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Investigation of Effect of Flow Parameter on Performance of Tube in Tube Helical Coil Heat Exchanger

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Abstract*: The helical tube heat exchanger has been a research hotspot in the heat transfer fields since a long time along various journals reported. There are all metals can transfer heat and copper is best from them. Copper has also been extensively studied in the heat transfer application for its extraordinary advantages including excellent thermodynamics properties, absence of corrosion, cheap raw materials and relative abundance. Here, the studies in helical tube heat exchanger research on development of heat transfer for enhance thermodynamics properties via method of convection are reviewed. Mainly Convection process, heat transfer method of helical tube heat exchanger, used instruments, and recent developments are discussed. There is also discussing about heat transfer from hot water to cold water and calculate the rate of water flow for both cold water and hot water. Heat transfer characteristics inside a helical coil for various parameters conditions are compared. It is found from research journals that the specification of a constant temperature or constant heat flux for an actual heat exchanger does not yield proper modeling. Tube in tube helical coil heat exchanger provides a compact shape with its geometry offering more fluid contact and eliminating the dead zone, increasing the turbulence and hence the heat transfer rate. An experimental setup is fabricated for validating the estimation of the heat transfer characteristics. Liquids have poor thermal properties, which is barrier in development in heat transfer /exchanger process. Hence nano-fluids (Base fluids + Nano particles) are used for accelerate or better performance in this process compare to simple base fluids. Nano particles are used as crystal for accelerate or speed up the reaction for being best heat exchanger from hot fluid i.e., water and nano particle to the cold fluid. Here we have to take different weight percentage of Zinc oxide nano particles i.e., 0%,3%,5% and 7% for checking the heat transfer enhancement form may be in regularly or systematic gradually or randomly. It is clear by showing graph and table.

***Keywords*: Helical coil, heat exchanger, thermodynamics, convection, water meter, digital display meter.**

1. Introduction

The study of heat exchanger in helical coiled heat exchanger characteristics inside a helical coil for various conditions is studied. The effects of different flow parameters are analysed by an experimental set up are done for estimating the characteristics of heat transfer. The heat transfer co efficient is calculated by the numerical method. The helical heat transfer rate depends on the heat transfer characteristics and various slope of helical coil heat exchanger, various researchers done for improve the heat transfer rate. While designing a double pipe helical heat exchanger the outer pipe should be given top importance in order to get a greater total heat transfer co efficient. The total heat transfer co efficient increased as coil pitch increases. There is increasing the shell side fluid mass velocity reduces the heat exchanger's effectiveness. There is lots of researcher on impact of design and operation factors on that transfer parameters such as heat flow, Reynolds no and annulus shape. For all intake temperature the performance of the helical coil heat exchanger was found to be higher than that of the straight tube heat exchanger. Because of the compact structure and high heat transfer co efficient helical coil heat exchanger has its wide verity of application in power generation, numerical reactor, chemical processing, food industry, refrigeration unit etc. The size of heat exchanger is decreased considerably by heat transfer enhancement technology .The enhancement technique divided into two group, active and passive. The active techniques required external forces like variation of fluid, surface variation and electric field. The passive techniques use the surface geometries. In the present study there are different nano particles used for improvement of heat transfer rate such as zinc oxide, aluminium oxide, copper oxide etc. Nano particles used for high the rate of heat transfer. Therefore, nano particles increased the heat transfer rate of base fluid used for heat exchanger. From all nano particles zinc oxide nano particles result in better heat transfer.

2. Literature Review

Most of the investigations on warmth switch coefficients are for simplified such as regular wall temperature or steady warmness flux, Nandakumar and Masliyah, 1982 [1]. Studies helical coil have compact measurement and higher warmness switch coefficient they are broadly used in industrial functions such as meals preservation, refrigeration, process plant, energy generation, etc. An strive has been made to learn about the parallel float and counter drift of inner higher temperature fluid float and decrease temperature fluid flow, which are separated by way of copper floor in a helical coil warmness exchanger.

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Helical geometry permits the advantageous coping with at greater temperatures and several temperature differentials besides any extraordinarily caused stress or enlargement of joints. This kind of warmth exchanger consists of series of stacked helical coiled tubes and the tube ends are linked through manifolds, which additionally acts as fluid entry and exit locations. In this paper, we centre of attention on layout parameters and warmness switch of a vaporizer.

Jayachandraiah, D. et al. [2] investigated the warmth switch of a helical coil warmth exchanger using CFD. The geometry featured an internal diameter of 8.41 mm for the coil tube and 260 mm for the shell, with a shell peak of 250 mm. CFD learn about is completed for various extent waft charges of 40, 60, 80, 100, and a hundred and forty LPH on aspect and a regular fee of 200 LPH on the Shell aspect underneath constant country circumstances. Better warmth transfers properties are recognized at an eighty LPH go with the flow rate. The warmth transmission price was once calculated. The whole warmness effectively enhance as the drift charge at the coil facet increases.

G. B. Mhaske., et al. [3] examined a helical coil warmth exchanger with a counter flow tube in tube. The consequences were compared to a numerically calculated value. The numerical work seemed at the have an impact on of pitch trade on the heat switch fee of inside wound wires. The warmness rate, efficiency and effectiveness are computed the use of the records from the experiment. The numerical and experimental effects are almost identical.

Karanth, V. K., et al. [4] carried out a CFD evaluation on a helical coil tubular warmth exchanger and in contrast the findings to these of a straight coil beneath same geometrical and operational circumstances. A CFD simulation of a helical coiled tubular warmness exchanger used to be carried out underneath consistent wall temperature circumstances. The helical coil tube warmness exchanger had an 11% larger warmness than the straight tube, whilst the strain drops for the helical coil used to be large area circumstances.

Palve, V. M. et al. [5] investigated the impact of tube diameter suggest float charge and stress drop characteristics in a helical coil warmth exchanger whilst gaining knowledge of drift and warmness switch phenomena associated with helically coil-tube warmth exchangers. The temperature loss was once proven to be perfect at low drift fees and reduces as the glide price increases. The findings confirmed that the form of the helical coil warmth exchanger had an impact on temperature drop.

Pawar, S. S., et al. [6] using water as the working or based fluid, they investigated warmth switch throughout vertical helical coils for Newtonian and non-Newtonian fluids, and there are relationships between the Nusselt range and the frictional non-Newtonian fluids. In evaluating the experimental and CFD data, it has been proven that they are almost identical.

Sreejith K et.al [7] located that the effectiveness of helical coil warmth exchanger is discovered to be greater when compared to that of the straight tube warmth exchanger for all the inlet temperatures offers the variant of effectiveness with inlet temperature of warm water for each helical coil and straight tube warmness exchangers.

Kannaadasan [8] compare Heat transfer and pressure drop in horizontal and vertical position was experimentally. In the experiment CuO/water based nanofluids used. It was result that vertical helical coil heat exchanger have better efficiency and better effectiveness than horizontal coil heat exchanger for their residence time (or more contacts).

Radkar [9] studied the convective heat transfer using ZnO nanofluids in helical coiled at constant wall temperature. It results that at 0.5% volume of ZnO at 40 and 50 degree celcious obsedved 62.80% and 136% enhancement in thermal conductivity. At 5% volume 26.5% enhancement in thermal conductivity at 30 degree celcious and at 4% volume 33.4% enhancement.

3. Experimental Procedure

1) First of all, the 2 water tanks are filled with water. Water tanks are for hot fluid inlet, cold fluid inlet, hot fluid outlet, cold fluid outlet.
2) Then warm the water of hot water container with the help of water rod heater as per required temperature which is measured by digital thermometer.
3) Then set the flow control valve of both hot fluid inlet valve and cold fluid inlet valve as per required.
4) Then plug are connected of both water pump to the circuit switching on the digital display meter where the temperature will be displayed.
5) In the structure above which the helical coil tube in tube heat exchanger is placed there a switch is present with connection to the motor. That switch is turned on to start the motor for water pumping.
6) Then water start getting pumping up from both the hot fluid inlet tank & cold fluid inlet tank.
7) Both the direction is counter flow direction and above process is same for parallel flow direction.
8) And it is during this time that the digital display meter starts showing temperature reading.
9) So due to water-to-water heat exchange finally the temperature changes occur & this procedure is repeated as temperature required and as flow rate required & during this time from the help of flow meter the values of mass flow rate are calculated.
10) Then add the Zinc oxide as nano particles as volume percentage i.e., 3%, 5% and 7% separately and continuously steering weather the nano particle stands down below the water and follows the above procedures for both counter flow and parallel flow heat exchanger.

4. Results and Calculation

Effectiveness = Actual heat/Maximum heat

Table 1
Effectiveness for parallel flow heat exchanger for base fluid at 0% ZnO

Temperature	ϵ at ṁ of 20sec/1L	ϵ at ṁ of 30sec/1L	ϵ at ṁ of 40sec/1L
40°C	0.2190	0.4634	0.2524
50°C	0.365	0.2405	0.2804
60°C	0.3993	0.2067	0.2620

Table 2
Effectiveness for counter flow heat exchanger for base fluid at 0% ZnO

Temperature	ϵ at ṁ of 20sec/1L	ϵ at ṁ of 30sec/1L	ϵ at ṁ of 40sec/1L
40°C	0.4062	0.5918	0.2957
50°C	0.2769	0.1782	0.3385
60°C	0.2796	0.2954	0.2789

Table 3
Effectiveness for parallel flow heat exchanger for base fluid at 3% ZnO

Temperature	ϵ at ṁ of 20sec/1L	ϵ at ṁ of 30sec/1L	ϵ at ṁ of 40sec/1L
40°C	0.154	0.314	0.305
50°C	0.142	0.195	0.231
60°C	0.194	0.237	0.253

Table 4
Effectiveness for counter flow heat exchanger for base fluid at 3% ZnO

Temperature	ϵ at ṁ of 20sec/1L	ϵ at ṁ of 30sec/1L	ϵ at ṁ of 40sec/1L
40°C	0.295	0.397	0.437
50°C	0.157	0.214	0.267
60°C	0.195	0.234	0.297

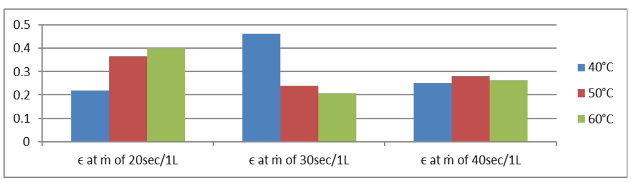

Fig. 1. Parallel flow heat exchanger for base fluid as water at 0% ZnO

Fig. 1 shows the parallel flow heat exchanger for base fluid as water at 0% ZnO shows that the effectiveness are variation according to temperature variation i.e., 40°C, 50°C and 60°C.The copper is good heat conductor and it carries heat long time compare to other materials. Also, the experiments are done continuously without time taken for rest to cool the copper tube.

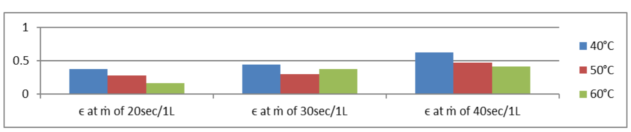

Fig. 2. Counter flow heat exchanger for base fluid as water at 0% ZnO

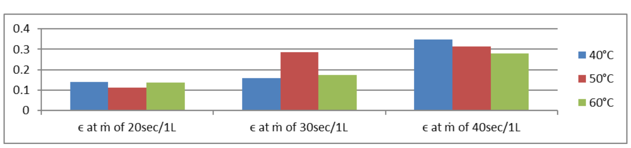

Fig. 3. Effectiveness for parallel flow heat exchanger for base fluid as water at 3% ZnO

Fig. 2 shows the counter flow heat exchanger for base fluid as water at 0% ZnO shows that the effectiveness are variation according to temperature variation i.e., 40°C, 50°C and 60°C. The reason for variation in effectiveness is thermal conductivity of copper coil is more and it carries heat and time needed to cool. But the experiments are done continuously. But when we consider according to time taken for rate of flow it become increases. The effectiveness increases approximately 10% according to temperature increases at 10°C means 40°C to 50°C or 50°C to 60°C.

Fig. 3 shows the effectiveness for parallel flow heat exchanger for nano fluid at 3% ZnO shows that the effectiveness increases 0.5% for 40°C both at mass flow rate 20sec/1min and 30sec/1min but it increases to 40% when it experiments at mass flow rate of 40sec/1min. The improvent in effectiveness reason is as the hot fluid flows more time so that the copper coil consumes heat and doesn't realise it. There is same result produced for both 50°C and 60°C. The enhancement in effectiveness at 3% ZnO compare to 0% ZnO for extra ordinary properties in thermal conductivity of Zinc Oxide.

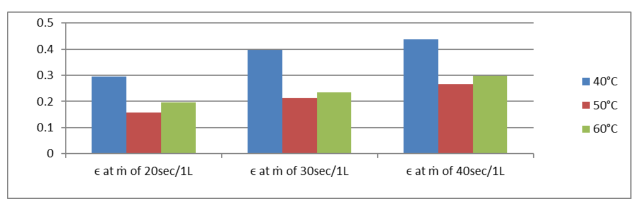

Fig. 4. Effectiveness for counter flow heat exchanger for base fluid as water at 3% ZnO

Fig. 4 shows the effectiveness for counter flow heat exchanger for nano fluid at 3% ZnO shows that the effectiveness increases 10% for all temperature taken for experiment i.e., 40°C, 50°C and 60°C according to time taken for rate of flow increases that's are 20sec/1min, 30sec/1min and 40sec/1min. The effectiveness of counter flow heat exchanger enhances 15% compare to parallel flow heat exchanger for nano fluid at 3% ZnO. The effectiveness variation for temperature taken for experiments that the copper coil carries heat and experiments are done continuously without cooling the copper coil.

Table 5
Effectiveness for parallel flow heat exchanger for base fluid at 5% ZnO

Temperature	ϵ at ṁ of 20sec/1L	ϵ at ṁ of 30sec/1L	ϵ at ṁ of 40sec/1L
40°C	0.131	0.351	0.516
50°C	0.16	0.217	0.434
60°C	0.126	0.355	0.381

Table 6
Effectiveness for counter flow heat exchanger for base fluid at 5% ZnO

Temperature	ϵ at ṁ of 20sec/1L	ϵ at ṁ of 30sec/1L	ϵ at ṁ of 40sec/1L
40°C	0.38	0.44	0.63
50°C	0.275	0.301	0.473
60°C	0.161	0.375	0.418

Table 7
Effectiveness for parallel flow heat exchanger for base fluid at 7% ZnO

Temperature	ϵ at ṁ of 20sec/1L	ϵ at ṁ of 30sec/1L	ϵ at ṁ of 40sec/1L
40°C	0.139	0.159	0.348
50°C	0.112	0.284	0.315
60°C	0.135	0.175	0.278

Table 8
Effectiveness for counter flow heat exchanger for base fluid at 7% ZnO

Temperature	ϵ at ṁ of 20sec/1L	ϵ at ṁ of 30sec/1L	ϵ at ṁ of 40sec/1L
40°C	0.389	0.341	0.517
50°C	0.167	0.478	0.492
60°C	0.207	0.401	0.601

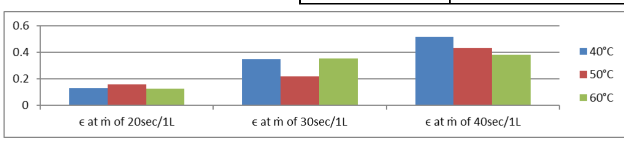

Fig. 5. Effectiveness for parallel flow heat exchanger for base fluid as water at 5% ZnO

Fig. 5 shows the effectiveness for parallel flow heat exchanger for nano fluid at 5% ZnO shows the effectiveness increases approximately 13% when time taken for rate of flow increases to 10sec/1min at 40°C. But the effectiveness increases 5% when time taken for rate of flow increases to 10sec/1min at 50°C. And 9% effectiveness increases when time taken for rate of flow increases to 10sec/1min at 60°C. As copper coil taken as experiment its best property is best thermal conductivity compare to other materials and it carries heat for long time and all experiments are done continuously without time taken for cooling the copper coil.

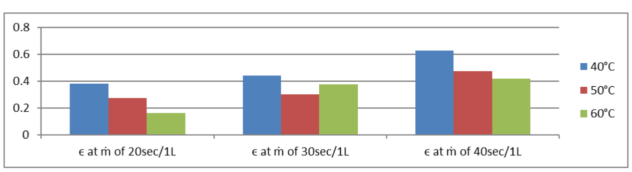

Fig. 6. Effectiveness for counter flow heat exchanger for base fluid as water at 5% ZnO

Fig. 6 shows the effectiveness for counter flow heat exchanger for nano fluid at 5% ZnO shows the effectiveness increases to 5% when the time taken for rate of fluid increases from 20sec/1min to 30sec/1min at 40°C. But the effectiveness increases to approximately 11% when the time taken for rate of fluid flow increases from 30sec/1min to 40sec/1min at 40°C. On the other hand the effectiveness doesn't change for time taken for rate of fluid flow for both 20sec/1min and 30sec/1min at 50°C. But the effectiveness increases approximately 10% in increases when the time taken for rate of fluid flow increases from 30sec/1min to 40sec/1min. The effectiveness increases approximately 10% according to time taken for fluid flow increases for 10sec/1min. The variation in effectiveness for Zinc Oxide nano fluid which is add to water at 5%. So that it carries heat for long time which cause for disturbance or variation in effectiveness according to temperature.

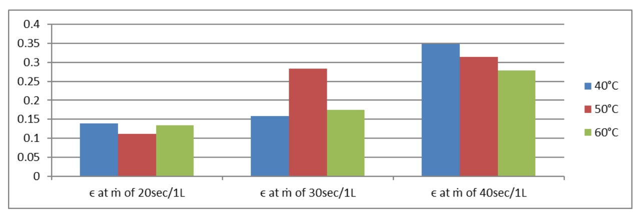

Fig. 7. Effectiveness for parallel flow heat exchanger for base fluid as water at 7% ZnO

Fig. 7 shows the effectiveness for parallel flow heat exchanger for nano fluid at 7% ZnO shows the effectiveness increases to 4% when time taken for rate of fluid flow increases from 20sec/1min to 30sec/1min at 40°C. But the effectiveness increases to 18% when time taken for rate of fluid flow increases from 30sec/1min to 40sec/1min at 40°C. On the other hand, 13% effectiveness increases when time taken for rate of fluid flow increases from 20sec/1min to 30sec/1min at 50°C. But the effectiveness increases to 7% when time taken for rate of fluid flow increases to 30sec/1min to 40sec/1min.At last the effectiveness gradually increases at the rate of 8% when the time taken for fluid flow increases at 10sec/1min at 60°C.

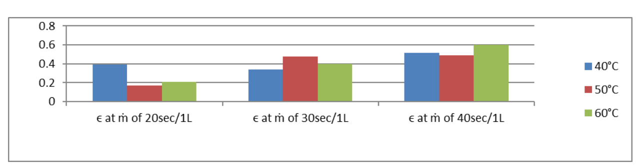

Fig. 8. Counter flow heat exchanger for base fluid as water at 7% ZnO

Fig. 8 shows the temperature of graphs of counter flow heat exchanger is variation for volume percentages of ZnO i.e., 7%. The reason is the experiments are done continuously without taking time for rest to cool the copper helical coil as we known well that copper is best heat conductor and it carry heat long time than other material. That's why the temperature at inlet and outlet for both hot fluid and cold fluid doesn't come properly. So that effectiveness is variation according to temperature. On the other hand, when flow rate increases respect to time the effectiveness gradually increases as time taken for flow in helical coil become more than more. The effectiveness increases to 15% when the time taken for fluid flow increases at 10sec/1min at 60°C. The effectiveness increases to 13% when time taken for fluid flow increases from 20sec/1min to 30sec/1min.

5. Conclusion

An experimental study of a double pipe helically heat exchanger was performed using two differently types of heat exchangers. There are taken different temperature at different flow rate for calculate their effectiveness both for parallel flow and counter-flow configurations were tested.

There is variation in effectiveness according to temperature taken for experiment i.e., 40°C 50°C and 60°C. Because normally copper is best heat conductor and it have best thermal conductivity properties. That's why it consumes heat for long time and all the experiments are done continuously without taken rest for cooling the copper coil. So that the effectiveness doesn't come regularly according to temperature increases.

On the other hand, the effectiveness gradually increases according to time taken for rate of fluid flow increases at rate of 10sec/1min.

As tested above we concluded that the effectiveness gradually increases as time taken for rate of flow increases for both counter flow and parallel flow heat exchanger.

The effectiveness of the counter flow heat exchanger is more as compared to the parallel flow heat exchanger.

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