Journal of Mechanical Engineering Research and Developments
ISSN: 1024-1752
CODEN: JERDFO
Vol. 44, No. 5, pp. 345-357
Published Year 2021

Review of Heat transfer enhancement using hybrid Nano fluid or twisted tape insert

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ABSTRACT

For all the aspects of our life, the heat energy is very important. There are many industries including air conditioning, the processing of chemical plants, thermal power plants, refrigeration equipment, etc. which faced with many problems like utilize effecting, conservation and heat recovery. Heat exchangers include large investments for many capital and operation costs. Therefore, becomes very important to design heat exchangers that make it more efficient, energy saving, less cost and even materials. There are many different techniques known as heat transfer enhancement are applied, we elaborate two of these techniques, the hybrid Nano fluid and twisted tape insets. In this work, we abridged the agents affecting the acting operation of hybrid Nano fluid in enhancing the thermal performance of heat transfer systems, significantly a review on work done in the area of heat transfer growth using twisted tapes has been carried out.

KEYWORDS

Heat transfer enhancement, hybrid Nano fluid, twisted tape insets, heat exchanger, related works.

INTRODUCTION

Heat is one of energy mode that can be transferred in spite of the fact if the temperature is divergent between the system and its setting. For [very] long time ago, the researching on heat transfer recently has taken significant attentiveness, with sound many applications with multiple areas such as cooling of electronic devices, solar energy system and manufacturing systems Jiji et al. [1]. There are three forms of heat transfer convection, conduction and radiation. Conduction is merely transfer of heat from matter for more energetic to another one which is less energetic particle consequently of the interactions between the particles. Convection is simply the transfer the heat between solid surface and contiguous moving fluid, on other hand, in radiation the heat is sent out by a level in form of electromagnetic waves based on the changing of the atom in electronic configurations Jiji et al. and Holman [1, 2]. Heat energy is inevitable to people for our existence and that made humans to tried by the investigation for its absolute utilization in indigenous activities and many commercial industrials. In order to lessen, the financial resources that go into generating the heat energy, it has become very essential to design heat exchanger which that more effectual in the performance along the same lines it lessens or saves energy, material and cost. In this respect, heat transfer becomes an influential process. Wang et al. [3] insinuated that the enhancement technology of heat transfer yield in decreasing of the heat exchanger size and that resulted in less capital cost.

Heat exchanger techniques van be classified into three methods:

- Active method requires some external power for the enhancement.
- Passive methods not require anything in input for enhancement.
- Compound method which is blending between two above methods.

The heat transfer was studied in different application and by using different technologies. It was found that mechanisms of heat transfer and flow characteristics effected by porosity considerably, aspect ratio, Rayleigh number, and Darcy number [4-11]. Bergies et al. [12], the efficient usage of heat dominates the operation and economic design of process plants. Noticeably there are various techniques are applied, we will appoint out related works on two of most important techniques are hybrid nano fluid and twisted type insets. In previous literatures there are a multiple of reviews, so on in this present paper an effort has been implemented to review various analytical on both, experimental and numerical studies done on twisted tapes.

TYPES OF NANO PARTICLES

As figure 1 the Nano particles might be divided into Nano fluids consisting of carbon and polymeric nanotubes, metal Nano fluids and ceramic Nano fluids. For the shape, the Nano particles has several divergent shapes shown in figure 2 for example the nanotubes with cylindrical shape based on the shape of Nano particles and one of the explanation for different shapes is that the heat can travel faster with more distance. Due to nanofluids contain nanotubes that need more pumping power through the channel.

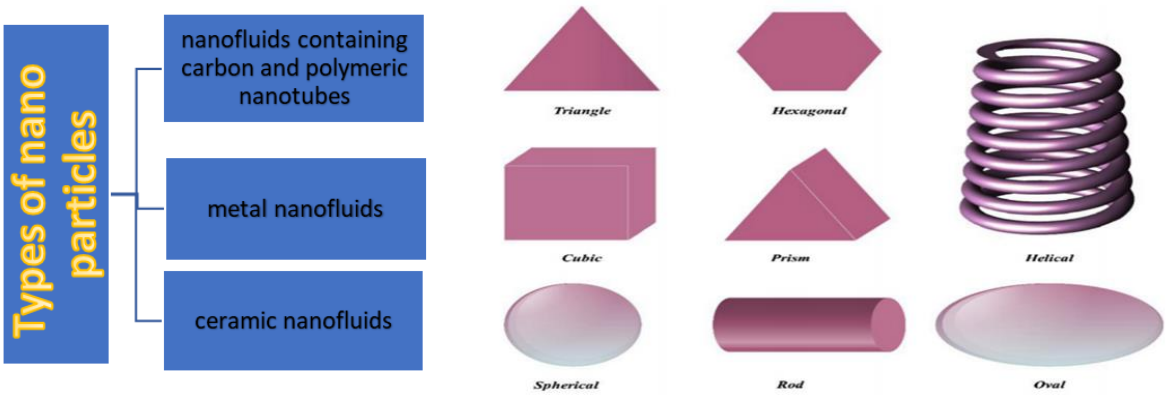


Figure 1. Types of Nano particles [43]

Hybrid Nano fluid

The nanofluids was produced by Choi et al. [13], made up the base fluid and nanoparticles. The thermal conductivities are basically in nanoparticles, usually the extent is higher than of base fluids with size that smaller than 100 nm and the nanoparticles enhance the heat transfer performance which is more than base fluids. The base fluids may be organic liquids like refrigerants, etc., oils, water and other common liquids. The nanoparticle materials include constant chemically metals like (copper, gold), metal oxides like (silica, titania, alumina, zirconia), (Al_2O_3 , CuO)like oxide ceramics, metal carbides, carbon in many molds like (fullerene, carbon nanotubes, diamond) and functionalized nanoparticles Sarkaret al. [14].

Given the importance of heat transfer technique and the availability of multiple researches in this, domain we will introduce a group of them as follows: -

Yıldız, et al. [15] used a mixture of two partials Nano fluid Al_2O_3 + SiO_2 / Water to show a comparative study between theoretical and experimental thermal conductivity in a square cavity. Two different Rayleigh numbers $Ra=10^4$, $Ra=10^5$ with three concentrations (φ= 1,2,3%), tested experimentally diameter for SiO_2 is (20nm), Al_2O_3 (43 nm). The outcomes of this paper**,** the mean Nu number increased with increase of Ra number or partial volume fraction. However, for SiO_2 /water nano fluids has inverse effect, which mean Nu, reduced as its volume fraction was increase regarding to the small size of SiO_2 Nano partials. In additional low thermal conductivity by the theoretical model. yet the enhancement effect of Al_2O_3 /water on heat transfer at φ=1, 2% but reduces at φ=3% volume fraction.

Kumar et al. [16], Experimental analysis radio effect for particle mixture on the mini channel heat sink performance in hybrid Nano fluid. The cross section for the heat sink 1 mm × 3 mm, the length 30 mm, the number of mini channels are nine parallel rectangular and made of aluminium. Al_2O_3 volume concentration 0.01% and for synthesizing water-based hybrid Nano fluids use (10:0, 8:2, 6:4, 2:8 and 0:10) with regarding different parameters. The outcome reveals the increasing in MWGNT fraction there are growing in heat transfer coefficient, pressure drop, Nusselt number and even friction factor. For MWCNT Nano fluid the utmost heat transfer coefficient increase 44.1% and pressure drop 68.1%. At the total volume concentration, the optimum mixing radios 6:4 hybrid Nano fluids comparing with the other.

Hussein et al. [17] produced an experimental study of using hybrid Nano fluid particle aluminum Nitride (30nm) diameter into the ethylene glycol as a base fluid. Following through a double pipe heat exchanger with different concentration. The nanoparticles scattered in an EG. The writer uses Reynold number range of from (500 to 1750). The outcomes denoted that when the flow rate increases the friction Factor was decrease in the inverse relation while when the flow rate increasing then an Nusselt number increase. Rahman et al. [18] invested disposed lid-driven triangular enclosure and copper-water as a working particle Nano fluid with many concentrations chosen Φ=0%,4%,8% and 10% under Newtonian, incompressible and laminar conditions, outcomes show that the Nano fluid can adjust the properties of fluid and for solid volume fraction there is an [significant] effect. So, this study denotes the correlation between the heat transfer coefficient and Nano particles.

Singh et al. [19] examined the effect of tapered wire coil in double pipe on thermophysical properties:

-Al_2O_3 50 nm , MgO 90 nm.
-water as a base fluid at Reynold number range (9000-40000).

Used sorts of wire coil (convergence type, difference type, convergence –divergence type) were made of aluminum one end with 13 mm diameter and another end 6.5 mm diameter with a constant pitch of 10 mm. Because of the decreasing in both hydrodynamic and thermal boundary layer thickness, it is found increasing in Nu and fraction factor drop when Re number was increasing, till the long path flow conducts to increase the friction factor. The study pointed out that the high enhancement in heat transfer at wire coil type divergence because the high contact surface between fluid and wall.

Kaska et al. [20] researched on hybrid Nano fluid flow in a flat horizontal tube 2 m in length. They used for the study:

- A base fluid obtains Al_2O_3 nanopraticles into water and Aluminum Nitride.
- Uniform heat flux.

At the end showed an increase with density and viscosity successively when the volume fraction has been increased. In additional, when Reynold number increased based on the velocity it led to increased Nusselt number. Abdolbaqi et al. [21] numerically studied for a Nano fluid dripped in water flow in square duct, regular heat effluence and turbulent flow. The researcher used divergent forms and volumes fraction of Nano particles (Al_2O_3, TiO_2, CuO), (1-4%) successively. The result registered that highest value in Nusselt number found at Cuo for the lowest viscosity and high thermal conductivity, and also found the direct relation between heat transfer coefficient and the concentration value.

Kumar et al. [22] stated a research with two sides experimentally and numerically using channel heat sink, using a hybrid Nano fluid in Two-phase mixture mode. They used Al_2O_3-TiO_2, hybrid Nano fluid with concentration of 0.1% even with multiple nanoparticle mixture (10:0 to 0:10) as coolant. They show by increase in hybrid Nano fluid the heat transfer coefficient even increases as the particle radio of Al_2O_3, with the coolant flow rate there increases in friction factor and pressure drop. Heat transfer coefficient and Nusselt number increases with the increase inlet temperature. Kumar et al. [23] used the water with different nanoparticles mixture scattered hybrid Nano fluids. For nanoparticles they. [regarded] Al2O3, MgO, SiC, AlN, MWCNT and Cu even with divergent collection like oxide-metal, oxide-nitride, oxide-carbide, oxide-carbon nanotube, with equal radio, (0.1-0.5LPM) for volume flow rate in laminar, (20-40 C) for fluid intel temperature and 50 W/cm^2 for heat flux. The outcome stated as increasing in the flow rate, for thermal resistance there is a decrement, amend in heat transfer coefficient.

Moldoveanu et al. [24] provides experimentally study for hybrid nanofluids, which made of Al_2O_3–SiO2 in pure water as thermal conductivity. For comparison, they provide different volume fraction Al_2O_3–SiO_2, performing 3- dimensional analysis in-depth. By preparing three kinds of nanofluids with different temperatures range (20-50 C) total volume fraction 1%-3%, the study shows increase volume fraction as increase of thermal conductivity. In the study they proposed some correlation. Mehryan et al. [25] provided a free convection heat transfer as numerical study with utilizing water based Al_2O_3-Cu consider two types porous media, aluminium metal foam and glass ball for porous matrix. Hybrid volume fraction range ($0 - 2 \times 10^{-2}$) with Darcy-Rayleigh ranging numbers ($1 - 10^3$). The experimental data provided enhancement in thermal conductivity, using nanofluids reported there is a decrement velocity flowing and strength flowing with more significant by compering to Al_2O_3 water mono Nano fluids.

Hooman Yarmand et al. [26] accomplished experimentally for heat transfer performance and friction loss hybrid Nano fluids with graphene Nano platelet and Platinum, by non-changing in the limit parameters of heat flux the experiment. Between (0.02% and 0.1%) the weight percentage ranges for Nano fluid movement and from (5000 to 17500) for Reynold number. For Nusselt number the best value registered 28.48% and with friction factor there is augmentation with highest load of nanocomposite (0.1 wt%). Naik et al. [27] worked on enhancement of heat transfer with using three divergent non-Newtonian Nano fluids which including Fe_2O_3, Al_2O_3 *and* GuO nanoparticles in aqueous carboxymethyl cellulose (CMC) based fluid. The cold fluid of flow rate was impact with preparing concentration range (0.002-0.1 wt), on shell side used Nano fluid and tube side on water. Different condition used like cold water with flow rate (0.5-5 lpm), Nano fluid temperature (40-60 C). The research states the increasing of Dean number, stirrer speeds, concentration of Nano fluid and shell slide fluid temperature leading increasing in Nusselt number. revealing that CuO/CMC-based Nano fluid more efficient in heat transferring than two others.

Shahsavar et al. [28] analyzed the influence of hybrid Nano fluid for double pipe mini channel, in the tube side the Nano fluid was invested as coolant and annulus side for hot water flow. For preparing the water-based hybrid Nano fluid they used two nanoparticles including tetramethylammonium hydroxide-coated Fe_3O_4 nanoparticles and gum Arabic-coated carbon nanotubes. The result of this study was for higher heat transfer rate, efficiency and heat transfer coefficient was in non-Newtonian hybrid Nano fluid than Newtonian hybrid Nano fluid. On parallel side the Newtonian hybrid Nano fluid was more impact in performance evaluation criterion, pumping power and pressure drop. Hayat et al. [29] worked for new model hybrid Nano fluid in three dimensions to inspect the effect of chemical reaction, heat generation and thermal radiation. The outcome reveal when increment in heat generation there is increasing in thermal boundary of the hybrid Nano fluid. By increasing the chemical reaction and Schmidt number there is enhancement in the rate of mass transfer at the surface. By increasing in rotation parameter the concentration profile has un increment.

Balla et al. [30] studied the flow of CuO–Cu hybrid Nano fluid in a circular pipe and discovered that the heat transfer rate increased by 30–35 percent as compared to normal water and the findings revealed that the heat transfer coefficient of Nano fluids is highly dependent on the nanoparticles. Rahman et al. [31], numerically forced heat transfer by convection on an Al_2O_3–Cu/water hybrid Nano fluid. It was discovered that the nanoparticles used in the hybrid Nano fluid had a significant impact on the thermal performance of the mixture. It can be shown that the average heat transfer coefficient increases as the Reynolds number increases. The average heat transfer coefficient increases as the volume concentration of hybrid nanoparticles increases. This improvement in the average heat transfer coefficient is due to the Al_2O_3–Cu/water hybrid Nano fluid's mass, viscosity, and thermal conductivity. Thermal conductivity is proportional to temperature.

Suresh et al. [32] tested the turbulent heat transfer of hybrid Al_2O_3–Cu/water hybrid Nano fluid, and an increase of around 8.02 percent in heat transfer rate was observed as compared to pure water. Their findings have revealed that 0.1 percent Al2O3–Cu/water hybrid Nano fluids had a significantly higher friction factor than 0.1 percent Al2O3/water Nano fluids. Pak et al. [33] used Al_2O_3/water and TiO_2/water Nano fluids, researchers studied convective heat transfer in the turbulent flow regime. They discovered a 3–12 percent decrease in heat transfer coefficient even though the Nusselt number and Reynolds number increased with particle volume concentration and Reynolds number. With increasing volume concentration and Reynolds number, the Nusselt number for distributed fluids improved. As compared under the condition of constant average velocity, the convective heat transfer coefficient of the distributed fluid was observed to be 13% lower than that of pure water. As a result, a better collection of particles with higher thermal conductivity and larger size is needed.

Yarmand et al. [34] investigated the volumetric nature of a functionalized graphene Nano platelet platinum (GNP-Pt) hybrid Nano fluid. At 20–40 C, they calculated the density of hybrid Nano fluid as a function of weight fraction and temperature, with particle weight percentages of 0.02 percent, 0.045 percent, and 0.06 percent. Based on the results of the experiment, the density of GNP-Pt water-based hybrid Nano fluid increased with increasing nanoparticle concentrations, but decreased as temperature increased. At 40 degrees Celsius, the density enhancement obtained was 0.11 percent for 0.1 percent concentrations.

Benkhedda et al. [35] studied the numerical investigation of the issue of steady forced convection heat transfer and fluid flow dynamics of a hybrid Nano fluid flowing through an isothermally heated horizontal tube considering different nanoparticle shapes. A computational parametric investigation of a tube filled with standard water, (TiO_2/water) Nano fluid, and (Ag–TiO_2/water) hybrid Nano fluid is performed with different volume fractions ranging from 0 to 8% using water as a base liquid. The friction factor in both Nano fluid and hybrid Nano fluid flow increased as the nanoparticle volume fraction increased for all types of nanoparticle forms, while it decreased as the Reynolds number increased. The Nusselt number improved as the nanoparticle concentration and Reynolds number increased. The blade nanoparticle form scored the highest heat transfer rate with the highest nanoparticle volume concentration, followed by the platelet shape, the cylindrical shape, and finally the sphere shape. The maximal values of the friction factor were discovered for platelet-shaped nanoparticles.

Toghraie et al. [36], to create a hybrid Nano fluid, an equivalent amount of zinc oxide (ZnO) and TiO_2 nanoparticles were spread in an ethylene glycol base fluid. They found that as the temperature and concentration of nanoparticles increased, so did the thermal conductivity of the Nano fluid. Higher temperatures and particle concentrations are correlated with greater thermal conductivity than lower temperatures and lower particle concentrations. These findings were consistent with the findings of the previous laboratory research. Akilu [37] produced single and hybrid Nano fluids with concentrations ranging from 0.5 to 2.0 percent, and thermo - physical properties were calculated from 30 to 80 degrees Celsius. Thermal conductivity and specific heat capacity of SiO_2 Nano fluid and SiO_2-CuO/ hybrid Nano fluid as a function of concentration Their findings showed that, regardless of temperature or concentration difference, hybrid Nano fluid has higher thermal conductivity than mono Nano fluid. In addition, the specific heat capacity of hybrid Nano fluid increases with rising temperature and decreases with decreasing concentration. They proposed that the decrease in specific heat capacity with growing nanoparticle concentration is due to solids having a lower specific heat capacity than liquids.

Leong et al. [38] investigated Cu-TiO_2 ethylene glycol/water-based) Nano fluid and compared with those of a non-hybrid (Cu, TiO_2) Nano fluid. The thermal conductivity properties of a copper-titanium dioxide (Cu-TiO_2) hybrid Nano fluid were investigated and compared to those of a non-hybrid (Cu and TiO_2) Nano fluid in this research. The thermal conductivity of the Cu-TiO_2 hybrid Nano fluid improved as the weight percentage of the nanoparticles increased. The hybrid Nano fluid consisting 0.8 wt.% Cu-TiO_2 and polyvinylpyrrolidone (PVP) as a surfactant demonstrated the best thermal conductivity, with a 9.8 percent gain over the base fluid. Some related works with summarize shown in Table 1.

Table 1. summary of investigations of hybrid nanofluids

Author/s	Hybrid nanofluids	Goals parameter
Yıldız, et al. [15]	Al_2O_3 + SiO_2 / Water	Rayleigh numbers, Nu number, volume fraction
Kumar et al. [16],	Al_2O_3+ MWCNT/water	heat transfer coefficient, pressure drop, Nusselt number
Hussein [17]	aluminum Nitride/EG	Reynold number, friction Factor, Nusselt number
Rahman [18]	Copper/water	heat transfer coefficient, volume fraction
Singh [19]	Al_2O_3 +MgO /water	Reynold number, Nu
Kaska [20]	Al_2O_3 + Aluminum Nitride/water	volume fraction, Reynold number
Abdolbaqi [21]	Al_2O_3, TiO_2, CuO/water	Nusselt number, thermal conductivity
Kumar [22]	Al_2O_3, TiO/water	heat transfer coefficient, friction factor ,pressure drop

Kumar [23]	Al_2O_3, MgO, SiC, AlN, MWCNT , Cu/water	Flow rate, temperature, heat transfer coefficient.
Moldoveanu [24]	Al_2O_3–SiO_2/water	Thermal conductivity. Temperature, volume fraction
Mehryan [25]	Al_2O_3-Cu /water	Darcy model, Rayleigh number
Hooman Yarmand [26]		Nusselt number, friction factor
Naik [27]	Fe_2O_3-Al_2O_3-CuO/CMC	Nusselt number, fluid temperature,
Shahsavar [28]	tetramethylammonium hydroxide-coated Fe_2O_4/water	higher heat transfer rate, effectiveness and heat transfer coefficient
Tanzila Hayat et al. [29]	Ag-CuO/water	heat generation, Schmidt number
Balla et al. [30]	CuO–Cu/ water	The results showed that the heat transfer coefficient of Nano fluids is strongly dependent on the nanoparticles.
Rahman et al. [31]	Al_2O_3–Cu/water	The nanoparticles used in the hybrid nanofluid were reported to have a substantial effect on the thermal stability of the mixture.
Suresh et al. [32]	Al_2O_3–Cu/water	The average heat transfer enhancement for Al_2O_3–Cu/water hybrid nanofluid is 8.02% when compared to pure water. The experimental results also showed that 0.1% Al_2O_3–Cu/water hybrid nanofluids have slightly higher friction factor compared to 0.1
Pak et al. [33]	Al_2O_3+ TiO_2/water	Despite the fact that the Nusselt number and Reynolds number increased with particle volume concentration and Reynolds number, the heat transfer coefficient decreased by 3–12%.
Yarmand et al. [34]	graphene nanoplatelet platinum (GNP-Pt)/ water	The hypothesis's findings, The density of GNP-Pt water-based hybrid nanofluid increased with increasing nanoparticle concentrations but decreased with the temperature.
Benkhedda et al. [35]	Ag+ TiO_2/water	-As the nanoparticle concentration and Reynolds number grew, so did the Nusselt number. The friction factor raised as -the nanoparticle volume fraction increased for all styles of nanoparticle forms in both nanofluid and hybrid nanofluid flow, although it decreased as the Reynolds number increased.
Toghraie et al. [36]	ZnO) - TiO_2/ethylene glycol	The thermal conductivity of the nanofluid improved as the temperature and concentration of nanoparticles improved. Greater thermal conductivity is associated with higher temperatures and particle concentrations than with lower temperatures and particle concentrations.
Akilu [37],	SiO2-CuO/ water	Specific heat capacity of hybrid nanofluid increases with rising temperature and decreases with decreasing concentration. They proposed that the decrease in specific heat capacity with growing nanoparticle concentration is due to solids having a lower specific heat capacity than liquids.

Leong et al. [38],	Cu-TiO_2/ethylene glycol/water	-The Cu- TiO_2 hybrid nanofluid with added PVP surfactant showed the highest improvement in thermal conductivity - The thermal conductivity of Cu-TiO_2 grew in proportion to an increase in the sonication time used during the nanofluid preparation. - When SDBS or PVP surfactant was applied to the base liquid, Cu nanofluids had poorer thermal conductivity than TiO_2 and Cu-TiO_2 nanofluids.

TWISTED TAPE INSETS

The most effectual approach is circular tube with the insertion of twisted tape. For heat transfer enhancement, twisted tape makes more longer path, whirling flow and blockage for the flowing that all of these are the powerful factors for the enhancement of heat transfer. By using this technique there is increasing pressure drop and heat transfer rate. Numerous works have demonstrated that by adding a twist tape, heat transfer is amended as shown below:

Eiamsa-ard et al. [39] spaced that experimentally provides heat transfer in the double pipe heat exchanger with the orderly twisted tape components. The inner diameter of the tube is 50.6 mm and the outer diameter of the tube is 25.8 mm by utilizing hot and cold water in tube side and shell side. The stainless steel was made of twisted tapes with 1500 mm in length and 1 mm in thickness. By using two different cases were full length at twisted radios (6.0 and 8.0) and many free space radios (1.0, 2.0, and 3.0). The outcome of this experimental show that increasing in heat transfer with twist radio while the friction factor and heat transfer coefficient will amend by increasing in the free space radio.

Karamallah et al. [40] numerically and experimentally introduced a horizontal tube for turbulent floe regime and uniform heat flux. Three types of Nano fluids (alumina ceramics Al_2O_3, zirconia oxide CuO and copper oxide ZrO_2)/ distilled water in a single phase. the twisted radio in the [work] was (4, 6, 8) and was achieved with many twisted tapes (twisted with V cut, typical type and wise counter clock wise type). The [examination] was done for nanoparticle concentrations 0,0.1, 0.05,0.1,0.5,1. The result shows more enhancement when φ=0.3%, at twisted radio 4. By increasing the temperature with the increasing of flow rate the flow become more Congenial.

Salman et al. [41] many work produced for friction factor and heat transfer where two types of swirl flow were used (Parabolic-cut twisted PCT tape and Classical twisted tape CTT) with the twisted radio (2.93, 3.91 and 4.89). The cut depth was (0.5, 1.0 and 1.5 cm) and volume concentration of CuO (2% and 4%). The [outcome reveals] that by using CTT and PCT increases with the twisted radio and decreases in cut depth the enhancement will support heat transfer rate and friction factor. Despite the fact that the work supplied that increasing in the heat transfer enhancement by increasing in the volume fraction of CuO nanoparticle.

Bas, et al. [42] stated the conduct of heat transfer and flow friction in a twisted tap. From the tube wall, the twisted tapes are detached and inserted with divergent twisted radio and clearance radios. For working fluid used air and under turbulent flow condition. The work outcomes reveal that, with twisted radio when the Reynolds number increase the Nusselt number was increase too. in this work.1.756 was the maximum heat transfer. Rashidi et al. [43] used Nano fluid, helical coil inserts as a compilation together for heat exchanger that can lead to increase in hydrothermal characteristics, and in the last years, there are numerous examinations.

Thianponget al. [44] examined done on enhancement of heat transfer by using twisted tape whirl and by using divergent pitch ratios (0.7 and 1.0) to pressure loss in dimpled tubes. 12000 to 44000 range for Reynolds number with (3, 5 and 7) for twist radio. The outcome of this experiment the twisted tape is adjusted with heat transfer coefficient and friction factor in dimpled tube are higher than plain tube and dimple tube acting alone even existed that heat transfer coefficient and friction factor increase by decreasing in pitch radio and friction factor.

Jaisankar et al. [45] completed examination on the heat transfer, friction factor and thermal performance of the thermosiphon solar by using divergent twisted radios (3, 4, 5 and 6) to examine the effect spiral twisted which result in increased the heat transfer with the pressure drop. The outcome reveals as, with minimum twist radio that twisted tape collector make more enhancement for heat transfer than plain tube collector and by increasing the twist radio there are. Step- by- step devaluated.

Wang et al. [46] tested in carbon steel tube and in high pressure; preheaters used copper smooth tube because tube may have corroded by boiler with ammonia water. The [outcome reveals] as heat transfer coefficient of the carbon steel smooth tube smaller than spirally fluted tube.

Murugesan et al. [47] tested on the heat transfer friction factor and thermal performance factor the effect of V-cut twisted tape insert with divergent twist radio (2.0, 4.4 and 6.0) even with combinations of depth and width, first combination (DR= 0.34 and WR=0.43), second (0.34,0.34) and last (0.43, 0.34). The outcome reveals as by decreasing in twist radios with decreasing in WR and increasing DR the V-cut twisted tape will supply more heat transfer rate.

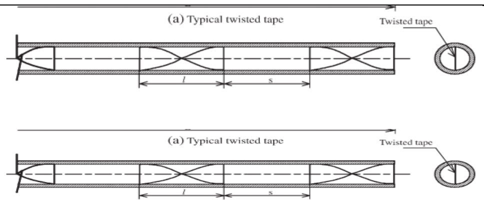
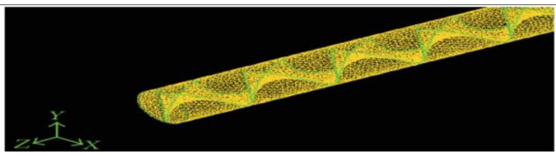
Al-Fahed et al. [48] accomplished a series of experimental to assert on the heat transfer the impact of tube tape in isothermal tube with fully develop turbulent. There are fifteen tapes, three groups each one has twisted tape radio and each group has divergent width. The outcome reveals as increasing the heat transfer enhancement while decreasing the tube-tape clearance for example twisted radio = 3.6 the enhancement 17%, twisted radio= 5.4 the enhancement = 9% and twisted radio= 57.1 the enhancement= 4%.

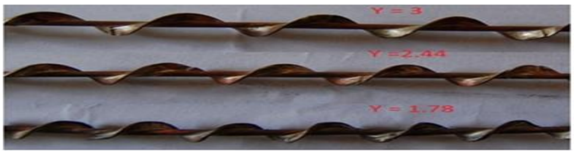
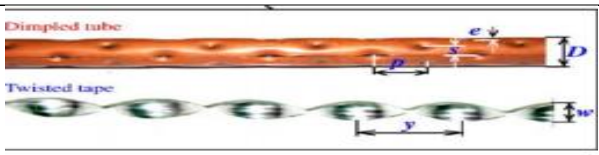
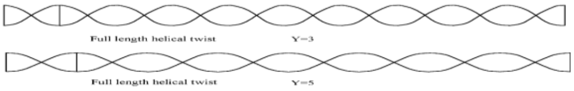
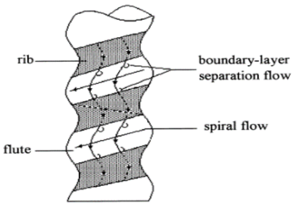
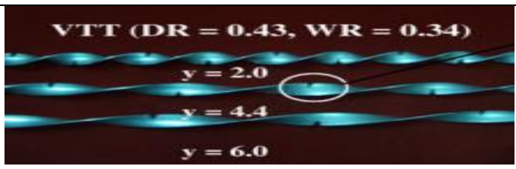
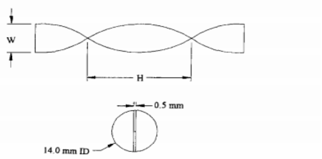
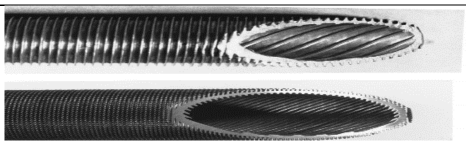
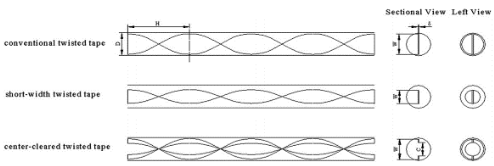
Webb et al. [49] accomplished tubes internal spiral rib for heat transfer and friction factor with geometric parameters like (18 to 45) for rib starts, (25 to 45 degree) for helix angle and (0.33 to 0.55 mm) for rib height. The outcome reveals as at the rib the flow splitting was enhanced with increasing in a surface area.

Guo et al. [50] produced numerical work in twisted tape for heat transfer enhancement by proposing a center cleared twisted tape to make good performance in thermohydraulic. In the laminar tubular flows, they performed numerically between short width and center cleared twisted tape. The outcome reveals that divergence in thermal behaviors between each other. For center cleared twisted tape the thermal performance can enhance by 7%-20%.

Bhattacharyya et al. [51] experimentally worked for friction and Nusselt number data by fitting Centre-cleared twisted-tape with laminar flow circular duct that having transverse ribs. By producing the predictive friction factor and the correlations of Nusselt number. The outcome reveals as there is compilation between Centre-cleared twisted tape and transverse ribs which accomplish significantly better than singular enhancement technique.

Table 2. Configuration sketches of different types of twisted inserts in the above studies

Authors	Schematic of twisted tape	Type of study	Working fluid
Eiamsa-ard et al. [39]		experimental	water
Karamallah et al. [40]		numerically and experimentally	Nanoparticles with water
Salman et al. [41]		numerical	water
Bas et al. [42],		experimental	Air

Rashidi et al. [43],		experimental	Nano fluid
Thianpong et al. [44],		experimental	air
Jaisankar et al. [45],		Experimental	ammonia-water
Wang et al. [46],		experimental	NH3±H2O
Murugesan et al. [47],		Experimental	Water
Al-Fahed et al. [48],		experimental	water
Webb et al. [49],		numerically	water
Guo et al. [50],		numerically	water
Bhattacharyya et al. [51],		experimental	water

CONCLUSION

For a future work there are numerous clearance and gabs for heat transfer enhancement especially with the two techniques a mentioned above, one of them for twisted tape to accomplish adjustment with best level more imitation and experiments requirements with a vast ranging in geometry parameters. For hybrid Nano fluid most work concentrate on thermal conductivity while ignoring the others, needing more work on stability and there are abundant challenges in these two techniques.

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