Impact Factor Value 4.046 **e-ISSN: 2456-3463**
National Conference on "Recent Advances in Engineering and Technology" SAMMANTRANA 19
Organized by Government College of Engineering, Nagpur
International Journal of Innovations in Engineering and Science, Vol 4 No.8, 2019
www.ijies.net

Review on Use of Twisted Tapes and Nanoparticles In Heat Exchangers

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***Abstract**: Heat exchanger is a device used to transfer heat from one medium to another with or without mixing the media. The heat exchangers are of various types such as shell and tube heat exchangers, plate heat exchangers, double pipe heat exchangers etc. which are used for many applications like HVAC, Sugar factories, automobiles, chemical factories etc. As we know that heat exchanger is a very important part of any system so its size considerations are also important, so we need to minimize the size of heat exchanger without decreasing its overall performance. There are many techniques available to make the heat exchanger compact called as heat exchanger augmentation techniques and are broadly classified into three types namely Active techniques, Passive techniques and compound techniques. The use of twisted tapes and Nanoparticles comes under Passive augmentation techniques. Twisted tapes help to increase the overall performance of the heat exchanger. There are various configurations of twisted tapes are available such as full-length twisted tape, short length twisted tape, full length twisted tape with varying pitch, regularly spaced twisted tape. Different twisted tape configurations have different flow properties and also have different impact on the performance. It will be discussed in detail in research paper. Nanoparticles are also used to improve the heat transfer rate. There are many nano particles available such as CuO, Al_2O_3 etc. which can be successfully used to improve the heat transfer rate. Some surfactants such as Sodium dodecyl sulphate may also be used in combination with nanoparticles so as to avoid the settling down of the nano particles in fluid. Water can be used as the base fluid for preparing the nano fluid. The effects and properties of nanoparticles will be discussed in detail in following topics of the paper*

***Keywords**: Heat exchanger and its augmentation techniques, twisted tapes, nanoparticles*

I- INTRODUCTION

Heat exchangers are common devices used to exchange the heat with or without mixing the media. Heat exchangers play a vital role in the industries as there work is very much important in regard with the transfer of heat. We can use heat exchanger for both cooling and heating purpose of the media. In Automotives we see a part radiator which is the classic example of heat exchanger. Suppose we have a copper or any other material pipe and we put it in exposure of sunlight, and pass the normal water through the pipe then after some time on investigating water we come to know that temperature of water increases whether in small scale or large scale. So what happens here is that the rays of sunlight carrying some heat with it comes in contact with copper or any metal tube then at first it transfers it heat to pipe and then pipe transfers that heat to the water flowing through it and hence temperature of water rises. This is the simplified example of heat exchanger. Common types of heat exchanger are Shell and tube heat exchangers, Double pipe heat exchangers, plate heat exchanger, Plate and shell heat exchangers, Adiabatic wheel heat exchangers etc., each heat exchanger type has its own advantages and applications. Solar water heaters are also the good example of heat exchangers. Basically there are two flow arrangements namely parallel flow arrangement and counter-flow arrangement. The counter-flow arrangement provides more heat transfer rates as compared to parallel- flow arrangement. We can have flow arrangement as per the construction of heat exchanger or in the basis of heat transfer rate required. The temperature along the heat exchanger is different in different locations so we find out the mean temperature difference that is called Log Mean Temperature Difference (LMTD). And with the help of some formulae and using LMTD we calculate the heat transfer rate. When the LMTD information is not known directly then we can use NTU method. As we know that there is always the need of miniaturization of the equipment we use for different applications so that we can get same performance in less space available thereby minimizing the size of whole plant, this not only saves the space but also saves some initial economic investment of the overall plant. So day by day we are always looking for the ways of making the heat exchanger smaller and smaller without compromising with its overall performance. There are many methods available to make the heat exchangers compact and are called heat transfer augmentation methods. They are broadly classified into three types namely Active method, Passive method, Compound method. We will discuss these methods in detail in following chapter.

2. HEAT TRANSFER AUGMENTATION TECHNIQUES

Heat transfer augmentation methods are classified in following three categories:

a) Active method.

b) Passive method.

c) Compound method.

Now we will discuss these methods in detail.

2.1 Active method

In this method we supply an external power input to the heat exchanger to obtain enhancement of heat transfer. In practical this method is found as a method with lower potential and it involves complexity in the system. As we know that it is difficult to supply external power in many applications so this method have some limitations due to which it is not widely used. In this method the heat transfer enhancement can be obtained by reciprocating plungers, jet impingement, suction, and pulsation by cams, magnetic field used to disturb light particles present in flowing stream, electrostatic fields, surface vibration, fluid vibration, injection etc. This method can be used where we can supply external power input easily or where we can afford complexities in design of the system otherwise we have to go for other methods of heat transfer augmentation.

2.2 Passive method

In this method the need of supply of power from an external source is eliminated. The available power in the system is used to generate the extra power necessary for the enhancement in the heat transfer rate so by doing this we eliminate the complexity in design of the system thereby making it more effective with available resources of power. But when we try to use the available power of the system to generate more power then the pressure drop is ultimately increased. So now we may need to find out such ways to generate the extra power without increasing the fluid pressure drop considerably. This is itself a big challenge as we cannot compromise with both power and fluid pressure drop. So ways to increase heat transfer rate and also not to increase fluid pressure drop should be analyzed carefully. The increase in pressure drop leads to increase in pumping power thereby asking for supply of more power which is not desirable as it will lead to more operating cost. We can increase the thermal contact and by doing this we can improve thermohydrualic efficiency. We can provide external fins to increase the contact area, twisted tapes, nano fluids, wire coils, rough surfaces, treated surfaces, extended surfaces, displaced enhancement devices, swirl flow devices, surface tension devices, additives for liquids, additives for gases etc. for the purpose of heat transfer augmentation.

2.3 Compound method

When we used other heat transfer enhancement methods collectively then it is called as compound method of heat transfer augmentation. The involvement of complexities in using this method is a big concern and hence it is not used widely. It has limited applications.

3. NANOPARTICLES

According to IUPAC, particle of any shape with dimensions in the 1 nm and 100 nm range is called as nanoparticle. According to ISO Technical Specification 80004, a nanoparticle is defined as a nano-object with all three external dimensions in the nanoscale, whose longest and shortest axes do not differ significantly, with a significant difference typically being a factor of at least 3. Nanoparticles are effectively used to enhance the heat transfer rate. CuO, Al2O3 nanoparticles etc. are used in heat exchangers.

Manish gupta et al. discussed thermophysical properties of nanofluids and heat tansfer applications. The important thermophysical properties of nanoparticles are thermal conductivity, viscosity, specific heat, density. The purity, shape, size, concentration of nanoparticles are major factors that affects thermophysical properties.

3.1. Thermal Conductivity

When we add nanoparticles in a fluid, it increases thermal conductivity which in turn increases the heat transfer rate. Nanoparticles have greater thermal conductivity than the base fluids. We can use water, Ethylene glycol, gear oils etc. as the base fluids to use with nanoparticles to make nanofluid. When we use water as the base fluid its pH is very important as thermal conductivity is found to be extremely dependant on pH of the water. Surfactants like sodium dodecyl benzene sulphonate etc. also has effect on thermal conductivity. Different volume concentration of nanoparticles in base fluids has different effects on the thermal conductivity of nanoparticles. On preparing nanofluids by dispersing the Cuo nanoparticles in ethylene glycol (EG) – water mixture, it was observed that with increase of weight percent of Cuo nanoparticles, the thermal conductivity of nanofluids increases. Briefly, thermal conductivity of the nanofluids is affected by particle shape, clustering, particle material and base fluids, acidity (pH), additives, particle size, temperature etc.

3.2 Viscosity

Pumping power and pressure drop is dependent on viscosity of the nanofluids. The more will be the viscosity more pumping power will be required. So we need to determine the effective proportion of the base fluid and nanoparticle so that viscosity does not cause any significant pressure drop thereby increasing the power requirement. Viscosity is also affected by temperature, particle diameter as well as type of nanoparticles used. So we need to research more on parameters which affects the viscosity.

Chandrasekhar et al. experimentally investigated Al2O3 nanoparticles with base fluid as H2O. He found out that with increasing volume concentration of nanoparticles, the viscosity of the nanofluid increases. Increase of 130% was noted in viscosity at 5% volume concentration. The various factors affecting viscosity of nanofluids are volume concentration, morphology of particles, shear rate and temperature. Temperature is also one of the important factors which affect the viscosity. By experiments it was found out that viscosity decreases with increase in temperature. Details available at A. Dewan et al. [1]

3.3 Specific heat

The heat transfer is greatly affected by the specific heat of nanofluids. Specific heat is defined as the quantity of heat needed to increase the temperature of 1 gm. of nanofluids by 1 degree centigrade. Various experiments were carried out to determine the specific heat of nanofluids base on two models namely volume concentration model and heat equilibrium mechanism model. Yang et al. investigated super carbon nanotubes (ST). And found out that the value of specific heat was constant for a given temperature and it was nearly independent of diameter and length of the ST.

When we use copper nanoparticles with a base fluid then copper nanoparticles changes the characteristics of melting processes and crystallization and hence decreases specific heat of nanofluids.

3.4 Density

Density is also an important property and it affect heat transfer properties of nanofluids. Nusselt number, Reynolds number, pressure loss, friction factor is greatly affected by density of the fluid. The density of nanofluid is decreased with increase in temperature and increases with increase in volume concentration. The experimental studies on density of nanofluids is very less, more experimental studies are required so as to predict exact behavior of density with respect to the factors like temperature and volume concentration of nanofluids.

Santosh G. Dabade et al.[4] experimentally investigated grooved type tube in tube heat exchanger with and without use of nanofluid. They kept flow rate constant and compared overall heat transfer coefficient with increase in inlet temperature. Also checked the variation of Nusselt number, friction factor and Reynolds number by varying the flow rate. They prepared nanofluid using water as a base fluid with Al2O3 nanoparticles with different volume concentrations of 0.75%, 0.5%, 0.25%.It was found out that with increasing concentration of nanofluid the overall heat transfer rate is increased. The maximum 48% increase in overall heat transfer coefficient was observed for 0.75% volume concentrated Al_2O_3 nanofluid.

From this study of thermophysical properties of nanofluid we come to know that volume concentration and temperature are major factors that affect thermophysical properties of the nanofluids along with other factors such as particle size and shape etc.

3. TWISTED TAPES

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This is the example of passive method of heat transfer augmentation. Twisted tape inserts are the additional arrangements made as an obstacle to fluid flow so as to augment heat transfer rate. Twisted tapes are metallic strips which are twisted with some suitable techniques with desired dimensions and shape which are finally inserted in tubes to disturb the flow. They are also called as turbulators or swirl generators. Twisted tapes induce swirl into bulk flow-disrupting boundary layer at tube surface due to repeated changes in surface geometries, twisted tapes induce turbulence and superimpose vortex motion results thinner boundary layer. They are of various types mentioned as below:

a) Plain twisted tape
b) Full length twisted tape
c) Varying length twisted tape
d) Short length twisted tape.
e) Regularly spaced twisted tapes.
f) Tape with attached baffles.
g) Slotted tapes and tapes with holes.
h) Tapes with dimpled surface modifications.
i) Serrated twisted tape.
j) Edge fold twisted tape.
k) Oblique teeth twisted tapes.

Fig. 3.1 Plain twisted tape.

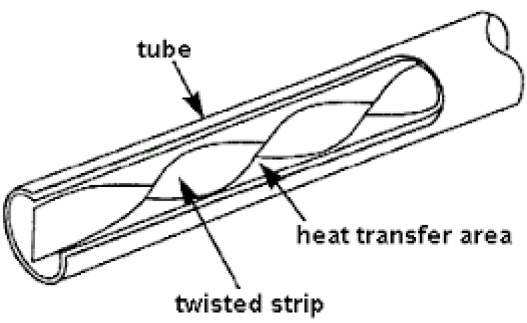

Fig. 3.2 Twisted tape inserted in tube.

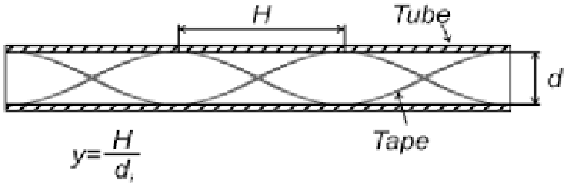

Fig. 3.3 Dimensions of twisted tapes

Fig. 3.4 Actual image of Plain twisted tape inserted in tube.

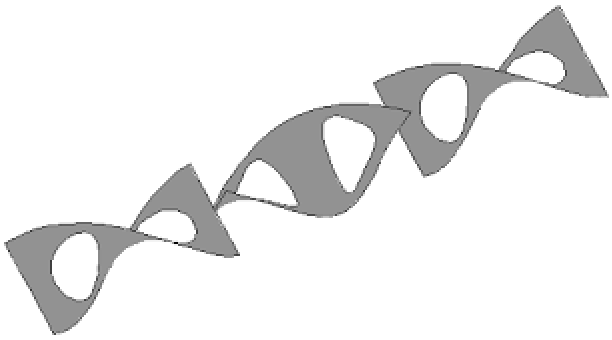

Fig. 3.5 ACCT (Anticlockwise - clockwise twisted) tape with perforation

Fig. 3.6 Perforated twisted tapes

Fig. 3.7 Plain, perforated, helical screw twisted tapes

3.2 Geometric parameters of twisted tapes

a) Width (W)
b) Thickness (d)
c) Pitch (y)
d) Twist ration (y/W)
e) Perforated diameter ratio
f) Width depth ratio

These geometrical parameter have different effects on the effectiveness of the twisted tapes. Twisted tape with twist ratio 5-7 increases the heat transfer rate about 159%-188% than plain tube. Smaller the twist ratio larger is the heat transfer but penalty of greater friction factor and pressure drop occurs. Small twist ratio gives rise to more Nusselt number , friction factor and enhancement of heat transfer at high Reynolds number.

3.3 Materials of twisted tapes

A. Hasanpour et al. [7] studied twisted tape inserts in turbulent flow conditions. He suggested following materials can be used to make twisted tapes.

a) Carbon steel
b) Aluminium
c) Stainless steel 304, 316
d) Copper
e) Other stainless steel types.

3.4 Applications

a) Boilers
b) Shell and tube heat exchangers
c) Double pipe heat exchangers
d) Car radiators etc.

Various studies and experiments have been carried out regarding twisted tapes and we can come to the conclusion that they are cheap, easy to manufacture and improves heat transfer rates considerably. But the problem with twisted tapes is that friction factor and pressure drop is increased thereby asking for additional power input. So we need to find out the twisted tapes which will induce less friction factor and pressure drop so that its effectiveness in heat exchangers can be further improved.

4. CONCLUSIONS

The heat exchangers need to be as compact as possible so that it acquires less space without compromising its overall performance. This is possible with heat transfer augmentation techniques. Though there are many techniques available for heat transfer augmentation we need to find out more techniques which can solve the problem of rise in pressure drop and friction factor. Nanofluids are found out to be an excellent alternative which results in increase of heat transfer rates but more investigation is required so as to obtain best performance out of it. Nanofluids with less viscosity are require to be developed which will reduce the extra power requirement. Nanofluids with more improved thermophysical properties are required to be studied. Use of twisted tape is also an excellent alternative required for the heat transfer augmentation. More types of twisted tapes are required to be developed which will ensure the reduced pressure drop and friction factor which in turn will result to increased overall performance of heat exchangers.

REFERENCES

[1] *A. Dewan, P. Mahanta, K. Sumithra Raju, P. Suresh Kumar(2004) "Review of passive heat transfer augmentation techniques" Institute of fluid mechanics (LSTM) Friedrich Alexander university of Erlangen-Nuremberg, Cauerstrasse 4, D-91058, Erlangen, Germany.*

[2] Jaafar Albadr, Satinder Tayal, Mushtaq Alasadi "Heat transfer through heat exchanger using Al2O3 nanofluid at different concentrations" Case studies in Thermal Engineerinr 1(2013) 38-44.

[3] *Ponnusamy SELVARAJ, Jagannathan SARANGAN, and Sivan SURESH "Computational fluid dynamics analysis on heat transfer and friction factor characteristics of a turbulent flow for internally grooved tubes" Thermal science (2013), Vol. 17, No. 4, pp. 1125-1137.*

[4] *Nitin V. Sali, Santosh G. Dabade "Experimental investigation of grooved tube in tube heat exchanger with and without nano-fluid" International journal of scientific and engineering research, Volume 8, Issue 4, April 2017.*

[5] *Ventsislav Zimparov "Prediction of friction factors and heat transfer coefficients for turbulent flow in corregated tubes combined with twisted tape inserts. Part 1: Friction factors" International Journal of Heat and Mass Transfer 47 (2004) 589-599.*

[6] *Ventsislav Zimparov "Enhancement of heat transfer by a combination of single start spirally corrugated tubes with a twisted tape" Experimental Thermal and Fluid Science 25 (2005) 535-546.*

[7] *A. Hasanpour, M. Farhadi, K. Sedighi "A review study on twisted tape inserts on turbulent flow heat echangers: The overall heat transfer ratio criteria" International communication in Heat and Mass Transfer 55 (2014) 53-62.*

[8] *Munish Gupta, Vinay Singh, Rajesh Kumar, Z. Said "A review on thermophysical properties of nanofluids and heat transfer applications" Renewable and sustainable Energy Reviews 74 (2017) 638-670.*

[9] *Veerana Shidhara, Laxmi Narayan Satapathy "Al2O3-based nanofluids : a review" Sridhara and Satapathy Nanoscale research letters 2011, 6:456.*

[10] *Kumbhar D. G., Dr. Sane N. K "Heat transfer enhancement in a circular tube twisted with swirl generator: A review, Proc. Of the 3rd International Conference on Advances in Mechanical Engineering, January 4-6, 2010, S. V. National Institute of Technology, Surat- 395007, Gujrat, India.*