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Numerical and Experimental Analysis of Heat Transfer Through Twisted Pipe Heat Exchanger

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ABSTRACT

The heat transfer characteristics of a double tube heat exchanger with twist are enhanced theoretically and numerically. Dimensions for the heat exchanger are, 0.0254m inner pipe diameter and 0.0508 outer pipe diameters, with a thickness of 0.001m and 0.0025m respectively with a length of 1m. The velocity of the fluid inside the both inner and outer pipes is considered as 0.4m/s Study of transient heat transfer in double tube counter flow heat exchanger was carried out with corrugations on the inner tube by twisting the pipe from one end, which gives the more swirling motion to the fluid particles flowing through it. The flow inside the pipe was considered as turbulent, and the analysis was done theoretically by using the ANSYS workbench and also experimentally. The experimental results in the twisted pipe heat exchanger were compared with that of the normal pipe heat exchanger. Theoretical and experimental values given that the heat transfer rate in twisted pipe was more comparing with that of the normal pipe heat exchanger.

Keywords: *Corrugated twisted pipe, Convective heattransfer, Turbulent flow, Counter flow, Transient heat transfer.*

Nomenclature:

- $\mathbf{A_i}$ *inner tube surface area*
- **C** *specific heat (J/Kg-K)*
- $\mathbf{h_c}$ *heat transfer coefficient(w/m²k)*
- **k** *Thermal conductivity(w/m-k)*
- **Q** *heat transfer rate (KW)*
- **T** *temperature (K)*
- **U** *overall heat transfer coefficient (W/m2-k)*

I. INTRODUCTION

The effectiveness of the heat exchanger plays a vital role in several industries. The effectiveness is considered as, directly proportional to the surface area through which heat transfer takes place, since the effectiveness depending on the rate of heat transfer and the heat transfer is proportional to the surface area and temperature gradient. Increase in the rate of heat transfer is done by changing the surface area of the tube by different ways, like arranging additional surface or by means of corrugation or by means of twisted tapes. In this paper, the surface area was increased by considering the corrugated twisted pipe as inner tube of the heat exchanger. Due to the twisting of the pipe, the flow inside the pipe was turbulent by having the more swirling motion , while flow through the pipe.

II. LITERATURE

In many industrial applications, it is found that heat exchangers are one of the most important equipments. The heat transfer rate through different heat exchangers was discussed by using the device with better effectiveness (mainly shell and tube, tube in tube type To increase the effectiveness of the heat exchanger the study was considered in it with nano-fluids and was discussed that the rate of heat transfer through pipes was increased by arranging the blocks to the walls of the tubes as extended surfaces[The experimental studies given that heat transfer through the heat exchangers increases, when using the nano-fluids as coolants. In plate type heat exchangers, the analysis of pressure drop, heat transfer, boiling and condensation were discussed to know the characteristics and factors playing for the effectiveness In coil tube heat exchangers the studies have been conducted to analyse the heat transfer rate by considering the flow inside the pipe as laminar and turbulent

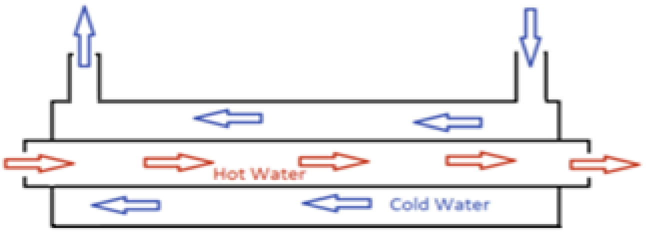

Fig. 1 Heat exchanger with flow direction

The numerical analysis was done on the pipes by considering the flow as laminar and turbulent. And by adding the extra surface to the pipe like corrugation for more effectiveness in straight pipes Considering nano-fluids and turbulent flow inside the pipe the numerical analysis was done for calculating the friction factor and heat transfer rate varying through the pipe. Corrugated coil tubes and the experimental assessment on those tubes for performance analysis and exergy was enhanced in spirally, helical, perforated twisted plates and more designs. Forced convection was discussed to describe the factors like friction and Reynolds. To improve the rate of heat transfer in heat exchangers twisted oval tubes were also discussed with the help of CFD in 3D.

III. EXPERIMENTAL ANALYSIS

The heat exchanger was designed as the inner pipe was corrugated twisted and the outer pipe was normal pipe. The heat exchanger pipes were made of stainless steel (202)

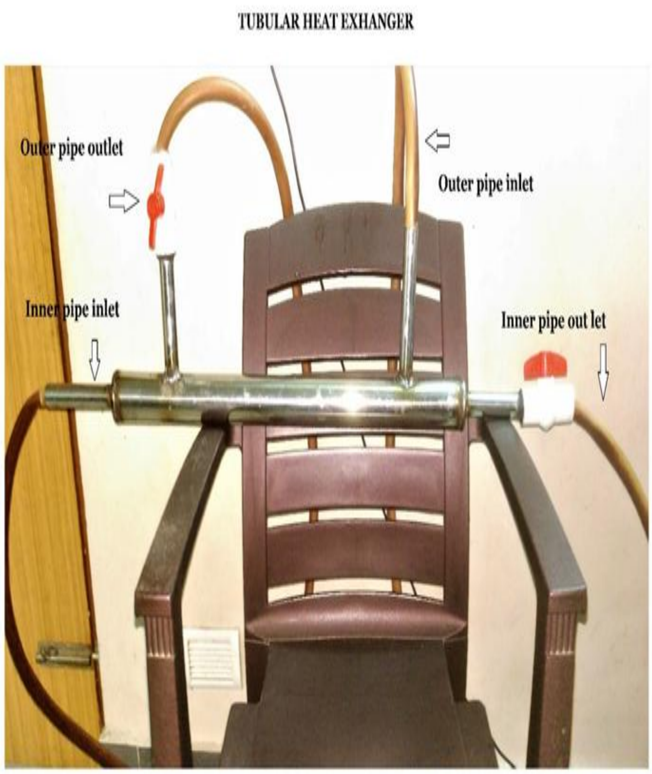

Fig 2 Experimental setup of heat exchanger with twisted pipe

The hot water supply was connected to the inner pipe of the test equipment to maintain the hot water flow rate inside. The outer pipe of the equipment was connected from the water tank to maintain the normal water directly. The flow rates of hot and cold water were maintained by arranging and adjusting the regulating controlling valves at the outlets of the pipes as shown in the above figure. Digital thermometers were arranged to measure the temperatures

Working

Circulation of water to be maintained in both inner and outer tubes at a constant discharge from water tanks by the control valves. The heated water allowed through the corrugated twisted pipe and its flow was regulated by the control valve at the outlet of it. The cold water circulation was maintained by the control valve which was arranged at its outlet. As the flow was maintained in heat exchanger it was taken more time to get required temperature. Once it was attaining the temperature, it will maintain that till the experiment. For every fifteen minutes the readings were taken.

IV. THEORETICAL ANALYSIS

Design of the geometry was constructed Ansys geometry software. As the twisting for the pipe was available to construct in it, by the command tool twist and was twisted by taking the reference points as axis of the pipe and for required number of twists in the pipe with a pitch value of 0.0254m. It was imported to Ansys workbench 14 in the Fluid Flow (Fluent). The geometry was edited to define the flow inside the pipe of fluid material. This geometry was fine meshed in the meshing model of fluent panel in Ansys. Naming of interface, wall, inlet and outlet for inner and outer pipes were given in the meshing window. The flow is considered to be turbulent and the study was done in transient state.

The models selected were energy, k-Є (2-eqn) and heat exchanger. The velocity of the fluid inside the pipes has been considered for studying the heat transfer analysis through them with acceptable value, for both type of the double tube heat *exchangers*. The flow of fluid in the heat exchanger is considered as counter-flow and the analysis was analyzed by Ansys Fluent. In Fig. 3, it is observed that the geometry of inner tube of the heat exchanger as corrugated twisted tube. Material of the pipes was considered as steel of grade 202.

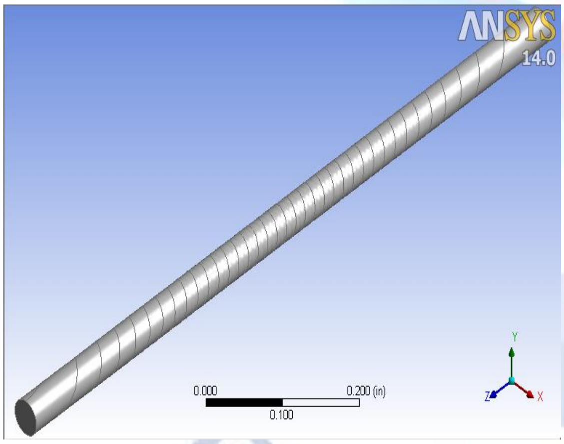

Fig 3 Geometry of the corrugated twisted pipe

V. SOLUTION

A. Initial conditions:

1) Velocity

Inner tube inlet : 0.4 m/s

Outer tube inlet : 0.4 m/s

2) Temperature

Inner tube inlet : 373K

Outer tube inlet : 303K

B. Experimental Solution:

Temperature : (Normal Pipe)

Hot water inlet ($T_{h,i}$) : 373K

Hot water outlet ($T_{h,o}$) : 366.3K

Cold water inlet ($T_{c,i}$) : 303K

Cold water outlet ($T_{c,o}$) : 308.6K

Heat transfer rate (Q) : 2.6KW

Temperature : (Corrugated Twisted Pipe)

Hot water inlet ($T_{h,i}$) : 373K

Hot water outlet ($T_{h,o}$) : 358.4K

Cold water inlet ($T_{c,i}$) : 303K

Cold water outlet ($T_{c,o}$) : 316.3K

Heat transfer rate (Q) : 6.1 KW

For fluid, at considered conditions, overall heat transfer coefficient value is U=820.8074W/m²K

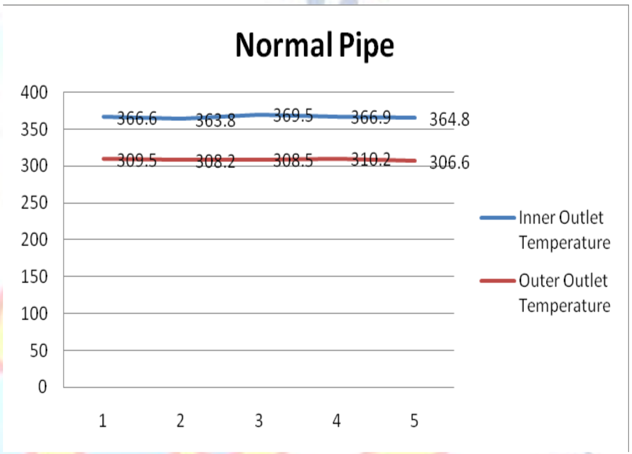

Fig. 4 Temperature graph in normal pipe heat exchanger

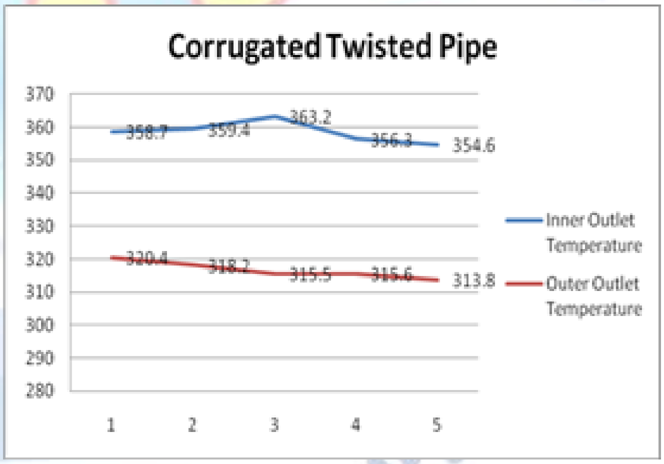

Fig. 5 Temperature graph in corrugated twisted pipe heat exchanger

Theoretical Solution:

The initial conditions of experimental values were taken for theoretical analysis. For the corrugated twisted pipe and normal pipe double tube heat exchanger the initial conditions were taken as same.

The enhancement of temperature distribution was done for the time interval of 3200s. The results were as follows:

Temperature: (Normal pipe)

Hot water inlet ($T_{h,i}$) : 373K
Hot water outlet ($T_{h,o}$) : 369.3K
Cold water inlet ($T_{c,i}$) : 303K
Cold water outlet ($T_{c,o}$) : 305.6K

Temperature : (Corrugated Twisted pipe)

Hot water inlet ($T_{h,i}$) : 373K
Hot water outlet ($T_{h,o}$) : 354.6K
Cold water inlet ($T_{c,i}$) : 303K
Cold water outlet ($T_{c,o}$) : 312.2K

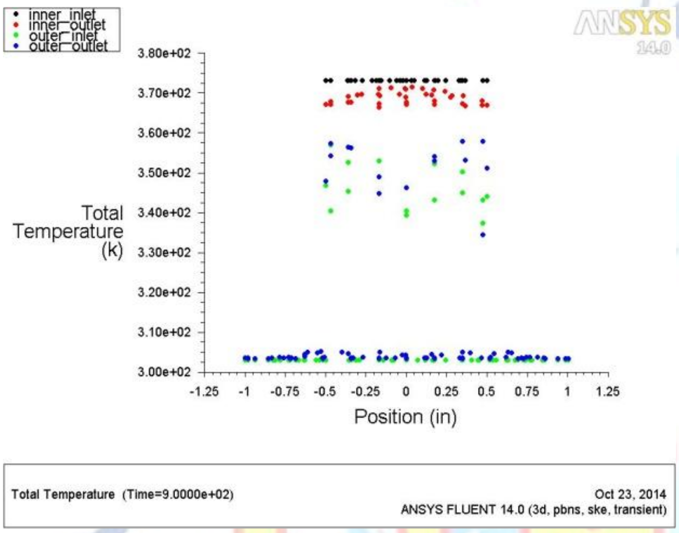

Fig 6 Temperature distribution in normal tube double type heat exchanger

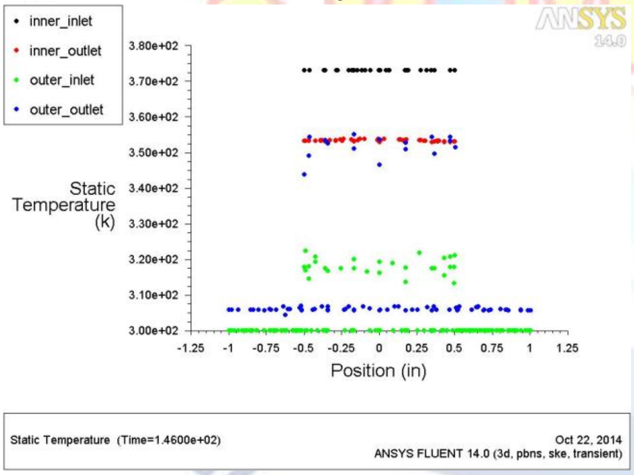

Fig 7 Temperature distribution in corrugated twisted tube double type heat exchanger

VI. CONCLUSION

On the basis of work data carried out under the present thesis, it was concluded that, it was better to use the corrugated twisted pipes as a substitute to the normal pipes in the tubular heat exchangers By using these corrugated twisted pipes the effectiveness of heat exchangers will be increased as they have more thermal conductivity compared to that of the normal pipes, which can lead to the increase in efficiency of the industry or plant and production rate also could be increased

	Experimental Temperature(K)		Theoretical Temperature(K)	
	Inner Outlet	Outer Outlet	Inner Outlet	Outer Outlet
Corrugated Twisted Pipe	358.4	316.3	354.6	312.4
Normal Pipe	366.3	308.6	369.3	305.6

Table 1 Comparison of results for temperature

FUTURE SCOPE

Here in this project, the material used for the equipment was stainless steel. By changing the material of the pipe with higher thermal conductivity and considering the coil type heat exchanger, it is better to give more efficiency. By considering the number of twists also increases the heat transfer rate of the pipe. This is applicable in all industries, power plants, automobiles, etc.

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