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Performance Enhancement of Heat Exchanger Using Turbulators

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Abstract – Heat exchanger is an important device in all the thermal systems. The heat exchanger is wide used instrumentation in several industries like process, petroleum refinement, chemicals, pharmaceutical and paper etc. when learning totally different literature concerning device and double pipe heat exchanger drawback is known on perform and experimental investigation of double pipe device with inner twisted tape sort insert at different mass rate of flow. The system has surveyed different types of flow arrangement and geometric dimension with circular tape to achieve heat transferred in experimental result. The objective of those experiments is Performance analysis of double pipe heat exchanger with twisted tape at totally different mass rate of flow. The experimental set up comprises of double pipe heat exchanger experiment. The equipment includes tube-within-a-tube heat exchangers and twisted tape sort insert with threaded thermocouple junction at every end, a water pump and electric motor. These strategies used to determine the heat transfer rate from the surface and connected temperature of fluid motions additionally used to find the effectiveness.

Keyword - Heat Exchangers, Turbulator, Experimental, Temperature, Insert Pipes etc.

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I. INTRODUCTION

Heat exchangers are broadly utilized in chemical, power generation and oil refining industry. Shell and tube heat exchanger can transfer vast measure of heat in moderately minimal effort, useful plans. The basic variable in reducing the size and cost of a heat transfer gadget are weight drop and heat transfer coefficient. Along these lines, it respects made procedure to improve the heat transfer coefficient. The twisted tape insert as stream turbulator's have been broadly connected because of their promising execution. Numerous analysts have detailed their impact of tube insert on heat transfer improvement.

The promising test for plan of heat exchanger is to reduce the pumping power while expanded heat transfer rate. In this manner it is fundamental to create hypothesis and technique about increased heat transfer in the double pipe heat exchanger to enhance the execution of heat exchanger. The presence of twisted tape brings down the hydrodynamic and thermal boundary layer thickness, prompting more noteworthy convective heat transfer. In spite of fact that pumping power may increment definitively and eventually the cost of pumping is more. In this way to accomplish a coveted heat transfer rate with least pumping power, the outline of twisted tape with legitimate geometry is important.

Twisted tapes are typically embedded into the tube to produce whirl movement of liquid for more prominent heat transfer this likewise prompts enhance flow speed, thermal boundary layer, hydrodynamic boundary layer, heat transfer rate, fluid mixing. Anyway all the more pumping power is required when twisted tapes are inserted inward tube.

By using heat exchangers we can transfer the heat energy of one fluid into another fluid. The heat exchangers that we encounter in our daily life's are the evaporators and condensers that are used in refrigerators and Air conditioners. Thermal power plants also use heat exchangers which include the condensers and Boilers. Air coolers and radiators are present in our automobiles which are also heat exchangers. Process and chemical industries also use heat exchangers.

The heat exchangers are constructed according to their use and are also classified accordingly. The heat exchangers that are used most commonly mostly depend on fundamental concepts.

Due to such wide variety of heat exchangers, they are classified according to the operation, heat transfer, construction and flow arrangement. The classifications are described below:

- Regenerators and recuperators
- Geometry: plates, tubes and extended surfaces
- Process of Transfer: direct and indirect contact
- Heat transfer: single or two phase flow

II. IMPROVE METHOD CLASSIFICATION

Heat expulsion change technique says the improvement of thermo water powered execution of heat exchanger. This improvement method is categorized in generally three categories. They are as follows:

a. Active method

b. Passive Method

c. Compound Method

Active method: In these approaches, external power is utilized to affect the need flow statement and related important in rate of heat transfer. The main source of powering the complete system is some applied external force to the system.

Passive method: These methods do not necessary have any direct input of exterior power. This method act as a passive medium to boost the system without utilizing any of the external applied force on the system. As there is no such external medium used in the method this is known to be the passive method of operation.

Compound method: A compound imperative technique is the one wherever more than one of the above expressed strategy is utilized in blend by the motivation behind further progressing the rate of heat transfer.

III. METHODOLOGY

1. Work being considered is to perform experimental examination and recreation of double pipe heat exchanger with and without twisted tape insert

2. The studies of the heat transfer performance of heat exchanger with and without insert twisted tape different geometry.

Calculation of its heat transfer performance at different mass flow rate involving:

a. Heat transfer coefficient for all cases.

b. Nusselt number for all cases.

c. Reynolds Number for all cases

Fig.1 twist tape insert

PROPOSED EXPERIMENTAL SET-UP

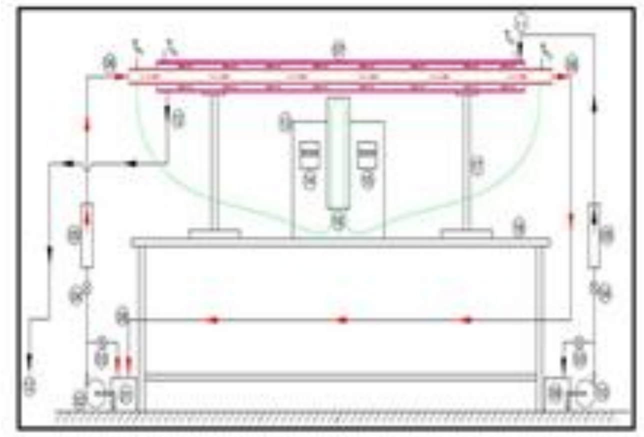

Fig.2 Experimental setup

a) Hot water tank

b) Hot water pump

c) By pass valve

d) Flow control valve

e) Rotameter

f) Hot water inlet

g) Test section

h) Hot water outlet

i) Cold water tank

j) Cold water pump

k) Cold water inlet

l) Cold water outlet

m) Control panel

n) Temperature indicator

o) Temperature controller

p) Inverted u- tube manometer

q) Stand Table

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IV. COMPONENTS WITH SPECIFICATION

The following is a list of all pieces of equipment and their specifications for the double-pipe heat exchanger.

1. Double-Pipe Heat Exchanger Inside Pipe Material:

Copper

Outside Pipe Material	Steel
Length	1.4 m
Inside Pipe	
Inside pipe Dia	0.0198 m
Inside Pipe thickness	0.0028 m
Outside Pipe Diameter	0.038 m
Outside Pipe thickness	0.003 m

Hot water

Pass: 1

Cold Water

Pass: 1

2. Valves

Ball Valves

Location: Process Valves, Tank Valve, Drain Valve, Bypass valves

3. Temperature indicating controller

Display: 31/2 digit red led 13 mm Height

Accuracy: 1%F.S.

Set point: 1 Potentiometric

Output: INO/NC, 3A

Control mode: ON/OFF

Power: 230VAC 50Hz +/- 10%

Size: 96 x 96 x 85 mm DIN ABS Cabinet

Panel cut-out: 92 x 92mm

4. Multipoint Temperature Indicator

Input: RTD-PT100, 3 Wires

Display:3 1/2 Digit Red Led 3mm Height

Range: 0 to 400 Deg. C.

Power: 230V AC, 50 Hz.

Size: 96 x 96 x 80 mm DIN

Panel Cut-out: 92 x 92 mm

Model: MPTI

5. Electrical Heater

Type: Emersion type

Body: SS304

Capacity: 1.5KW

Power: 230VAC 50Hz

6. Pumps

Type: Centrifugal

Capacity: 1/5HP

Discharge: 2000LPH

Foot mounting

Power: 250VAC 50 Hz

Size: 1”

7. U tube manometer

MOC: Acrylic

Range: 250 – 0- 250mm WC

8. Temperature Sensor

Type: RTD-PT100 3 wire

Assembly: Transition type

Range: 0 to 300Deg C

Diameter: 6mm

Length: 100mm

Cable: 3mtr. Teflon/Teflon Cable

9. Rota meter

MOC: Acrylic

Range: 100-1000LPH

Media: Water

Connection: ½”

Float : SS316

10. Power relay

Power: 250VAC 50Hz

V. FORMULAE USED

1. Properties of hot water

$$Tbh = \frac{Th1 + Th2}{2} \quad \text{in °C}$$

Where
Tbh = mean bulk temperature hot water in °C
Th1 = inlet temperature of hot water in °C
Th2 = outlet temperature of hot water in °C

$$Tbh = \frac{335+325}{2}$$

$$= 330°C$$

2. Properties of cold water

$$U = 8984.295 KW/m^2 °C$$

Reynolds number

$$R_e = \frac{pvd_i}{\mu}$$

p = density of water

v = velocity of water

μ = viscosity of water

$$v = \frac{m}{pAs}$$

$$= \frac{0.1667}{1000x0.0003077}$$

= 0.5417m/s

$$R_e = \frac{1000x0.05417x0.0198}{8.90x10^{-4}}$$

=12052.67

(a) Plain tube

For mass flow rate =0.1667kg/s

Re=12052.67

$$Nui = 0.023(Re)^{0.8} (Pr)^{0.3}$$

$$Nui = 0.023(12052.67)^{0.8}(5.42)^{0.3} = 70.27$$

f= 16/Re

=16/12052.67

=0.00132

Same as calculate for all mass flow rates

(b) Twisted tape inserted

For mass flow rate =0.1667kg/s

Re=12052.67

$$Nui = \frac{h*di}{k}$$

$$= \frac{4189.66x0.0198}{0.6} = 138.26$$

$$f = \frac{\Delta pdi}{2PLv^2}$$

$$F = \frac{1294.6x0.0198}{2x1000x1.4x0.5417^2}$$

= 0.03197

Same as calculate for all mass flow rates

Table 1 Sample observation table

Sr.no	cold water mass FLOW	cold water Inlet temp(°c)	Coldwater Out let Temp (°c)	Hot water mass FLOW	Hot water Inlet temp (°c)	Hot water Out let Temp (°c)
1	0.0833	300	308	0.0833	335	225
2	0.1112	300	308	0.1112	335	225
3	0.1388	300	308	0.1388	335	225
4	0.1667	300	308	0.1667	335	225
5	0.1945	300	308	0.1945	335	225
6	0.2223	300	308	0.2223	335	225
7	0.2361	300	308	0.2361	335	225
8	0.2561	300	308	0.2561	335	225
9	0.2638	300	308	0.2638	335	225

Table 2 observation table with plane tube

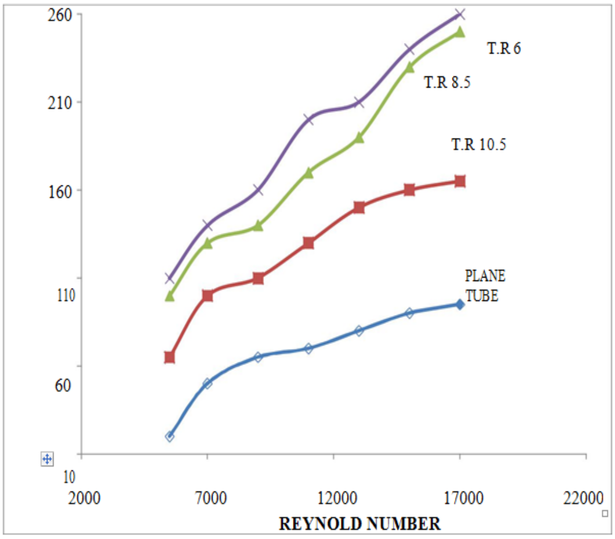
Sr. no	Mass flow rate(m) (kg/s)	Reynolds number(Re)	Nusselt number(Nu)	Friction factor (f)
1.	0.0833	6022.53	40.34	0.00256
2.	0.1112	8039.93	50.83	0.00199
3.	0.1388	10035.45	60.69	0.00159
4.	0.1667	12052.67	70.27	0.00132
5.	0.1945	14062.65	79.50	0.00113
6.	0.2223	16072.63	88.47	0.00099
7.	0.2361	17070.39	92.83	0.00093
8.	0.2561	18516.42	99.07	0.00086
9.	0.2638	19073.15	101.26	0.00083

Table 3 observation table with twist tape

Sr. no	Mass flow rate(m) (kg/s)	Reynolds number(Re)	Nusselt number(Nu)	Friction factor (f)
1.	0.0833	6022.53	69.13	0.12489
2.	0.1112	8039.93	97.27	0.07012
3.	0.1388	10035.45	115.18	0.045004
4.	0.1667	12052.67	138.26	0.03197
5.	0.1945	14062.65	148.4	0.0227
6.	0.2223	16072.63	153.1	0.017548
7.	0.2361	17070.39	161.8	0.011548
8.	0.2500	18516.42	165.4	0.0132
9.	0.2638	19073.15	171.8	0.01245

Graph represent between Reynolds number and nusselt number of twist tape or without twist tape inserted in heat exchanger. In below figure T.R represent the twist ratio.

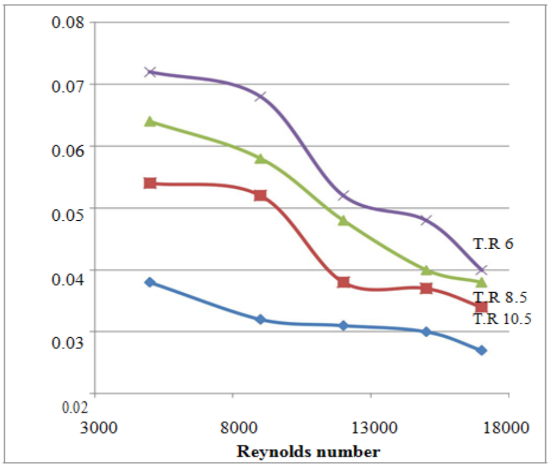
$$\text{Twist ratio} = \frac{\text{pitch}}{\text{Width of tape}}$$



Above figure Plot between Nusselt number and Reynolds number for without twist tape and twisted tape with various twisted ratio inserted, concludes that nusselt number and Reynolds number. Nusselt number rise with rise in reynolds number .hence rate of convective heat transfer is more with higher reyonlds number.

Further, it can reasoned that, twisted tapes with higher contort (with lesser turn proportion) give increment nusselt number for specific reynolds number. Heat transfer rate is hitter with twisted tape of lower contort proportion.

Graph between Reynolds number and fraction factor is shown below



Above figure plot drawn between factor of friction and Reynolds number with varying twisted tape ratio, one can easily observe the change fraction factor with varying twisted ratio with increase in fraction, Reynolds number also increase.

VI. CONCLUSION

It administrated by taking double pipe heat exchanger with cold and hot fluids with totally different boundary conditions by incorporating twist tape inserts .It may be complete as follows: By using passive techniques that's by inserting twist tape inserts the heat transfer improvement increased by 10-15% with the price of reasonable allowable pressure drop .In this report we tend to achieved improvement of heat transfer effectively.

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