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EXPERIMENTAL ANALYSIS OF AUGUMANTATION IN HEAT TRANSFER COEFFICIENT USING TRANGULER BEFFELED TWISTED TAPE

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Abstract - *Research is going to investigate the level of the heat transfer enhancement in water that can be achieved by the modification in the twisted tape used in a concentric tube heat exchanger. The modification of the triangular baffle is applied which are cutted from the strip itself & used as a baffled. This gives the laminar flow to gets converted in turbulent flow by giving it the swirl motion, this will cause a noticeable decrement in the thickness of the boundary layer & consequently result in the enhancement in the heat transfer rate. In the proposed work implementation of the modification in the twisted tape gives higher value of Re no. & a pressure drop, Nu. no., friction factor are experimentally determined. The test is conducted using six different setups far a Re no. ranges from 8000 to 12000 under a uniform flow rate.*

***Key Words*: Heat exchanger, Triangular baffled twisted tape (TBTT), Augmentation of heat transfer, Turbulent flow**

1.INTRODUCTION

The transfer of heat from high scale temperature to lower scale temperature is natural; the device in which the process is followed may term as heat exchanger. In a classification based on the nature of augmentation technique used in a heat exchanger, there are mainly two types, one is passive and other is active. The swirl flow inserts are the part of the passive technique in which no external work is required. There are several modifications done on the twisted tape insert which helps to convert the laminar flow to turbulent flow by decreasing the thickness of the thermal boundary layer of the flow. Now a days the plane twisted tape are replaced by modified twisted tapes like tape with attached baffles, notched tape, slotted tape, tape with holes, Diamond shaped tape, Delta winglet twisted tape etc. These modifications in the twisted tape are analyzed under a wide range of Reynolds number which comes to the conclusion of augmentation in heat transfer rate.

2. EXPERIMENTAL SET-UP

The experimental setup with its various measuring devices is shown in the fig. 1. 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.

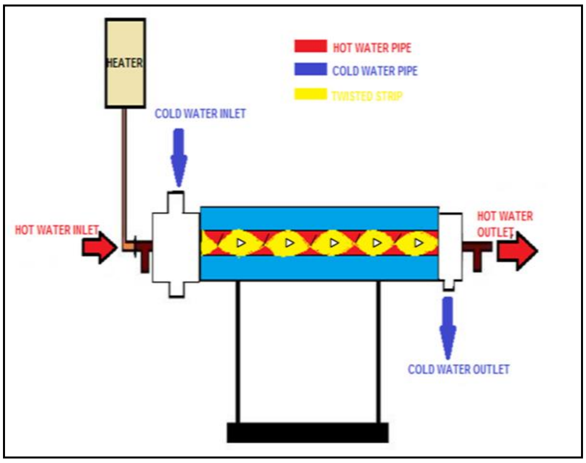

Fig .1 The Schematic Diagram of Experimentation

For Heating up the water from its ambient temperature to a higher temperature a 1lit, 2000 W power water heater working under a voltage range of 230V, 50Hz on Single Phase AC supply, For the setup 8 point multi point temperature indicator is used to indicate the temperature of the four position were the four k Type thermocouple is connected.

Fig .2 Actual Photograph of Experimentation

2.1 PROCEDURE

In 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 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.

Fig .3 Actual Photograph of Triangular baffled twisted tape

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.

Setup 1 -: It is the parallel flow plan concentric tube heat exchanger.

Setup 2 -: It is the parallel flow twisted tape concentric tube heat exchanger

Setup 3 -: It is the parallel flow triangular baffled twisted tape concentric tube heat exchanger

Setup 4 -: It is the counter flow plan concentric tube heat exchanger.

Setup 5 -: It is the counter flow twisted tape concentric tube heat exchanger

Setup 6 -: It is the counter flow triangular baffled twisted tape concentric tube heat exchanger.

2.2 SPECIFICATION OF INSERTS

Table-1: The constant parameters

Parameter	Value
Inner pipe (copper) inner dia. (d_{ci})	1cm
Inner pipe (copper) outer dia. (d_{co})	1.1 cm
Outer Pipe (PVC) inner dia. (d_{pi})	2.54 cm
Outer Pipe (PVC) outer dia. (d_{po})	2.74 cm
Length of copper pipe & Length of twisted tape strip (l)	1.53 m
Width of twisted tape strip (b)	1 cm
Inlet temp. of cold water (t_{ci})	30°C
Inlet temp. of hot water (By Geyser) (t_{hi})	57°C

2.3 SAMPLE CALCULATIONS

1. Discharge of cold and hot water,

Q= Volume filled by fluid per unit time

2. Velocity of hot water in plane co centric tube,

$$V = Q/A_{cs}$$

3. Velocity of hot water in plane co centric tube with simple twisted tape & triangular baffled twisted tape,

$$v = \frac{G}{\rho}\left[1 + \left(\frac{\pi}{2y}\right)^2\right]^{1/2}$$

4. Mass flow rate,

$$m = \rho AV = \rho Q$$

5. Hot water heat rate,

$$Q_h = m\, c_P\, (t_{hi} - t_{ho})$$

6. LMTD (Logarithmic Mean Temperature Difference),

$$\Theta_m = \frac{\theta 1 - \theta 2}{\ln\frac{\theta 1}{\theta 2}}$$

7. Experimental overall heat transfer coffiecient,

$$U = Q_h / A\,\Theta_m$$

8. Reynolds No. of hot water ,

$$Re = \rho VD/\mu$$

9. Theoretical Nusselt number,

$$Nu_{th} = 0.023\, Re^{0.8} Pr^{0.3} \quad \text{(Mc Adam Equation)}$$

$$Nu_{th} = 5.172(1 + (.005484 Pr^{0.7} (Re/y)^{1.25}))^{0.5}$$

(Hong & Bergles Equation)

10. Experimental Nusselt no. ,

$$Nu_{ex} = hd/k_w$$

11. Experimental Convective Heat Transfer coefficient (w/m^2k),

$$h = 1/(U^{-1} + (D_i/2K_{cu})(\ln(D_o/D_i)))$$

12. Theoretical Friction factor,

$$f_{th1} = 16/Re \quad \text{(For PT)}$$

$$f_{th2} = (0.790 * \ln(Re) - 1.64)^{-2} \quad \text{(Petukhov Equation)}$$

13. Effectiveness,

$$\mathcal{E} = C_h\, (t_{hi} - t_{ho}) / C_{min}\, (t_{hi} - t_{ci})$$

2.4 RESULT AND DISCUSSION

The results of the arrangements by applying all the six experimental setup conditions are obtained with the help of comparative table no 2 and graphs between Re number and Nu number are plotted. The increase in the rate of heat transfer, increase in overall heat transfer coefficient, increase in velocity and increase in effectiveness are obtained from the calculation which are arranged in the tabular form.

Table -2: Result comparison in parallel flow setups

COMULATIVE DATA	Setup 1	Setup 2	Setup 3
Qh (KW)	1.198	1.4629	2.0203
Qc (KW)	1.142	1.4309	1.959
LMTD (°c)	19.15	18.065	13.48
U (KW/°C m^2)	1.183	1.531	2.846
EFFECTIVNESS Ɛ	0.328	0.3888	0.537
EFFICIENCY η (%)	w.r.t.	22.11	68.63

Table -3: Result comparison in counter flow setups

COMULATIVE DATA	Setup 4	Setup 5	Setup 6
Qh (KW)	1.4476	1.7695	2.326
Qc (KW)	1.5326	1.8666	2.5
LMTD (°c)	18.76	17.125	13.7936
U (KW/°C m^2)	1.459	1.954	3.1895
EFFECTIVNESS Ɛ	0.385	0.47	0.6185
EFFICIENCY η (%)	20.834	47.70	94.156

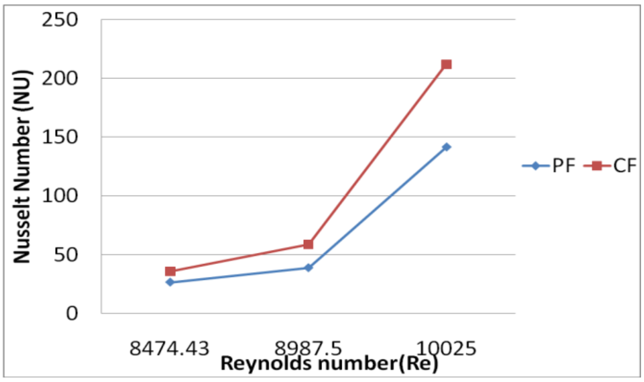

Fig. 4 Nu number Vs Experiments Re number

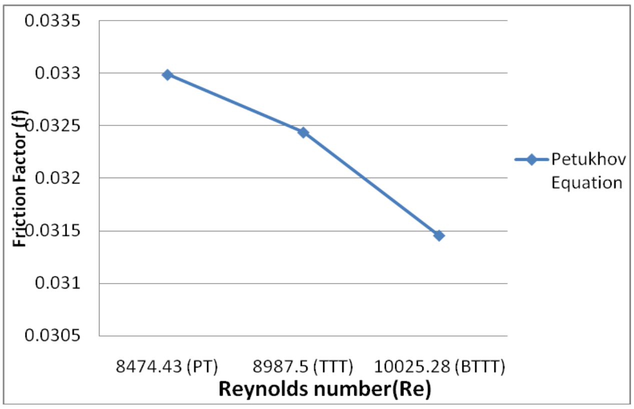

Fig. 5 Friction Factor Vs Re number

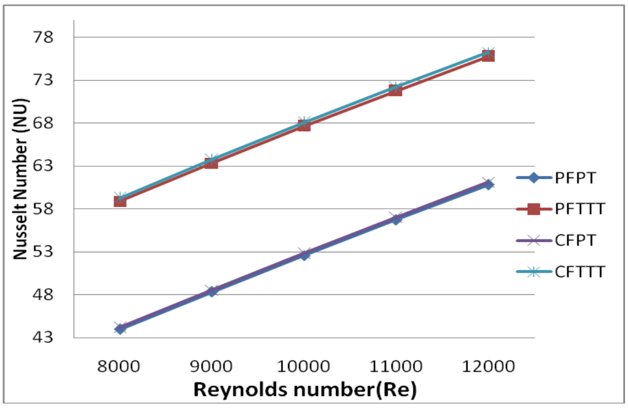

Fig. 6 Nu number Vs Theoretical Re number

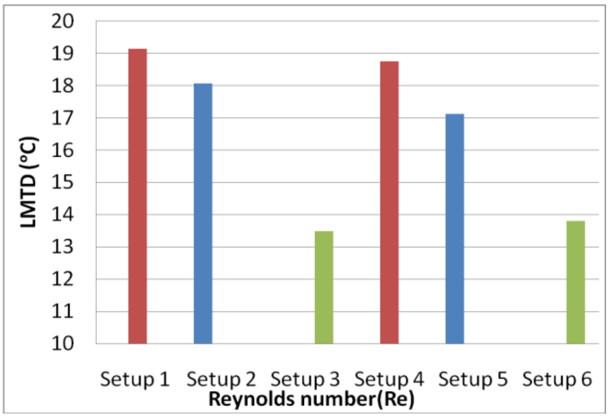

Fig. 7 LMTD Vs Re number

3. CONCLUSIONS

From this experimental study, compare to conventional heat exchanger, augmented (with BTT) heat exchanger the results can be concluded as follows:-

- 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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