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DESIGN AND ANALYSIS FOR HEAT TRANSFER THROUGH TWISTED TAPE WITH NANOPARTICLES

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ABSTRACT

Different techniques have been used to achieve a high heat transfer rate. Among them, one of the advanced techniques is a suspension of nanoparticles in the base fluids as water and coated with aluminum and titanium. The present work has been carried out on a double pipe heat exchanger with twisted tape insert with twist ratio (y/w = 4 and 6) and thickness (0.8mm) for heat transfer investigation of water to water and nanofluid to water with counter flow arrangement under turbulent flow conditions. The computational fluid dynamic code simulates different concentrations of nanofluid (0.01% to 0.19%) in ANSYS FLUENT R 18.1 software. The overall heat transfer coefficients for all concentrations are measured as a function of the hot and cold stream's mass flow rates. The thermal performance parameter overall heat transfer coefficient is compared for nanofluids with water. The work concludes that there is a good enhancement in heat transfer rate using nanofluid.

Keywords: *Circular pipe, twisted tape, Aluminium, Titanium, CFD analysis and Thermal analysis*

1. Introduction

A double-pipe heat exchanger is a type of heat exchanger which consists of concentric pipes parted by a mechanical closure. The double-pipe heat exchanger has a small pipe surrounded by another large pipe. One fluid flow inside the small pipe, and the other fluid moves by the annulus between the two pipes.

The counterflow heat exchanger is one of the double-tube heat exchanger types. In a counterflow heat exchanger, one working fluid has an opposite flow direction to the flow direction of the other working fluid. The heat exchanger has the highest heat transfer rate in this design, and we can efficiently heat or cold the outlets according to our requirements. In heat exchangers, there are three types of heat enhancement techniques are used (1):

Active Techniques: These techniques are more complex from the use and design point of view as the method requires some external power input to cause the desired flow modification and improvement in the rate of heat transfer. It finds limited application because of the need for external power in many practical applications. Compared to the passive techniques, these techniques have not shown much potential as it is difficult to provide external power input in many cases (2).

Passive Techniques: These techniques generally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices.

Compound Techniques: When any two or more techniques are employed simultaneously or combined to obtain enhancement in heat transfer is termed a compound enhancement technique. The heat transfer rate in the case of the compound technique is more significant than that produced by either of them when used individually.

In this paper, the compound technique is used for heat transfer enhancement. Add twisted tape inside the heat exchanger and use nanoparticles as base fluid or coated with twisted tape(3).

Nanofluid has metal particles in the fluid which is smaller than a μ(9-10 times) in size and highly volatile and capable material, which will be used for increasing factors like thermal conductivity of any metal or material and rate of reaction because they are so much intense and reactive.

If the nanoparticles are appropriately distributed, the following result will be obtained: Higher heat conduction, Stability, Micro passage cooling without clogging, reduced chances of erosion, and a decrease in pumping power.

The heat transfer coefficient and flow friction characteristics in a concentric double pipe heat exchanger can be studied by introducing the swirling flow with the help of twisted tape placed inside the inner test tube of the heat exchanger with different twist ratios, y = 5.0 and 7.0. It is found that the increase in heat transfer rate of the twisted-tape inserts is found to

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be strongly influenced by tape-induced swirl or vortex motion (4).

2. Experimental work

The 3D model and design of the heat exchanger and the twisted tape are formed with the help of Solid works software.

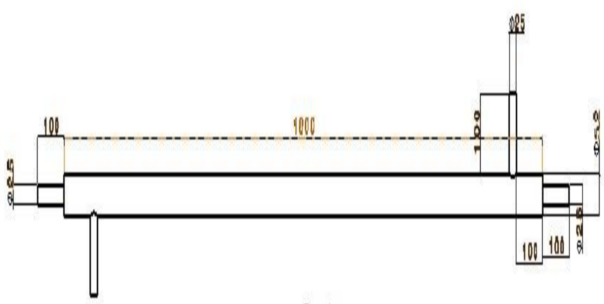

Fig. 1 2D dimensions of heat exchanger with twisted tape

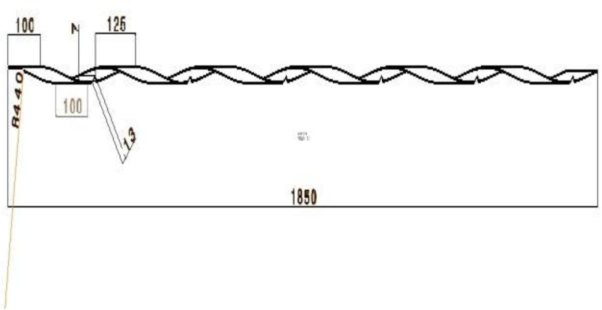

Fig. 2 2D view of twisted tape

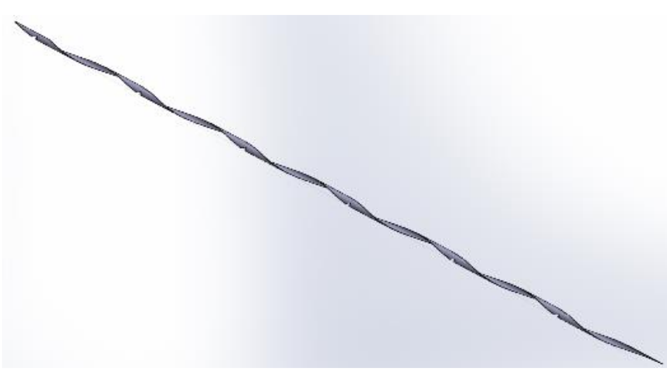

Fig. 3 3D view of twisted tape (with v-cut)

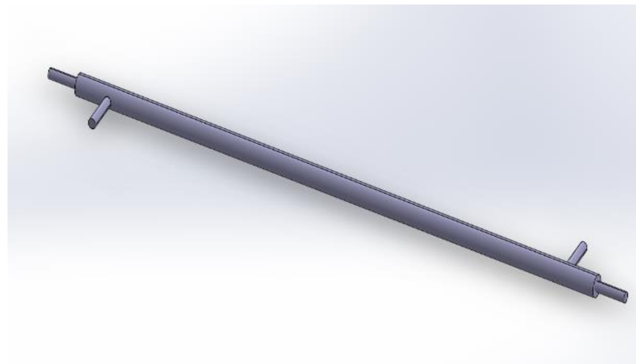

Fig. 4 Isometric view of heat exchanger

CFD analysis of the double-side heat exchanger is performed using ANSYS FLUENT R18.1 software. And the three-dimensional model of the heat exchanger with twisted tape is imported from solid works software.

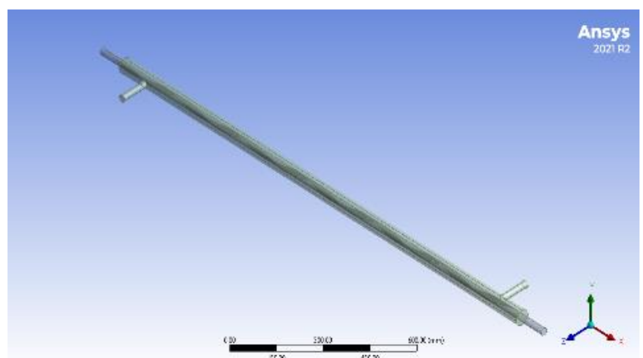

Fig. 5 CAD model in ANSYS

In the outer tube, the air is used as a working fluid, and the inside tube fitted with twisted tape, water-fluid or nanofluid is used as base fluid. The temperature at the hot inlet of the inside tube is constant at 314K (4).

Table 1 Properties of Materials

Materials	Densit y(ρ)(kg /m3)	Thermal conductivity (k)(W/mK)	Specific heat (Cp) (J/kg K)
Aluminum	2719	202.4	871
Titanium	4850	7.44	544.25
Air	1.225	0.0242	1006.43
Water	998.2	0.6	4182
silicon	2.77	0.0104	4105.29

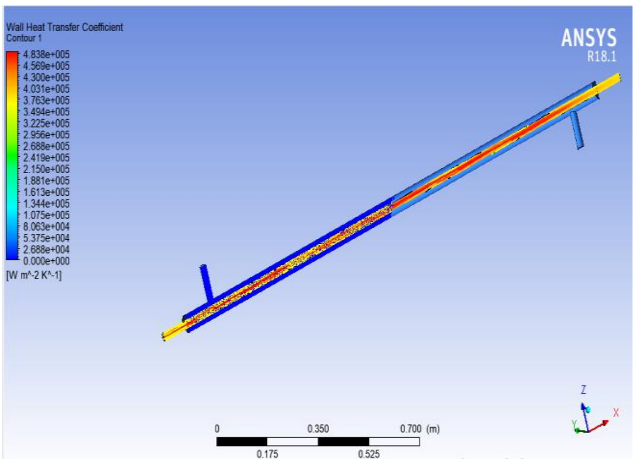

Fig. 6 Minimum Heat Transfer

3. Results and Discussion

A double-pipe Heat exchanger with a counterflow arrangement was used with three different boundary conditions. The first setup uses aluminium oxide-coated twisted tape with water as a base fluid; the second use aluminium oxide-coated twisted tape with silicon dioxide Nanofluid as base fluid; and the third use titanium dioxide-coated twisted tape with water as base fluid. We will analyze the heat transfer coefficient and temperature difference using CFD analysis (5).

The maximum temperature in the inlet for this process is 314 k (40.85°C), and the minimum output temperature is about 308.15 k (35°C). The temperature distribution for condition (i) is shown in Fig. 6. The minimum heat transfer occurred is 309.953 K (36.803°C). For condition (ii), the minimum heat transfer occurred is 308.15 K (35°C), and is shown in Fig. 7. For condition(iii), The minimum heat transfer occurred is 309.908 K (36.758°C), and is shown in Fig.8

The heat transfer coefficient is calculated for condition (i). The maximum heat transfer coefficient that occurred is 530519.6 W/m^{2}k, shown in Fig.10. For condition (ii), the maximum heat transfer coefficient obtained is 719699.25 W/m^{2}k, which is shown in Fig.9. For condition(iii), the maximum heat transfer coefficient occurred is 530519.56 W/m^{2}k, and is shown in Fig.11.

The velocity of the fluid will be maximum at the inlet, and the outlet as the fluid enters at a speed of 40m/s in the inlet. As the pipe consists of twisted tape, there will be a loss in velocity. The velocity contour for this process is shown in Fig.12.

After the analysis, it was revealed that the maximum heat transfer coefficient and maximum temperature difference occurred in condition (ii) twisted tape coated with aluminum oxide and silicon dioxide Nano fluid as base fluid(6).

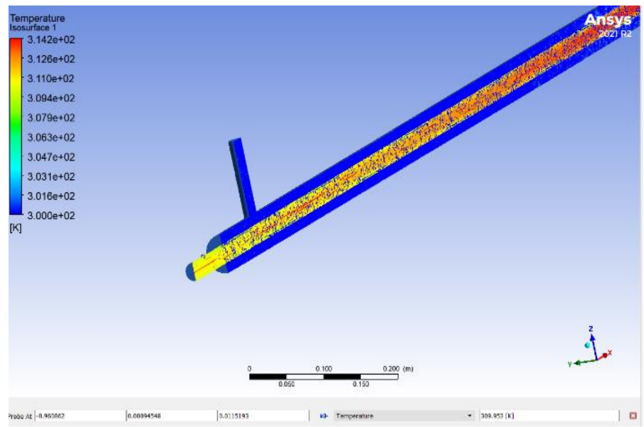

Fig. 7 Minimum temperature for Aluminum twisted tape

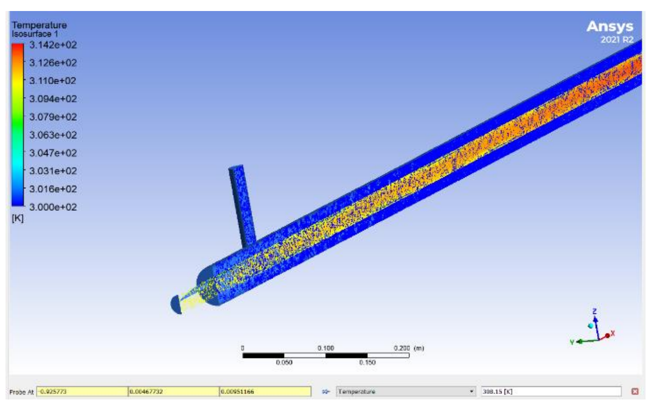

Fig. 8 Minimum temperature for Silicon Solid fluid used in Aluminium twisted tape.

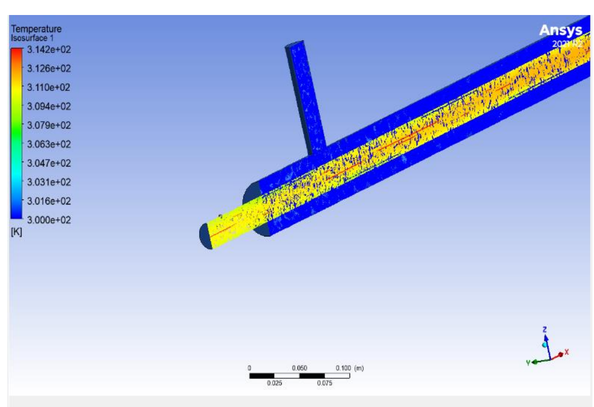

Fig. 9 Minimum temperature for Titanium used twisted tape

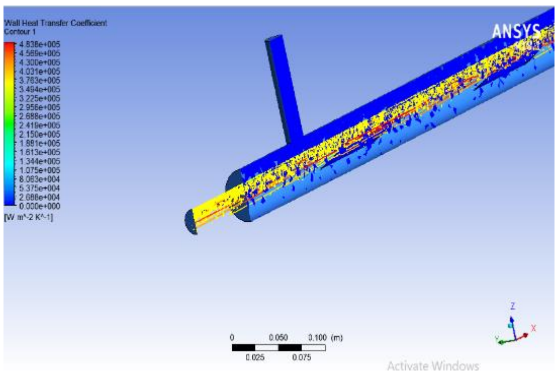

Fig. 10 for Silicon Solid fluid used in Aluminium

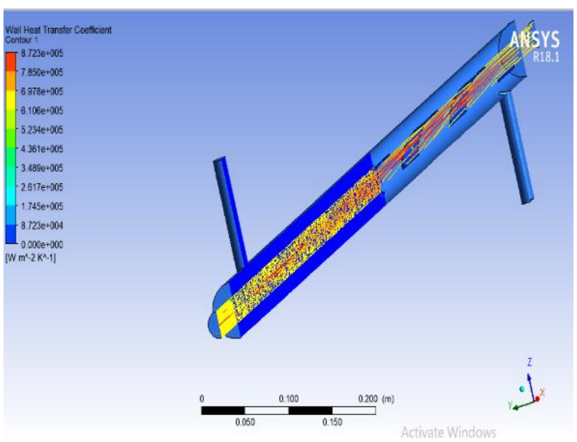

Fig. 11 Heat Transfer Coefficient of Titanium

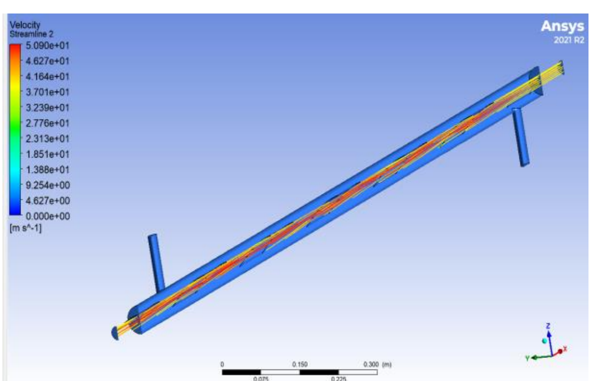

Fig. 12 Velocity Contour of Twisted tape

4. Conclusion

It the present work, analyses were performed to study the design parameters of heat exchanger design. The results revealed the effectiveness of CFD analysis in determining the temperature along with the parameters, such as Pressure, Velocity and Turbulence. The modelling has been done in the SolidWorks software to specified dimensions. Then the CFD analysis is performed in ANSYS FLUENT.

Based on the analysis, the efficient or effective heat transfer rate occurred in the silicon solid(fluid) with the twisted material of Aluminium. It has a higher rate of transfer and heat transfer coefficient (719699.25 W/m^2k) than compared to the other two twist material of titanium and aluminium. Whereas the result for titanium and aluminium are seem to be similar in temperature 309.908 K and 309.953 K or said to be almost the same, but the aluminium twisted tape with the fluid of silicon has a temperature of 308.15 K. Hence from the above analysis, we can conclude that the better heat transfer rate of heat exchangers occurs in silicon fluid with aluminium twisted tape

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