International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Analysis of Heat Transfer Rate in a Concentric Tube Using Triangular Baffled Twisted Turbulator

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ABSTRACT

Heat transfer Augmentation techniques are used to increase convective heat transfer coefficient by reducing the thermal resistance. As the heat exchanger gives a vital role in several places, it is required to enhance the heat transfer rate with the help of some technique. For enhancing of heat transfer rate techniques which are referred are classified in two categories one is active techniques and other is passive techniques. In terms of the simple geometrical design changes, comes in the passive techniques, in which swirl flow device is a metallic strip which is of width 'w', thickness 't', having a periodical helical pitch of 1800 twist. The flow rate of the fluid is fully dependent on the no. of twist per unit length i.e. related to pitch 'p' and the space between the wall of the pipe and the twisted strip. In the present work, optimization of the design of twisted tape by making triangular baffles on it has been done and analysis of the result by the experimental setup has been carried out. Experiment is performed on the setup with six different settings, three for parallel flow and other three for counter flow, in which plane concentric pipe and twisted tape heat exchanger is used as a reference to compare with the modified i.e. triangular baffled twisted tape heat exchanger. The study revealed that rate of heat transfer in the term of efficiency of heat exchanger is the highest in the counter flow triangular baffled twisted tape which is a counter flow triangular baffled concentric tube heat exchanger. The efficiency of this setup with respect to the plane tube is 94.156% and effectiveness is also highest in this setup which is 0.618.

Keywords: Heat exchanger, Parallel & counter flow, Augmentation of heat transfer, Triangular baffled twisted tape (TBTT), Turbulent flow

INTRODUCTION

The energy transit due to change in temperature may be termed as Heat. There are two forms in which the heat can be termed the first one is sensible heat and other one is latent heat. Till now there are three ways in which energy can be transferred, first is conduction second is convection and the third is radiation. The unwanted heat (wherever not required) is possible to be removed by the help of Heat Exchanger. There are various types of heat exchangers and a lot of work has been done in this regard [1, 2, 3]. Understanding and improving heat transfer rate are the main concerns. Several techniques have been carried out to reduce operating cost.A tube inserted with a twisted-tape performs better than a plain tube, and a twisted-tape with a tight twist ratio provides an improved heat transfer rate at a cost of increase in pressure drop for low Prandtl number fluids.

EXPERIMENTAL SETUP

The schematic representation of the experimental setup is depicted in Fig.1

Fig.1: Experimental Setup

The material which is used in the setup for outer pipe is PVC and inner pipe is of copper which have higher thermal conductivity. The material of the twisted tape is Aluminum because of its light weight, easily available, moldable and cheaper in comparison to copper. For all the setups the cold water is supplied from the inlet of the supply pipe which is divided in two flows, one is supplied to a 2000W 1 lit continues supply geyser and other to the PVC pipe after passing through a thermocouple which gives the temperature of the cold water at the inlet. Same a thermocouple is used to measure the outlet temperature of the cold water at the outlet of the PVC pipe. The secondary flow which is supplied to the geyser gets heated up and passes through the copper pipe after passing through a thermocouple which measure the temperature of the hot water and same a thermocouple is used at the exit of the copper pipe. The reading of all four thermocouple is displayed on the digital temperature indicator on by one. Experiment is performed on the setup with the six different settings, three for parallel flow and other three for counter flow, in which plane concentric pipe and twisted tape heat exchanger is used as a reference to compare with the modified i.e. triangular baffled twisted tape heat exchanger.

RESULTS AND DISCUSSION

The experimentation was carried out with the parallel flow and counter flow in a concentric tube heat exchanger without, with simple twisted tape and with modified (triangular) baffled twisted tape i.e. Passive heat transfer rate enhancement methods. LMTD, Overall heat transfer coefficient, Convective heat transfer coefficient Nusselt no. and friction factors are calculated for all cases experimentally and theoretically. These parameters were plotted by following graphs are plotted to compare the performance of all the six different setups.

Table 1: Observation for All Setup

COMULATIVE DATA	Setup 1	Setup 2	Setup 3	Setup 4	Setup 5	Setup 6
Qh (KW)	1.198	1.4629	2.0203	1.4476	1.7695	2.326
Qc (KW)	1.142	1.4309	1.959	1.5326	1.8666	2.5
LMTD (°c)	19.15	18.065	13.48	18.76	17.125	13.7936
Overall heat transfer coff. U (KW/°C m^2)	1.183	1.531	2.846	1.459	1.954	3.1895
Effectiveness of heat exchanger Ɛ	0.328	0.3888	0.537	0.385	0.47	0.6185
Efficiency of heat exchanger η (%)	w.r.t.	22.11	68.63	20.834	47.70	94.156

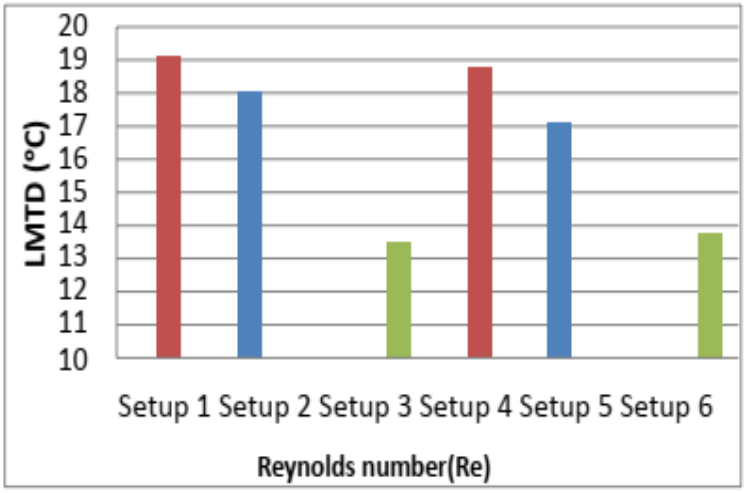

Fig.2: Experimental Logarithmic Mean Temperature Difference vs. Different setup

The rate of heat transfer in the term of efficiency of the heat exchanger is the ighest in the setup 6 which is a counter flow triangular baffled concentric tube heat exchanger. The efficiency of this setup with respect to the parallel flow plane tube heat exchanger is 94.156%

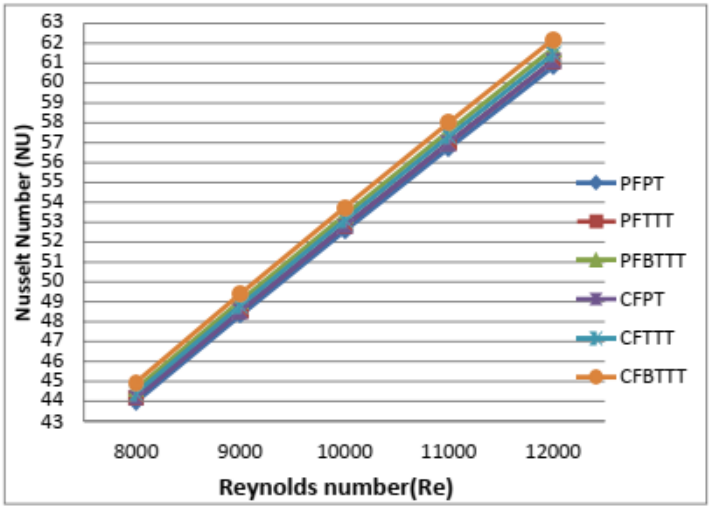

Fig. 3: Theoretical Nusselt number vs. Theoretical Reynolds number by Mc Adam Equation

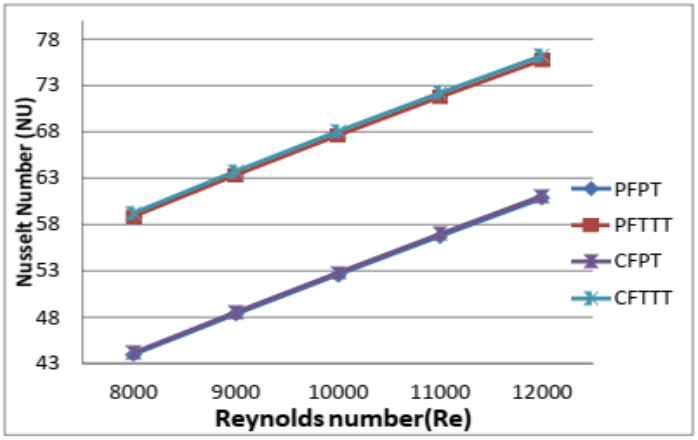

Fig. 4: Theoretical Nusselt number vs. Theoretical Reynolds number by Mc Adam Equation for Plane Tube and Hong & Bergles Equation for Twisted Tape Tube

The theoretical Nu number is increased from 26.5 for plan pipe to 38.756 for pipe having twisted tape then to 141.63 for the baffled twisted tape for parallel flow (PF) & similarly from 35.62 to 58.75 to 212.3 for counter flow. This increase in Nu number is due to increases the convective heat transfer coff. i.e. cause by increases the heat transfer rate.

CONCLUSION

As compare to conventional heat exchanger, augmented (with BTT) heat exchanger has shown a significant improvement in the following parameter.

- Enhancement of heat transfer.
- Increase in effectiveness. The effectiveness of the heat exchanger is highest in the setup 6 which is counter flow triangular baffled concentric tube heat exchanger.
- Higher value of Re number i.e. promoting the flow towards turbulence.
- Gives a high range of Nusselt number under a predefined domain.
- Increase in heat transfer efficiency with increase in overall heat transfer coefficient.

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