ISSN XXXX XXXX © 2017 IJESC

Research Article Volume 7 Issue No.11

Heat Transfer Enhancement in Heat Exchanger with Rotating Twisted Tape Insert Using Water and TiO_2 Nanofluid

Pavan .K .N[1], Varun .S .M[2], Madhushudan[3], Suhas .H .C[4]
Assistant Professor[1], M. Tech (Thermal Power Engineering) [2], professor[3], Mechtrix Engineers[4]
Department of Mechanical Engineering
Nitte Meenakshi Institute of Technology Bengaluru, Karnataka, India

Abstract:
The present work demonstrates the outcomes of experimental examination in Horizontal pipe heat exchanger with twisted tape insert where water and TiO_2 Nanofluid are used as working fluids. Performance characteristics are determined by considering operating conditions such as flow rate, flow turbulence, heat transfer coefficient of liquids in horizontal pipe heat exchanger by using heat transfer enhancement techniques. A stainless steel pipe of inner diameter 30mm and outer diameter 34mm and length of 800mm is used, Twisted tape (TT) made of stainless steel of 2.97 twist ratio inserted in horizontal pipe heat exchanger where heaters are placed on outside of the pipe, TT is made to rotate inside the pipe with rotational speed up to 300 RPM considering flow rate of 4 to 8 LPM. The results demonstrated a dramatic increase in heat transfer coefficient, Nusselt number and Reynolds number of nanofluids due to their higher thermal conductivity.

Keywords: Nanofluid, Heat transfer coefficient, Twisted tape, Nusselt number, Reynolds number

I. INTRODUCTION

Heat exchangers are equipment that transfer heat from one medium to another. Heat exchangers are utilized as a part of different distinctive procedures ranging from conversion usage recovery of thermal energy and it is a fundamental part in domestic and commercial applications [1]. The technique of enhancing the performance of heat transfer is mentioned to as heat transfer enhancement. [2] Heat transfer enhancement techniques are broadly in areas like heat recovery process, refrigeration apparatus and cooling and chemical reactors. In general heat transfer enhancement techniques are distinguished in to two types namely active and passive techniques. The active method requires additional external power source and the other is passive method which requires no direct implementation of the external power. [3] Among various techniques, insertion of inserts like mess, coil, brush, twisted tape inserts. [4] Insertion of twisted tape swirl generation is a stand out amongst the most optimistic technique which has been broadly received for heat transfer enhancement. The insertion of a twisted tape in a flow channel disturbs the flow stream and generates the flow swirl and turbulence, swirling motion of the fluid inside the pipe causes the generation of new fluid thermal layer near the heat transfer area there by more molecules are comes in contact with heat transfer area, the time of residence for the fluid molecules increases and thereby increasing heat transfer can be increased, the rotation of twisted tape inside the pipe causes the increased turbulence of fluid molecules. However, in the process pumping power increased, which will lead to a considerable increase of pumping cost. In concern of fluid the Nanofluids give preferable upgrade properties over the ordinary liquids for example water, glycol, lubricating and so on. [5] Researches have examined the impact of twisted tape insert on heat transfer in a circular tube and further more a few Nanofluids for ex oxides of Aluminum, Copper, Silver and Zinc and metallic particles like Iron, Copper, Silver, Gold and Titanium and so on dispersed in base fluids in both experimental and numerical examinations. In the present examination, the impact of rotating twisted tape inserts on improvement of efficiency of heat transfer utilizing water and water based 0.2% Titanium oxide Nano-fluid is investigated. In the test condition, a rotating twisted tape was embedded into the tube at the convolution ratio of y = 2.97. Experimentation was completed in a similar test conditions as 4, 6, 8 lpm and with rotational speed of twisted tape is between 0 to 300 RPM. Also, contrast the experimental outcomes and the plain tube utilizing water as running fluid and hypothetical correlations.

II. METHODOLOGY

A. EXPERIMENTAL SETUP

The Fig.1 demonstrates the present test setup and coupling with twisted tape rotating the test segment comprises of horizontal pipe made of stainless steel of ID 30 mm and OD 34 mm. The electric heaters are put on the external surface of the pipe and protected the pipe utilizing asbestos and rope to reduce the loss of heat. Three washer sort thermocouples are put on the external surface of the pipe at various length meanwhile to estimate the normal external surface temperature and two stem kind thermocouples are embedded at the inner and outer hose to determine the liquid inlet and outlet temperature individually.Fig.3 shows the incorporation of twisted tape with DC motor and embedded into the pipe with rpm sensor grouped for measuring the speed of the tape inside the pipe as appeared in Fig.2. Two different storage tanks are utilized for collecting the cold and hot liquids. The pipe of length 800mm inserted with twisted tape having width 20.8 mm, thickness 1 mm and convolution ratio 2.97 is embedded. The volumetric stream rates of the liquid are controlled by utilizing a control valve put before the inlet.

B. PREPARATION OF NANOFLUID

The arrangement of Tio_2 Nano-liquids isn't just the simple mixing and dispersing strong particles in a base fluid. It is the most noteworthy stage in the utilization of Nano particles since it needs to improve the traditional liquids thermal characteristics. The reason is that deposition of strong particles could happen to base fluid media if the Nano-liquids are not

Figure.1. Experimental Setup

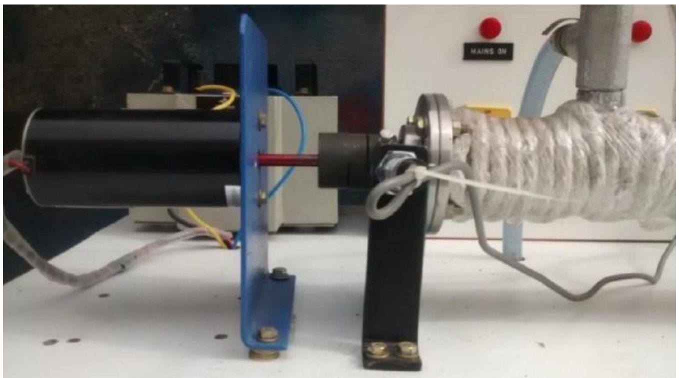

Figure.2. Twisted Tape Coupled with Motor

Figure.3. Twisted Tape

Set up in the correct way, which may bring outcomes about poor thermo-physical property of Nano Fluids. In the present test think about a normal size of 30-50 nm titanium oxide Nano particles having density 4010 kg/m3 is utilized and titanium oxide Nanofluid is prepared utilizing refined water as a base fluid and after planning the Tio_2 Nanofluid is as demonstrated Fig.4.

Figure.4. Tio_2 Nanofluid

C. EXPERIMENTAL PROCEDURE

In current work, the experiment investigation was done in three stages utilizing the apparatus as displayed in fig. primarily, the experiment carried out utilizing water as the working liquid and without swirled tape embedded into the tube. then begins the test rig at first setting the stream rate to consistent utilizing the valve to 4, 6, 8 LPM and switch on the console, next the control supply is balanced utilizing the dimmer to a steady heat rate. Then three readings are taken at 15 minutes of time interval for each stream rate and data are appeared in the indicators arranged and take the average of the readings for promote calculating. In this, we compute the coefficient of heat transfer and other. And this is base outcomes for our further calculation. Then additionally work is carried in a same apparatus at same test condition, yet utilizing with the turning twisted tape and water as the working medium. The test is conveyed with an alternate rotation speed of the twisted tape like 100, 200,300 RPM, and so on and stream rate of 4, 6, 8 LPM. The readings are considered and tabulated next continuing further calculation. In the third stage the work is conveyed with same test situation as expressed above however utilizing Titanium oxide Nanofluid. The principal stage comprises of assurance of the qualities of heat transfer without utilizing the embed and utilizing water as working liquid. The second stage comprises of examination of heat transfer attributes utilizing a insert (rotating) at different RPM. The third stage comprises of determination of features of heat transfer utilizing a rotating twisted tape insert at different RPM and titanium nanofluid as working liquid. A dimmer of specification 1.5 KVA was utilized to apply a steady voltage of 220 volts over the heater wound above the external surface of a stainless steel pipe. A plain swirled tape of swirl ratio of 2.97 is embedded into the pipe and guided by two heading at the two ends. The temperature of the trial portion is raised by including heat the external surface of the test segment utilizing a variable dimmer stat of most extreme limit of 4 amps. After some time, the temperature achieves an unfaltering (constant) state. The temperatures are shown on a temperature indicator. On the external surface of the test segment three (T1, T2, T3) sensors were set to decide the surface temperatures and at channel inlet and outlet hose two (T4, T5) independent sensors are put for deciding the water inlet and outlet temperature. The working liquid is made to move through the pipe at three diverse stream rates as noticed previously. The theoretical Nusselt number has been calculated for fluid flowing inside pipe by using the correlations:

For 2100<Re<10000 using Hausen equation

$$Nu_{th} = \{0.116(Re^{0.66} - 125)Pr^{0.33}(1 + (\frac{Di}{L})^{0.66}(\frac{\mu_b}{\mu_w})^{0.14})\}$$

III.THERMO PHYSICAL PROPERTIES OF 0.2% VOLUME CONCENTRATION OF TITANIUM OXIDE

Table.1. Thermo Physical Properties of 0.2% Titanium Oxide

Thermal conductivity(W /m k)	Density(Kg/m^3)	Viscosity(pa-s)	Specific heat(J /kg k)
0.719	1602	0.001364	3481.8

IV. RESULTS AND DISCUSSION

In this part the variation of Nusselt number, Reynolds number and Heat transfer co-efficient are reviewed, with various rotational speed of twisted tape. Further more towards the end of correlation the outcomes are compared between Tio_2 Nanofluid and water at 300 RPM of TT. It is observed from all figures that addition of TT of y=2.97 creates the auxiliary swirling movement of the liquid inside the tube which thus offers formation of another thermal boundary layer and consequently an upgraded time of residence for liquids and increased rate of heat transfer etc.

1.Variation of Heat Transfe Co-Efficient, Nusselt Number with Reynolds Number Using Water as Working Fluid.

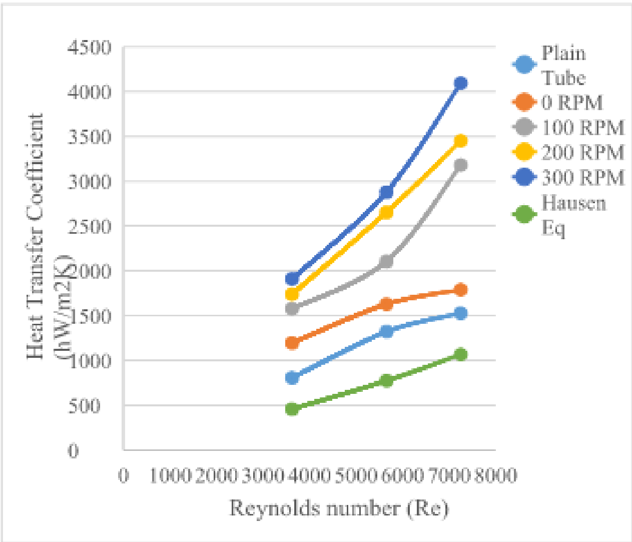

Figure.5. Variation of heat transfer co-efficient with reynolds number for water as working fluid

Above fig demonstrates the variation of co-efficient of heat transfer Vs reynolds number for various rotation speeds of TT and for different experimental outcomes, hausen equation for 4, 6 and 8 LPM flow rates defining three various reynolds number and for various rotational speed of 0,100,200 and 300 RPM. For a given flow rate and rotational speed in a heat exchanger equipped with aTT gives higher heat transfer enhancement at higher speed which is relatively higher efficiency when compared to bare pipe.

2.Variation of Nusselt number with Reynolds number for pure water

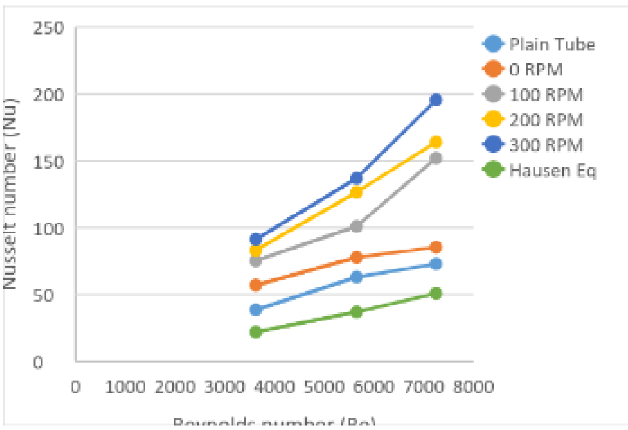

Figure.6. Variation of Nusselt number with Reynolds number for pure water

Above fig shows immense rise in heat transfer co-efficient and thus in the Nusselt number for different rotational speed of 0,100,200,300 of TT. At flow rates of 4 LPM the relative increase in Nusselt number are 47.9%, %95, 115%, 136%respectively.

At 6 LPM the relative increase in Nusselt number are 23%, 60%, 99%, 117%respectively.

At 8 LPM the relative increase in Nusselt number are 17%, 108%, 115%, 167 respectively.

3. Variation of heat transfer co-efficient Vs Reynolds number for 0.2% Tio_2

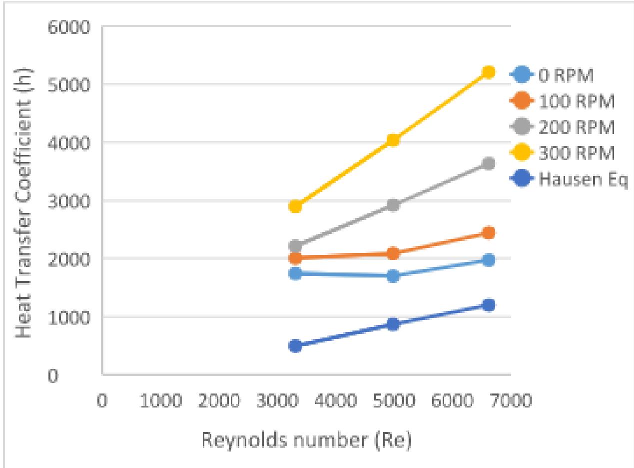

Figure.7. Variation of heat transfer co-efficient Vs Reynolds number for 0.2% Tio_2

Above fig demonstrates the variation of co-efficient of heat transfer Vs reynolds number for various rotation speeds of TT and for different experimental outcomes,hausen equation for 4, 6 and 8 LPM flow rates defining three various reynolds number and for various rotational speed of 0,100,200 and 300 RPM. Comparsion made plain tube using water as running fluid. At 4 LPM the realtive increase in heat transfer coefficient are 115%,148%,173,258%.

At 6 LPM the realtive increase in heat transfer coefficient are 28.3%,58%,120%,203%.

At 8 LPM the realtive increase in heat transfer coefficient are 29%,61%,137%,241%.

4.Variation of Nusselt number Vs Reynolds number for 0.2% Tio_2

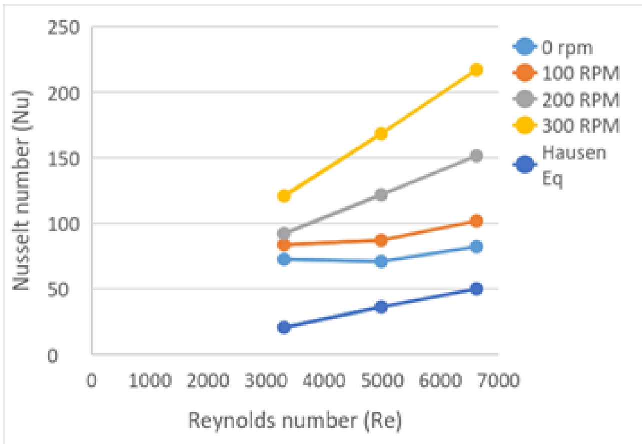

Figure.8. Variation of Nusselt number Vs Reynolds number for 0.2% Tio_2

Above fig shows immense rise in heat transfer co-efficient and thus in the Nusselt number for different rotational speed of 0,100,200,300 of TT. At flow rates of 4 LPM the relative increase in Nusselt number are 88%,116 %,138%, 212% respectively.

At 6 LPM the relative increase in Nusselt number are 12%,39%,92.9%,168%respectively.
At 8 LPM the relative increase in Nusselt number are 15%,43%,110%,197 respectively.
5.Variation of Heat transfer co-efficient Vs Reynolds number for Water and 0.2% Tio_2

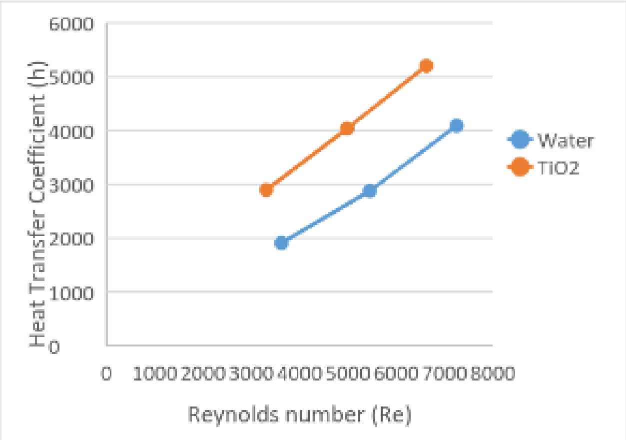

Figure.9. Variation of Heat transfer co-efficient Vs Reynolds number for Water and 0.2% Tio_2

Above fig demostrares the variation of heat transfer coefficient Vs Reynolds number for water and Tio_2 nanofluid with TT at 300 RPM. It is observed that the relative increase in heat transfer coefficient is found to be 73%.

V. CONCLUSION

- Rate of heat transfer is extremely effected by flow rate of fluid flowing in the apparatus. Higher heat transfer can be accomplished at higher Reynolds number.
- Rate of heat transfer would be increased by reducing twist ratio which increases pressure drop and pump power.
- Insertion of TT generates secondary swirling motion of the fluid inside the pipe, there by producing new thermal boundary layer of the fluid flow.
- Insertion of twisted tape will cause turbulence flow of fluid and which causes more turbulence by rotating the TT.
- Higher the speed of rotation of the TT actuates expanded swirling movement of the liquid there by expanding the rate of heat transfer.
- Nanofluids cause greater heat transfer rate because of their enhanced thermal conductivity.
- Thermo physical properties of nanofluids varies temperature and volume concentration.
- The usage of Nanofluids causes us in expanded heat transfer with the goal that they better substitution liquids in the place of traditional heat transfer liquid. The utilization of nanofluids diminishes the heat exchanger for a given heat application.

VI. REFERENCES

[1]. S.Eiamsa-ard *et al.* (2015) "Heat transfer enhancement of TiO2/water nanofluid in a heat exchanger tube equipped with overlapped dual twisted-tapes". "Engineering Science and Technology, an International Journal". 18 (2015) 336-350.

[2]. Dr. Abdul Hassan A. Karamallah et al. (2014) "Experimental Investigation of Heat Transfer Enhancement and Flow with Ag, Tio2ethylene Glycol distilled Water nanofluid in Horizontal Tube"."The 4th International scientific Conference on Nanotechnology& Advanced Materials &Their Applications (ICNAMA 2013)3-4 Nov, 2013". Vol.32 Part (B) No.3, 2014.

[3]. Nivedita Uzagare *et al.* (2016) "Enhancement of Heat Transfer Using V-Jagged Twisted Tape in Circular Tube". "Journal of Mechanical and Civil Engineering". ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 13, Issue 2 Ver. I (Mar. - Apr. 2016), PP 14-17.

[4]. S. Naga Sarada1 *et al.* (2010) "Enhancement of heat transfer using varying width twisted tape inserts". "International Journal of Engineering, Science and Technology". Vol. 2, No. 6, 2010, pp. 107-118.

[5]. Mohammed Saad Kamel *et al.* (2016) "Heat Transfer Enhancement Using Nanofluids". "American Journal of Nano Research and Applications". Vol. 4, No. 1, 2016, pp. 1-5.