A REVIEW ON USE OF TURBULATORS IN TUBE IN TUBE HEAT EXCHANGERS

[1]Faisal J. Khan, [2]Dr. Piyush K. Soni, [3]Pawan Pal

Department of Mechanical Engineering
SORT, People's University, Bhopal-MP

***Abstract*: The performance of heat exchanger mainly depends on the different process parameters in which turbulence is one of the major one. For increasing the turbulence inside the heat exchanger turbulators or baffles are used inside the heat exchanger. Researchers have used different turbulator to improve the performance of heat exchanger. So in order to analyze the effect of use of turbulator and for further improvement of turbulator design, it is necessary to review the use of turbulators inside the heat exchanger. Here in this work, review of use of turbulators inside the heat exchanger was done, which also includes the different mechanism that are used for increasing heat transfer rate inside the heat exchanger.**

***Keywords:* Heat exchanger, Review, Turbulator, Mechanism, Input parameters**

1. Introduction

A heat exchanger is an adiabatic machine based on open system built for resourceful heat transfer from a solid object and a fluid, or between two or more fluids. The fluids could possibly be separated by a solid wall to eliminate mixing or they may possibly be in direct contact. The rate by which heat transfers is reliant on the conductivity concerning the separating wall and then convective heat transfer coefficient between the wall and simply fluids. The heat transfer rate likewise deviate reckoning on the boundary circumstances that include adiabatic as well as insulated wall conditions. This device offers a thermal energy flow among two or more fluids at some temperatures. Tube in tube heat exchangers are most valuable type of heat exchanger equally applied in an extensive range of industrial uses like power generation, heat recovery in wastage system, engineering firms, cooling and refrigeration, space applications, petrochemical activities and many different areas. The foremost attentions regarding the effectiveness of tube in tube heat exchanger are comes in a region of turbulence, drop in pressure, coefficient of heat exchanger, length of heat exchanger as well as turbulator types. By increasing the turbulence power level, conflict to the flow also extended, which advanced the heat exchanger effectively. Heat exchanger rate may be developed with huge loss of pressure though it stimulates to increase in power consumption, which is its real downside.

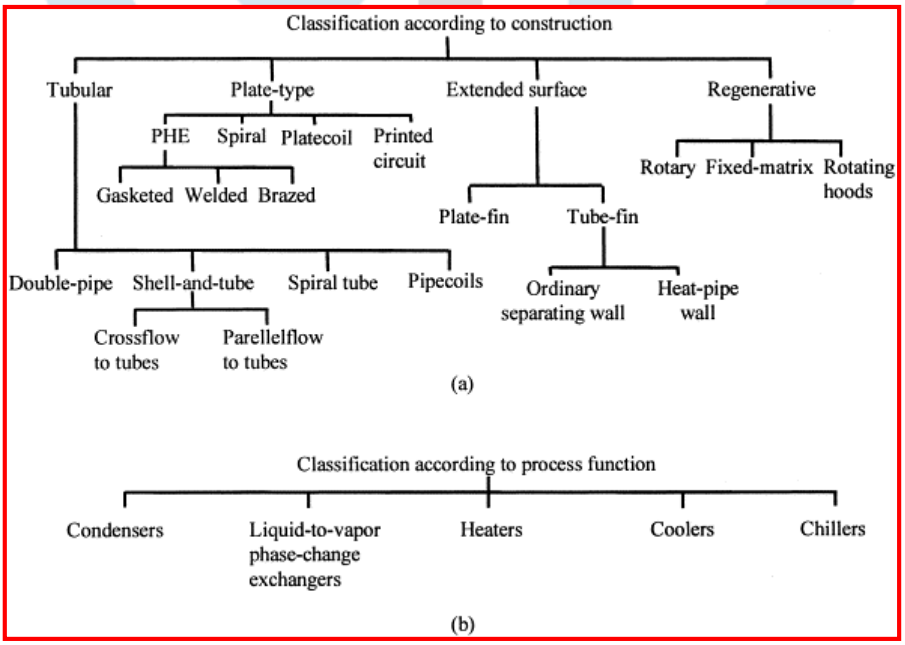

Fig.1 Different types of heat exchangers

2. Turbulator

A turbulator is equipment which usually spins a laminar flow towards a turbulent flow. Turbulent flow can easily be preferred on hardware associated with surface of an aircraft wing (air foil) or in commercial functions including heat exchangers and so the mixing of fluids. The terminology "turbulator" is utilized to an assortment of tasks and is employed as an offshoot of the phrase turbulent. Turbulators are actually engineered to generate and simply preserve turbulent flow and then support to strengthen the tube-region heat transfer effectiveness. A turbulator is a gadget which in turn is introduced upon the tube region of fire tube boilers, shell along with tube heat exchangers and several other versions of heat transfer hardware or equipment. A turbulator is crafted to

assist tube bundles and guide fluids flow pertaining to the uppermost level of efficiency. Baffle style and tolerances intended for heat exchangers are talked about in the specifications of the Tubular Exchanger Manufacturers Association (TEMA).

2.1 Discontinuous Helical Turbulators with Circular Perforation:

The intention associated with this paper is usually to review the influences of helical fin in addition to circular perforation on hydrothermal remedies/treatment in a water to air heat exchanger. Air flows all the way through outer pipe and simply water goes with the assistance of inner pipes, respectively. Consequence concerning pitch ratio (PR), open area ratio (λ) and so Reynolds number (Re) are actually analyzed. Scientific formulae intended for thermal performance (η), Nusselt number (Nu) and Darcy factor (f) are attained. Outcomes uncover the fact that pressure loss and then Nusselt number has reduced with progression of λ. The temperature gradient across the hot wall raises with increasing velocity of the inlet air. The thermal performance, η, is a strengthening function belonging to the open air ratio, λ.

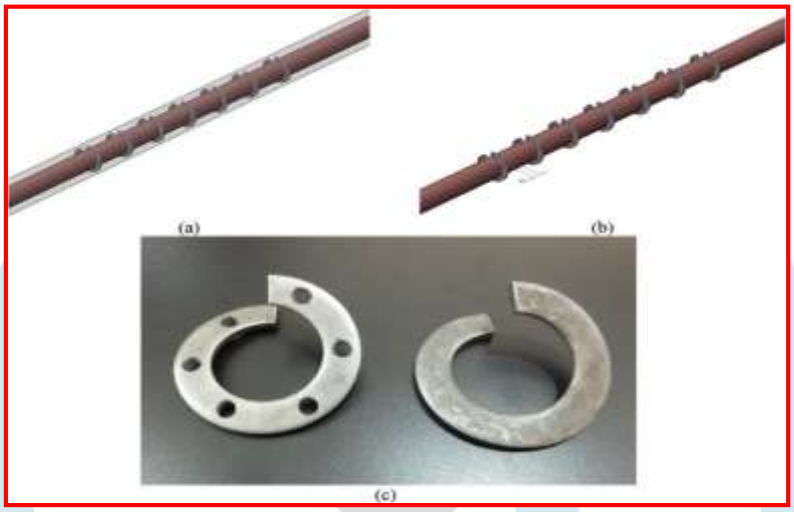

Fig.2 shows the discontinuous helical turbulator (a) complete setup of heat exchanger, (b) shows the helical turbulator, (c) perforated helical turbulator

2.2 Applications

Heat exchangers are actually broadly utilized in enterprise both equally for cooling and heating large scale commercial operations. The type and specifications of heat exchanger employed can be personalized to fit a technique based on the variation of fluid, its phase, heat range, density, viscosity, pressures, chemical substance composition and numerous other thermodynamic properties. In various commercial functions generally there is surplus of energy or a heat stream explicitly being bushed, heat exchangers can certainly be applied to retrieve this heat and placed it to usage by warming an altered stream in the practice. This practice helps you to save a lot of funds in industry, as the heat delivered to additional streams from the heat exchangers would probably originate from an external supply that is even more expensive and more dangerous to the ecosystem. Heat exchangers are employed in multiple market sectors, incorporating:

- Waste water treatment
- Refrigeration
- Wine and beer making
- Petroleum refining
- Nuclear power

3. Existing research work

Since many years turbulators are used to increase the heat transfer rate of heat exchanger. Researchers are optimizing the different process parameters of heat exchangers; they mainly focus on the design of different turbulator. Turbulators are mainly design to increase the turbulence inside the heat exchanger which enhances the heat transfer in between two mediums. But with the use of turbulator other challenge is to overcome the increase of friction factor with the use of turbulator. So in order to reduce the increase in friction, design of turbulators was modified by different people. For increase the efficiency of tube in tube heat exchanger, turbulator play an important role, some of the existing work related to use of turbulator in heat exchanger are mention here.

1. **Nalavade *et.al* (2019)** it investigates the fluid flow and heat transfer characteristics of circular tube incorporating the flow divider type turbulator under turbulent flow condition was deliberated experimentally and numerically. An experimental study was accompanied to scrutinize the portrayal assessment of heat exchanger tube assimilated with novel flow divider type turbulator with pitch to diameter ratio (p/d) 0.54, 0.72 and 1.09 respectively beneath turbulent flow condition. The usage of flow divider type turbulator efficiently interrupts the boundary layer to augment the thermal performance. To elaborate the consequence of change in angle of twist of the turbulator, CFD simulations were accompanied which illustrate that Nusselt number augments by 1.33 to 1.46 times and 1.43 to 1.60 times respectively for 45° and 30°.
2. **Patidar *et.al* (2018)** the motive of this work was usually to examine the outcome of baffled twisted tape inserts and change in heat transfer rate in a heat exchanger. Twisted tape could be utilized as the passive methods to improve the functionality of a heat

exchanger and now there exists a scope of even more in this field for the improvement of heat transfer and that of pressure drop with different selection of Nusselt number, Prandtl number. Modified triangular baffled twist-straight turbulators support in the improvement of heat exchanger's efficiency.

3. Akyurek *et.al* (2018) an experiment was conducted to employing water as a working fluid in a heat exchanger without wire coils. In this work, the characteristics of the turbulent heat transfer and Al_2O_3-nanofluid-water pressure drop in the heat exchanger with and without cables were investigated experimentally. The experiment had an effect on the particle concentration of 0.4-0.8-1.2-1.6 volts.

4. Surywanshi *et.al* (2017) they aim at heat transfer enhancement of heat exchanger utilizing helical strip in circular pipe with operating fluid as standard water. Heat exchanger process in industrial in addition to application in engineering is very popular. This geometry really helps to generates swirl movement of fluid stream and disturbs that boundary layer which will raise the effective surface area, residence time, reduce pressure drop and increase heat transfer coefficient. As compared with simple pipe and twisted pipe, heat transfer rate raises up to 50% to 70%. However, in other part pressure drop also raises up to 90% significantly because of huge turbulence stream. In the event of different twist ratio, as twist ratio increases heat transfer coefficient as well as pressure drop both increases concurrently.

5. Zhouhang Li *et.al* (2017) in this work, helical coil had gained increasing interest in the carbon dioxide region from the critical range with the ancient Rankin cycle due to tight assembly and high heat transfer rates. In this work, it complements such an opening with a fluid-based heat transfer model in which the cascading turbulent flow is explained by the k-u shear transport function. Effect of sensor alignment and internal roughness of the fins on the heat transfer from carbon dioxide tested in different optical tubes d. The consequence describes that the effect of alignment is properly related to the effect of gravity.

6. Ali *et.al* (2017), this article defines the thermal analysis of the trends parallel to the Earth's surface, and at right angles to the Earth's surface, the horizontal geothermal changes with the changing water velocity of mass flow in a continuous and continuous manner. Copper pipe, an outer area secured by low density polymers, was defined as the material of the heat exchanger pipe, defined as the mill. The actual heat units of the horizontal and vertical horizontal heat exchangers are taken into account in the heat exchanger modes. The empirical results determine the differences in standing activity and tilt orientation, the impact on the global temperature of the horizontal geothermal converter due to heat extraction, and the consequence of the global temperature gap on the horizontal geothermal exchanger. Performance. The improvement of heat efficiency from the periodic operation of the ground heat exchanger is also discussed. In addition, unstructured soil temperature and ambient temperature must also be occupied into account. The unplanned temperature of the earth data provides a useful pin for mounting the heat exchanger at depths suitable for heating and cooling.

7. Kabeel *et.al* (2017) in this work, it has experimentally investigated the effects of Al_2O_3-water nanofluid as a heat transfer media in a Plate Heat Exchanger (PHE) with corrugated plate design. For this purpose, an experimental rig was built and the thermo-physical properties of the nanofluid such as heat transfer coefficient, effectiveness, transmitted power and pressure drop were measured and compared with the values attained from the theoretical models. It was observed that with the increase in concentration of the nanoparticles in the base fluid, the heat transfer coefficient and the transmitted power also increased. The heat transfer values corresponded to an increase of 13% at a volume concentration of 4 wt %. The pressure drop and the pumping power also increased with the concentration of nanoparticles.

8. Sheikholeslami *et.al* (2016) in this research work, hydrothermal evaluation of turbulent in a very double pipe heat exchanger is conferred through an experiment with the help of forced convection method. Perforated turbulators are used into annulus section. Hot water transfers heat to the cold air in outer tube. Numerous ranges pertaining to pitch ratio, Reynolds number and then open area ratio are actually considered. Examination of Correlations intended for Nusselt number, Darcy friction factor and then thermal functionality has been done. NSGA II is used in order to maximize the model. Physical trends are displayed by that of FVM. Outcomes reveal that thermal overall performance promotes with augment from open area ratio. Maximum significance of thermal performance attained at g = 1.59 that is appeared for Re ¼ 6000; k ¼ 0:07; PR ¼ 1:06.

9. Sisodiya *et.al*. (2016) study on the use of helical coil heat exchangers (HCHEs) with (Aluminium Oxide) Al_2O_3 -Water phase change material to understand that the HCHEs can produce better rates of heat transfer. A systematic study was accompanied employing a counter flow HCHE incorporating of 8 helical coils. Two analyses was conducted for finding the heat transfer, one where water was employed as heat transfer fluid (HTF) in the coil and sell sides, respectively; while the second one was made by use of different Volume fractions of Al_2O_3 and water in the coil and shell sides, respectively. The NTU effectiveness relationship of the HCHE is, when Al_2O_3 fluid is a used methodology that of a heat exchanger with a heat capacity ratio is zero.

10. Bandos *et.al* (2016) here, the method of obtaining the keys to a finite source is to obtain a cylindrical model for heat exchangers with well-defined apertures that take into account the heat capacity inside them and allow the rate of heat transfer by action. Mind. The logical approximation of the soil temperature with the mean value is justified by incorporating specific results above the cylindrical source, which is the depth for vertical correction and be contingent on the time of heating velocity. Fresh results for the average temperature response from a heat exchanger that model the soil as a cylindrical source with uniform heat flux incorporated in the semi-infinite region at a distance d from its surface are available in a single integral model. Although the response of mean temperature from the finite cylinder source getting the ones from the different models in the middle and long lasting scales, correspondingly, the planned fundamentals shorting the recognized issue of discontinuity in the time interval, where finite-curvature and -depth contributions are significant.

11. Bajestan *et.al* (2015) in the current analysis, he looked at whether nanoparticles are not limited to use in the fridge cycle as additives in refrigerators and lubricants, but they have also been studied and analyzed. Also to use in the solar cycle. To this end, they carried out experiments to study the behavior of nanowires based on TiO2 / water when allowed to flow through a tube of equal heat. Based on the experiment, thermal conductivity and viscosity are measured. The attained consequences were compared

to that of pure water and it was pragmatic that there was an increase of 21 % in the average heat transfer coefficient. Also these results were compared and modeled with the existing single-phase model and two-phase model. Based on their analysis they determined that the single-phase model underestimated the results whereas the two-phase model overestimated it.

12. Vahidifar *et.al* (2014) they studied the features of heat transfer concerning double pipe horizontal tube heat exchanger and therefore the pressure drop associated with inserted wire coils and then rings. Wire coil being a swirl flow will increase turbulence and then roughness although rings speed up heat transfer being a promoter pertaining to turbulence and then roughness. When associate target is certainly positioned through a very boundary layer that influence the entire flow structure and then varies the speed and thermal profiles. In most liquids during which the density is reduced relative to the temperature, the force transfers the heated fluid from the physical phenomenon towards the tube axis that will increase the heat transfer. With reference to heat transfer and so friction, wire coils show superior performance than rings.

13. Hsieh and Jang *et.al* (2012) Here, they examined the influence of the flap step, the outer diameter of the flap, the cross section of the tube, the length of the tube, the number of tubes, the height of the flap thickness, the thickness of the flap and the loudness of the blade The blade. Pipe heat exchanger by numerical method. The parameters of a good heat exchanger were enhanced by the Taguchi method. The consequence revealed that the outer diameter of the blower, the cross section of the pipe, and the blade gradient are the major factors that significantly influence the thermal conductivity of the heat exchanger. Therefore, these three factors are considered to be the most important factors for optimum thermal design.

14. Dehghandokht *et.al* (2011) they had performed the multi-objective optimization of the parallel flow condenser by applying the Genetic algorithm technique. The design parameters (decision variables) were the hydraulic diameter of the flat tube with multi-pass channels, length of flat tube, and the height of the louvered fin. Among the design parameters, fin height had the least, and the hydraulic diameter had the most inspiration on the heat transfer rate and pressure drop. With a change in the fin height from its minimum to the maximum value, the condenser heat transfer rate decreased by 0.3% and the pressure drop increased by 1.3%. With the change in the hydraulic diameter from its minimum to the maximum value, the condenser heat transfer rate increased by 17.4% and the pressure drop decreased by about 90%.

15. Khaled *et.al* (2011) Develop an analytical method using the base equation for heat transfer, modeled by a heat exchanger to determine the thermal efficiency of a cross-cooled heat exchanger as a utility of the flow rate statistics. A two-dimensional computation code has also been developed to calculate the operation of the heat exchanger in relation to the upper airflow of the heat exchanger as a result of its integration in a complex environment such as a car under your room. The journey. In conclusion, it has been shown that increasing the heterogeneity (represented by r) of the distribution current upsurges the heat transfer velocity and thus reduces its thermal properties.

16. Singh et.al (2009), in this work, the swirling flow was introduced by using half length twisted tape placed inside the inner test tube of the heat exchanger. The results obtained from the heat exchangers with twisted tape insert are compared with those without twisted tape i.e. Plain heat exchanger. The experimental results revealed that the increase in heat transfer rate of the twisted-tape inserts is found to be strongly influenced by tape-induced swirl or vortex motion. The heat transfer coefficient is found to increase by 40% with half-length twisted tape inserts when compared with plain heat exchanger. It is also observed that the thermal performance of Plain heat exchanger is better than half length twisted tape by 1.3-1.5 times.

17. Munoz-Esparza et.al, (2011), in this work helical wire coils fitted inside a round pipe is a simple and well-known heat transfer enhancement technique in order to improve the overall performance of heat exchangers. Our full domain numerical calculations reveal the onset of a linear instability into the range $500 < Re < 550$ that becomes the flow unsteady and breaks the periodic axial pattern of the flow. The friction factor becomes constant in the range, $600 < Re < 850$, and only the full numerical model shows a good agreement with the experimental results, but periodic numerical simulations fail. For $850 < Re$, even the full domain laminar model fails due to the onset of turbulent outbreaks. Finally, the effect of the pitch on the friction factor showing that the increase of the non dimensional pitch, p/d, decreases the friction factor.

18. S. Eiamsa-ard et.al, (2010), in this work, strong turbulence and recirculation flow is expected by using tandem diamond-shaped turbulators (D-shape turbulator) connected to each other by a small rod and placed inside the test tube. The experimental result reveals that the heat transfer rate increases with increasing Reynolds number and the included cone angle (q) but decreases with the rise of the tail length ratio (TR). This is because of the mixing of the fluid in the boundary layer thereby enhancing the convective heat transfer and increasing pressure loss. Correlations of the Nusselt number (Nu) and friction factor (f) are developed for the evaluation of interactive effects of using the turbulators on the heat transfer and pressure loss. The good agreement between the experimental and the correlated results is obtained within 5e7% deviation.

19. Serageldin et.al, (2016), in this work, the soil temperature profile and the temperature distribution of flowing air through horizontal Earth-Air Heat Exchanger (EAHE) are experimentally studied. The results show that some of the parameters have noticeable results in air temperature. Whereas, the pipe diameter increases the air temperature decreases. The outlet air temperature declines from 20.4 to 18.7 ^{0}C as the pipe diameter expands from 2 to 3 in. Furthermore, as pipe length increases, outlet air temperature enhances. The temperature changes from 19.7 to 19.9 ^{0}C as the pipe length elongates from 5.45 m to 7 m. So the conclusion is that the change in outlet air temperature for various pipe materials is neglected compared with their prices. Finally, the effect of fluid velocity was investigated. Therefore, the outlet air temperature declines from 20.4 to 19.2 ^{0}C as air accelerates from 1 to 3 m/s.

4. Conclusion

The use of turbulators inside the heat exchanger is mainly for the increment of turbulence inside the annular space. With the use of turbulator though the heat transfer rate increases, value of friction factor also increases with the degrades the performance of heat exchanger. For reducing the friction helical turbulators was used inside the tube in tube type heat exchanger. So for the further

improvement in efficiency of the heat exchanger, it is necessary to improve the design of turbulator and make it more compatible to improve efficiency of heat exchanger.

References

[1] P. Nalavade Sandeep, L. Prabhune Chandrakant, K. Sane Narayan, "Effect of novel flow divider type turbulators on fluid flow and heat transfer", Thermal Science and Engineering Progress (2019), Vol. 9, March 2019, page 322-331.
[2] Virendra Patidar, Nishant Vibhav Saxena, "Enhancement of heat transfer through pipe with the help of various types of turbulators – A Review", international research journal of engineering and technology (JRTI) (2018).
[3] Akyurek, E.F., Geliş, K., Şahin, B., Manay, E., Experimental Analysis for Heat Transfer of Nanofluid with Wire Coil Turbulators in a Concentric Tube Heat Exchanger, Results in Physics (2018), Vol. 9, pages 376-389.
[4] Sachin S. Surywanshi, Sanjay V. Kadam, Suhas S. Mohite, "Numerical Heat Transfer Analysis of Flowing Fluid through a Circular Tube with Helical Twisted Strip Inserts", Journal of Advances in Science and Technology (2016).
[5] Zhouhang Li, Yuling Zhai, Dapeng Bi, Kongzhai Li, Hua Wang a, Junfu Lu, "Orientation effect in helical coils with smooth and rib-roughened wall: Toward improved gas heaters for supercritical carbon dioxide Rankine cycles", Energy 140 (2017) 530e545.
[6] Md. Hasan Ali, Keishi Kariya, Akio Miyara, Performance Analysis of Slinky Horizontal Ground Heat Exchangers for a Ground Source Heat Pump System, www.mdpi.com/journal/resources 2017, 6, 56; doi:10.3390/resources6040056.
[7] A.E. Kabeel, T. Abou El Maaty, Y. El Samadony, "The effect of using nano-particles on corrugated plate heat exchanger performance", Applied Thermal Engineering 52 (2013) 221-229.
[8] M. Sheikholeslami, D.D. Ganji, "Heat transfer enhancement in air to water heat exchanger with discontinuous helical tubulators; experimental and numerical studies", Energy 116 (2016) 341-352.
[9] Vinita Sisodiya, Dr. Ankur Geete 2016 ―Heat Transfer analysis of Helical coil Heat Exchanger with Al_2O_3 Nanofluid, International Journal of Engineering and Technology, Volume 3, Page 366-370.
[10] Tatyana V. Bandos, Alvaro Campos Celador, Luis M. Lopez-Gonzalez, Jose M. Sala-Lizarraga, "Finite cylinder-source model for energy pile heat exchanger: Effect of buried depth and heat load cyclic variation", Applied Thermal Engineering 96 (2016) 130-136.
[11] E. Ebrahimnia-Bajestan, Mohammad Charjouei Moghadam, Hamid Niazmand, Weerapun Daungthongsuk, Somchai Wongwises, "Experimental and numerical investigation of nanofluids heat transfer characteristics for application in solar heat exchangers", International Journal of Heat and Mass Transfer 92 (2016) 1041–1052.
[12] S. Vahidifar and M. Kahrom, "Experimental Study of Heat Transfer Enhancement in a Heated Tube Caused by Wire-Coil and Rings" Journal of Applied Fluid Mechanics, Vol. 8, No. 4, pp. 885-892, 201.
[13] Hsieh, C.T. and Jang, J. Y. "Parametric study and optimization of louver finned tube heat exchangers by Taguchi Method", Applied Thermal Engineering, Vol. 42, pp. 101-110, 2012.
[14] Sanaye, S. and Dehghandokht, M. "Modelling and multi-objective optimization of parallel flow condenser using evolutionary algorithm", Applied Energy, Vol. 88, pp. 1568-1577, 2011.
[15] Khaled, M., Harambat, F. and Peerhossaini, H. "Analytical and empirical determination of thermal performance of louvered heat exchanger-Effects of air low statistics", International Journal of heat and mass transfer, Vol. 54, pp. 356-365, 2011.
[16] Anil Singh Yadav, "Effect of half length twsited tape turbulators on heat transfer and pressure drop characteristics inside a double pipe U-bend heat exchanger", Jordan Journal of Mechanical and Industrial Engineering, Vol. 3, Number 1, March-2009, page 17-22.
[17] D. Munoz-Esparza, and E. Sanmiguel-Rojas, "Numerical simulations of the laminar flow in pipes with wire coil inserts", Computers & Fluids, Vol. 44, Jan. 2011, page 169-177.
[18] S. Eiamsa-ard, and P. Promvonge, "Thermal characterization of turbulent tube flows over diamond-shaped elements in tandem", International Journal of Thermal Sciences, Vol. 49, Jan. 2010, page 1051-1062.
[19] Ahmed A. Serageldin, Ali K. Abdelrahman, Shinichi Ookawara, Earth-Air Heat Exchanger thermal performance in Egyptian conditions: Experimental results, mathematical model, and Computational Fluid Dynamics simulation, Energy Conversion and Management 122 (2016) 25–38.