Comprehensive Review on Double Pipe Heat Exchanger Techniques

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Abstract. The heat exchanger is a thermal device use for heat exchange between higher fluid temperature to lower fluid temperature. Growing need to improve the heat exchangers effectiveness and develop a broad range of investigations for enhancement heat transfer rate along with minimizing the size and cost of the industrial apparatus accordingly. The purpose of the present work to review the articles that related to major types of double pipe heat exchanger and factor effect on heat transfer rate and pressure drop the double pipe heat exchanger considers one of the apparatuses which are used in among industries. Researchers proposed several models of double pipe heat exchanger heat exchangers. Double pipe heat exchangers are used in many industrial processes, cooling technology, refrigeration device, sustainable energy applications and another field. Different classification of Double pipe heat exchangers includes parallel, counter and cross flow. Research operate were also conducted to improve the effectiveness of Double pipe heat exchangers by using turbulators, inserts, rips at both ends, modifying the geometry of channels, methods of injection fluids and, etc. This study reported various research works of Double pipe heat exchangers research works in a technique to satisfy the right effectiveness deciding parameter.

Keyword: Double Pipe, Heat Exchanger, Sustainable Energy, Enhancement of Heat Transfer, Refrigeration & Cooling Technology.

1. Introduction

Heat exchangers would be classified according to several designs. The first type is based on flow direction (parallel fluids flow, counter fluids flow, and cross fluids flow) [1]. The second type is based on the construction of the heat exchangers (like tubular or plate heat exchangers) [2]. Also, the third types depend based on the way of contact between the fluids (direct or indirect) [3]. Heat exchangers have various types of applications [4] regulating from transformation [5], retrieval of the thermal energy field in industrial, commercial and domestic processes [6]. Some universal application includes cooling of sustainable energy implementation, condensation enforcement, products of several agricultural, chemical and pharmaceutical scope, sensible heating, production of steam generation in power plant, waste heat recapture and fluid heating mode in manufacturing [7-11]. Improve the...
performance of heat exchangers to make other economical design of heat exchanger that aid to improve thermal energy exchange, select the better component to increase thermal exchange rate, and reduce cost which related to thermal exchange process [12].

There are several designs that have been made to moderate the enhancement of heat exchange techniques to reduce the size, costs of heat exchangers building to raise the performance of heat exchangers [13-16]. An extensive of research is done on all types of enhancement techniques. Generally, enhancement of heat exchange methods can be classified in three major categories [17]. firstly, the active enhancement technique involves additional external power input for the enhancement in heat transfer methods, for example, Mechanical Aids, surface vibration, fluid vibration, electrostatic fields, injection suction, Jet impingement, etc. Some cases of this technique have been investigated in [18-19]. Secondly Passive enhancement technique the process of heat transfer enhancement does not require any addition of external power input [20]. Convective mode is one of several ways used to enhance thermal exchange rate by increase the surface effectiveness area and time residence of thermal fluids. In this method, various types of inserts require to enhance and augment the heat transfer rate. For example, baffles, twisted tape, ribs, wire coil, plates, helical insert of the screw, insert meshing, convergent–divergent conical rings, conical rings, etc. Some cases of this technique have been investigated in [21-31]. Lastly, the compound enhancement technique refers to the use of any two or extra more techniques from active and passive may be utilized simultaneously to improve the rate of heat energy transformation for any device, which is larger than getting the result by any of those separate techniques. This technique has been investigated in [32].

The importance of enhancement the thermal energy transformation of heat exchangers performance has moderate and utilize of several modes refers to heat transfer performance. This technique growing convective mode by decrease the thermal resistance in a double pipe heat exchanger [33]. Employ of augmentation thermal energy transformation techniques lead to utilizing in convective coefficient mode but at the increased value of pressure drop. To reach a high rate of heat exchange while taking concern of the rise in insufflation power, different techniques have been approached in modern decade [34]. Recently, modes swirl flow have been used for raising the heat energy exchange in different industries [35]. The major aim of this paper is to present the several modes that are used to improve thermal energy transformation between different fluids. An overall survey of several turbulators (coil pipes, extended object on surfaces (fins, strips, winglets), tough surfaces (outer or inner corrugated pipes, Ribs) and devices caused swirl flow like twisted tape, conical rings, entry snail turbulators, vortex rings, coiled wires) are research.

2. Scope in researches of double pipe heat exchangers
Suxin Qian et. al [36] argued the rudimentary principles, features and major differences of regeneration methods for various typical cooling technologies. This study attempts to prove that the regeneration methods are grouped into three categories: recuperative type for steady-state operating systems, regenerative type for systems under cyclic operation, and heat recovery type for systems with solid-state functional materials. For each of the three regeneration methods, their physical principles, a summary of their state-of-the-art development status, and assessments of their advantages, limitations and unique features are presented.
A. Bejan et.al [37] analyzed the flow architecture toward greater performance in a counter flow heat exchanger by attaching a plenum with the core at both ends. In this formation, the thermal resistance reaches its lowest value. This conclusion holds for fully developed laminar flow and turbulent flow through the core.
Kevin J. Albrecht et.al [38] exhibited a steady-state reduced-order model of a shell-and-plate moving packed-bed heat exchanger and is used to investigate the design considerations and performance limitations. It is an effective modeling methodology for simulating moving packed-bed heat exchangers for the application of particle-to-sCO2 heat transfer in next-generation concentrating solar power (CSP) plants. Overall heat transfer coefficients for the particle-to-sCO2 heat exchanger at CSP
operating temperature (500-800 °C) can approach 400 Wm−2K−1 using particle channel dimensions of 4 mm with particle diameters of 200 µm. Han Xiaoxing et.al [39] inspected a new concentric tube heat pipe heat exchanger. It was designed and expected to be used in integrated waste heat recovery equipment with higher heat transfer efficiency at lower temperature heat sources. The findings showed that when the length of the evaporator was 260 mm, the inclination angle was 60°, the flow of cooling water was 0.5 m³/h, the cooling water temperature was 30 °C, the new heat exchanger delivered a better heat transfer performance with maximum heat transfer quantity that is about 1600 W, and the average thermal resistance is 0.042 °C/W.

Z. Said et.al [40] investigated an efficiency enhancement of the heat exchangers by reserving the overall cost and energy consumption. Shell-and-tube heat exchanger operating with CuO/water Nano fluid is investigated. Experimental outcomes highlight the improvement of heat transfer due to nanofluids. As a result, the overall heat transfer coefficient increased by 7%, convective heat transfer increased by 11.39% and a reduction in the area of 6.81% was achieved.

N. Piroozam et.al [41] came out with the thermal performance and fluid features of counter flow heat exchangers (CFHEs). In this simulation, the impact of parameters is studied and CFHEs are solved unilaterally using various numerical procedures. It has been concluded that all procedures will improve the performance of the CFHEs.

T.N. Verma et.al [42] speculated the thermal performance by using different pipes surface shapes such as non-corrugated and corrugated pipes of the heat exchanger. In the case of corrugated pipe, the pitch and depths are varied. The largest heat transfer coefficient value is achieved with ribs of helical shape have 4 mm pitch and 1.5 mm depth with the several values of Reynolds number from 5000 to 17000, mass discharge varies from 0.03 to 0.13 kg/s and 0.04 to 0.14 kg/s for hot and cold fluid. The length and diameter of the pipes are 25.4 mm and 2000 mm. The artificial neural network is modeled for predicting the heat transfer coefficient.

J.M. Gorman et.al [43] attempted to discover the thermal and fluid flow design of a double-pipe heat exchanger in which the wall of the inner pipe is helically corrugated. A comparison is made between a smooth-walled double-pipe heat exchanger and corrugated double-pipe heat exchanger. Reynolds numbers for the investigated cases ranged from 420 to 2000.

Abdalla Gomaa et.al [44] showed the experimental and numerical investigation of the triple concentric-tube heat exchanger with reference to the double tube heat exchanger. The fluid being used is water. The numerical CFD model is developed using a finite volume discretization method and is validated. Correlations of Nusselt number, friction factor and heat exchanger effectiveness with the dimensionless design parameters are also presented.

There are major factors affecting the double pipe heat exchanger performance are turbulence, dropping in pressure, coefficient of heat transfer, fouling, the ratio of flow rates on the inner tube side to outer tube side, length of heat exchanger and type of inserts [14-30-45]. Table (1) illustrate several design and results for authors.

**Table 1. Survey on Different flow in Double Pipe Heat Exchanger.**

| Authors            | Procedures                                                                 | Findings                                                                                                                                 |
|--------------------|----------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| G.A. Quadir et.al  | Investigating the performance of a triple concentric pipe heat exchanger   | The temperature variations predicted by using FEM follow closely to that of the experimental findings. Parametric studies are also being fulfilled on individual design parameter of the heat exchanger. |
| [46]               | numerically using finite element method under steady state conditions for both insulated as well as non-insulated conditions. |                                                                                                                                           |
| Tianyi Gao et.al   | Predicting the transient response of an                                   | This study comes up with fundamental                                                                                                       |
unmixed-unmixed cross flow heat exchanger by numerically solving the established thermal dynamic model. Transient response for different mass flow rates and inlet temperatures are analyzed. Transient conditions such as step and linear ramp functions are used for the variation of flow rate and step, ramp and exponential functions are applied to the fluid inlet temperature. Insights that can improve the cooling unit performance of the heat exchanger.

M. Sheikholeslami et al. [32] Presenting a forced convective turbulent hydrothermal analysis in a double pipe heat exchanger. Perforated turbulators are used in annulus area.

K. M. Shirvam et al. [45] Utilizing turbulent models K - $Ε$ and Darcy - Brinkman - Forchheimer to accomplish heat transfer mode and exchanger influences. The boundary parameters, Reynolds number, Darcy number and porous substrate thickness are analyzed. It is manifested by experimentation that thermal performance reinforces with augment of open area ratio and temperature gradient decreases with augment of pitch ratio. NSGAII is applied to optimize the design. Maximum thermal performance obtained at $η=1.59$ which is occurred for $Re=6000$, $λ=0.07$, $PR=1.06$. Numerical analyses are fulfilled to inspect finned tube heat exchanger with and without winglets at the fin surface.

P. Wais [48] Scrutinizing thermal efficiency of single row cross flow heat exchanger and comparing it to the fin/tube weight. The fundamental parameters to be considered are fin thickness, length and orientation of winglet.

Shuyong Liu et al. [49] Designing a non-contacted double-walled-straight-tube heat exchanger for Lead-Bismuth Eutectic (LBE) loop KYLIN-II. It is identified that the flow rate and temperature distribution influence the performance of the heat exchanger. The results of numerical simulation reveal that non-uniform LBE flow does not affect thermal performance of the heat exchanger filled with powder in the gap between tubes.

Soheil Soleimani kutanaei et al. [50] Numerically studying the effects of different tube spacing and the inlet water vapor mass fraction on the overall performance of a membrane-based heat exchanger using a combined condensation model based on the capillary condensation and condensation on a solid wall. The results were obtained in terms of the Euler number, dimensionless volumetric heat transfer density, and contours of the water mass fraction and temperature distribution inside the transport membrane condenser (TMC) heat exchanger.

Uttam Roy et al. [51] Evaluating the performance parameters of shell and tube heat exchanger (STHX) through simulation modeling. The In the validation process different training algorithm are used to train the network structure. The result shows that the proposed
performance parameters include energetic plant effectiveness, energetic cycle efficiency, electric power; fouling factor and cost are analyzed with the help of feed forward back propagation network (FFBN) algorithm.

Ma et.al [52] Studying heat transfer experimentally between super critical CO$_2$ and water H$_2$O near the artificial - critical temperature liaisons are presented as polynomial relations. Increase of SCO$_2$-side pressure reduces the total and SCO$_2$-side heat transfer coefficients

Sheikholeslami et.al [53] Investigation of turbulent flow of fluids and heat transfer mode Values of Nusselt number of water side flow raise with raise temperature of water flow rate in the upper tank, while the Nusselt number for air side will be reduction

Templeton et.al. [54] Studying the solar energy storage by using a double pipe heat exchanger which was done numerically with finite volume method. The simulation was based on the current samples in northern climates such as Canada. they presented model would be simulated the transient of temperature variation at both scenarios of extraction and injection mode.

3. Geometry Change of Test section
In any experimental work for several scientific authors, Yang and Chiang [55] attempted to study the heat transfer in a double pipe heat exchanger including a periodical curvature – variation of interior pipe with clear water using as working fluid as illustrated in Figure 1. Prime influences, Reynolds number, Prandtl number and the curvature ratio (curvature – variation) on the rate of heat transfer and coefficient of drop in pressure were widely investigated and it was got that the Nusselt number and coefficient of friction, at similarly of a smooth pipe, raised 100 and 40 percent, respectively.

Figure 1. Inner pipe with a periodical curvature – variation [55].

Dizaji et al. [56] showed an experimental study of thermal exchange and pressure reduction for corrugated inner pipe in a double pipe heat exchanger which turned out to perceive the significance of the field as shown in Figure 2. Both inner pipe and outer pipe were corrugated in convex and concave forms. Working fluids procedure for this experimental study were hot water flowed in the inner pipe and cold water flowed outer pipe which investigated thermal energy exchange, respectively. Researcher findings that the maximum effectiveness of heat exchanger was obtained for a state when inner and outer pipes had the concave and convex corrugated segment.

Bhadouriya et. al. [57] examined thermal exchange and drop in pressure of a double pipe heat exchanger both theoretically and experimentally in which that prime objective was the ratio of twist impact for inner pipe for flow features which illustrate below in Figure 3. The boundary condition of
the inner pipe wall of the annulus is a constant temperature. Working fluids flow in this experiment heat exchanger rig in two paths the were water and flowed in the inner path has square duct and airflow at the annulus of the heat exchanger rig. The finding showed that the changing inflow geometry led to a rise in the rate of heat exchange and causing a drop in pressure for different flow patterns. The finding of this work will help the designer of heat exchangers in produce heat exchangers more compact. And showed that, Nusselt number, Reynolds number and twist ratio were dependent on flow pattern and physical parameters when the flow was laminar.

Tang et al. [58] presented the influences that were accomplished experimentally and numerically for twisting pipe of inner flow in a double pipe heat exchanger. This process was done experimental that had different three forms of the cross-section for the inner pipe which were circle cross-section, trilobed and oval shapes as illustrated in Figure 4; however outer pipe has cylindrical shape. Higher performance estimation at the trilobed shape with the simple cross-section of the outer pipe. Moreover, a wide range of studies were done in numerical analyses, mostly in various irregular sections.

Numerous authors began to done numerical investigations for different problems of heat exchanger. One of these was presented by Agrawal and Sengupta [59] who pointed influence of four various promoter types, the thermal exchange and flow regimes of annulus part of a double pipe heat exchanger. Table 2 shows different experimental test section in double pipe heat exchanger.

![Figure 2. Different corrugated tubes in a double pipe heat exchanger [56].](image-url)
Figure 3. Twisted Inner Tube of The Double Pipe Heat Exchanger [59].

Figure 4. Various section of inner pipe in [58]. (A) Circular, (B) oval shape, and (C) trilobed.

Table 2. Different Experimental test section in double pipe heat exchanger.

| Authors   | Formation                        | Structure                                                                 | Heat Exchange | Outcome                                                                                                                                 |
|-----------|----------------------------------|---------------------------------------------------------------------------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------|
|           | (T.T.) Twisted tape, straight type | Water at 200, 2100, 2300, Cold water outlet                               | Water         | At different values of Reynolds number find heat exchange rate at higher twist ratios will be lower than of lower once. The factor that strongly effects on the heat exchange rate is the inlet temperature of hot water. |
| Naphon    | [60]                             | Water                                                                     | Water         | noticed Half-length twisted tape that inserts causes increase in coefficient of pressure compared with plain type. The heat exchange rate at same mass flow rate for half-length |
| Yadav     | Half-length twisted tapes, U-type | Oil                                                                       | Water         |                                                                                                                                         |
| [61]      |                                  |                                                                           |               |                                                                                                                                         |
| Reference     | Description                                                                 | Fluids | Observation                                                                                                                                                                                                 |
|---------------|-----------------------------------------------------------------------------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Akpinar ETJ. [62] | Inner pipe equipped with helical wires, straight type                        | Air water | Observed increasing in Nusselt number and friction factor when use helical wire in double pipe straight type heat compared with smooth empty pipe. Boundary layers will delay as effect helical wires in the pipe, the temperature and velocity profiles in plug flow will approach. |
| Naphon [63]   | Inner pipe in straight type with added coil-wire                             | Water Water | Effect of insert the coil-wire when flow is laminar to improve the heat exchange rate tends as raise values of Reynolds number.                                                                                   |
| Akpinar ETJ. et al. [64] | inner pipe of straight type has elements make swirl as utilized in entry section. | Water Water | The rates of heat transfer will be increased when also increasing holes number & decreasing diameters. The highest rate of heat transfer increased compared to the smooth pipe when used swirl element. Swirl element arranged at zigzag configuration as 5 holes with 3mm diameter. |
| Eiamsa-ard et. al. [65] | Added rod in the core of inner pipe, straight type                        | Water Water | The results of this design explained intensity to made strong turbulence. Louvered strips generated turbulence and causing rapid mixing for flow and got better result at max inclination angles. |

Twisted tape has better performance than smooth pipe, and vice versa at same pressure drop.
| Authors                  | Description                                                                                                                                                                                                 | Flow Media          | Flow Media          | Details                                                                                                                                                                                                 |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Zhang L. et al. [28]    | fins of helical shapes attach to surface of inner pipe will be used for generators vortex at concentric region between inner and outer pipe                                                                    | Water              | Water              | Helical fins are simultaneous and using these for generator vortex flow. This design was more efficient and better thermal energy exchange                                                                  |
| Sheikholeslami M. et al. [29] | Design penetrating circular ring and attach it to the outer surface for inner pipe in a double pipe heat exchanger.                                                                                       | Water              | air                | The penetrating circular ring is not better than circular rings because the penetrating circular make reduction in enhancement of heat transfer rate, this due to reduction of crossing angle between the temperature field and the velocity. Thermal exchange will be raises when raise number of perforated hole but this decreases when increase values of pitch ratio and Reynolds number. An augmentation in friction factor results from lowering of the distance between from pair to another of the turbulators, and this due to the more interception toward the stream of flowing. |
| Author(s) | Description |
|-----------|-------------|
| Sheikhol ESLAMI M. et. al. [66] | Agitator used in the inner tube of a double pipe heat exchanger. The raising in temperature causing rise in value of Nusselt number for the inner pipe. This addition due to decreasing in thickness of thermal boundary layer in water side. Nusselt number of the outer pipe will reduction as lowering values of temperature for upper tank and discharge of water. The insert tapes generate turbulence and swirl flow which causing thinner boundary layer. |
| Sheikhol ESLAMI M. et. al. [27] | Turbulators link to inner pipe at outer surface. This turbulators as discontinuous helical to make vortex at middle region of double pipe heat exchanger. The ratio of open area and pitch ratio have major effect when there increase Nusselt number and factor of Friction will be decreased. Thermal energy exchange directly proportions with the ratio of open area but opposite proportion with pitch ratio. In order to reduce pressure losses, is a fined good method for this reduction called presence of holes. |
| Braga C. and Saboya F. [67] | Utilize continuous fins has rectangular shape & longitudinal. This investigated as numerical and experimental study. Unfinned annulus increase rate of heat transfer, and fined thermal energy rate for unfinned annulus larger than the finned annulus. |
4. Heat Transfer Improvement Technique

Generally speaking, heat transfer intensification procedures are categorized into three primary categories:

4.1. Active Technique

This technique refers to using another external requirement to improve thermal energy exchange. Regular models that presented as plungers of reciprocating, magnetic of implementing field for different turbulence at flow, the turbulence causing shear force and led to vibration in flow and also effect on fields of electromagnetic. That is showed several considerations to augmentation this technique in the double pipe heat exchanger. El-Maghlany et al. [69] presented an experimental result for the double pipe heat exchanger that has rotation in the inner pipe to made turbulence. The identical results were depending on the influence of heat exchange between fluids, the flow arrangement as parallel or counter flows. The speed rotation of inner pipe effect the exchanger effectiveness and the number of transfer units. In general form when raise rotation speed led to raise effectiveness, thermal heat exchange and number of transfer unit’s parameter.

In the meantime, Zhang Z. et al. [70] presented the improve of thermal heat exchange in a double pipe heat exchanger by using strands of assembled-rotor. Three various types of strands in geometries which blade rotor were helical type, discrete type and used ladders in third blades type. For this case noted when made a comparison with using smooth pipe, the Nusselt number percentage raise about three quarters to once and a quarter, this congruent to friction factor percentage raise about a quarter to three quarters. From this work deduced, largest value of performance evaluation criterion of the double pipe heat exchanger when ladders in third blades type. This study presented experimental active technique in double pipe heat exchanger and not done numerical simulation for this case yet.

4.2. Passive Technique

The passive technique defines as a thermal energy exchange in the double pipe heat exchanger without added external force and this technique is shown in the condensation process, the change in geometrical style, outer surface shape and several types of addition take the major rule in this technique [71-72]. Many authors illustrated and accomplished numerous types of addition of passive techniques in the double pipe heat exchanger which implication twisted wire tapes [60-73], fins on pipe surface [23-25], coils with different mode [26-62-63] and find another object likes turbulators to made swirl flow. The additional types of this technique will describe and illustrate as shown in below paragraph:

4.2.1. Twisted Wire Tapes Attach to Inner Pipe

This type of inserts is one of several efficient modes that used to increase the rate of thermal energy exchange and has employ significantly because the different reason of which; easy design and computation, not expensive, maintenance it take short time [20]. In general form, these inserts generate vortex flow and this led to swirl and fluid layers overlap resulting from flow collision with them. The resultant from this mode gave good rapid mixing between fluid layers and this process raise thermal energy exchange. In previous beliefs these inserts of twisted tape granted the best

| Taborek J. [68] | Employ longitudinal finned pipe under different flow pattern as laminar and turbulent in double pipe heat exchanger | Water | Water | Low Reynolds values give advantageous cut and twist fin modifications |
effectiveness in flow patterns as laminar [71]. And then authors deal with this case and usage in the double pipe heat exchanger

Naphon P. [60] showed the thermal energy exchange and pressure drop for the double pipe heat exchanger as straight type. And illustrated the procedure of this heat exchanger type without and with inserts twisted tape in experimental work. The inserts made of aluminum have and thicker 1 mm. the water using as hot in inner pipe and also, using water as cold working fluid in the region between inner and outer pipes. The detection from employs twisted tapes in double pipe heat exchanger have high influence on pressure drop and thermal energy exchange. In the end, correlations are done and find these results are accepted with other results.

Yadav AS. [61] pointed the influence of using twisted tapes at half-pipe-length on pressure drop and thermal energy exchange of U-type double pipe heat exchanger. This inserts compound at inner pipe of a double pipe heat exchanger. This structure rise amount of thermal energy exchange as compare with heat exchanger has inner smooth pipe. The effectiveness of double pipe heat exchanger with smooth inner pipe was found larger than effectiveness of modify double pipe heat exchanger. This increasing in effectiveness about 30 % - 50 %. This modification in double pipe heat exchanger illustrated by several authors. The Numerical simulation that deals with different type of inserts twisted taps was fewer [73].

4.2.2. Extended Surfaces (fins)

fins is an object attach to surface in order to dissipate or accumulate thermal energy exchange at all modes, generally heat conduction mode and heat convection mode are take into account. All authors using fins with any heat transfer modes though the heat exchange will rise. In real must take into account fins efficiency that defined as the ratio of thermal energy exchange rate with fins to the thermal energy exchange rate without any fins.

Considering fins in double pipe heat exchanger, several implementations have been achieved. The studies that offered experimental and theoretical solution for any case in this field, Barga and Saboya [73] pointed that extended surface with rectangular geometry causes turbulence in flow pattern in the annulus region of a double pipe heat exchanger and done in theoretical and experiment works. These fins improve thermal energy exchange, dropping in pressure and efficiency of heat transfer rate. Water and air using as Working fluids for in experimental work. The water flow in inner pipe and air flow in middle region between pipes. The theoretical work done by solve 2-dimension heat equation. The extended surface efficiency dependent on several dimensionless parameters. First parameter was ratio of inner pipe diameter to outer pipe diameter. Second parameter was ratio of fin high to the concentrating length of pipes. Last parameters represented ratio of Nusselt number of finned inner pipe for double pipe heat exchanger to the Nusselt number of smooth inner pipe usage in same heat exchanger, this ratio less than one and it reduce when rise Reynolds number. And fined the inner pipe with extended surface enhancement thermal energy exchange.

Kumar et al. [74] presented experimental and numerical solution for double pipe heat exchanger with attach to fins to inner pipe. fins usage in three various shapes as triangular, rectangular and parabolic. At the end deduced that thermal energy exchange depends on efficiency, and the fins efficiency of rectangular shape was largest than the other shapes; while parabolic shape fins generate smallest drops in pressure.

When going to scope in the survey of fins in the double pipe heat exchanger, find the different arrangement of numerical works in this scope. Many of them, Kahalerras H. and Targui N. [75] shown methods of improving heat energy exchange of double pipe heat exchanger by extended surface fins. This method implements numerically by using porous fins attached to the exterior surface of the inner pipe. The finite volume method solves this model by using different boundary conditions and governing equations. This numerical model called Brinkman-Forchheimer Extended Darcy which was applied for porous regions. At the same conditions and flow discharge, the authors get comfortable results and made validation with several researches. At this present some parameters improve thermal
energy exchange like fins dimension, fins porous, thermal properties of material fins and flow discharge, effects of geometrical, physical and thermal parameters.

Another study done numerically, Syed K. et al. [76] illustrated simulation of heat transfer in the convective mode for the laminar flow in a double pipe heat exchanger with various altitude tip-fin. The fins geometry implements in this research as triangular cross-section and rectangular cross-section. Theoretical solution of governing equation done by using finite element method called Discontinuous Galerkin method. In order to computation the effectiveness of this moderate double pipe heat exchanger must take into account j-factor, pressure drop and Nusselt number. Two cases were studied and compare these results with result of the basic case as smooth inner pipe. Firstly, rectangular geometry fins attached to the inner pipe and found increasing in Nusselt number and j-factor. Secondly, triangular geometry fins attached to the inner pipe also found increase in Nusselt number and j-factor increase. When compare between first case and second case found first case have values of Nusselt number and j-factor increase larger than second case. They pointed fins height and number strongly effect on thermal energy exchange. At the end, this research clarified major rule for several parameters that influence thermal mechanism in the double pipe heat exchanger and implement important design considerations and reduce cost. Also, recognized several arrangements and numerical assumptions for finned double pipe heat exchanger have to improve thermal energy exchange [77-78].

Different researches illustrated numerous techniques which arrangement and used to get maximum performance in this field. One of these is research, Sahiti N. et al. [79] presented new technique and design which used to reduce entropy generation as possible as. This technique impalement by using pin-finned attach to inner pipe of double pipe heat exchanger. The getting result from this moderate heat exchanger type at different flow rates, pin – fins length related to Reynolds number. Thermal energy exchange and reduction in pressure illustrated in experimental mode for this type of heat exchanger. The water used as interior working fluid and air as exterior working fluid for this experiment mode. It is found the better mode that improve thermal energy exchange was used little height pin fins with multi paths in comparison great height pin fins with fewer paths.

4.2.3. Wired Coils

Akpinar EK, [62] presented experimental study that deals with the mechanism of thermal exchange in the annulus region of the double pipe heat exchanger. There are numerous parameters estimated like the rate of heat transfer, dropping in pressure and losses in energy as dimensionless value. This experimental rig was built by inserting coil-wire in the interior pipe of the double pipe heat exchanger. Hotter water used as working fluid flow in the interior pipe and colder fluid used as working fluid flow between inner and outer pipe. The reduction of thermal energy exchange and losses in exergy because of increased numbering of helical wires turns and lowering pitches swirls. There were presented compression for this moderate state with smooth pipe and finding augmentation in important parameters like as dimensionless Nusselt number, coefficient of friction and losses of exergy. At the end, the better configured experimental test for this moderate heat exchanger type that raise thermal energy exchange when the working fluids flow in the opposite direction and max height of helices wires. Naphon [34] investigated the influence on reduction in pressure and thermal energy exchange for the double pipe heat exchanger when inserts wired coil. For this study used water as a working fluid in interior pipe and annuls region. The implement of wired coils and working fluid flow was laminar that causes more influence at thermal energy exchange. At same state observed this influence reduced when raising flow and this cause rise in Reynolds number value. The research in same field [37-38] will accomplished and noted same influence on thermal energy exchange.

4.2.4. Different Types of Turbulators

Turbulators is inserted object used to made swirl flow that led to raise thermal energy exchange of double pipe heat exchanger. Turbulators are found in different forms and the amount of thermal
energy exchange depends on each form. Turbulators also cause pressure drop. These forms of turbulators were implemented in numerous experimental studies in the double pipe heat exchanger. One of the studies, Yildiz C. et al. [80] illustrated swirl flow generation in annulus region of a double pipe heat exchanger experimentally and how this mode affected pressure losses and rate of thermal energy exchange. Swirl flow generated by propellers which was placed free in direction of flow. For this experimental rig, it was pointed that thermal energy exchange increases about twice and a half than the double pipe with smooth inner pipe, and pressure drop raise from five to ten times in comparison with smooth pipe. This experimental test depends on volumetric discharge and the propellers number.

Another research, Durmus [81] demonstrated thermal energy exchange and loss in exergy at sides annulus region of the double pipe heat exchanger with snail entrance. There are two working fluids used. Firstly, the cooled working fluid is air that flows in the interior pipe. Secondly, water is used as a hot working fluid which flow in the entrance region. The snail entrance putting on at port of the interior pipe to generating swirl flow to raise thermal energy exchange. Thermal energy exchange does not affect when reduce air discharge because snail create a vortex and this causes increase in the thermal exchange rate. The Nusselt number calculated at each side of concentering region. The Nusselt number pointed reach to larger values when flow is counter current flow in compare with parallel flow. The exergy losses also presented and reach to maximum at counter current case. When made a compression for this moderate heat exchanger type (co–current state or counter current state) and smooth pipe found pressure drop increases.

Akpinar EK. and Bicer Y. [64] presented new paths for working fluid and attached tabulators with numerous configuration of holes to inner pipe of a double pipe heat exchanger. The working fluids paths were hot air path in interior pipe and cold-water path in concentering region. This case deals with influence holes configuration from where diameter, number, and formation linear or zigzag. This research shown the thermal energy exchange raise at increase holes number with reduction in their diameter. The Nusselt number reach to maximum and has values about 1.3 larger than that of smooth pipe.

Eiamsa-ard S. et al. [65] explained louvered strips influence on thermal energy exchange and dropping in pressure of a double pipe heat exchanger. The working fluid in interior flow was hotter water and working fluid in concentering region was cold water. There are two forms of louvered strips firstly, backward and secondly, forward. When compare this case with case of smooth pipe, at case of forward form of louvered strips, mean Nusselt number and factor of friction raise about 2.84 and 4.13, respectively. And at case of backward form of louvered strips, mean Nusselt number and factor of friction raise about 2.63 and 2.33, respectively. When compare between these result of different louvered strips forms, we find the case of forward form of louvered strips better result.

Zhang L. et al. [28] illustrated how increasing of thermal energy exchange in concentering region a double pipe heat exchanger by attached fins of helical form and vortex generators also in different form and simultaneous this case. The working fluid in interior flow was steam and working fluid in concentering region was cold air. These vortex generators that used in this research have four different geometries. These geometries called firstly, delta winglet pair secondly, delta wing thirdly, rectangular wing and at last rectangular winglet pair. The getting result showed thermal energy exchange per unit area of vortex generator reach to maximum for delta wings geometry, delta winglets pair geometry, rectangular winglets geometry and rectangular wing geometry, respectively.

Sheikholeslami M. et al. [27-29-66] presented different types of turbulators used to raise thermal energy exchange and pressure dropping of a double pipe heat exchanger at experimental rigs. For these cases using water as working fluid flow in interior pipe air used as working fluid flow concentering region.

The rough surface is one of technique that presented to improve thermal energy exchange in double pipe heat exchanger. This technique presented by Raj R. et al. [33] when analyzed thermal energy exchange and flow characteristics in a double pipe heat exchanger. The working fluids are water and
Ethylene Glycol. This study done under different flow regimes (laminar, transient and turbulent). The better regime that gave largest thermal energy exchange was turbulent.

There are several numerical research done numerically for porose turbulators as shown in [82-83]. These researches illustrated influence of porous turbulators on effectiveness of a double pipe heat exchanger and how-to enhancement thermal energy exchange. porose turbulators insert at each surface for inner pipe and that led to raise thermal energy exchange for different flow mode (parallel flow, counter flow). The raise in thermal energy exchange reach to maximum at high thermal conductivity ratios. And thermal conductivity ratio is represented ratio of thermal conductivity effectiveness for porous domain to the thermal conductivity of fluid.

Another technique investigated numerically to improve thermal energy exchange. This technique done by Al-Kayiem HH and El-Rahman M [84], where used ribs as the turbulators to create vortex flow in double pipe heat exchanger.

Different types of research implement to improve heat transfer rate which is illustrated for shell and tube heat exchangers was used baffles to create vortex flow. These types of inserts (baffles) not presented in double pipe heat exchanger. But this case presented numerically by Targui N. and Kahalerras H. [85-86].

4.3. compound Technique

The thermal energy exchange in double pipe heat exchanger need to increase to get better result at several application. This technique of thermal exchange focusing on incorporation of both active technique and passive technique. So, to get best result from this technique should use better modes from active technique likes vibration in fluid, surface and passive technique like fins, coils, turbulators [87]. Some applications investigated mechanism of thermal exchange in double pipe heat exchanger and take into account several from parameters, geometry shapes and different inserts. In one of these few investigations, Omkar et al. [10] illustrated computation fins in helical form on the surface outside of inner pipe that rotate at different angular speed. The water used as working fluid in in inner pipe and as working fluid in annulus side. And pointed increase about sixty percent in values of Nusselt number result from state of 100 r.p.m angular speed of the inner pipe in compared with values took from fixed inner pipe.

5. Conclusion

This review paper presents experimental and theoretical survey linked to improve thermal energy exchange by the forced convective mode that happen in the double pipe heat exchanger. It is illustrated this kind of heat exchanger was enormously used in the application of sustainable energy, industrial process and engineering field. Reducing area of the heat exchanger with capable of transferring more effective heat occupied are still in demand. optimal design of heat exchanger established researchers are still trying to detect that converts the known input into an efficient output. Several researchers wanted to increase the heat transfer rate by different methods like as forming inserts, using different configuration core of tube in heat exchanger and also by using nanofluids. There is numerous research which confirms on the getting of thermal energy exchange as much as and a reducing factor that relates to friction, this almost related to passive enhancement technique. the thermal energy exchange for many cases of study detects to raise about quadruple, while minimizing pressure drop to nifty in comparison to smooth tube. The active technique for enhancement thermal energy exchange in the double pipe heat exchangers is not mostly propagation and applied, which is imagined the researcher should take specific detect this technique. Several scopes on research illustrated using of nano fluids and these techniques in different types of heat exchangers, that taken numerous attentiveness in modern. Other trails are wide necessary in after time to scope on the conjunction of nanofluids and passive techniques to enhance thermal energy exchange which is discovered the better selection of several problems.
6. References

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