International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 5, pp: 393-396 www.ijaem.net ISSN: 2395-5252

A Review on Cfd Analysis of Double Pipe Heat Exchanger with Double-Side Delta-Wing Tape Inserts

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Date of Submission: 16-08-2020 Date of Acceptance: 01-09-2020

ABSTRACT: Heat transfer devices have been used for conversion and recovery of heat in many industrial and domesticapplications. Over five decades, there has been concerted effort to develop design of heat exchanger thatcan result in reduction in energy requirement as well as material and other cost saving. Heat transferenhancement techniques generally reduce the thermal resistance either by increasing the effective heattransfer surface area or by generating turbulence. Sometimes these changes are accompanied by anincrease in the required pumping power which results in higher cost. The effectiveness of a heat transferenhancement technique is evaluated by the Thermal Performance Factor which is a ratio of the change inthe heat transfer rate to change in friction factor. Various types of inserts are used in many heat transferenhancement devices. Geometrical parameters of the insert namely the width, length, twist ratio, twistdirection, etc. affect the heat transfer. The artificial roughnesscan be developed by employing a corrugated surface which improves the heat transfer characteristicsby breaking and destabilizing the thermal boundary layer. This paper provides a comprehensive reviewof heat transfer devices and their relative merits for wide variety of industrial applications.

Keywords: Heat transfer, passive techniques, thermal performance, insert.

I. INTRODUCTION

Heat exchangers have several industrial and engineering applications.The design procedure of heat exchangers is quite complicated, as it needs exact analysis of heat transfer rate and pressure drop estimations apart from issues such as long-term performance and the economic aspect of the equipment. The major challenge in designing a heat exchanger is to make the equipment compact and achieve a high heat transfer rate using minimum pumping power.

A majority of heat exchangers used in thermal power plants, chemical processing plants, air conditioning equipment, and refrigerators, petrochemical, biomedical and food processing plants serve to heat and cool different types of fluids. Both the mass and overall dimensions of heat exchangers employed are continuously increasing with the unit power and the volume of production. This involves huge investments annually for both operation and capital costs. Hence it is an urgent problem to reduce the overall dimension characteristics of heat exchangers.

The need to optimize and conserve these expenditures has promoted the development of efficient heat exchangers. Different techniques are employed to enhance the heat transfer rates, which are generally referred to as heat transfer enhancement, augmentation or intensification technique.

The study of improved heat transfer performance is referred to as heat transfer enhancement, augmentation, or intensification. Ingeneral, this means an increase in heat transfer coefficient. Energy- and materials-saving considerations, as well as economicincentives, have led to efforts to produce more efficient heat exchange equipment. Common thermal-hydraulic goals are to reducethe size of a heat exchanger required for a specified heat duty, to upgrade the capacity of an existing heat exchanger, to reduce theapproach temperature difference for the process streams, or to reduce the pumping power. The study of improved heat transferperformance is referred to as heat transfer enhancement, augmentation, or intensification. In general, this means an increase in heattransfer coefficient.

Heat transfer is a discipline of thermal engineering that concerns the generation, use, conversion, and exchange of thermal energyand heat between physical systems. Heat transfer is classified into various mechanisms, such as thermal conduction, thermalconvection, thermal radiation, and transfer of energy by phase changes. Engineers also consider the transfer of mass of differingchemical species, either cold or hot, to achieve heat transfer. While these mechanisms have distinct characteristics, they often occursimultaneously in the same system. To improve the performance of heat exchanging devices for reducing material cost and surfacearea and decreasing the difference for heat transfer thereby for reducing external irreversibility, lot of techniques have been used.

Among different passive means to increase heat transfer coefficient various types of inserts are promising. The secondary flow(swirl flow) generated by inserts effects fluid flow across inserts-partitioned tube, promotes greater mixing and higher heat transfercoefficients.

Heat transfer augmentation techniques (passive, active and compound) are commonly used in areas such as process industries,heating and cooling in evaporators, thermal power plants, air-conditioning equipment, refrigerators, radiators for space vehicles,automobiles, etc. Passive techniques, where inserts are used in the flow passage to augment the heat transfer rate, are advantageouscompared with active techniques, because the insert manufacturing process is simple and these techniques can be easily applied inan existing application. In the past decade, several studies on the passive techniques of heat transfer augmentation have beenreported.

Heat Transfer Augmentation Techniques

Heat transfer augmentation techniques are generally classified into three categories namely: Active techniques, Passive techniques and Compound techniques.

1. Active Techniques: Active techniques involve some external power input for enhancement of heat transfer.

Example: Mechanical aids, Surface vibrations, Fluid vibrations and Jet impingement.

2. Passive Techniques: Passive techniques do not require any direct input of external power. They generally use geometrical or surface modifications to the flow channel by incorporating inserts or additional devices. Example: Rough surfaces, Extended surfaces, Swirl flow devices and Coiled tubes.
3. Compound Techniques: Combination of active and passive techniques may be employed simultaneously to obtain enhancement in heat transfer that is greater than that produced by any of those techniques separately. This simultaneous utilization is termed compound enhancement.

Computational Fluid Dynamics

Fluid (gas and liquid) flows are governed by partialdifferential equations (PDE) which represent conservationlaws for the mass, momentum and energy. ComputationalFluid Dynamics (CFD) is used to replace such PDEsystems by a set of algebraic equations which can be solvedusing digital computers. The basic principle behind CFDmodeling method is that the simulated flow region isdivided into small cells. Differential equations of mass,momentum and energy balance are discretized andrepresented in terms of the variables at any predeterminedposition within or at the center of cell. These equations aresolved iteratively until the solution reaches the desiredaccuracy (ANSYS FLUENT 14.0). CFD provides aqualitative prediction of fluid flows by means of

1. Mathematical modeling (partial differential equations)
2. Numerical methods (discretization and solution techniques)
3. Software tools (solvers, pre- and post-processing utilities)

II. LITERATURE REVIEW

Agung Tri Wijayanta et al (2018) double-sideddelta-wing (T-W) tape inserts were designed to enhance convective heat transfer of adouble-pipe heat exchanger. The effects of the wing-width ratio (0.31, 0.47, and 0.63) on theheat transfer and fluid flow characteristics of the heat exchanger were investigated byexperiments where water was used as the working fluid and the Reynolds number was variedfrom 5,300–14,500. The results were compared with those obtained for a plain tube and tubewith longitudinal strip (L-S) insert. The T-W tape insert (wing-width ratio: 0.63) results in thehighest average Nusselt number, where the average Nusselt number is higher by 177%relative to that for the plain tube. Despite the significant heat transfer enhancement, thefriction factor is 11.6 times higher relative to that for the plain tube, indicating that frictionloss is more pronounced due to the presence of T-Ws. The T-W tape insert (wing-width ratio:0.63) also results in the highest thermal performance factor (1.15).**Shailesh Dewangan (2018)** made helical ribs on the tube surface by machining the surface on the lathe So that artificial roughness can be created The artificial roughness that results in an undesirable increase in the pressure drop due to the increased friction; thus the design of the tubes surface of heat exchanger should be executed with the objectives of high heat transfer rates.**N**

Sreenivasalu Reddy (2017) investigated the heat transfer analysis in the horizontal double pipes with helical fins in the annulus side. The material is copper with inner tube internal diameter 10 mm, inner tube thickness 1 mm, outer tube external diameter 40 mm, outer tube thickness 1.5 mm, helical pitch of 50mm, 75mm and 100mm, heat exchanger length 1100 mm. The experimental results of plain tube are validated with numerical results. The results obtained for helical fins in the annulus side provide enhanced heat transfer performance compared to the simple double-pipe exchangers.**Bilawane (2017)**presented a review of one of the passive augmentation techniques used in a concentric tube heat exchanger using inner wavy tube. The performance of counter flow heat exchanger will be studied with inner plain tube and inner wavy tube. Then this enhanced performance due to inner wavy tube will be compared with performance of heat exchanger with inner plain tube and percentage of enhancement will be calculated in different hot fluid temperature input and different mass flow rates of hot as well as cold water. Experimentally, Overall heat transfer enhancement will be studied and also, the experimental results will be validated with CFD simulation.**Yogeshwari (2017)**discussed analytical solution of the compartment based double pipe heat exchanger model obtained using Differential Transform Method for parallel flow with theoretical varying initial and boundary condition. The working fluid is transformer oil i.e. hot fluid and water act as coolant. Convergence analysis of solution is also discussed.**Pourahmad and Pesteei(2016)**experimentally investigated on double pipe heat exchanger by inserting wavy strip turbulators in the inner pipe, their findings are on considerable improvements in enhancement of heat transfer characteristics.**Pimple (2016)** investigated the heat transfer and friction factor data for single -phase flow in a shell and tube heat exchanger fitted with a helical tape insert. In the double concentric tube heat exchanger, hot air was passed through the inner tube while the cold water was flowed through the annulus. The influences of the helical insert on heat transfer rate and friction factor were studied for counter flow, and Nusselt numbers and friction factor obtained were compared with previous data (Dittus 1930, Petukhov 1970, Moody 1944) for axial flows in the plain tube. The flow considered is in a low Reynolds number range between 2300 and 8800. A maximum percentage gain of 165% in heat transfer rate is obtained for using the helical insert in comparison with the plain tube.**Goudiya (2016)** presented the literature survey of enhancement techniques in heat transfer using inserts.**Kumar (2015)**discussed with different configurations. Here CDD (convergent divergent spring tabulators) CDDSTs were placed in the inner tube of double pipe heat exchanger and effect on heat enhancement and friction factor was experimentally investigated. CDDSTs at various pitches i.e (p=0,p=15,p=16) were used for the different ranges of Reynolds number. For cold water its ranges between 9000to17000 and for hot water 18000 to 24000. Results from CDDSTs were compared with plane tube and results showed that Nusselt number increased while friction factor decreased with increased in Reynolds number. Friction factor was increased by 287% while Nusselt no increased by 28%. However thermal performance factor was maximum for CDDSTs (p = 15) with value 0.319.**Tripathi (2015)**presented a reviewon different arrangement of finned tube bundles placed on inline arrangement and staggered arrangement in cross flow. A large number of experimental and numerical works had been performed for enhancement of air-side heat transfer. A brief discussion is done on the effect of local heat transfer behaviour of circular finned tube and analysis of geometric and flow parameters included in this paper. Different parameters like fin height, fin spacing, fin thickness, tube diameter, tube spacing, effects of row and arrangement of tube bundles affect directly on the performance of solid circular finned tube. All these parameters are briefly discussed in this paper. Discussions on some important points which affect the performance of tube bundles (i.e. inline and staggered arrangement) from various authors and their problem and related issues are presented in this paper. The flow profiles and the related heat transfer characteristics in the complex geometries are still needed to be verified.

III. CONCLUSION

From the aforementioned literature survey, it is clear that there arenumerous shapes of fins, turbulators, and inserts that were used aspassive heat transfer enhancement techniques. It was shown that themain problem in using conventional inserts is the sharp increase in flowpressure drop. In addition, there is no experimental study performed toinvestigate the effect of the geometrical shapes of the double-sided delta-wing tape inserts conductedon the performance of DPHEs. The DWTI will beselected in the present study as it was expected that it might enhancethe hydrothermal performance of the DPHEs. Therefore, the presentwork is devoted to investigate the characteristics of theforced convective heat transfer and pressure drop in horizontal DPHEs with inserting a double-sided delta-wing tape inserts with semi-circular wing shape.

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