International Journal of Multidisciplinary Research and Modern Education (IJMRME)
Impact Factor: 6.725, ISSN (Online): 2454 - 6119
(www.rdmodernresearch.org) Volume 3, Issue 1, 2017

A REVIEW ON HEAT TRANSFER AUGMENTATION TECHNIQUES FOR DOUBLE PIPE HEAT EXCHANGER WITH DIFFERENT INSERTS AND EXTENDED SURFACES

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Cite This Article: J. P. Kolhe, N. N. Bhostekar & Dr. Kiran Chaudhari, "A Review on Heat Transfer Augmentation Techniques for Double Pipe Heat Exchanger With Different Inserts and Extended Surfaces", International Journal of Multidisciplinary Research and Modern Education, Volume 3, Issue 1, Page Number 136-138, 2017.

Abstract:

Researchers are used different heat transfer enhancement techniques in double pipe heat exchanger by inserting various types of twisted tapes in last few years. These techniques are more applicable in various industrial areas such as cryogenics, process industries, HVAC systems etc. There is need to improve the outside heat transfer coefficient, effectiveness and thermal performance of heat exchanger, thereby reducing the cost and size of heat exchanger. In present paper importance is work related to double pipe heat exchanger with various types of inserts and extended surfaces are helpful in increasing the heat transfer rate.

Index Terms: Double Pipe Heat Exchanger, Inserts, Fins, Heat Transfer Rate & Heat Transfer Coefficient

Introduction:

'Heat Exchanger' is one of the most commonly used process equipments in industry and research. Function of a heat exchanger is to transfer energy; this transfer of energy may occur to single fluid or between two fluids that are at different temperatures .In some cases, there are more than two streams of fluid exchanging heat in a heat exchanger. Heat exchangers of several designs in a variety of sizes varying from miniature to huge have been developed over the years. The weight and size of heat exchangers used in space or aeronautical applications are very important parameters, and in these cases cost consideration are frequently subordinated in so far as material and heat exchanger construction costs are concerned; however, the weight and size are important cost factors in the overall applications in these fields and thus may still be considered as economic variables. Heat exchangers are used to transfer heat from one fluid to another. A heat exchanger is a component that allows the transfer of heat from one fluid (liquid or gas) to another fluid. Reasons for heat transfer include the following:

- ✓ To transfer the heat from hot fluid to cold fluid.
- ✓ To condense the hot gases by means of cold fluid.
- ✓ To boil the cold fluid by means of hot fluid.

Some typical examples of heat exchanger applications are:

- ✓ Thermal power plants (boilers, superheaters, steam condensers).
- ✓ Automobile industry (radiators, all engine cooling and fuel cooling arrangement).
- ✓ Cryogenics industry (condenser-reboilers used in distillation columns, evaporators etc.).
- ✓ Research (superconducting magnet systems, ceramic heat exchangers).

Literature Review:

M. Sheikholeslami et al. [1] investigated the influences of conical ring turbulators on heat transfer improvement and pressure drop in an air to water heat exchanger. They concluded that thermal performance increase with increase of open area ratio, pitch ratio while it decreases with increase of Reynolds number .They also found that for direct conical ring array, thermal performance is an increasing function of conical angle while opposite trend is observed for reverse conical ring array.

M. Sheikholeslami et al.[2] investigated the impact of helical fin on hydrothermal treatment in water to air heat exchanger. They concluded that the temperature gradient over the hot wall increases with increasing the velocity of the inlet air. The Nusselt number and pressure loss reduces with enhanced of open area ratio. The thermal performance is an increasing function of the open area ratio.

Shiva Kumar et al.[3] conducted experiments in double pipe heat exchanger using different fin profiles under various operating conditions to evolve with the best possible configuration. Three different configurations namely rectangular, triangular and concave parabolic were selected. They concluded that for better performance the mass flow rate of cold fluid should be kept low and that of hot fluid should be high. Rectangular

configuration shows marginal improvement over the other in terms of temperature rise, heat transfer rate and heat transfer coefficient. When mass flow rate of cold fluid is kept constant to 0.02 kg / sec and mass flow rate of hot fluid was increased, the effectiveness of fin increased and rectangular fins showed highest effectiveness and is 21% and 11.5 % higher than triangular and parabolic based fins .Parabolic fins showed minimum pressure drop for all mass flow rates. It has reduced by 38% and 65% compared to the triangular and rectangular finned tube. Hence it can be concluded that parabolic finned configuration can be better alternative compared to the triangular and rectangular because of reduced pressure drop and reduced weight of finned assembly even through the thermal performance was being marginally reduced.

Vinous. M. Hameed et al. [4] performed study of investigate the Nusselt number for turbulent flow through annular channel with triangular fins attached to the inside wall of the annulus. They concluded that annulus side Nusselt number was increased with increased in Reynolds number in annular side.

Bodius salam et al. [5] investigated the tube side friction factor and heat transfer of circular tube fitted with rectangular-cut twisted tape insert. They concluded that the Nusselt number increased with the increase of Reynolds number. The heat flux is enhanced by 68% for tube with rectangular-cut twisted tape insert. Heat transfer enhancement effectiveness were found to be increased with Reynolds number and effectiveness values ranged between 1.9 and 2.3.

Shashank S. Choudhari et al.[6] investigated the variation of Nusselt number with Reynolds number for a tube fitted with coil wire insert of different materials are used. These different materials are copper, aluminium and stainless steel with different pitches are used. They found maximum Nusselt number is obtained for copper coil wire insert than aluminium and stainless steel coil wire insert. The copper, aluminium and stainless steel coil wire insert cause heat transfer enhancement up to 1.58, 1.41 and 1.31 respectively as compared to plane tube.

P. V. Durga Prasad et al. [7] conducted experiment to enhanced the rate of heat transfer in double pipe heat exchangers using Al_2O_3 nanofluid. An experimental analysis on trapezoidal-cut twisted tape insert in a double pipe U-tube heat exchanger using Al_2O_3 water based nanofluid is presented. The heat transfer coefficients and the corresponding friction factors required for performance analysis are determined taking into account the typical operating conditions of the heat exchangers in turbulent flow regimes. They concluded that the enhancement in the heat transfer coefficient and friction factor with an increase in volume concentration of the nanoparticles. The results show that the average Nusselt numbers increase with an increase of nanoparticles volume concentration and Reynolds number. Convective heat transfer, friction factor as well as thermal performance factor tends to an increase by increasing Al_2O_3 concentration of nanofluid and twist ratio of trapezoidal-cut tape inserts.

D. G. Kumbhar et al.[8] In this paper the experimental analysis of heat transfer enhancement, friction factor and thermal performance of a dimpled tube heat exchanger with regularly spaced twisted tape inserts. Water is used as a working medium. They concluded that full length twisted equipped with in dimpled tube performed better than any other combination of dimpled tube heat exchanger. From the above experiment it is observed that combine heat transfer enhancement technique causes an increase in heat transfer rate at the increased friction factor. The results obtained for dimpled tube with regularly spaced twisted tapes are compared with the result for with and without twisted tape. Also comparison is made with plain tube.

Naphon [9] experimentally studied the pressure drop and heat transfer characteristics in the horizontal double pipe with and without twisted tape inserts. They concluded that heat transfer is increased in case of inserted double pipe heat exchanger as compared to the plain tube.

Eiamsa-ard et al. [10] investigated the fluid friction characteristics and heat transfer in double pipe heat exchanger fitted with regularly spaced twisted tape elements. They concluded that the friction factor and heat transfer coefficient is increased with the decreased of twist ratio.

Bhramara Panitapu et al. [11] experimentally studied the heat transfer enhancement in a 2-pass double pipe heat exchanger with and without twisted tape insert. Cold water is passed through the inner pipe were hot water is passed through the annulus. The twist ratio is assumed to be 10. The study revealed that the twisted tape insert caused an increase of heat transfer rate by 22% to 33% for 6LPM flow rate of hot water and 15% to 45% for 10 LPM flow rate of hot water as compared with plain type.

Nice Thomachan et al.[12] In this paper cfd analysis was done for double tubes with varying pitch length and constant depth. The geometry of tube in tube with 50,75,100 mm pitch length is provided. The study revealed that the effectiveness of heat exchanger with 100 mm pitch is higher than that of others. As pitch length is increases with constant depth effectiveness of heat exchanger also increases.

Prabhat et al.[13] studied on the performance of counter flow heat exchanger for low temperature applications. Counter flow heat exchanger has a high effectiveness than parallel flow heat exchanger hence they are commonly used in Cryogenic industries. They observed that losses such as heat in leak from surrounding, flow maldistribution, longitudinal conduction through wall etc.

Conclusion:

From the literature review of experimental investigation of performance of double pipe heat exchanger using various types of inserts and extended surfaces we came to the conclusion that:

- ✓ Heat transfer is more in case of counter flow heat exchanger than parallel flow heat exchanger using water as a working medium.
- ✓ Heat transfer enhancement in double pipe heat exchanger increased as compared to tube without any insert or without extended surfaces.
- ✓ Pressure drop in double pipe heat exchanger increased as compared to tube without any insert or without extended surfaces.
- ✓ Heat transfer increased when mass flow rate of cold fluid is kept low and mass flow rate of hot fluid is kept high.
- ✓ Heat transfer coefficient is increased as compared to the tube without any insert or without extended surfaces.
- ✓ Inserts creates turbulence in the flow path thereby increasing the heat transfer rate in double pipe heat exchanger.
- ✓ Friction factor and heat transfer coefficient is increased with the decreased of twist ratio of inserted tape.
- ✓ The increase in the Nusselt number increases the heat transfer rate.
- ✓ The provision of baffles in double pipe heat exchanger increases the pressure drop and hence thereby increasing the pumping power. This limitation is overcome by using fins, full length twisted tape, dimples etc.

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