.025 kg/sec and 0.033 kg/sec for both cold and hot water. The inlet temperatures of hot water have been varied from 50 °C to 80 °C & inlet temperature of cold water kept constant at 33°C and 34 °C throughout the experimentation. These input temperatures were achieved by controlling power input given to the water geyser. This power was controlled by dimmerstat. T type thermocouples were used to record the inlet & outlet temperatures of hot & cold fluid.

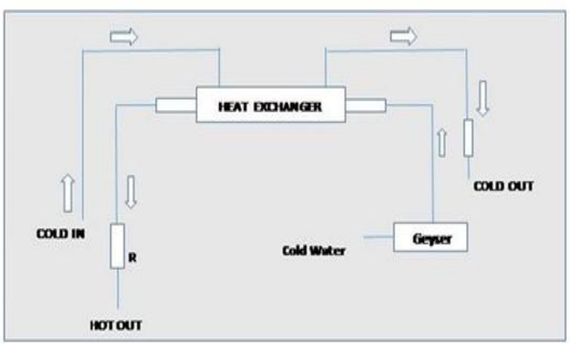

Fig.2.1: schematic view of experimental setup

Fig. 2.2: Test Pipe Used for Experimentation

3. RESULT & DISCUSSION

Experiments have been done for single mass flow rate of hot water and varying the mass flow rate of cold water. Similarly by increasing mass flow rate of hot water, above procedure repeated for different mass flow rate of cold water. Comparison has been done with, without twisted strip & slotted twisted strip heat exchanger for parallel as well as counter flow. Figure 3.1 shows the variation of overall heat transfer coefficient with mass flow rate of cold water while the hot water temperature & mass flow rate maintained constant at 50˚C & 0.003kg/sec respectively under parallel flow condition. It has been observed that overall heat transfer coefficient increases with increase in mass flow rate of cold water. The maximum value of overall heat transfer coefficient has been achieved by inserting the twisted strip with slot in heat exchanger. One can see that the % increase in U for twisted strip with slot heat exchanger is 16.6% than without slot strip heat exchanger.

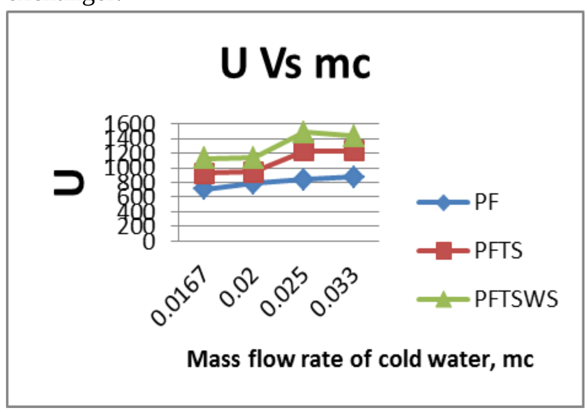

Fig.3.1: Variation of U vs mc for mh=0.033 Kg/sec &Thi=50°C (parallel flow)

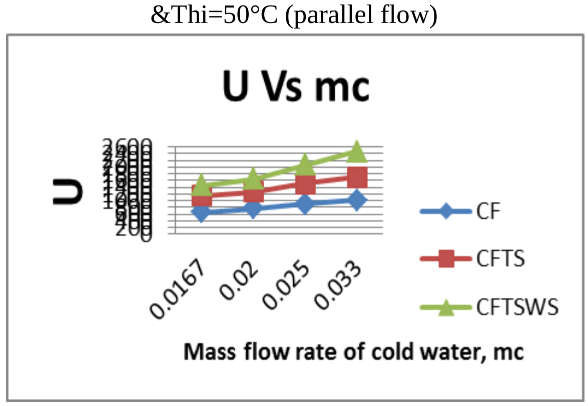

Fig.3.2: Variation of U vs mc for mh=0.033 Kg/sec &Thi=50°C (Counter flow)

Figure 3.2 shows that the overall heat transfer coefficient is maximum at mass flow rate of cold water, mc = 0.003kg/sec. The % increase in U of counter flow twisted strip heat exchanger (CFTS) is 30% than counter flow without strip heat exchanger (CF)& % increase in U of counter flow twisted strip with slot heat exchanger (CFTSWS) is 40% than counter flow twisted strip heat exchanger (CFTS). Comparison between parallel & counter flow heat exchanger with slotted twisted strip has been shown in fig.3.3. One can see 45% improvement in U for the case of using counter flow slotted twisted strip heat exchanger than parallel flow.

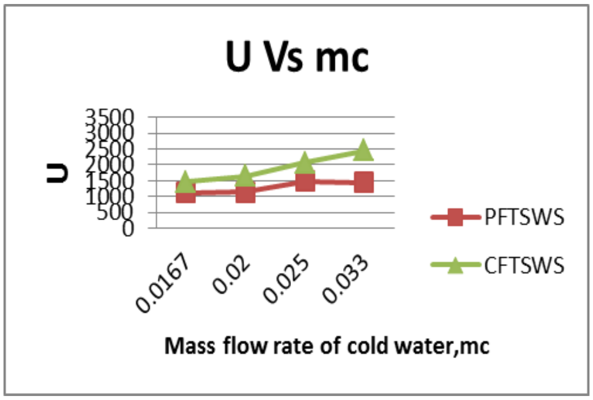

Fig. 3.3: comparison between parallel & counter flow heat exchanger with slotted twisted strip

From the above figure, it is cleared that the counter flow heat exchanger can transfer more heat than parallel flow as the LMTD unit for counter flow is always greater than parallel flow.

4. CONCLUSION

The described test in this paper shows that the overall heat transfer coefficient increases by inserting the slotted twisted strip in heat exchanger than without strip heat exchanger. By inserting twisted tape with slot geometry in heat exchanger, more turbulence is created during the swirl of fluid and gives higher heat transfer rate compared to plain twisted tape and without twisted tape. The result shows that for twisted tape with slot geometry, the heat transfer rate is higher with reasonable friction factor for both parallel & counter flow.

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