

Review paper for investigating the effect of twisting tube on the heat transfer and fluid characteristics

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ABSTRACT

Twisted Tube heat exchangers are a form of heating system which originated in engineering applications and became commercially accessible in the mid-1980s. It was created largely to address the drawbacks of traditional shell and tube applications. The twisted tube technique was largely used in single phase and condensing errands in pulp, as well as district heating, with only a small amount of exposure in the process sectors.

I. REVIEW OF TWISTED TUBE HEAT EXCHANGER

Morgan, R. Donald, 2001 [1] noticed that conventional shell and tube heat exchangers are used in over 85% of new heat exchanger applications in oil refining, chemicals, petrochemicals, and power generation. The foundation for this design is shell and tube technology, which is a low-cost, time-tested solution for a large variety of heat transfer requirements. However, there are several drawbacks to the technique, such as inefficient use of shell side pressure drop, dead or low flow zones around the baffles, which can lead to fouling and corrosion, and flow induced tube vibration, which can lead to equipment failure and he discussed the recent invention and discovery of a new technology called twisted tube technology. It has succeeded in overcoming the limitations of conventional technologies while also providing higher overall heat transfer coefficients through tube side improvements. Twisted tube exchangers were compared to conventional designs in terms of construction, performance, and cost for a variety of materials, including reactive metals. This type of heat exchanger has been shown to have several benefits over the conventional shell and tube exchanger with segmental baffles.

II. REVIEW OF NUMERICAL ANALYSIS

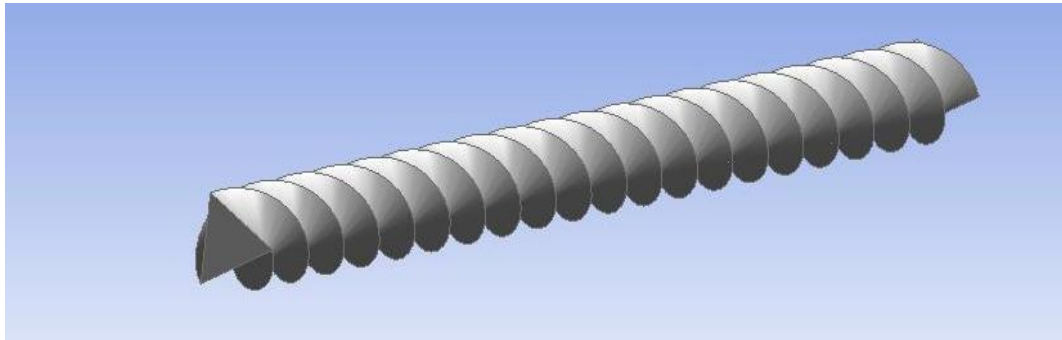
Masliyah, J. H., and K. Nandakumar, 1981 [2] solved numerically the Navier-Stokes equation in the context of a revolving reference frame in a square cross-section twisted tube to produce the flow field for a steady newtonian fluid with fully developed laminar flow. The calculated friction factor values are provided for twist ratios that are dimensionless of 20, 10, 5, and 2.5, as well as Reynolds number up to 2000. The swirling motion had no effect on the qualitative character of the axial velocity profile. When the twist rate is raised, the axial velocity profile changes from a straight square tube to a straight circular tube. The secondary motion was discovered to be very important near the wall.

Nandakumar, K., and J. H. Masliyah., 1983 [3] utilized numerical solutions to the momentum and energy equations to investigate fluid flow and heat transfer properties in a twisted rectangular tube with only a two aspect ratio. Fluid flow solutions are used to represent a newtonian fluid with fully developed laminar flow. The heat transfer data for the case of an axially uniform wall temperature is provided. In specific ranges of twisted lengths, the total Nusselt number inside a twisted rectangular tube was shown to be up to 30% bigger than a straight tube in the case of a wall with a peripherally homogeneous temperature. In the event of non-uniform wall temperature, on the other hand, the total absolute Nusselt number rises relatively quickly when the twist length was reduced.

Mushatet Khudheyer and Haiyder M., 2006 [4] performed a numerical solution for the turbulent flow field and heat transfer is guided by the finite volume approach method by using ANSYS Fluent 17.1. The momentum, continuity, and energy equations are the governing equations utilized in heat transfer and flow field analysis. They

improved turbulent heat transfer in twisted triangular tube heat exchangers. Different twist ratios (5,10,20) and Reynolds number ($Re = 5000$ to 25000) were evaluated on a triangular twisted tube having a length of 1 m and a diameter of 0.03 m.

According to the computational results, the twisted tube exhibited an increase in heat transmission when compared to a simple tube. The twisted ratio was the most important factor in improving heat transmission and reducing friction losses.



Figure(1) Schematic representation of the material problem[4].

Abdulkareem Abbas and Khudhair Al-Musawi, 2013 [5] evaluated heat transfer enhancement because of twisting of a tube with a square cross-sectional area. In laminar and transient region flow, the effect of the twist parameter on the convective heat transfer coefficient was analyzed. The finite volume approach and a conventional turbulence model were used to simulate three-dimensional, steady-state incompressible flow in body-fitted coordinates. A comparison was performed with a straight untwisted duct using four twist parameters: 5, 10, 25, and 50. For laminar and transient flow, two sets of Reynolds numbers were examined. At 500, 1000, 1500, and 2000, the laminar flow is conducted. The Reynolds number range for transient flow is 5000, 6000, 7000, 8000, and 9000. It was discovered that as the twist parameter is reduced, the heat transmission coefficient increases. As the swirling moves farther from the tube center and closer to the walls, the cross flow velocity vectors rise. Internal thermal equilibrium is increased by swirling, which causes internal mixing.

Bhadouriya, Rambir Amit Agrawal, et al. 2015 [6] investigated flow inside a square-sectioned twisted duct. Three-dimensional numerical solutions were used for fully developed steady laminar flow and homogenous wall heat flux boundary conditions. The range of Reynolds number investigated was 100 to 3000. Twist ratios of 2.5, 5, 10, and 20 are employed. Fluids with Prandtl numbers of 0.7 to 20 are considered. The friction factor multiplied by the Reynolds number is discovered to become a function of the Reynolds number and the greatest values are recorded at 2.5 of a twist ratio and 3000 of a Reynolds number. For the same parameters, the maximum Nusselt number

is recorded, as well as a Prandtl number of 20. Using the swirl parameter, the correlations between the friction factor and the Nusselt number are generated. An enhancement factor is calculated based on constant pumping power requirements to compare twisted and straight ducts. The enhancement factor is used to guide the selection of the twisted square duct. The twisted duct is found to function effectively in the laminar zone for a variety of parameters. For twist ratios of 2.5, 5, 10, and 20, the heat transfer improvement for Reynolds number 3000 and Prandtl number 0.7 is 20%, 17.8%, 16.1%, and 13.7%, respectively. These findings will help to advance the construction of energy-efficient and compact heat exchangers.

Kim, Hyung Rak, et al., 2016 [7] used three-dimensional (3-D) numerical modeling to compare the impact of geometric factors such as the twisted elliptic tube's aspect ratio and number of rotations. The flow and heat transfer properties of (TET) were investigated. In the TET, they also solved the continuity, momentum, and energy conservation equations numerically. The TET's fully evolved flow was described using the realizable $k-\epsilon$ turbulence model and the stable incompressible Reynolds-averaged Navier-Stokes (RANS) equations. Reynolds values of 100, 1000, and 10000 were used in the simulation. The Darcy friction and Colburn j -factor were used to evaluate the TET's pressure drop and heat transfer, and the area and volume goodness factors were used to measure overall performance. The friction factor varies a lot with λ_t , but not so much with α . Colburn j -factor is bigger in the case of λ_t increases than in the case of a straight circular tube at $Re = 1000$ and $Re = 10000$.

Cheng Junlin, et al., 2017 [8] investigated the influence of geometric parameters in terms of

twisted oval tubes for just a constant wall temperature using a three-dimensional numerical model. The high Reynolds number region is where twisted oval tube heat transfer enhancement is concentrated. This research uses the low Reynolds $k-\epsilon$ model to evaluate the thermal performance and flow properties of the flow of water within twisted oval tubes (TOT) with a Reynolds number ranging from 50 to 2000. The twisted pitch ratios of 0.17, 0.25, 0.33, and 0.5, as well as the flattening of 1.2, 1.4, 1.63, 1.8, and 2.0. The Nusselt number and friction factor local distributions are shown. To reveal the heat transfer enhancement mechanism, the field synergy principle is used. The results reveal that the heat transfer capability of the twisted oval tube has improved, although the pressure drop has

increased. The transition from laminar to turbulent was found at $Re = 500$, which was one of the study's main results. Laminar flow occurs when the Reynolds number is between 50 and 250, and turbulent flow occurs when the Reynolds number is between 500 and 2000. It is also revealed that the smooth oval tube exceeds the twisted oval tube as a result of secondary flow's influence. The maximum enhancement factor PEC of 1.7 is obtained at 2.0 flattening, 0.33 twisted pitch, and 350 Reynolds number. Furthermore, the PEC of twisted oval tubes increased when flatness was increased but dropped as the twisted pitch ratio was raised. These results will help in the design and development of compact heat exchangers and will better understand the heat transfer performance of twisted oval tubes.

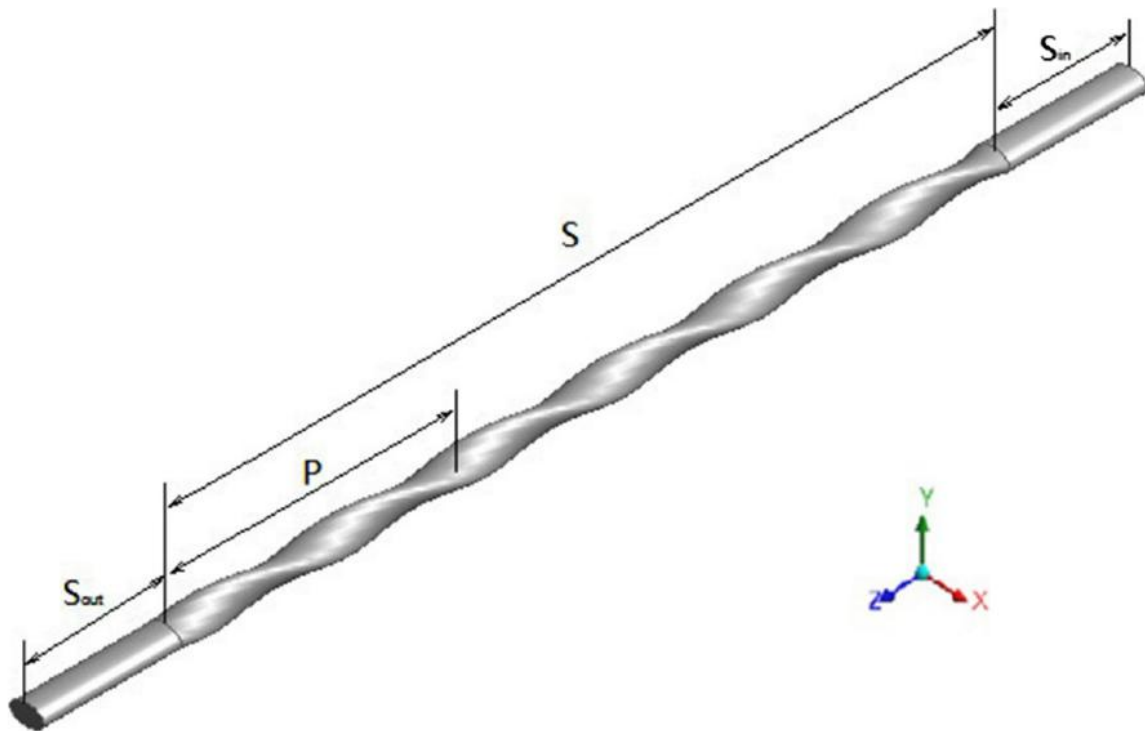


Figure (2) The cross section of a twisted oval tube[8]

Mahato, Shambhu Kumar, et al., 2018 [9] used numerical simulations studied in a shell and tube system. Counter flow was used to cool the swirling flow inside of the twisted duct with a hexagonal cross section. They looked at hexagonal twisted ducts' heat transfer and friction characteristics. The friction factor and Nusselt number were calculated for Reynolds number ranging from 1,000 to 100,000. It has been discovered that there is a transition point between laminar and turbulent flow. The findings of the

twisted hexagonal duct and the twisted square duct were compared. In the laminar regime, the Nusselt number is higher for hexagonal twisted ducts than for square twisted ducts. But for square twisted duct, the Nusselt number is higher than for hexagonal twisted duct in the turbulent regime. The friction factor, on the other hand, reduces as the Reynolds number rises. The study found that in laminar flow, hexagonal ducts can be utilized, while in turbulent flow, square ducts can be utilized.

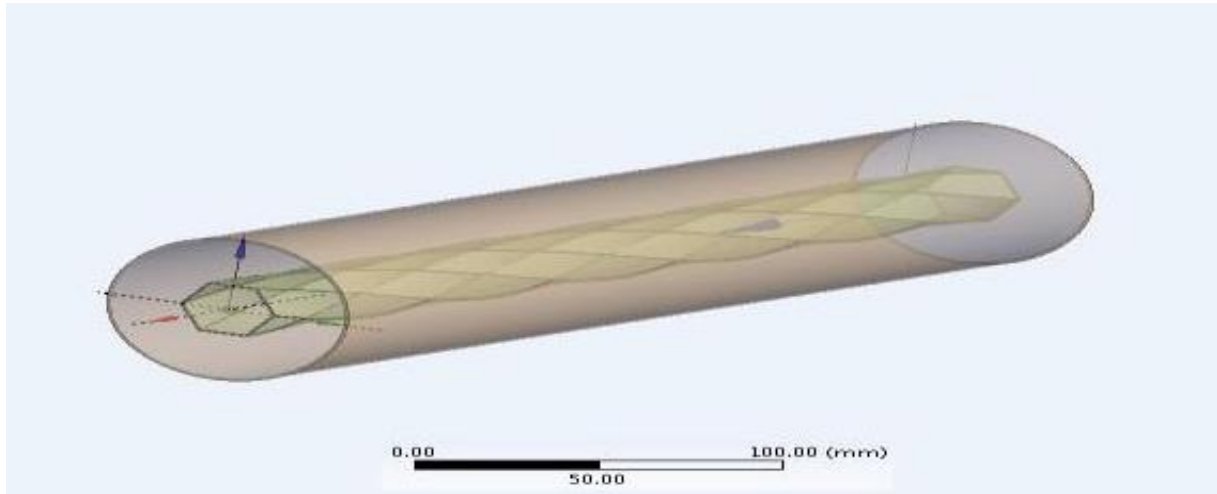


Figure (3) Numerical modeling of a twisted hexagonal duct [9]

Wu, Ching-Chi, et al., 2018 [10] present the results of a numerical study in a three-dimensional twisted elliptical tube with turbulent water forced convection and constant wall temperature. Reynolds number and twist pitch parameters are used to investigate in a twisted elliptical tube both water flow resistance and heat transfer characteristics. The influence of the factors discussed on twisted elliptical tube performance was investigated and calculated to give the total thermal-hydraulic performance. In comparison to an oval tube, the results reveal that twisted elliptical tubes induce rotating movements in the flowing fluid, which increases the synergy among velocity vectors and temperature gradients and improves thermal performance. The twisted walls of the twisted

elliptical tubes cause a pressure fall. When the twisted elliptical tube is compared to the oval tube, both at a diameter of $d = 96$ mm, the pressure drop of the twisted elliptical tube rises by 58% to 60%, and the mean Nusselt number rises by 16% to 19%. Furthermore, when the Reynolds number increases, both the average Nusselt number and the pressure drop rise, and when the twist pitch increases, both decrease. The entrance dissipation-based thermal resistance of the twisted elliptical tube can be reduced, resulting in a significant increase in heat transfer efficiency. The results reveal that the overall thermal-hydraulic performance of the twisted elliptical tube with a $d=128$ mm is the best.

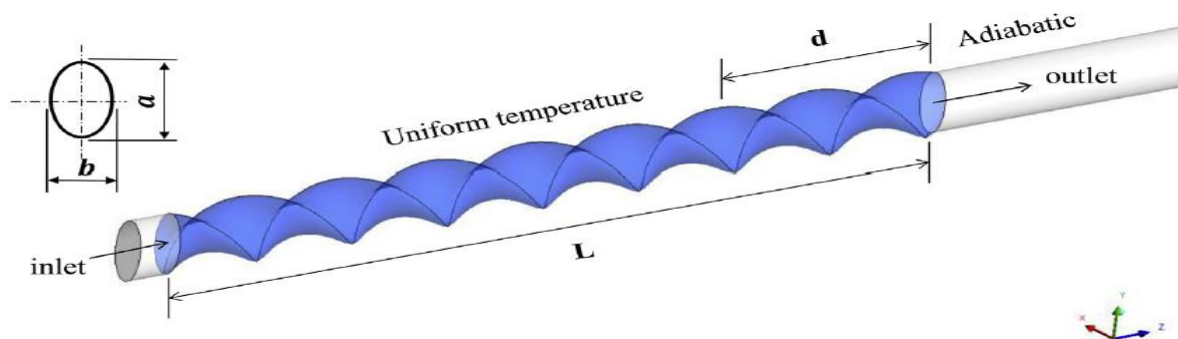


Figure (4) The twisted elliptical tube as a physical model [10]

Mahato, Shambhu Kumar, et al., 2019 [11] studied numerically the friction factor and heat transmission properties of nano-particles of Al_2O_3 /water within the twisted square duct (TSD). Water is used as a basic fluid. The external walls are subjected to a uniform heat flux. Using commercially available software, a fully developed three-

dimensional (3D) laminar flow within the flow area of a twisted duct with a square cross-section is conducted for a Reynolds number of 600 to 2000 and a nanoparticle concentration range of 0.5% to 1%. In terms of heat transfer and friction factor, they compared water/ Al_2O_3 flowing through a twisted square duct as the working fluid to water flowing

through a straight square duct as the normal fluid. A numerical evaluation was carried out for a uniform wall temperature case with 7.5, 11.5, and 16.5 twist ratios and 8 to 10 Prandtl numbers. One of the most important findings of this research is that the nanoparticle concentration in the base fluid has a

limit concentration beyond which it drops. It's also been discovered that increasing the Prandtl number while decreasing the twist ratio enhances the Nusselt number. In the case of the friction factor, however, as the Reynolds number rises, the friction factor steadily drops.



Figure(5) three-dimensional model of a twisted square duct [11]

Cheng, Junlin, et al., 2019 [12] used numerical simulation to look at the heat transfer and flow properties of varied cross-sectional shapes of twisted tubes. The Reynolds number varies between 50 to 2000. In the simulation study, the requirement for a constant wall temperature is taken into account. The twisted square tube numerical findings are compared to the available earlier experimental data. The results show that the heat transmission capability of the twisted tube is better than the smooth tube, although the pressure drop is also higher. At $Re = 500$, the twisted square tube's transition point from laminar to turbulent was identified and determined. It's also revealed that twisted tubes' cross sections have a reduced influence on heat transfer but have a significant impact on the flow pattern. So, The findings show that the twist pitch does have a significant impact on twisted tube heat transmission. Furthermore, the highest value of PEC is 2.69 in a twisted pentagon tube with a 350 Reynolds number and a 0.17 twist pitch ratio. The significance of these results is that they will give to the creation of compact twisted tube heat exchangers.

Alempour, Seyed Mohammadbagher, et al., 2020 [13] used three-dimensional cross sections of elliptical and circular tubes to model turbulent flow and heat transfer by using a finite volume approach. The primary goal of this research is to look at the effects of elliptical aspect ratio and twisting tube walls on

heat transfer and flow properties. The outcomes indicate that when converting from circular to elliptical cross section and lowering an elliptical tube with a smooth wall's aspect ratio, the friction factor and heat transmission will increase. According to research into the effects of wall twisting, The heat transmission and friction factor increase as a result of secondary flow production. When the twist pitch is reduced, the produced vortices combine into a high vortex that affects the flow throughout the whole cross section, improving mixing and increasing heat transmission. According to the findings, heat transfer increases by 5% and 20% in an elliptical tube with a 1.65 aspect ratio and twist pitches of 0.4 and 0.2, respectively. In comparison, a smooth tube of the same cross section will improve heat transfer by up to 30% when the twist pitch is suddenly reduced from 0.2 to 0.1 along the path.

Luo, Chao, et al., 2020 [14] studied numerically the thermal hydraulic performance of a novel annular tube composed of straight outer tubes and twisted inner tubes. For comparison, the researchers looked at an annular tube made of two straight oval tubes. The various aspect ratios and twist ratios of inner twisted oval tubes are investigated. The main findings are presented below. The inner twisted oval tube clearly improves fluid mixing in the annulus. As the aspect ratio and twist ratio both drop, Nu and f rise. The Nu increases by 116% and 46%,

respectively, with inner twisted oval tube. In the laminar regime, thermal performance improvement is high. At $Re = 3000$, which is the highest Re in the

laminar regime, the maximum thermal performance factor $JF = 1.9$ is found for 0.4 aspect ratio and 10twist ratio.

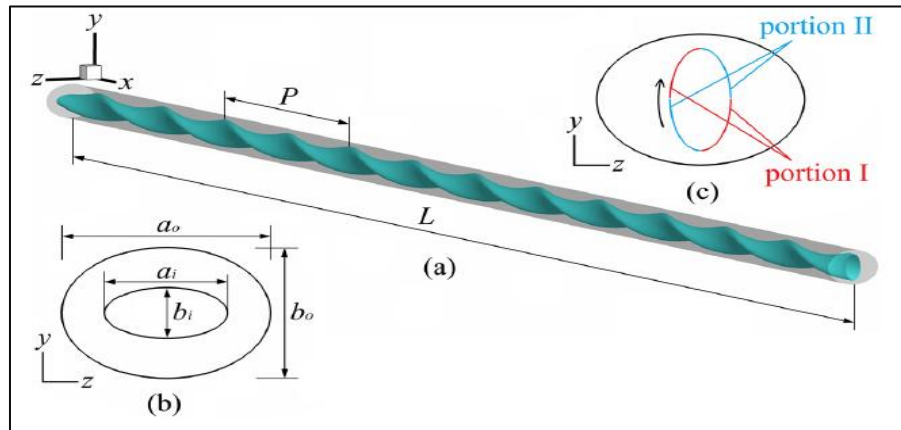


Figure (6) Physical model, (a) annular tube, (b) cross section, (c) inner oval tube portions I and II[14]

Mahato, S. K., et al.,2021 [15] compared numerically the thermal performance of water flowing inside the twisted square duct with the Gnielinski and Blasius equation's correlation value. Investigations were performed for boundary conditions of water with constant wall temperature, twist ratios of 16.5, 11.5, and 7.5, Reynolds number of 100 to 6000, and Prandtl number of 8 and 10 for ducts with fully developed laminar fluid flow. The

numerical results showed In the twisted square duct, the Nusselt number is greater than the correlation finding, and the friction factor is smaller. Twist ratios of 16.5, 11.5, and 7.5 increased the average Nusselt number by 25.56, 33.21, and 37.73 percent, respectively, when compared to theoretical values. The square twisted duct's heat transfer coefficients increase with a lower twist ratio and a larger Prandtl number

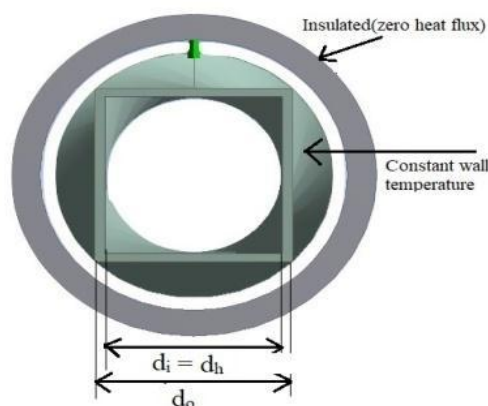


Figure (7) Dimensional properties[15]

Luo, Chao, and KeWei Song., 2021 [16] investigated numerically the thermal performance of a new twisted annulus formed by two counter-twisted oval tubes, for various aspect ratios and the inner tube's twist ratios, The twist pitch of the annuli's oval tubes is the same, but the twisting directions are opposite. The findings show that in the twisted annulus, a strong secondary flow is created, which can considerably improve heat

transmission. Twisted annuli have a maximum Nu and f of 118% and 157% greater, respectively, than the equivalent straight annuli. With a value of 1.98, the thermal performance factor is the highest in the studied range of geometrical parameters. The Nu and f correlations as a function of Re , which show the twist ratio and aspect ratio with variations of 10% and 8%, respectively.

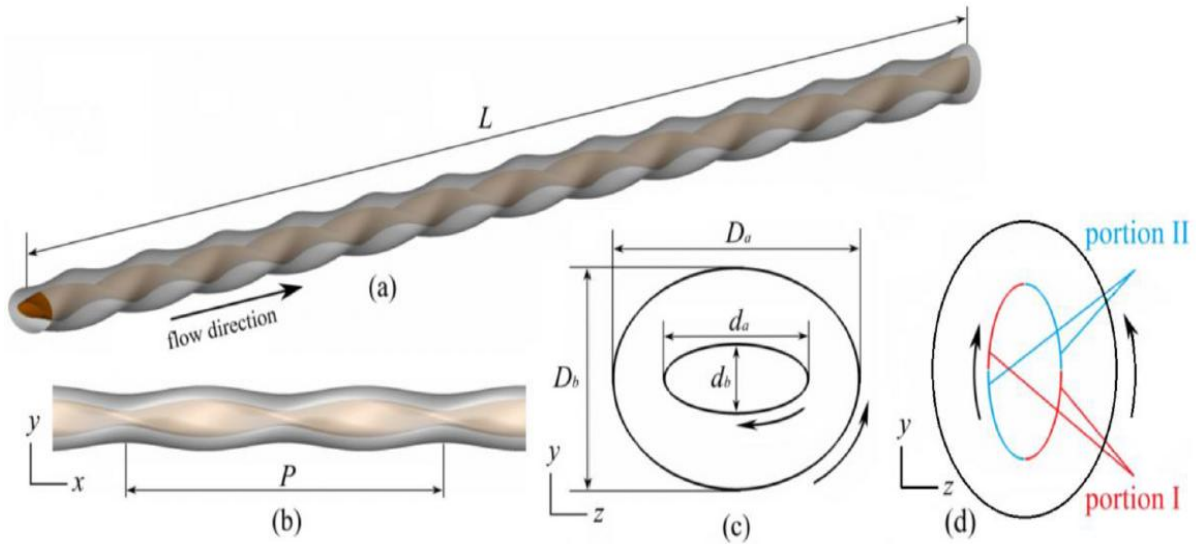


Figure (8)(a) diagrammatic view, (b) twist pitch, (c) (d) a physical model's cross section[16]

Shahsavari, Amin, et al., 2021 [17] Investigated numerically to increase the performance of a heat exchanger with double pipes (DPHE), twisted tubes and nanofluid were used. CuO flow (cold non-Newtonian) and hot water flow in steady-state laminar flow within the tube and annulus sides, respectively. A concentrated carboxymethyl cellulose aqueous solution with a concentration of 0.5% serves as the base liquid. The implications of nanoparticle volume concentration (ϕ), Reynolds number, and twist pitch on the performance measures were investigated, and the results will be compared to a standard DPHE. The findings revealed that increasing Re had both positive and negative impacts, including enhanced performance of heat transmission and heat exchangers, as well as negative ones like increased pressure drop as well as pumping power. Furthermore, it was discovered that the nanofluid outperforms the basic fluid with the exception of $\phi \leq 1.5\%$ and $Re = 500$. In addition, it was found that the overall hydrothermal efficacy of nanofluid varies in an ascending–descending pattern with twist pitch. Moreover, the results showed that twisted DPHE outperforms plane DPHE in terms of total hydrothermal performance, with a maximum

value of 2.67, which corresponds to the situation of $\phi = 3\%$, $Re = 2000$, and 4 mm twist pitch.

Li, Xiuzhen, et al., 2021 [18] Studied numerically Enhancement of heat transmission on the shell side is composed of TOT alone and TOT linked with circular tubes with a Reynolds number ranging from 2700 to 22000. The aspect ratio's influence, the length of twist pitch, the direction of twisting, and the diameter ratio between the inner and outer tubes by convection heat transfer and hydraulic resistance on the shell side are also being investigated. Secondary flow and spiral flow are realized as a result of the rotational movements induced by the twisted oval tubes. This breaks the boundary layer and increases heat transmission on the shell side of TOT in DTHE. Reducing the twist pitch length while raising the inner tube aspect ratio at the same time can improve the shell's overall heat transmission performance considerably. They concluded that the length of the smallest twist pitch and the inner tube with the highest aspect ratio have the best overall heat transport performance. The shell side heat transfer and frictional hydraulic resistant performance are the same in both the left and right twisting orientations of the inner TOTs.

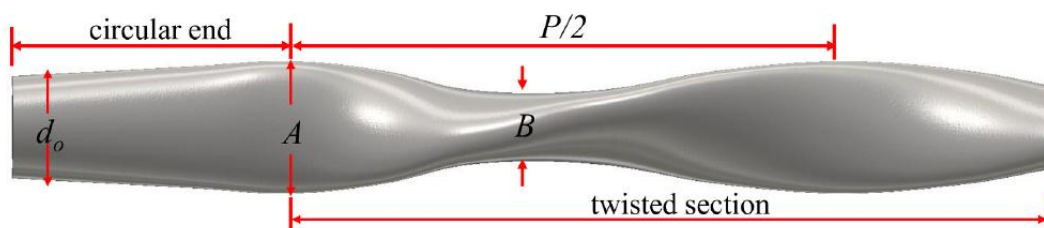


Figure (9)A TOT diagram (leftward twisting)[18]

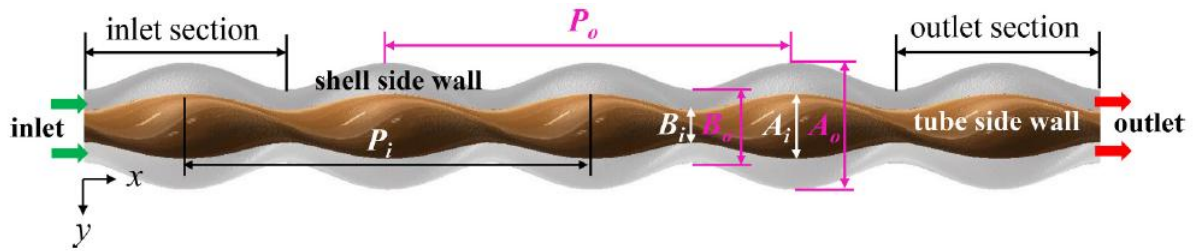


Figure (10) A DTHE with two coaxial TOTs has a diagram of the computational domain[18]

III. EXPERIMENTAL WORK REVIEW

Yang, Sheng, Li Zhang, et al., 2011 [19] investigated experimentally the heat transfer properties and water flow resistance inside elliptical tubes twisted with a variety of structural variables. Aspect ratio and twist pitch effects on TET were analyzed, as well as the total thermalhydraulic performance of the system, which was calculated. The experiments' findings indicated that TET can provide significant heat transfer enhancement as well as a large pressure drop inside the tube. Raising heat transfer coefficients and friction factors as a result of the lower twist pitches

and higher aspect ratios of tubes. The TET performs better at a reduced Reynolds number. The Nusselt numbers and friction factors that have been observed for the full Reynolds number range can also be represented using a single unified equation, confirming the early laminar-to-turbulent flow transition in TET. The field synergy perspective was used to examine the heat transfer enhancing mechanism of TET. The synergy is increased by the longitudinal vortex in the temperature gradient and the velocity vector. That will improve heat transfer performance in twisted tubes.

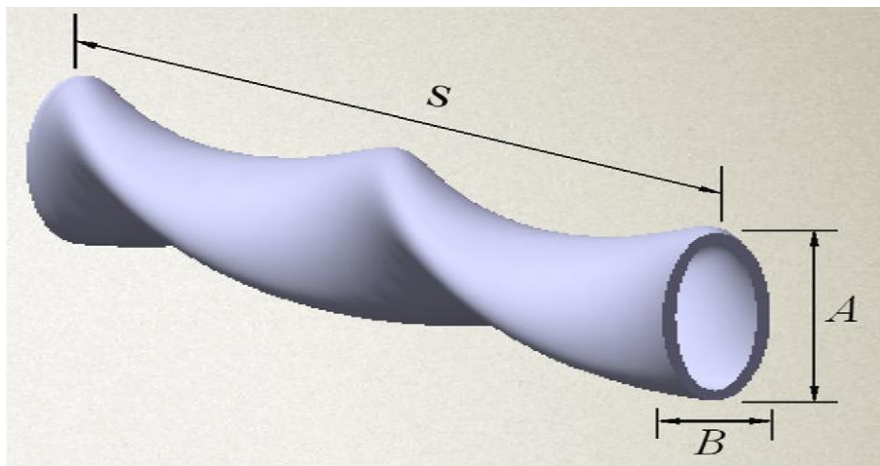


Figure (11) Section of twisted tube[19]

Tan, Xiang-hui, et al., 2013 (20) conducted an experimental study to find out a twisted oval tube heat exchanger's performance in terms of heat transfer and pressure drop on the tube and shell sides. The tube side's performance was compared to that of a smooth circular tube, and the performance of the shell side was compared to a rod baffle heat exchanger on the shell side with fluid flowing longitudinally. They experimentally investigated a round tube with a diameter of 25 mm that is smooth on both sides and a twisted oval tube with

dimensions of $A = 29$ mm, $B = 19.5$ mm, and $S = 230$ mm. The result reveals that the twisted oval tube has a greater heat transfer coefficient than the smooth round tube at the cost of a little pressure decrease. In addition, as the modified Froude number (Fr_M) decreases, the heat transfer coefficient and pressure drop on the shell side rise. According to the comparative results, the shell side heat transfer coefficient of the rod baffle heat exchanger is higher, and the shell side pressure drop is smaller.

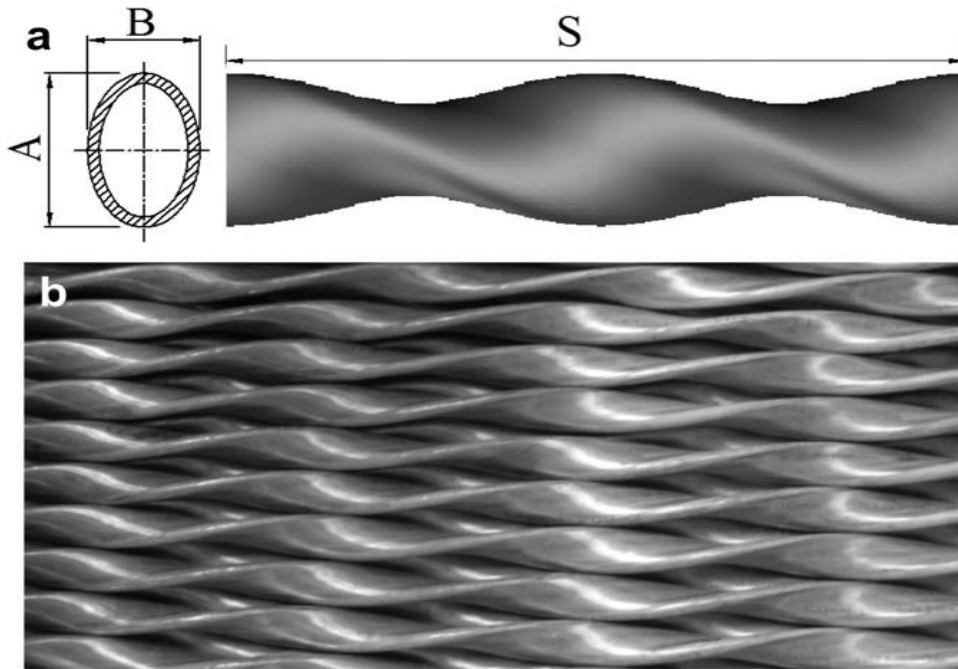


Figure (12): Drawing of a. A twisted oval tube. b. Twisted oval tubes with self-support. [20]

IV. NUMERICAL AND EXPERIMENTAL STUDIES REVIEW

Tan Xiang-hui et al., 2012 [21] investigated experimentally and numerically the performance of twisted oval tubes in terms of heat transmission and pressure drop. When compared to the smooth round tube, heat transfer may be enhanced in the experimental research of the twisted oval tube, although pressure drop increases. The impact of geometrical factors on the twisted oval tube's performance was numerically studied. Results show that when the axis ratio a/b increases and the length of the twist pitch P decreases, both the friction factor and the heat transfer coefficient rise. The

influence of axis ratio a/b and P are also being investigated on the twisted oval tubes' overall performance. According to the study, secondary flow is caused by the formation of a twist in the twisted oval tube. When a/b is large, it takes the shape of a spiral flow. When a/b is small, it appears as a series of ups and downs. When compared TOT to a smooth oval tube with the same geometric dimensions, this secondary flow is what causes the net velocity and temperature profiles of the twisted oval tube to change. The heat transfer mechanism is improved when the twisted angle between the velocity vector and temperature gradient is lowered.

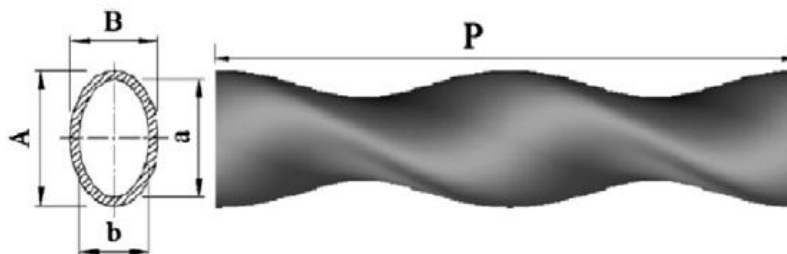


Figure (13) Sketch of TOT [21]

Thantharate, V., et al., 2013 [22] carried out an experimental investigation of the performance of heat transfer of plain tube and twisted tube for multipass heat exchangers. The results were compared in this work. An analytical investigation was also carried out in order to verify the experimental and numerical data. The Reynolds

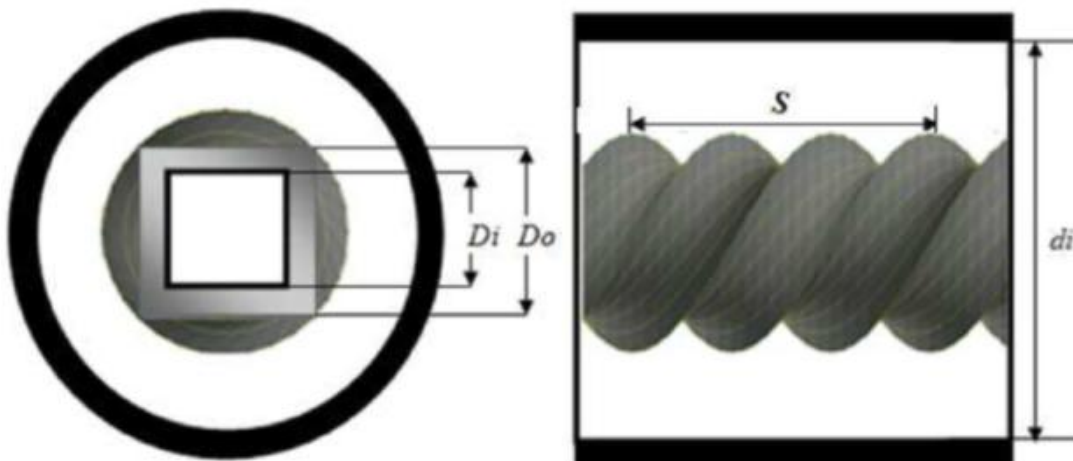
number ranges from 600 to 7000, which includes both laminar and turbulent flow. Plain tube dimensions are 14 mm ID and 16 mm OD, twisted tube dimensions are 9.21 mm major radius and 6 mm minor radius, and both tubes have a length of 1.2 meters. The twisted tube has an ellipticity of 0.76. The air side flow rate is set at 0.52 kg/s while

the water side flow rate varies between 0.24 and 1.5 l/min. For good heat transmission performance, the twisted tube aspect ratio, defined as the major to minor diameter ratio of a twisted tube, should be high, and the pitch should be low. The results revealed that at low flow rates, plain tubes outperform twisted tubes for the same mass flow rates and input temperature. Twisted tubes perform better in high Reynolds number environments because of the attached flow through tubes. They concluded that for multi-pass configurations, twisted tubes should always be chosen based on the required flow rate. As a result, this study shows that for multi-pass configurations, twisted tubes should always be chosen based on the needed flow rate.

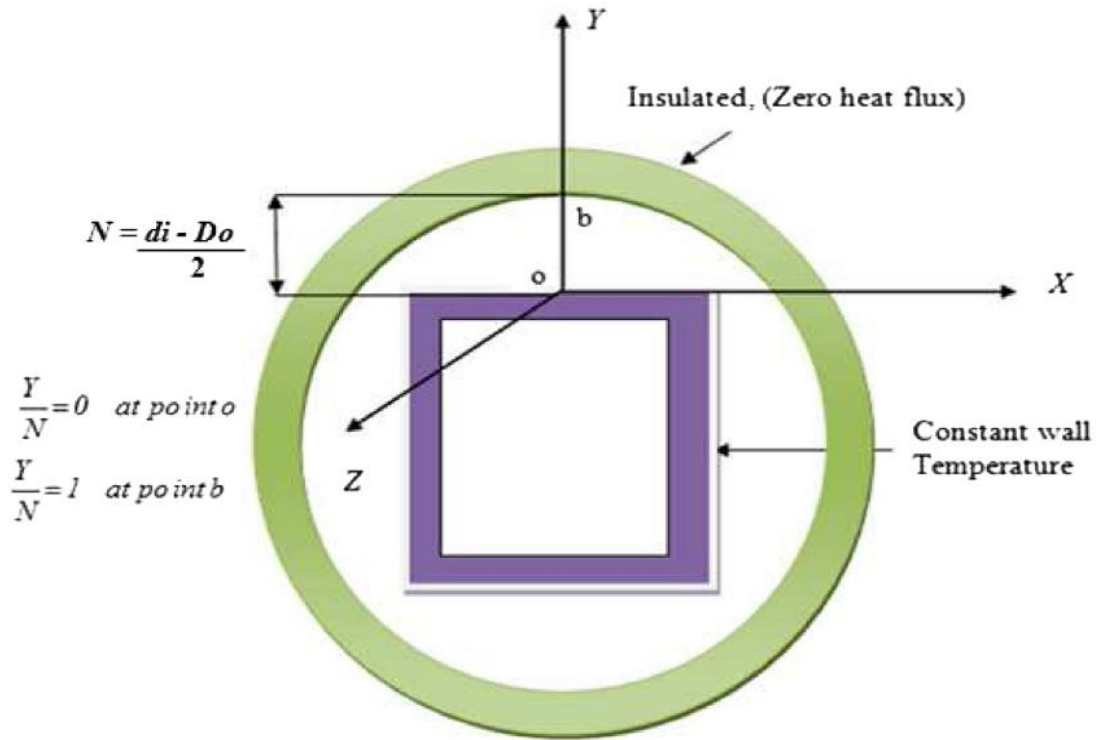
Bhadouriya, Rambir, et al., 2015 [23] investigated in experimental research and by numerical simulation the heat transfer and flow properties within a twisted square duct of air flow. Experiments were carried out using air that had a boundary condition of constant wall temperature, an 11.5 to 16.5 twist ratio, and a Reynolds number of 600 to 70000. $Re = 3000$ was found to be the transition point from laminar to turbulent flow. Up to a Re of 9500, the findings show significant improvements in heat transfer and pressure reduction in both laminar and turbulent flow regimes. When compared to a straight square duct, the twist ratio of 11.5 indicates greater heat transmission and pressure drop. Numerical research is carried out for a case of uniform wall temperature

with twist ratios of 2.5, 5, 10, and 20, and Prandtl numbers ranging from 0.7 to 20. When the Reynolds number is multiplied by the friction factor at 2.5 twist ratio and a 3000 Reynolds number, the maximum value is produced. For identical values of Prandtl number 20, the highest Nusselt number is found. These results will aid in the research and design of compact heat exchangers.

Bhadouriya, et al., 2015 [24] did an experimental and numerical study on the flow of air inside an annulus formed by an inner twisted square duct and an outer circular pipe to look at heat transfer and air flow characteristics. For the annulus, the inner wall was kept at a constant temperature while insulation was kept on the outside pipe. In the experiments, twist ratios of 10.6 and 15 were used. Here, the twist ratio is the twisted square duct pitch to the outer width ratio. The Re ranged from 600 to 60,000. The transition from laminar to turbulent was determined at Re 3000. When the flow was laminar and turbulent, the results revealed significant improvements in heat transfer and pressure drop. Variation of the outer pipe diameter was used to investigate the effects of the annulus parameter on the friction factor and heat transfer. For lower annulus parameters, greater values of Nu and friction factor were found at a given twist ratio (square twisted duct cross section area divided by circular pipe cross section area). The findings are noteworthy because they will aid in the creation of small twin pipe heat exchanger.



a) Twisted square duct ($M=10.6$)
 b) Terminologies for Annulus flow

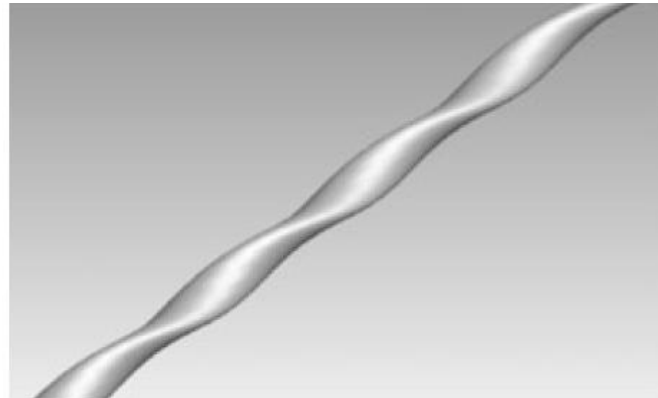


c) Boundary condition

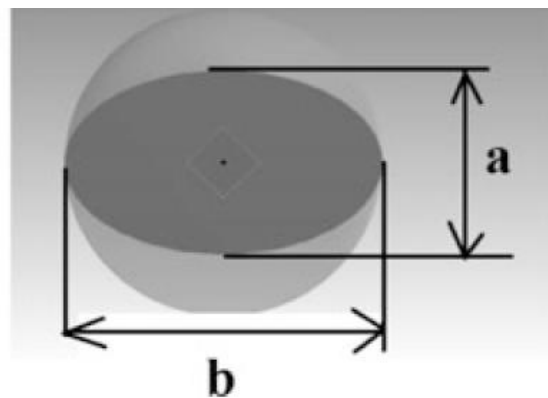
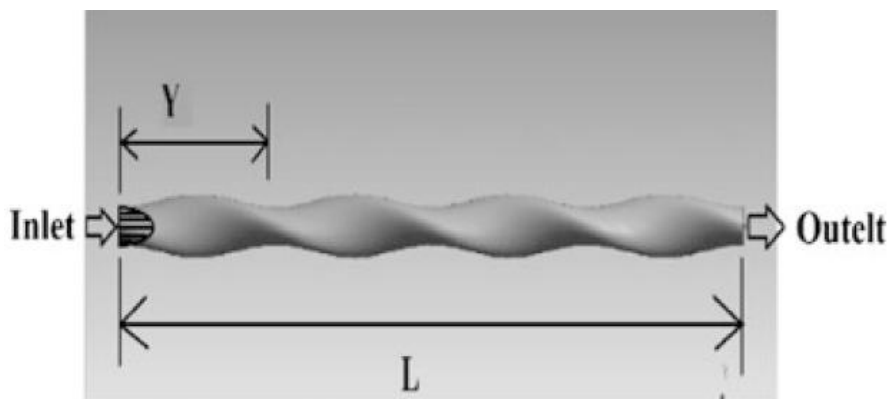
Figure (14) Outer circular pipe and twisted square duct details [24]

Bhattacharyya, Suvanjan, et al., 2016 [25] used computational fluid dynamics (CFD) modeling to investigate an elliptical twisted duct ETD for air-turbulent heat transfer. For several twisted pitches of 0.5, 0.62, 0.75, 0.87, and 1.0, the impact of an elliptical twisted duct on heat transfer with variations in Nu , friction factor (f), and turbulence intensity (Tl) has been explored using both experimental and analytical methods. It has also been looked into in terms of improving efficiency. According to the computational results, the Nusselt number is higher for the elliptical duct's smooth circular tube. This reveals that it has a beneficial effect on heat transfer. The axial variation of the

friction factor value was reduced rapidly in the ETD. The local friction factor decreases as the Reynolds number increases. The heat transfer efficiency is greater than unity across the full Reynolds number range for most ducts. According to the numerical analysis, the heat transfer rate may be increased by using a lower twisted pitch. However, when turbulence intensity rises, flow resistance rises with it. According to the calculations, A twist ratio of 0.87 to 1 would result in much improved efficiency. The elliptical twisted duct's ease of manufacturing makes it a promising heat transfer enhancement.



a)



b)

Figure (15) a. Section of twisted elliptical duct, b. elliptical twisted-duct major and minor axes [25]

Bhattacharyya, Suvanjan, et al., 2019 [26] examined the heat transfer and fluid flow properties of turbulent flow through a heat exchanger fitted with a circular twisted tube where the study was both numerically and experimentally. The tests are carried out for Reynolds number ranging from 100 to 50000, which include laminar, transitional, and turbulent regimes, as well as three length and pitch ratios. With a small pitch ratio and a large length ratio, the twisted geometry results in the highest increase in heat transfer, with the Nusselt number

increasing by roughly 50% on average when compared to the plain tube. When the length to pitch ratio and pitch to length ratio both fall, the friction factor decreases and increases as the Reynolds number rises. According to the findings, a long length ratio and a small pitch ratio result in a higher heat transfer rate with a low performance cost. The performance factors are larger than unity in almost all of the situations studied.

V. CONCLUSIONS

From the literature review, it can be noticed that by collecting a large number of studies related to the current study, a lot of research was found. However, no work existed that was comparable to present work. The aim of this study was to deal with the effects of the twisted elliptical tube on heat transfer in several cases and compare that with other configurations.

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