ISSN: 2582-7561

International Journal For Academic Research & Development

Vol. 3 (2021)

ISSUE 4

(Multidisciplinary)

E-mail Id: editor@iifard.org

url: www.iifard.org/about-journal/

INTERNATIONAL JOURNAL FOR ACADEMIC RESEARCH AND DEVELOPMENT

INTERNATIONAL JOURNAL FOR ACADEMIC RESEARCH AND DEVELOPMENT
https://iifard.org/web/AWABbgJhBD0=/IJARD
www.iifard.org

ISSN: 2582-7561

IJARD

Volume 3, Issue 4
2021

Published by

International Institute For Academic Research and Development
Email: trustforacademic@gmail.com, editor@iifard.org

www.iifard.org

INTERNATIONAL JOURNAL FOR ACADEMIC RESEARCH AND DEVELOPMENT

INTERNATIONAL JOURNAL FOR ACADEMIC RESEARCH AND DEVELOPMENT

https://iifard.org/web/AWABbgJhBD0=/IJARD
www.iifard.org

ISSN: 2582-7561

About Journal - I J A R D

International Journal for Academic, Research and Development (IJARD) is an autonomous, peer reviewed online journal. It mainly serves as universal discussion identified with building training, distributed at present quarterly. IJARD welcomes researchers and academicians to submit their original research work which meets the journal criteria of significance and scientific excellence. IJARD is scholarly online open access and peer received journals emphasizing on research studies and application in the field of Science, Engineering and Management. Researchers are requested to submit their original articles online for a peer review and analysis before its publication. The editorial board encourages academicians, research scholars and partitions to publish their articles related to science, engineering and management and relevant fields.

IJARD publishes its journals in full open access format. The scientific community and the general public can unlimitedly and immediately access all content published in our journals for free as soon as it is published on the Internet. Therefore, IJARD needs to defray its editorial and production costs by collecting article processing charges from authors' institutes for research funding bodies. IJARD is committed to keep its open access publication charges at a minimum level.

We believe that immediate, worldwide, barrier-free, open access to the full text of research articles is in the best interests of the scientific community. We also intend to build mutually beneficial and long-lasting relationships with our authors and always provide them full support throughout the publishing and the post-publishing processes.

IJARD invites contribution in the following categories:

Original research work.
Review articles, comprehensive review on a topic.
Survey on a topic
Self-contained articles on ongoing research.
Technical Notes.

IJARD is committed to publishing only original work including research which has neither been published elsewhere, nor is under review elsewhere. All manuscripts that are found to have been plagiarized from a manuscript by other authors, whether published or unpublished, will incur plagiarism sanctions. Conference papers are very welcome; however it is imperative that these papers are significantly revised and updated. Actually, such papers have a better chance of acceptance if their merits were already prescreened at high quality conferences.

Manuscript should be submitted at https://iifard.org/web/AmMJZlY1V24=/IJARD
All correspondence should be made to editor@iifard.org trustforacademic@gmail.com
Phone no./WhatsApp: +918005351780, +67581509800

Welcome to International Journal for Academic, Research and Development ! ! !

IJARD
www.iifard.org
INTERNATIONAL JOURNAL FOR ACADEMIC RESEARCH AND DEVELOPMENT
INTERNATIONAL JOURNAL FOR ACADEMIC RESEARCH AND DEVELOPMENT
https://iifard.org/web/AWABbgJhBD0=/IJARD
www.iifard.org
ISSN: 2582-7561

Indexed with

A Review on Twisted Helical Coiled Heat Exchanger

Yadav Anand*
yanand1897@gmail.com
Department of Mechanical Engineering, Bansal Institute of Engineering & Technology, Lucknow, India
Kumar Adarsh
adarsh.ideal14@gmail.com
Department of Mechanical Engineering, Bansal Institute of Engineering & Technology, Lucknow, India

Abstract: *The term "heat transfer augmentation techniques" refers to several strategies used to boost the pace of heat transfer without significantly impacting the system's overall performance. Heat exchangers use these methods. These methods can either be active or passive. In contrast to passive approaches, which do not require any more energy to boost the thermohydraulic performance of the system, active methods require external power to enter the process. When examining friction losses and heat transfer enhancement, passive approaches are frequently utilised in experimental and numerical applications to conserve energy. Various elements found in the fluid flow route, such as twisted tapes, coiled or tangled wires, and nozzle turbulators, are only a few of the numerous passive approaches for accelerating heat transfer rate. The fluid to fluid heat exchange is considered in current research. The majority of heat transfer coefficient studies are conducted under constant wall temperatures or constant heat flow. For the parallel flow and counter flow configurations of the helical coil and straight tube heat exchangers, the effectiveness, overall heat transfer coefficient, effect of cold-water flow rate on heat exchanger effectiveness when hot water mass flow rate is kept constant, and effect of hot water flow rate on effectiveness when the cold-water flow rate is kept constant, were studied and compared. The Wilson plot method was used to calculate the interior heat transfer coefficient. Then, using the interior heat transfer coefficient as a foundation, Nusselt no and correlation were derived. All measurements were made when the heat exchanger was operating at a steady state.*

Keywords: Helical Coil, Heat Exchanger, Temperature, Active methods, Passive methods.

1. Introduction

Twisted-tape inserts are now often used to improve convective heat transmission in a variety of industries because of their efficiency, low cost, and simplicity of installation. The pursuit of more energy- and material-efficient heat-exchanger equipment has been motivated by economic factors as well as material and energy conservation. Therefore, if thermal energy is preserved, it will be able to handle thermal energy economically using a heat-exchanger [1].

The creation of highly effective thermal systems has sparked research into ways to enhance heat transmission. Enhancing heat transfer aims to promote or allow for high heat fluxes. Heat exchangers can run at lower speeds while yet achieving the same or even better heat transfer coefficients thanks to heat transfer methods. This translates to cheaper operational expenses due to a decrease in pressure drop [2].

The term "heat transfer augmentation techniques" refers to several strategies used to boost the pace of heat transfer without significantly impacting the system's overall performance. Heat exchangers employ these methods. Process industries, thermal power plants, air-conditioning devices, refrigerators, radiators for space vehicles, autos, etc. are some of the places where heat exchangers are used. These methods generally fall into one of three categories: passive, active, or complex methods [3].

2. Heat exchanger

A heat exchanger is a device that transports process energy by continually transferring heat from one medium to another. Heat exchangers are used in a variety of systems for the following purposes:

- Directly recovering heat from one flowing medium to another or through a storage system, or indirectly through a heat transformer or heat pump.
- Getting process steam to the right temperature for a chemical reaction by heating or cooling it.
- Enabling a power, refrigeration, or heat pumping operation, which involves exchanging heat between steam or hot source, the working fluid, and a low-temperature heat sink, as an inherent element

* Corresponding Author

For best effectiveness, heat exchangers are designed to enhance the surface area of the wall separating the two fluids while reducing the flow resistance through the exchanger. The efficacy of the exchanger may also be impacted by the inclusion of fins or corrugations in one or both directions, which increase surface area and may channel fluid flow or create turbulence [4-7].

2.1 Compact Heat Exchanger

A compact heat exchanger is one that has an area density of more than 700 m^2/m^3 when running in gas and more than 300 m^2/m^3 when operating in liquid or two-phase streams. Compact heat exchangers are designed to reduce size while increasing heat load, which is a common feature of contemporary heat exchangers. For the past 60 years or more, the value of compact heat exchangers (CHEs) has been recognised in the car, aerospace, gas turbine power plant, cryogenics, and other sectors. This is owing to a number of issues, including packing restrictions, often stringent performance requirements, cheap cost, and the use of gas or air as one of the exchanger's fluids.

Another driving element for heat exchanger design over the last three decades has been decreasing energy consumption for heat exchanger operation and minimising capital expenditure in enterprises. As a result of some of the inherent benefits described above, the usage of helical coil-tube heat exchangers and other CHEs has been expanding in process industries where not-so-compact heat exchangers were previously the norm.

Heat exchangers are widely utilised in a variety of industries, including oil refining, refrigeration, and a variety of chemical systems. It is critical to improve the efficiency of heat exchangers utilizing heat transfer enhancement techniques in order to save energy. Heat exchanger efficiency may be improved in two ways: by raising the heat transfer coefficient and lowering the pressure drop [1]. The majority of heat transfer enhancement approaches, such as the use of fin tubes and corrugated tubes, attempt to increase the heat transfer coefficient. However, the reduction of pressure drops receives little attention. Twisted oval tube heat exchangers are a sort of longitude flow heat exchanger that can boost the tube side's heat transfer coefficient while lowering the shell side's pressure drop. Smooth round tubes are used to make tubes that play a key part in this heat transfer improvement technology. Special procedures are used to shape them into an oval part with a twist on top. In the consideration of constructing the tubes with the tube sheet, two ends of the tubes remain spherical. In Figure 1, a and b represent the inner major and minor axes, respectively. This unique geometrical property may be used to create a longitude flow channel, lowering the heat exchanger's pressure drop significantly.

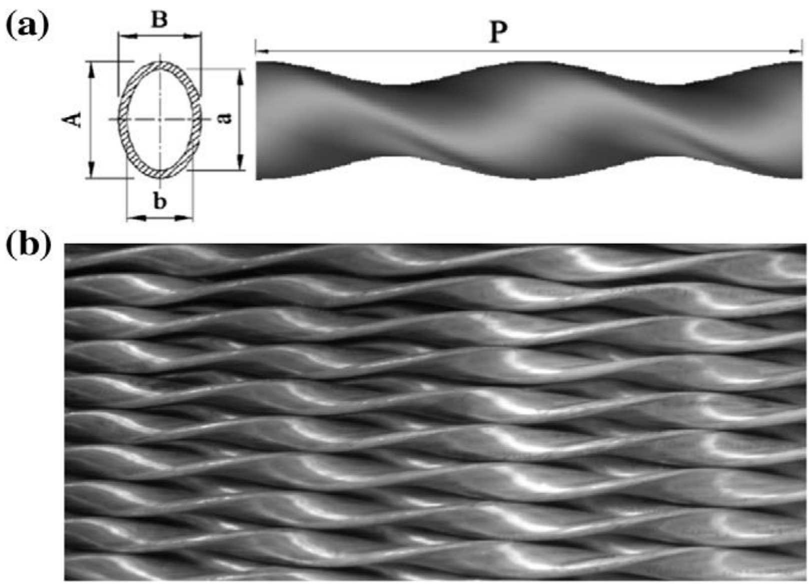

Figure 1. Sketch of self-supported twisted oval tubes and twisted oval tube (a) The twisted oval tube. (b) The self-supported oval tubes

In Dzyubenko's research, there are numerous reports about heat and fluid flow in the shell side of a twisted oval tube heat exchanger, such as analyses of turbulent intensity, boundary layer depth, and heat diffusion coefficient [2, 3], as well as numerical models for forecasting the performance of the shell side heat transfer and pressure drop [4,] and optimization techniques for designing a twisted oval tube heat exchanger [5, 6]. Using experimental and numerical study, it has also been possible to calculate the shell side heat transfer and pressure drop correlations of the twisted oval tube heat exchanger [7, 8]. Mushabbab [9] looked at the fouling characteristics of fluid flow in a heat exchanger with twisted oval tubes from an application perspective.

Experiments on the tube side have been carried out in order to determine the pressure drop and heat transfer performance of the twisted oval tube. The performance of twisted oval tubes in order to determine heat transmission and pressure drop correlations [10]. In a turbulent condition, tests on the effects of Pr, and geometrical factors on the performance of the twisted oval tube were also carried out [11, 12]. When the twisted oval tube approach is paired with a porous medium, the phenomena of boiling [13]. Little study has been done on the influence of flow field on temperature field in twisted oval tubes, except that [14] examined the flow in a twisted oval tube numerically at Re = 500–1500 to determine the heat transfer and pressure drop correlations. A twisted oval tube to replicate laminar flow. However, the specifics of their findings remain unavailable. The twisted oval tube's heat transfer increase method is currently unknown [15].

Because helically coiled pipes are commonly utilised in practice as chemical reactors and heat exchangers the flow through a curved pipe has gotten a lot of attention. The secondary flow in curved tubes is caused by the fluid flowing through them. Due to fluid mixing, this secondary flow in the tube has a great potential to improve heat transmission. The tube diameter (d) and coil diameter (d) determine the strength of secondary flow [16, 17]. The study of flow and heat transfer properties in the curved tube is critical due to the improved heat transfer in the helically coiled structure.

Helically coiled tubes have been demonstrated in several studies to be superior to straight tubes in applications involving heat transmission. Due to the curvature of the tube, the centrifugal force causes secondary flow generation, which improves heat transmission.

2.2 The twisted tube exchanger

Far from being a new design, twisted tube exchangers have been available in Sweden since 1984 from Allard of Falun. Successful applications of the exchanger by Allards have included single phase and condensing duties in the power, chemical and paper industries. Since 1994the twisted tube exchanger has been manufactured and marketed outside Scandinavia by the Brown Fin tube Company which found good synergy between this design and their technology of tube-side, twisted-tape turbulators.

3. Construction

By arranging for the tubes to support themselves, the twisted-tube exchanger avoids the need for baffles altogether. With a superimposed twist, the tubes are shaped into an oval cross-section. It is emphasized that this is done in a one-step method that assures the wall thickness remains consistent and the yield threshold is not surpassed. The good mechanical integrity of the tubes is therefore retained. Hydraulic tests have been carried out at pressures up to 1340 bar to obtain ASTM code approval. The stainless steels, nickel alloys, titanium, Carbon steels and copper are just a few of the materials that may be used to make them.

The flow on the shell side follows a convoluted meandering route that is mostly axial. The shell side flow area is usually about the same as the tube side flow area. To avoid bypass flows, the bundle is frequently wrapped. At the extremities of the bundle, paths are accessible to allow fluid to flow into and out. When it comes to intake and outlet velocities, excessive inlet and exit velocities must be avoided. "Vapour belts" can be employed in the same way as they are in traditional designs. The tube-side fluid has a whirling flow due to the architecture. In order to increase design flexibility, twisted tubes and plain tubes may be mixed in the same bundle but this is only done when high thermal effectiveness is not required.

4. Advantages

High thermal-Hydraulic performance: - More unidirectional flow on the shell side leads in a significantly higher heat transfer coefficient per unit of pressure drop. For the same pressure drop, heat transfer coefficients are typically 40 per cent greater or, conversely, pressure drop is half for the same heat transfer coefficient. In addition, the swirl on the tube side boosts the coefficients by a comparable amount as twisted tape inserts in a plain tube. When a twisted tube exchanger is compared to a conventional exchanger for the same task, the overall impact is a significant reduction in the heat transfer area. Alternatively, substituting a conventional bundle with a twisted-tube bundle can significantly increase the performance of an existing exchanger.

High Thermal Effectiveness: - Because twisted tube exchangers are closer to pure plug flow on the shell side, designs with increased thermal efficacy, more characteristic of plate exchangers, are available.

Lower Fouling and Cleanability: - Fouling is reduced by eliminating dead areas on the shell side and increasing turbulence on both the shell and tube sides. The scouring action reduces particulate fouling. The elimination of hot spots prevents other forms of fouling, such as scaling and chemical reactions. As a result, fouling characteristics are more similar to plate exchangers than shell and tube exchangers. Higher velocities are attainable due to the decreased shell side pressure drop for a given flow, decreasing clogging with fibrous materials. Practical evidence of lower fouling comes from the pulp and paper industry where a conventional exchanger had to be cleaned every three or four weeks whereas the replacement twisted tube exchanger only has to be cleaned with hot condensate. Even though a triangle pitch is employed, the twist alignment in the twisted tube exchanger enables cleaning channels if fouling occurs. As a result, the cleanability of a traditional square plan is mixed with a triangle arrangement's heat transfer area density.

Vibration Avoidance: - Flow-induced vibration can occur in standard exchangers, but specific designs, such as "no tubes in the window," can alleviate the problem by providing additional tube support. The most harmful vibration is caused by fluid-elastic instability, which can cause damage within hours of operation. By switching to axial flow and supporting the tubes every 80 mm or so, the likelihood of such vibration in twisted tube exchangers is almost totally removed. Clearly, there is some cross flow at inlet and outlet but the good tube support ameliorates this and the use of shrouds within a slightly larger shell provides additional inlet flow area before having to go to the expense of “vapour belts”. Furthermore, the “cleaning lanes” mentioned above provide smooth paths for the flow entering and escaping the bundle.

5. Heat exchanger

An apparatus used to transfer heat from one medium to another is a heat exchanger. It is used for maintaining the lower temperature or higher temperature according to requirements. Heat exchangers can be classified based on the fluid utilised, phase changes, and relative flow direction (liquid-to-gas, gas-to-gas, gas-to-liquid, liquid-to-liquid) (counter-flow, co-flow, cross-flow). On the basis of application, the heat exchanger is classified mainly into three types. Because of their structural simplicity, cheap cost, and design versatility, shell-and-tube heat exchangers are widely utilised in different industrial domains such as the petrochemical industry, food preservation, energy conservation systems, electrical power production and manufacturing industry. They account for more than 35-40% of the heat exchangers utilised in global heat transfer operations, according to Master and coworkers [2]. As a result, it's critical to boost their thermal-hydraulic performance while lowering their costs as much as feasible [1, 3, 5].

5.1 Shell-and-tube heat exchanger (STHE)

One flow runs parallel to a series of tubes, while the other runs within an outside shell, either in cross-flow or parallel to the tubes [1], as shown in Figure 2.1.

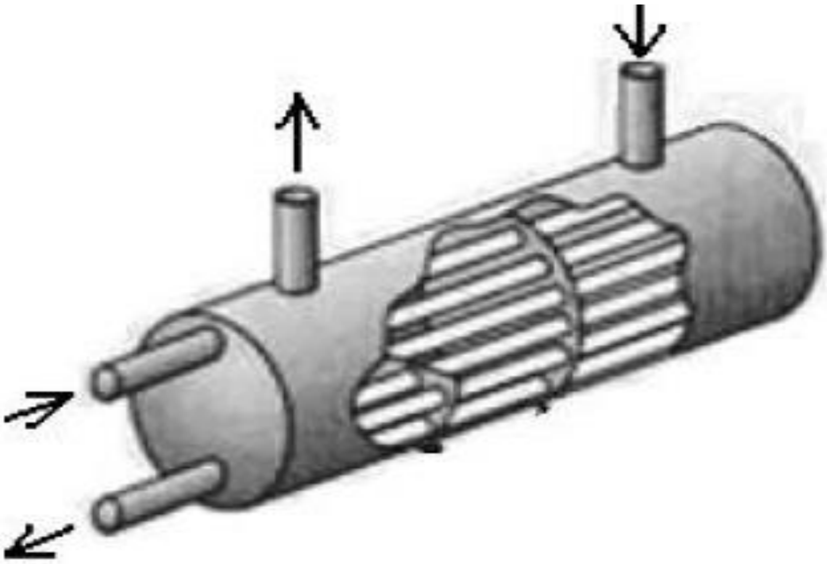

Figure2.1: Shell-and-tube heat exchanger [1]

5. 2 Open-flow heat exchangers

In this heat exchanger, one flow is not restricted inside the apparatus. They originate in air-cooled tube banks and are mostly employed for ultimate heat transfer from a liquid to air, such as in a vehicle radiator, but they are also used in condensers and vaporisers in refrigeration and air-conditioning systems, as well as indirectly fired residential water heaters [1]. Figure 2.2 depicts an open flow type heat exchanger.

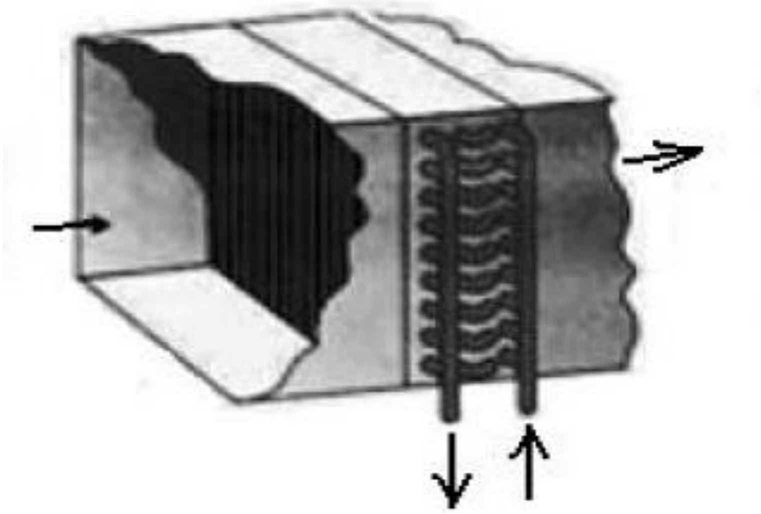

Figure2.2: Open-flow type heat exchanger [1].

5.3 Plate heat exchanger (PHE)

Both fluids move independently along neighbouring channels in the corrugation, and ribbed plates are employed in contact. The PHE was first invented in the food business (for pasteurisation of milk) in the 1920s, but due to its compactness and effectiveness, it is currently sweeping all markets [1]. The plate-type heat exchanger is given in Figure2.3.

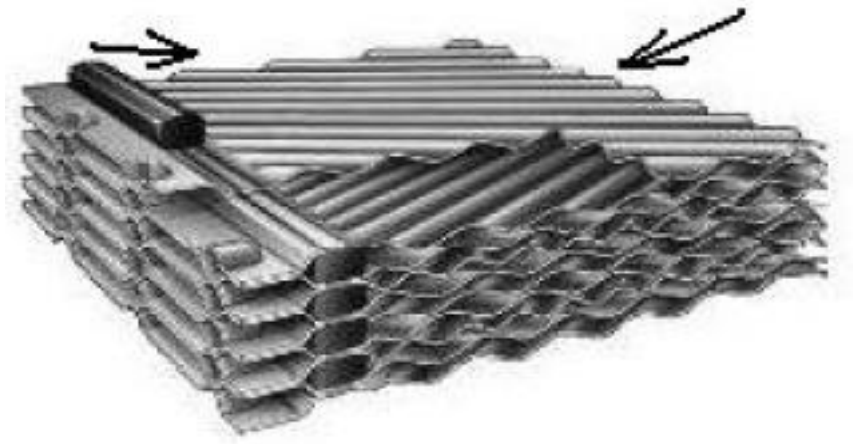

Figure2.3: Plate type heat exchanger [1].

There are many handbooks which cover the design methods of shell-and-tube heat exchangers for enhancing heat transfer are available. These handbooks comprise the collection edited by many researchers [6-9]. These references are useful for obtaining design parameters for heat exchangers, especially shell-and-tube heat exchangers. The heat transfer coefficient and pressure drops of segmented baffle shell-and-tube heat exchangers are determined through an iterative design process in which many configurations are tested by trial and error until the pressure drops and heat transfer coefficient are within the maximum allowable values [10].

6. Types of Heat Transfer Enhancement Techniques

Heat transfer enhancement techniques are widely used in a wide range of engineering applications, including heat recovery, air conditioning shell-and-tube heat transfer exchangers, refrigeration systems, chemical reactors, nuclear energy, chemical process plants and high-power laser systems, among others. For improvements in thermo-hydraulic efficiency of heat pipes different enhancement techniques are used. The enhancement techniques are categorized into three parts [1, 3, 11, 12].

6.1 Active Method

This method is used for desired flow improvements and modifications in heat transfer rate. This active method is very complex because this technique requires some external source of power input. Its use is very limited for heat transfer, In comparison with another type of enhancement techniques. It does not have so much potential because it is more complicated to provide a power supply as input in many other cases. Different active techniques are given as following [1, 3, 13].

- **Surface Vibration**: For surface vibration low or high frequency is used in single-phase flow. High convective heat transfer coefficients are observed in this type of vibration.
- **Electrostatic Field**: A magnetic fields or summation of AC and DC sources is being used in a heat exchanger system and it generates very much bulk mixing, electromagnetic pumping, forced convection. For increasing heat transfer with the involvement of dielectric fluid this technique is used in heat transfer.
- **Fluid Vibration:** This type of vibration enhancement method is used for single-phase flow in which pulses are created itself in the fluid.
- **Mechanical Aids**: Rotating tube heat exchanger and crapped surface type mass and heat exchangers are the example of mechanical aids. By rotating the surface or mechanical means this device stir the fluids.
- **Suction**: It may be utilised in both single-phase and double-phase heat transfer processes. Vapour removal occurs in a two-phase nucleate boiling process with a porous heated surface and a single-phase flow with a porous heated surface.

6. 2 Passive Methods

This method is used for heat transfer by adding some external inserts in the pipe. It provides more heat transfer due to disturbance of flow. The inserts converts flow pattern in to shape of the insert used, due to which pressure drop takes place. The main advantage of passive techniques is that it doesn't require external input power source. The methods and surfaces used in passive method are given as [1, 3 11, 13].

- The surface having pits, cavities or scratches and alteration on the surface is treated surface. In this type of surface the heat transfer area may be discontinuous or continuous and it is used for considering and boiling process.
- Modification of rough surface creates disorderness in the sub layer of the viscous region and this technique is used in single phase turbulent flow.
- Plain fins acts as extended surfaces, is the earliest type of heat exchanger device used in many type of heat exchanger. Finned surfaces have a great ability to disturb the flow field instead of increasing heat transfer and it is very popular now. Ducts and different altered surface types of devices are used in both single flow and double flow (coiled tubes) blue dares.
- Secondary flow or vortices are generated in to coiled tube-type surface due to the curvature nature of the coiled tube.
-

6.3 Compound Techniques

Compound enhancement occurs when two or more of the following approaches are applied simultaneously to provide a heat transfer improvement that is larger than that achieved by any of them when used alone. Because this technology necessitates a sophisticated design, its applications are restricted [14].

Many heat transfer enhancement techniques considered that, by reducing size of the heat exchanger, increasing overall heat transfer of thermal systems, by enhanced surface and material modification which optimize three-dimensional fluid flow which increases heat transfer. Viper tube increases transfer of heat by combination of these factors which includes increased fluid flow turbulence, generate secondary fluid flow pattern, boundary layer disturbance and increased heat transfer surface area, which results in a recent transition to increase heat transfer. Use of heat transfer tubes is very effective design for cost and it can be used in development of highly efficient thermal system. Turbultors or twisted tape inserted in the tube type heat exchanger is different method for producing heat transfer performance. For flow condition in some cases, given type of flow enhancement component like, twisted tape, turbultors etc. made from vipertex enhanced surface to increase further for any complicate condition and gives enhanced heat transfer for a wider range of flow case (low flow in single phase, two phase flow etc.) than present normal surface of twisted tape, and around 15% enhancements seen in some flow condition [1,3].

7. Improvements in Enhancement Techniques

Heat transfer improvement is the process of increasing the heat transfer coefficient to increase the performance of a heat transfer system. Heat transfer enhancement tools have been created and widely used in heat exchanger applications in recent years, such as chemical industry, automotive, process industry, refrigeration and so on. There have been several attempts to reduce the cost and size of heat exchangers to date [1,3].

7.1 Treated surface

In 1992, Holmen discovered specific conditions in turbulent flow when forced convection dominates the heat transfer process. It has a number of different structural surfaces and coatings (continuous or discontinuous significant surface roughness). The irregularity caused by this motion has no influence on single phase heat transfer. These are only used in circumstances when two-phase heat transmission is required. Machined or grooved surfaces, low-fin surfaces that have been formed or modified, multi-layered surfaces, and coated surfaces are all examples of treated surfaces. Because they provide a high number of nucleation sites and stable vapour traps on the face for bubble production, these surfaces are used in boiling. Dropwise condensation happens when vapours condense on treated surfaces, which is beneficial for minimising surface wetness and breaking up the condensate layer into droplets [1,3, 11, 12, 15].

7.2 Rough surface

By disturbing the viscous laminar sub layer, small range irregularity or surface variation induces turbulence in the flow field near the wall region. Momentum and heart transfer are increased as a result of this perturbation. In laminar flows, this small-scale roughness has no impact. However, in turbulent single-phase flows, it is quite successful. In many applications these days, manufactured and planned roughness is employed as a replacement to natural irregularity. Roughness might be beneficial to the surface if it is planned ahead of time. To provide protuberances in the face, wire coil type inserts can be put within the pipe. By machining, casting, or welding, an almost infinite number of arithmetical variants can be made in the case of planned roughness. Figure 2.4 shows ribbed tubes, which are a sort of 2-D roughness. The forced, mixed, and free convection regimes in horizontal tubes were suggested by Metais and Eckert (1964) [1, 11, 15].

Figure 2.4: Corrugated tubes, two-dimensional roughness [1]

7.3 Extended surfaces

In the case of fluids with low heat transfer coefficients, extended or finned surfaces increase the heat transfer area, which is particularly efficient. Natural or induced convection is utilised to cool electrical and electronic components, and finned surfaces facilitate heat transmission. Extended surfaces, as seen in Figure2.5, enhance fluid boundary layer partition and disrupt the whole bulk flow field inside circular tubes. The heat transmission rate is improved by partitioning the boundary layers. Compact heat exchangers of the plate fin or tube type, with finned surfaces that provide a wide surface area, are utilised in a variety of waste heat recovery, automotive, air conditioning, and refrigeration applications [1, 3, 11, 12].

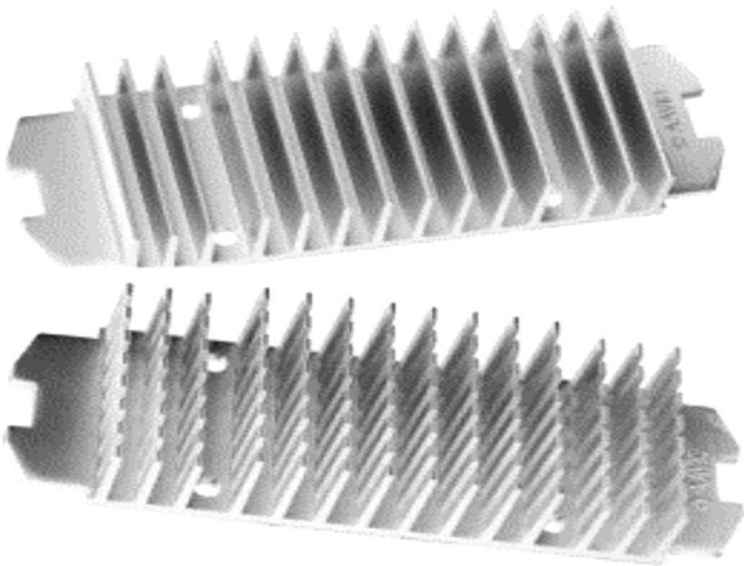

Figure 2.5: Segmented fin heat sink [3]

7.4 Coiled tubes

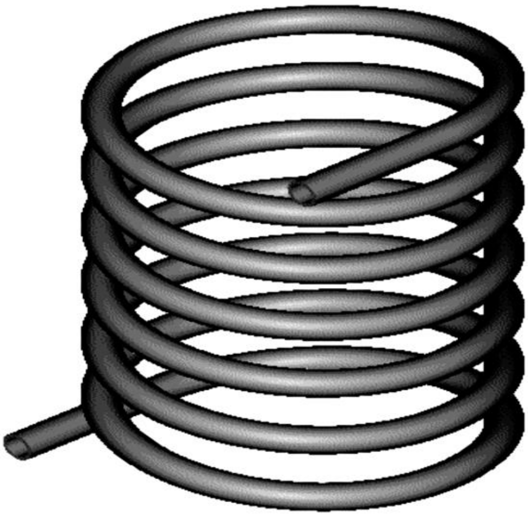

Figure 2.6: Coiled Tubes [1]

The permanent change in the velocity vector at the duct's curve surface causes secondary flows in a coiled or curved tube. Coiled tubes are employed in chemical reaction reactors, residential water heaters, solar heating systems, industrial and renal dialysis equipment, naval boilers, and blood oxygenators.

The centrifugal force acting on the fluid motion causes secondary flows to form. A centrifugal force is generated due to the coils' curvature. The geometrical variables such as radius of curvature, helical number, and others influence the induced flow characteristic of coiled tubes [1, 3, 11].

7.5 Displaced enhancement devices

The fluid components are moved from the path's centre to heated or cooled surfaces by the displaced improvement component. Inserts such as metallic mesh, static mixer components, and wire matrix inserts, as well as discs, rings, and balls, are used in this sort of device. Figure 2.7 depicts several types of conical ring inserts used in circular tubes. This sort of insert does not modify the heat transfer surface and provides a number of mixing options for the fluid particles. In contrast to rings and spherical balls, which have relatively high friction factors, disk-type improvement devices encourage higher heat transport. Bergles comes to the conclusion that pressure decrease in unsteady flows is quite high. The majority of the components are only suitable for laminar flow. The major goal of using this sort of mixer is to improve fluid mixing; as a result, it is employed in chemical processes for heat transfer in part [1, 3, 12]

7.6 Additives for liquids

The frictional loses with the solid surface is taken place due to pressure drop when fluid is flowing in circular pipe. The drag force is acting on the surface which creates pressure drop. This method is related with dropping the drag coefficient by the use of some additives to the fluid. When the additives are added to the fluids then it provides many effective profits by decreasing the frictional losses. Fixed pressure or pumping expenses might be examples of functional profitability. Polymeric additives give the output a viscous-elastic quality, allowing secondary circulation in the bulk flow. The heat transfer coefficient is greatly influenced by this sort of secondary flow. Polymeric additives that are soluble in water thin solutions boost the heat transfer coefficient and significantly reduce frictional loss. Polystyrene spheres suspended are employed as additives in the injection of gas bubbles and oil [1,3, 11, 12].

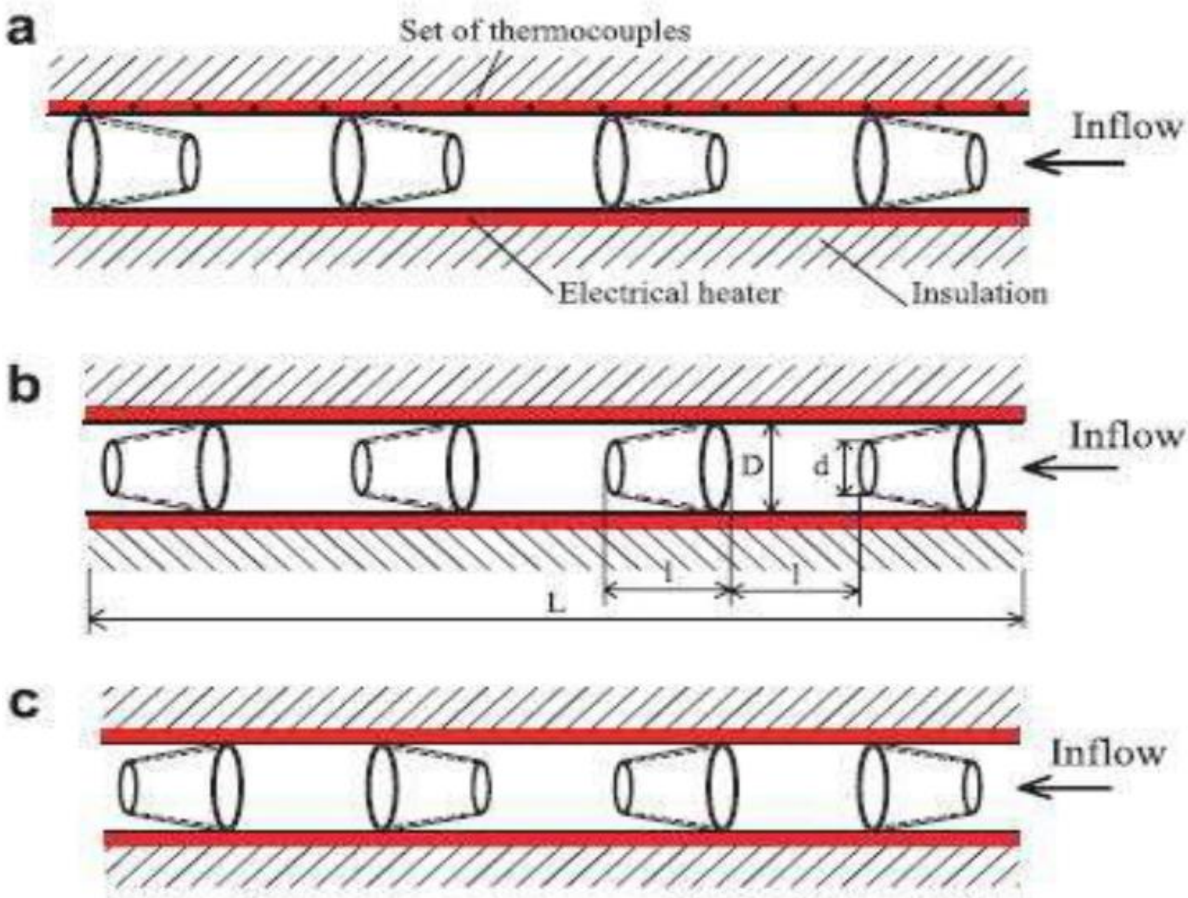

Figure 2.7: Conical Ring inserts in circular tubes; (a) diverging ring; (b) converging ring; (c) converging and diverging rings. [3]

7.7 Swirl Flow Devices

A twisted tape was firstly used in laminar flow by Du Plessis and Kroger in1987, and it is seen that this device is most valuable method for opting great heat transfer enhancement rate. The secondary flow or swirl flow in the fluid is causes by swirl flow devices. Tube inserts, changed tube flow arrangements, and duct geometry alterations are among the devices that can be utilised to achieve this effect. Modifications to duct geometry include ribs, dimples, and helically twisted tubes. Twisted-tape inserts, wire coils, and helical strip or cored screw–type inserts are all examples of tube inserts. A form of changed tube flow arrangement is tangential (periodic) fluid injection. Twisted-tape inserts are particularly common in swirl flow devices all over the world because of their good thermal hydraulic performance in single phase, condensation, forced convection and boiling as well as for design and application concerns. Figure 2.8 shows a common twisted tape layout that is widely used [1, 11, 12, 15].

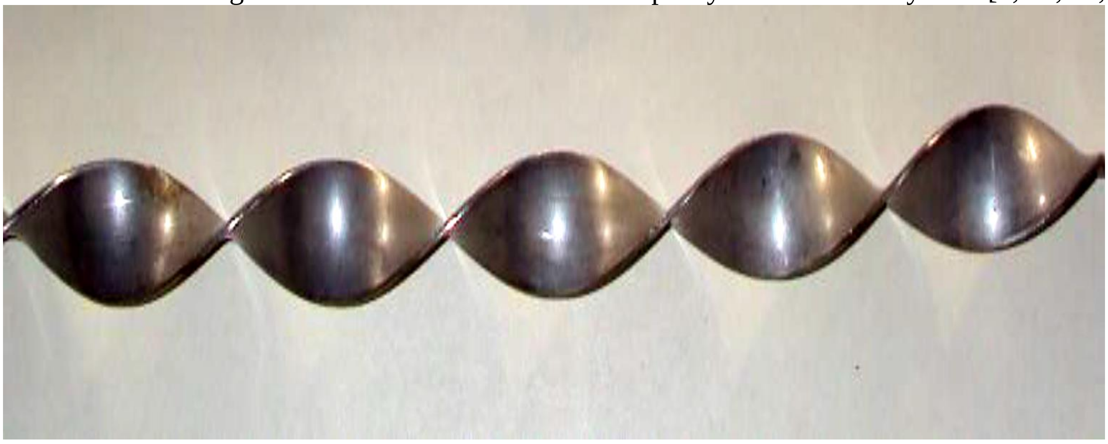

Figure2.8: Twisted tape [1]

Twisted tape inserts boost heat transfer coefficients with just a modest increase in pressure drop. Twisted tape was one of the earliest swirl flow techniques used in single phase heat transfer systems. Twisted tape has been widely utilised for decades to induce swirl movement in fluids due to its ease of design and application [3]. The above work is done on the basis of different literature review discussed as bellow.

Jayakumar, J. S. The heat transfer coefficients were incorrect due to the use of constant values for the fluid's thermal and transport properties. In order to ascertain the coil's heat transfer coefficient, a correlation was built based on the results of the CFD analysis. In this paper, the boundary conditions for continuous wall heat flow and constant wall temperature were analysed. The outer coil had the highest obtained Nusselt values, whereas the inner coil had the lowest. The coil characteristics were linked to heat transport using a variety of computational calculations. Heat transfer is significantly influenced by the pitch, pitch circle diameters, and pipe diameters, but not by pitch.

Experimental measurements were made of the isothermal and non-isothermal friction factors, mean Nusselt Numbers, and the uniform wall temperature heating and cooling of Servotherm oil for flow in a circular tube with twisted tape insert. In addition, the heat transfer resulted in a very beneficial consequence [17].

They conducted an experiment using regularly spaced twisted tapes in laminar flow and discovered that the pressure drop was significantly reduced but the heat transfer was not. It was found that, for twisted tapes, a high number of turns outperform a single turn in terms of thermo-hydraulic performance at a constant pumping power [18].

A modified dean number was proposed for laminar flow in coils and tubes made of twisted tapes and helical components. The Dean number determines the magnitude of the secondary flows by taking into account the curvature of the coiled tubes or helical components. The thermo-hydraulic functionality of twisted tape inserts in an annulus with a large hydraulic diameter. The major thermal resistance in laminar flow is evenly distributed over the tube's cross section. As a result, because it mixes the bulk flow, a twisted tape insert is more successful than other techniques [19].

The twin pipe helical heat exchanger's heat transfer characteristics for both counterflow and parallel flow. Steady heat flow and constant wall temperature were used as boundary conditions. The simulation findings were found to be within the range of the previously obtained results in the research. The total heat transmission coefficients were calculated for dean numbers ranging from 38 to 350. While the fluid flow characteristics in the outer pipe had a substantial influence on the overall heat transfer coefficient, the overall heat transfer coefficients altered immediately with the inner dean numbers. The results show that in order to build a dual pipe helical heat exchanger with a higher overall heat transfer coefficient, the outré pipe should be given primary priority [3][20]

Pongjet Promvonge and Smith Eiamsa-ard [21] In an experimental context, it was looked into how twisted tape inserts affected the properties of heat transfer and friction factor in concentric tube heat exchangers with Reynolds numbers ranging from 2000 to 12000. They found that decreasing the twist ratio significantly raises friction factor while increasing the enhancement efficiency and Nusselt number.

Under laminar flow circumstances, S.Suresh and P.Sivashanmugam [22] A circular tube fitted with full length helical screw components of different twist ratios and helical screw inserts with spacer lengths of 100mm, 200mm, 300mm, and 400mm was tested for its heat transmission and friction factor qualities. They discovered that regularly spaced helical screw components may be employed for heat transfer enhancement without significantly increasing pressure drop when compared to full length helical screw inserts.

J. S. Jayakumar et al. [23] investigated the heat transfer medium's constant thermal and transport parameters, as well as their impact on heat transfer coefficient prediction. Heat transfer for a fluid-to-fluid heat exchanger could not be determined using arbitrary boundary conditions. An experimental setup was created to study heat transmission, and computational fluid dynamics was used to mimic the process. The simulation's results for computational fluid dynamics agreed rather well with the experimental data. Based on data from both experiments and computer simulations, a correlation for the interior heat transfer coefficient was created.

Usman Ur Rehman et al. [24] investigated flow distribution and heat transfer in a tube and shell heat exchanger and compared their findings to experimental findings. In terms of heat transmission and pressure differential, the model had an average inaccuracy of roughly 20%. Instead of k-models, Reynolds Stress models might be used to enhance the model. Because there was little contact between the fluids, the heat transmission was determined to be modest. Instead of enhancing the parallel flow, the design might be enhanced by improving the cross flow zones.

Sheng Yang et al. [25] demonstrated that across the full Reynolds number range, the experimental Friction Factors/Nusselt numbers can be described using a single unified equation, confirming the early flow transition from laminar to turbulent in Twisted Elliptical Tubes. TET heat transfer augmentation mechanisms were examined in terms of field synergy.

The influence of geometrical factors on the performance of the twisted oval tube were described by Xiang-hui Tan et al. [26]. The heat transfer coefficient and friction factor both rise as the axis ratio a/b increases, whereas they both drop as the twist pitch length P increases.

The mechanical and thermal performance of elliptical tubes used in polymer heat exchangers was investigated by Nawras et al [27]. The streamlined design of the outer tube provided the best thermal performance, according to the mechanical study. A collection of design curves was created from which a variety of tube geometries and materials could be easily selected to fulfil the deformation limitations. For strain as a function of tube material, a finite element solution was obtained.

When the concentration of SiO_2 nanofluid was increased to 3.0% with nanoparticles of 22 nm size, Azmi et al. [28] observed a reduction in heat transfer coefficient at an average temperature of 300. The majority of TiO_2 nanofluid research is restricted to determining characteristics and heat transfer coefficients for flow in a simple tube.

An experimental analysis was carried out by P Vivek et al. [29] to evaluate the Commercially pure copper was utilised in this project. In the turbulent zone, Reynolds values ranged from 50000 to 350000. For varied flow rates of water, 0.2 kg/s, 0.147 kg/s, 0.095 kg/s, and 0.055 kg/s, experimental data was acquired from the test section. The goal of this research is to see if twisted elliptical tubes may be used in applications like vehicle radiators, air conditioners, and other multipass applications.

8. Conclusion

The careful analysis of the literature demonstrates that twisted tape is widely applicable in tubular heat exchangers. When twisted type inserts are used instead of plain tubes, the rate of heat transmission is increased because the twisted type inserts produce more turbulence in the flow. Eccentricity is usually advantageous for heat exchangers with straight and helical tubes. Heat transport is improved by adding baffles, fins, and twist geometry to the straight tube. By altering the model's geometry, for as by enlarging the coil diameter and the number of inner tubes, outer tubes at different inclination angles are also used for heat transfer enhancement. Another effective option for improving heat transmission is to employ Nanofluids. Straight tube heat exchangers are inferior to helical coil heat exchangers.

References

[1] *K Adrian, D Allan, "Heat transfer enhancement In Heat Transfer Handbook", Wiley-Interscience, pp. 1033-1101,2003.*

[2] *Anderson John David, "Computational Fluid Dynamics: The Basics with Applications", ISBN:9780070016859, McGraw-Hill, 1995.*

[3] *Bergles, A.E, "Techniques to augment heat transfer", McGraw-Hill, New York,1985.*

[4] *Eiamsa-ard Smith and Pongjet Promvonge, "Performance assessment in a heat exchanger tube with alternate clockwise and counter-clockwise twisted-tape inserts", International Journal of Heat and Mass Transfer, Vol-53, pp-1364-1372, 2010.*

[5] *BI, Master, K S, Chunangad, V Pushpanathan, "Fouling mitigation using helixchanger heat exchangers", Proceedings of the ECI conference on heat exchanger fouling and cleaning: fundamentals and applications, Santa Fe, USA, pp. 317–22, 2003.*

[6] *E.U. Schlunder, "Heat Exchanger Design Handbook", Hemisphere, New York, 1983.*

[7] *G.F. Hewitt, "Hemisphere Handbook of Heat Exchanger Design", Hemisphere, New York, 1990.*

[8] *E.A. Saunders, "Heat Exchanges: Selection, Design and Construction, Longman Scientific and Technical", New York, 1988.*

[9] *R.K. Shah, D.P. Sekulic, "Fundamentals of Heat Exchanger Design", Wiley, New York, 2003.*

[10] *M. Serna, A. Jiminez, "An efficient method for the design of shell and tube heat exchangers", Heat Transfer Eng. Vol-25, pp. 5–16, 2004.*

[11] *AE Bergles, W. M Rosenhow, "Techniques to Augment Heat Transfer", Handbook of Heat Transfer Applications, Chapter 3, New York, McGraw-Hill, 1985.*

[12] *AE Bergles, RL Webb, "Guide to the literature on convection heat transfer augmentation", Advances in Enhanced Heat Transfer, vol.-43, pp.-81, 1985.*

[13] *C. Thianpong, P. Eiamsaard, P. Promvonge, S. Eiamsaard, "Effect of perforated twisted-tapes with parallel wings on heat transfer enhancement in a heat exchanger tube", International Conference on Advances in Energy Engineering, vol-14, pp. 1117-1123, 2012.*

[14] *S. A. Dahake, S. C Pillai, H. J. Golar, "A review on heat transfer enhancement using various twisted tapes", International Journal of Engineering Science and Technology, vol. - 6, pp. 1-4, 2014.*

[15] *William G. Osley, Peter Droegemueller, Peter Ellerby, "CFD Investigation of Heat Transfer and Flow Patterns in Tube Side Laminar Flow and the Potential for Enhancement", Chemical engineering transactions, vol. 35, pp. 997-1002, 2013.*

[16] *J.S. Jayakumar, "Helically Coiled Heat Exchangers".*

[17] *S. K. Agarwal and M. Raja Rao, "Heat transfer augmentation for the flow of viscous liquid in circular tubes using twisted tape inserts" Int. J. Heat Mass Transfer, vol-99, pp.-3547– 3557, 1996.*

[18] *S. K. Saha, and D. Chakraborty, "Heat transfer and pressure drop characteristics of Laminar flow through a circular tube fitted with regularly spaced twisted tape elements with multiple twists", In Proceedings of 3rd ISHMT–ASME Heat and Mass Transfer Conference India, pp.-313–318, 1997.*

[19] *Ujhidy, "Fluid flow in tubes with helical elements, Chemical Engineering and Processing vol.-42, pp.-1–7, 2003.*

[20] *Timothy John Rennie, "Numerical and Experimental Studies of a Double pipe Helical Heat Exchanger", Dept. of Bio-resource Engg. McGill University, Montreal August 2004.*

[21] *Watcharin Noothong, Smith Eiamsa-ard and Pongjet Promvonge, "Effect of Twisted tape Inserts on Heat Transfer in a Tube", The 2nd Joint International Conference on Sustainable Energy and Environment (SEE 2006) Bangkok, Thailand, 21-23 November 2006.*

[22] *P. Sivashanmugam, and S. Suresh, "Experimental studies on heat transfer and friction factor characteristics of turbulent flow through a circular tube fitted with regularly spaced helical screw tape inserts", Experimental Thermal and Fluid Science, vol- 31, pp-301-308, (2007).*

[23] *J.S. Jayakumar, S.M. Mahajani, J.C. Mandal, P.K. Vijayan, and Rohidas Bhoi, "Experimental and CFD estimation of heat transfer in helically coiled heat exchangers", Chemical Engg Research and Design, pp.-221-232, 2008.*

[24] *Usman Ur Rehman, "Heat Transfer Optimization of Shell-and-Tube Heat Exchanger through CFD Studies", Chalmers University of Technology, 2011.*

[25] *Sheng Yang, Li Zhang, Hong Xu, "Experimental study on convective heat transfer and flow resistance characteristics of water flow in twisted elliptical tubes", Applied Thermal Engineering, vol. 31, p.p. 2981- 2991, 2011.*

[26] *Xiang-hui Tan, Dong-sheng Zhu, Guo-van Zhou, "3D numerical simulation on the shell side heat transfer and pressure drop performance of twisted and oval tube heat exchanger", International Journal of Heat and Mass Transfer, vol. 65, p.p. 244-253,2013.*

[27] *Nawras H. Mostafa Qusay R. Al-Hagag, "Structural and Thermal Analysis of Heat Exchanger with Tubes of Elliptical Shape", IASJ, Vol-8, Issue-3, 2012.*

[28] *W.H. Azmi, K.V. Sharma, P.K. Sarma, R. Mamat, S. Anuar, V. Dharma Rao, "Experimental determination of turbulent forced convection heat transfer and friction factor with SiO2 nanofluid", "Exp. Therm. Fluid Sci., Vol.51, pp.103-111,2013.*

[29] *Vivek P. Thawkar, Hemant S. Farkade "Experimental and CFD Analysis of Twisted Tube Heat Exchanger under Forced Convection," International journal of science and research (ijsr), pp. 137-142, 2013.*

[30] *ANSYS Fluent Guide, Release 14.5, October 2012.*

[31] *Jiyuan, H Y Guan, Chaoque, "Computational Fluid Dynamics," A Practical Approach, Elsevier Publication.*

[32] *S .V Patakar, "Numerical Heat Transfer and fluid Flow", McGraw-Hill Company, New York,1980.*

[33] *MINITAB. User's Guide 2: Data Analysis and Quality Tools, 2000.*

[34] *Usman Ur Rehman, "Heat Transfer Optimization of Shell-and-Tube Heat Exchanger through CFD Studies", Chalmers University of Technology, 2011.*

[35] *S Chandourene, A Gruss, "Theoretical and experimental study of high-temperature heat pipe heat exchanger application to 1300kW respirator", Sixth International heat pipe Conference, Grenoffle France, 1987.*

[36] *Kamaldeep Singh, Sumeet Sharma, D. Gangacharyulu, "Experimental study of thermophysical properties of al2o3/water nanofluid", International journal of research in mechanical engineering & technology, vol.-3, pp.229-233, 2013.*

[37] *M. Rahimi, S. R. Shabanian, A. A. Alsairafi, "Experimental and CFD studies on heat transfer and friction factor characteristics of a tube equipped with modified twisted tape inserts," Chemical Engineering and Processing, vol-48, pp. 762–770, 2009.*

[38] *Ranjit K.Roy, "Design of Experiments Using the Taguchi Approach", John Wiley & Sons, New York, 2001.*

[39] *G Taguchi, Hocheng, "Taguchi methods orthogonal arrays and linear graphs", Tools for quality engineering", vol. - 35, pp. 38, 1987.*

[40] *Kamal, Anish, M.P. Garg, "Experimental investigation of Material removal rate in CNC turning using Taguchi method", International Journal of Engineering Research and Applications, Vol-2, pp.1581- 590, 2012.*

[41] *F.Ci Tsa, B.H Yan, C.Y Kuan, F.Y Huang,"A Taguchi and experimental investigation into the optimal processing conditions for the abrasive jet polishing of SKD61 mold steel", International Journal of Machine Tools and Manufacture, vol.-48, pp. 932-945, 2008.*

[42] *Rama, Padmanabhan, "Application of Taguchi methods and ANOVA in optimization of process parameters for metal removal rate in electrochemical machining of Al/5%SiC composites", International Journal of Engineering Research and Applications, Vol.-2, pp.192-197, May-Jun 2012.*

[43] *WH Yang, YS Tarng, "Design optimization of cutting parameters for turning operations based on the Taguchi method", Journal of Material Processing Technology, vol.- 84, pp.122–129, 1998.*

[44] *G Taguchi, "Introduction to quality engineering", Asian Productivity Organization, Tokyo, 1990.*

[45] *F. Incropera, P.D. Dewitt, "Introduction to Heat Transfer", 3rd ed., John Wiley & Sons Inc., 1996.*

[46] *H Lindman, "Analysis of variance in experimental design", Springer-Verlag, New York, 1992.*

[47] *PJ Ross, "Taguchi techniques for quality engineering", McGraw-Hill International Editions, Singapore, 1996.*

[48] *JA Ghani, IA Chaudhary, HH Hassan, "Application Of Taguchi method in optimization of end milling Parametre", J Mater Process Technol, vol.-145, pp. 84-92,2004.*