Review on Experimental Investigation of Convective Heat Transfer Coefficient of Nanofluid using Twisted Tape in Circular Duct

Jitendra Pachbhai[1] Ankosh M. Hattimare[2] Swarup Y. Vaidhye[3] Vikas D. Vaidhya[4] Shubham M. Narnaware[5]

[1]Assistant Professor [2,3,4,5]UG Scholar

[1,2,3,4,5]Department of Mechanical Engineering

[1,2,3,4,5]JD College of Engineering & Management, Nagpur- 441501, Maharashtra, India

Abstract— This review is mainly on investigation of heat transfer coefficient of nanofluids containing Al2O3 Nanoparticles. Also compound techniques of heat transfer used to increase heat transfer coefficient of nanofluids. In these investigation combination of two passive techniques of heat transfer is being performed for the evaluation of heat transfer coefficient of nanofluids, namely Swirl flow device and Additives for liquid. For these purpose the Twisted Tapes use as Swirl Flow devices and nanoparticles are Al2O3 used as additives to the fluid.

Keywords: Convective Heat transfer coefficient, Passive Methods, Tape Inserts, Nanofluid, Reynolds Number, Nusselt Number, Friction Factor, Prandtl Number

I. INTRODUCTION

Experimental investigation of heat transfer coefficient of nanofluids refers to enhancement of heat transfer rate by by enhancing the heat transfer coefficient. The heat transfer coefficient can be increases by incorporating the inserts to disturb the flow and the additives to the fluid. These enhancement follow certain techniques that broadly classified into following three categories,

A. Passive Techniques

These techniques plays an important role for increment of heat transfer coefficient of the heat exchanger. By these techniques heat transfer coefficient can be improved which is the ultimate aim of increment of heat transfer rate. These can be achieved by using:

1) Treated Surface
2) Rough Surface
3) Extended Surface
4) Swirl Flow Devices
5) Coil Tubes
6) Additives for liquids

B. Active Techniques

For design point of view these is more complex method as it requires the external power input to cause the flow modification and improvement heat transfer coefficient. These techniques often used for the improvement of heat transfer rate because of the need of external power in many practical applications.

C. Compound Techniques

When any two or more than two techniques employed simultaneously for obtaining the enhancement in heat transfer rate by enhancing the heat transfer coefficient of the fluid is termed as compound enhancement. For these investigation the individual passive techniques is used but the more than one technique that are

1) Swirl Flow Devices (Twisted Tapes)
2) Additives to Fluid (Nanoparticles)

1) Twisted Tapes:

The twisted tapes are the simply metallic strip. These tapes used for converting the flow i.e. from linear to spiral along the tube length when inserted in the pipe of circular cross section. The tapes does not act as the fin as there is no good thermal contact between tube wall and the twisted tape. These plays an important role in the increment of heat transfer rate and also gives increase in pressure drop.

2) Review on Twisted Tapes:

The paper focuses mainly on the review of work done on the Twisted Tapes in Turbulent and Laminar flow by using three types of twisted tapes that are described below.,

D. Plane Twisted Tapes:

The review works on plane tube is describe as the following,

1) Behabadi [1] Experimental Investigation of Heat Transfer Coefficient and pressure drop during consideration of HFC-134a in horizontal tube fitted with twisted tapes. The imperial correlations were developed to predict smooth tube and swirl flow and pressure drop.
2) Syam Sundar and Sharma [2] investigated the thermo-physical properties like thermal conductivity and viscosity of Al2O3 nanofluid is determined through experiments at different volume concentrations and temperatures. From the results it is observed that, heat transfer coefficient and Friction Factor is higher when compared to water in plane tubes.
3) Promvonge [3] experimentally investigated the heat transfer rate, friction factor and thermo hydraulic efficiency of combined devices of twisted tapes and wire coil. The experiment is carried out by arranging in two different form decreasing coil and increasing coil while the twisted tape was prepared with two different ratios.

E. Modified Twisted Tapes:

The review works on Modified Twisted Tapes described in the following,

1) Saha [4] experimentally investigated the heat transfer enhancement and pressure drop characteristics in the tube with regularly spaced twisted tapes element. From the results it is observed that pinching of tape rather than in connecting the tape element with rods is be twisted tapes proposition from thermo hydraulic point of view.
2) Yadav[5] experimentally investigated on half length Twisted Tape insertion on heat transfer and pressure drop characteristics in U-bend double pipe heat exchanger. The experimental results revealed that the increase in heat transfer rate of twisted tape inserts is found to be strongly influenced by tape induced swirl.
3) Mengna [6] investigated experimentally the pressure drop and compound heat transfer characteristics of a

converging - diverging tube with evenly spaced twisted tape. From result is is observed that Swirl vary in twist ratio and rotation angles.

F. Modified Twisted Tapes:

The review work on Modified Twisted Tapes is described in following,

1) Radha krishnan[7] experimentally investigated the several thermo-physical properties and the non dimensional numbers. From result it is observed that the Nusselt number is 13 % higher for twisted tape as compared to plane tube.
2) Eiamsa-ard et al. [8] experimentally investigated the pressure drop and plane twisted tube pumping power required for plane twisted tube. From result it is observed that Nu, Friction Factor increased with increase in depth ratio.
3) Bharatdwaj et al.[9] experimentally investigated the heat transfer enhancement by using the Swirl flow devices. It is observed that the heat transfer rate increased by using the Swirl flow devices compared to plane tube.

G. Additives to Fluid:

For enhancing the heat transfer rate the additives are added to Fluid and the most popular techniques is the addition of solid particles to fluid. These solid particles is in micrometer or millimeter-size. These particles have high potential to serve some problems like high pressure drop and sedimentation of particles. These particles are mixed into the base fluid like water, ethylene glycol, propylene glycol, propylene, distilled water which results in the new fluid called the nanofluids. Due to the use of nanoparticles it exhibits the better thermal enhancement properties which is required to high heat transfer of fluid. These is only because of the very low concentration and nanometer sized particles. So with these properties of Nanofluid prevents the problem of sedimentation in the flow and may result in clogs the flow channels. By considering these point of view, there have several study conducted by the researchers on nanoparticles suspension in base fluid. These review on the nanoparticle suspension in fluid and its effects is described in following review article.

H. Review on Nanofluid:

The paper focuses mainly on the review of work done on nanofluids uses for the enhancement of heat transfer rate by enhancing the convective heat transfer coefficient of nanofluids is described as following,

1) Reza Aghayari, Heydar Maddah by using the Al2O3 nanofluid with base fluid water and from the results it is observed that Heat transfer coefficient and Nusselt number of the nanofluid increase from 15 to 20% compared to the base fluid. Also With the addition of nanoparticles in base fluid heat transfer coefficient is increases in turbulent flow.
2) Ali Esmaeilnejad, Habib Aminfar, Maddieh Shafiee, Neistanak experimentally investigated the heat transfer rate by using the CuO, Al2O3 nanofluid with base fluid water and from result it is observed that by using Al2O3 & Cuo nanofluid individually increment in average heat transfer coefficient occurs but large pressure drop.
3) Nguyen et al. experimentally investigated the heat transfer coefficient of nanofluids using Al2O3 nanofluid. From result it is observed that Nanofluid with 36 nm size nanoparticles gives higher heat transfer coefficient than 47 nm size particle.
4) P. B. Maheshwary, C. C. Handa, K. R. Nimade experimentally investigated the thermo-physical properties of Nanofluid by using TiO2 Nanofluid. From the result it is observed that the Enhancement in Thermal conductivity over base fluid contribution of concentration is 69.43%, by size 24.95%, by shape 5.62%.
5) Hafiz Muhammad Ali, HasanAli, Hasan Liaquat, Hafiz Maqsood, Malik Ahmed Nadir experimentally investigated the heat transfer enhancement by using ZnO Nanofluid and from result it is observed that The enhancement in heat transfer of Nanofluid compared to base fluid found to be 46% at 0.2% concentration of nanoparticle.

II. Conclusion

This review paper has considered the heat transfer and improvement of heat transfer coefficient investigation of Al2O3 nanofluid using twisted tape inserts placed in the heat exchanger. All the possible research have been summarized on the case in the literature, such as heat transfer and improvement of heat transfer coefficient of nanofluid and also the heat transfer improvement by the Swirl flow devices. According to the literature survey the modified twisted tape have shown the greater heat transfer as compared to plain Twisted Tape due to creating the turbulence in the fluid flow of normal fluid. The attention has been focused on the heat exchanger efficiency improvement. By adding the solid particles to heat transfer fluid the rate of heat transfer have been found to be greater than the base fluid. Many researchers have investigated the effect of turbulent flow of nanofluids on heat transfer. On the review of Nanofluid it has been observed that the heat transfer rate increases in the turbulent flow of fluid. Particular for the double pipe heat exchangers the heat transfer rate is increases by creating the turbulence in the fluid.

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