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Heat transfer enhancement using CuO/water nanofluid and twisted tape insert in circular tube- A Review.

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Abstract—A Heat Transfer augmentation technique implies different method used to enhance heat transfer without affecting overall system performance. As these techniques has huge application in heat exchanger which are used in different processes ranging from conversion utilization and recovery of thermal energy in various industrial commercial and domestic applications .Heat transfer enhancement can be done by active passive and compound techniques. Now days much research is carried out with a new class of fluid to enhance the thermal conductivity of fluid by using nanopowder in base fluid. Several researchers has concluded that simultaneous use of both nanofluid and twisted tape significantly enhance heat transfer performance. This paper mainly reviews of heat transfer enhancement using CuO/water nanofluid and twister tape insert.

Keywords-*heat transfer enhancement,CuO/water nanofluid,twisted tape insert, constant heat flulx.*

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I. INTRODUCTION

Heat transfer is a discipline of thermal engineering that concerns the generation, use, conversion and exchange of thermal energy through system. The energy and material saving consideration as well as economic incentives have led to effort to produce more efficient heat exchange equipment.

The attempt to increase heat transfer performance is referred as heat transfer augmentation, enhancement or intensification. The study to increase heat transfer coefficient have been recorded for more than a century. Heat transfer enhancement techniques can be divided into two categories-Passive and Active techniques in passive heat transfer enhancement technique an object which does not use external energy such as an insert increases the heat transfer using tube insert in heat exchangers has received a lot of attention. The twisted tape insert generate considerable increase in heat transfer rate by formation of a swirling flow and increasing the turbulence intensity close to the tube wall. Heat transfer augmentation using various type of swirl flow generator s like twisted tapes, helical screw tapes have been widely reported in literatures such a devices induce turbulence and super imposed vertex motion causing a thinner boundary layer and consequently resulting in higher heat transfer coefficients. The main problem for this technique lies in the large additional pressure drop associated with heat transfer enhancement many researches that have investigated the effect of introduction of swirl flow devices for the convective heat transfer enhancement in tube are available in literature.

II. HEAT TRANSFER ENHANCEMENT TECHNIQUE

Heat Transfer enhancement or augmentation techniques refer to the improvement of thermo hydraulic performance of heat exchangers, existing enhancement techniques can be broadly classified into three categories are as follow.

1) Passive Technique.
2) Active Technique.
3) Compound Technique.

Passive technique generally uses surface or geometrical modifications to the flow channel by incorporating inserts or additional devices. They promote higher heat transfer coefficient by distributing altering existing flow behavior which also lead to pressure drop. Passive technique hold advantage over active technique as they do not required input of external power.

Active technique is the method which involves some external power input for enhancement of heat transfer and has not show much potential owing to complexity in design. Furthermore, external power is not easy to provide in several applications. In comparison to the passive techniques, these techniques have not show much potential as it is difficult to provide external power input in many cases some example of active methods are include pulsation by cam and reciprocating plungers, the use of a magnetic field to disturb the seeded light particles in a flowing stream, etc.

Compound techniques is one where more than one of the above mentioned techniques is used in combination with the purpose of further improving the thermo hydraulic performance of a heat exchanger.

III. NANOFLUID

The concept of nanofluid is not new as in 1857 Michael Faraday first carried the study on the synthesis and colours of colloidal gold. The suspension of nanoparticales in the base liquid is usually referred to as a nanofluid. Nature is full of nanofluid, like blood, a complex biological nanofluid where different nanoparticals accomplish different functions. One can get different type of liquids like process extraction nanofluids, environmental, bio and pharmaceutical nanofluids. A new class of polymer nanofluid drag-reducing nanofluids, aim at enhanced heat transfer, as well as, flow friction reduction. Nanoparticales resist sedimentation, as compared to larger particles, due to Brownian motion and interparticle forces and posses much higher surface area which enhances the heat condition of nanofluids since heat transfer occurs on the surface of the fluid. Three properties that make nanofluids

promising by increase thermal conductivity conductivity increasing single phase heat transfer rate and enhance critical heat flux.

IV. TERMED USED IN TWISTED TAPE TECHNIQUE

A. *TWISTED TAPE :*

It refers as metallic strip twisted with a suitable technique with desired shape and dimensions.

B. *TWIST RATIO :*

Twist ratio is refer as ratio of pitch length to inner diameter of tube.

C. *PITCH :*

Pitch is defined as distance between two points that are on same plane measure parallel to the axis of twisted tape.

V. LITERATURE REVIEW

Khwanchit Wongchavee and Smith Eiamsard (2012), studied heat transfer enhancement by using CuO /water nanofluid in a corrugated tube equipped with twisted tape. The present work apply CuO nanofluid with three different volume concentrations of 0.3%, 0.5%, 0.7% by volume and twist ratios (y/w= 2.7, 3.6, 5.3) for Reynolds number range from 6200 to 24000. The experiment revels that at the same operating condition heat transfer rate, friction factor as well as thermal performance associated with the simultaneous application of CuO/water nanofluid and twisted tape are higher than those associated with the individual techniques. It revels that heat transfer rate increases with increasing CuO/water nanofluid concentration and decreasing twist ratio.

The improvement of heat transfer with increase in Reynolds number is responsible by a decrease of thermal boundary thickness due to the promoted turbulent intensity at similar condition Nusselt number is higher than base fluid and increase due to increase in concentration of nanoparticals. It is found that due to application of nanopartical and increase in concentration results in an increase of thermal conductivity and collision of nanopartical which increases heat transfer rate. The obtain result implies that for the present range the effect of the increase in thermal conductivity and collision of nanoparticales are more than increase in viscosity. Increase in fluid viscosity which decreases the fluid moment and thus heat transfer rate decreases. As the result obtain Nusselt number of tube equipped with twisted tape is considerably improved compared with that of the tube without twisted tape this is due to the swirl generated by a twisted tape. The heat transfer enhancement become more significant with decreasing twist ratio of twisted tape.

It is found that influence of twisted tape on heat transfer is much more significant than that of the presence of nanoparticals in the fluid moreover; heat transfer enhancement associated by the application of nanofluid and corrugated tube and twisted tape is found to be more effective than those offered by individual techniques.

S. Suresh, M. Chandrasekhar (2011) had done experimental studies on heat transfer and friction factor characteristics of CuO/water nanofluid under turbulent flow in a helically dimpled tube under turbulent flow with a constant heat flux using CuO/water nanofluid in circular tube with fully develop developed turbulent flow for the Reynolds number in a range of 2500 to 6000. The height of dimple was 0.6 mm. The experiment perform using helically dimpled tube with CuO/water nanofluid having 0.1, 0.2, 0.3% volume concentration of nanoparticals.

The result revels that the Nusselt number with dimpled tube and nanofluid under turbulent flow is about 19%, 27%, 39%, for volume concentration of 0.1%,0.2%, and 0.3% than Nusselt number of water and the result shows that for isothermal pressure drop for turbulent flow shows that friction factor were about 2-10%that of plain tube.

The experimental result revels that the use of nanofluid in helically dimpled tube increases the heat transfer rate with negligible increase in friction factor compare to plain tube the result also revels that thermal conductivity of nanofluid remarkably increases with volume concentration of nanoparticals.

S. Ramteke and V. P. Ate studied the convective heat transfer enhancement of pure distilled water and Al_2O_3 nanofluid in circular pipe with twisted tape insert .The experiment was conducted with pure distilled water and nanofluid with insert and without inserts. The experiment conduct at particle volume concentration 0<4<0.5%and twisted tape with twist ratio in the range of 0<(y/w)<10. The result indicates that the increase heat transfer coefficient is found with decrease in twist ratio and with high nanofluids volume concentration from the result obtain the rate of heat transfer is more with twist ratio 2.5 at 0.3% loading of AL_2O_3 by volume and as the flow rate of heat transfer also increases.

The heat transfer coefficient at Reynolds numbers in the range of 1000-2000 with nanofluids of 0.3% of volume concentration of nanofluid Al_2O_3 is higher when compared to the pure distilled water and without insert. High the concentration of nanofluid results into considerably high thermal performance.

S. Suvesh, K. P. Venkitaraj, P. Selvakumar, M. Chandrasekhar, studied a comparison of thermal characteristic of Al_2O_3/water and CuO/water nanofluid in transition flow through a straight circular duct filled with helical screw tape insert was made in this study with twist ratio of Y= 1.78, 2.44 and 3 using 0.1% volume concentration Al_2O_3/water and CuO/water nanofluid. They found the average enhancement in Nusselt number for water 156.24%, 122.16% and 89.22% for twist ratio of 1.78, 2.44 and 3 respectively when compared to plain tube.

The use of Al_2O_3 and CuO nanoparticals as the dispered phase in water significantly enhances the convective heat transfer in transition flow. The average increase in Nusselt number for Al_2O_3/water and CuO/water nanofluids are 10.22% and 18.19% respectively compared to pure water . It is resulted that the use of helical screw tape insert with twisted tape inserts with both nanofluid causes very high enhancement in Nusselt number compared to plane tube.

The average increase in Nusselt number corresponding to the twist ratio of 1.78, 2.44 and 3 are 166.84%, 128.67%and 89.22% respectively for Al_2O_3/water nanofluid for CuO/water nanofluid. The enhancements in Nusselt number are 1.78, 2.44 and 3 respectively.

M.T Naik, Syed Sha Fahad, L. Syam Sunder, Manoj K. Simgh, done comparative study on thermal performance of twisted tape and wire coil inserts in turbulent flow using CuO/water nanofluid. Experiment performed in the Reynolds

number range from 4000 to 20,000 and volume concentrations of 0.1% and 0.3% with twisted tape inserts of h/d=5 and 10 and wire coil insert of p/d=1.97 and 2.95.

The experimental result shows that Nusselt number enhancement for 0.3% nanofluid with different condition that is without insert, with twisted tape, with wire coil found 17.62%, 31.88% and 44.45%respectively compared to water at same condition. It is found that more heat transfer enhancement take place in wire coil compared to twisted tape whereas the friction at the same condition enhances 1.149 times without insert 1.179 times with twisted tape insert and 1.198 times with wire coil compared to water. The thermal performance factor of 0.3%nanofluid in tube with twisted tape and wire coil insert are 1.24and 1.36 compared to water.

Experimental result indicate under same operating condition and flow rate heat transfer coefficient, friction factor and thermal performance factor associated with nanofluid in a tube with wire coil insert are higher than those with the twisted tape insert.

M. Saeedinia, M. A. Akhavan-Behabadi and M. Nasr performed an extensive experimental study on heat transfer and pressure drop of CuO/water nanoflid flow in a horizontal coiled wire inserted tube under constant heat flux laminar flow the experiment performed at practical volume fraction in a range from 0.07% to 0.3% and five coiled wires having pitches of 25-35 mm and wire diameter of 0.91-1.5 mm were put one by one. The result specify that for a specific nanopartical concentration, increase in both heat transfer and pressure drop is obtained by using wire coil.

The average enhancement in heat transfer coefficient in heat transfer coefficient is found to 45% while decrease in pressure drop is 63% at highest Reynolds number with highest wire diameter.

L. Syam Sunder, M. T. Naik, K. V. Sharma had performed an experimental study on effect of full length twisted tape insert on heat transfer and friction factor enhancement with Fe_3O_4 magnetic nanofluid inside a plain tube the experiment deals with turbulent convective heat transfer and friction factor characteristics of Fe_3O_4 nanofluid flowing through a uniformly heated horizontal circular tube with and without twisted tape inserts experiment conducted at particle volume concentration range of $0 < u < 0.6\%$, twisted tape inserts of twist ratio in range of $3000 < Re < 22000$.

Experimental result revels that the enhancement of heat transfer coefficient in plain tube with 0.6% volume concentration of Fe_3O_4 nanofluid is 20.99% and 30.96% for Reynolds number of 3000 and 22000 respectively as compared to water further heat transfer enhances with twisted tape insert into plain tube. The heat transfer enhancement of 0.6% nanofluid in plain tube with twisted tape inserts, h/d = 5 is 43.37 and 51.88% compared to water flowing in a plain tube without inserts at Reynolds number 3000and 22000 respectively. With the enhancement of heat transfer the friction factor also increases in a plain tube. The friction factor enhancement of 0.6% volume concentration of Fe_3O_4 nanofluid with twisted tape insert , h/d =5 is 1.179 times and 1.231 times compared to water flowing in a plain tube without inserts at Reynolds number 3000and 22000 respectively.

VI. CONCLUSION

The reviews of the paper concluded that twisted tape exhibits higher thermal performance while use of nanofluid further enhances the thermal conductivity of flowing fluid to higher extent. Result revels that heat transfer rate further increases by the simultaneous use of both nanofluid and twisted tape inserts as compared to the use of twisted tape and nanofluid alone at the same operating condition while pressure drop also increases but it is not much significant compared to increase in thermal performance.

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