Kanhaiya Kumar, 2021, 9:6
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

A Review on Numerical Analysis of Flow and Heat Transfer Enhancement in a Pipe with Twisted Tape

M. Tech. Scholar Kanhaiya Kumar, Prof. Neetesh Gupta
Department of Mechanical Engineering
BITS,Bhopal,MP,India

Abstract- Nowadays, heat exchangers with twisted-tape inserts have widely been applied for enhancing the convective heat transfer in various industries such as thermal power plants, chemical processing plants, air conditioning equipment, refrigerators, petrochemical, biomedical and food processing plants. In general, twisted tape insert introduces swirl into the bulk flow which consequently disruptsa thermal boundary layer on the tube surface. Recently, the use of twisted tape with cuts and holes becomes popular due to their thermal performance improvement in comparison with other types of twisted tape and several studies have been carried out on these types of modified twisted tape.

Keywords- Twisted tape, design, thermal analysis, heat exchanger.

I. INTRODUCTION

Heat transfer enhancement techniques have grown in popularity as high-performance thermal systems have been developed. Heat transfer augmentation procedures refer to many different of methods for increasing heat transfer rates while minimizing the system's overall performance. In industrial, heat exchangers are commonly utilized both for cooling and heating. The use of twisted tape within flow route to create turbulence was among the most popular passive heat transfer augmentation strategies owing to its advantages of ease of fabrication, operation, and low maintenance.

The enhancement of something like the thermo hydraulic performance of heat exchangers is referred to as heat transfer enhancement or augmentation approaches. A broad range of inserts are often used in numerous strategies (both passive and active) researched for augmentation of heat transfer rates within circular tubes, particularly if turbulent flow was included. To improve the thermal performance of heat transfer devices, a variety of techniques are used, including treated surfaces, rough surfaces, swirling flow devices, coiled tubes, and surface tension devices. Moreover, due to fouling or scaling, the barrier to heat transmission rises as a heat exchanger gets older.

Heat exchangers used during maritime applications and also the chemical industry are especially prone to these issues. There seems to be a requirement to improve the heat transfer rate in particular applications, including such heat exchangers dealing with poor thermal conductivity fluids (gases and oils) and desalination facilities.

The heat transfer rate can indeed be enhanced by disrupting the fluid flow (breaking the viscosity and thermal boundary layers), but really the pumping power used in the process will likely rise dramatically, resulting in a high pumping cost. As a result, numerous strategies have been presented in recent years to accomplish a desired heat transfer rate inside of an existing heat exchanger while using little pumping power.

Inserts are gotten a lot of press, but not for their impact on the properties of the employing fluid [8, 14]. Fins, twisted tapes, porous discs, tabulators, perforated plates, and dimples are among some of the inserts used within tubes to improve heat transmission towards the working fluid [15–19]. Twisted tapes have already been commonly used inside tubes to improve heat transfer performance and to have demonstrated to have a lower impact on pressure drop than other improvement techniques such fins [20–23].

Swirl flow is formed with increased axial fluid velocity and along tube in some kind of a tube integrated using twisted tape inserts, resulting in enhanced heat transfer [24–27]. Twisted tapes also produce a mixing flow similar to that of a turbulator that improves heat transmission [27–30].

As a result, the thermal performance of a twin pipe heat exchanger with or without twisting tape inserts was examined in this work with varied cut-out ratios.

II. REVIEW OF PAST STUDIES

Heat transfer improvement in various types of heat can result in improved heat exchanger performance and, as a result, lower system cost and size [1–4]. Fluted [4], various finned [5, 6] and micro fined [7], louvered [8, wire brushes [9], coiled wires [10], and twisted-tape inserts are the some of the ways utilized to promote and improve heat transmission. The use of twisted-tape inserts in pipes to improve heat transmission in heat exchangers is widespread.

Using the CFD approach to analyze the flow behaviour of interior flows, which would be difficult to get through standard experimental studies, can indeed be beneficial [11, 12]. Various researches have been conducted in order to get the optimum design and heat transfer performance [13, 14].

The findings of a case study on the thermal performance assessment of a concentric tube heat exchanger using regularly-spaced twisted-tape inserts as swirl generators were reported by Eiamsa-ard et al. [15].

The study additionally provides a comparative analysis to findings achieved with full-length twisted-tape inserts, as well as the construction of a mathematical model to replicate the whirling caused by regularly-spaced twisted tape inserts in the concentric tube heat exchanger. Researchers discovered that full length twisted tapes had a greater heat transfer rate and thermal performance factor than regular-spaced inserts under identical conditions." They also found that when the space ratio was increased, the boosted heat transfer reduced.

Tamna et al. [16] to improve heat transfer within the heat exchanger, V ribbed twisted-tapes were utilized. Assuming constant wall heat flux, the air with in test flowed with a Reynolds number range (between 5300 and 24,000).

The pressure drop and heat transmission increased with greater Reynolds values, according to the findings. Researchers also claim that now the twisted-tape type V-ribbed attained the highest relative rib heights for maximal pressure drop and heat transmission.

Suri et al. [17] The impact of square wings on multiple square perforated twisted-tapes on fluid flow and heat transfer of heat exchanger tubes was investigated in an experimental investigation. "Their experimental investigation comprised measurement of the Nusselt number and friction factor of circular tube heat exchanger fitted using multiple square perforated and square wing twisted-tape inserts under a ranging of Reynolds number from 5000 to 27,000. Researchers reported that the maximum increase in Nusselt number and friction factor over the simple circular tube was 6.96 and 8.34 times, accordingly."

Bhattacharyya [18] the use of a twisted-tape insert to improve heat transport within in the pipe was statistically studied. They experimented with different twist ratios ranging from 100 to 20,000 Re. The transition-SST turbulence model has been used. The first-order upwind approach was employed for such energy and momentum equations. The numerical model was constructed using Ansys Fluent 15 CFD code. To incompressible liquid, a 3D steady-state inquiry was employed. The numerical findings showed that employing twisted-tape inserted in the heat exchanger pipes can improve heat transfer with a larger pressure drop in the pipes. Researchers also discovered that now the thermal-hydraulic increase is only visible for Re and certain configurations.

"Osley et al. [19] the flow and heat transfer enhancement in tubes was quantitatively explored. They discovered that numerical simulations were an effective tool for studying the flow field in complicated geometries. The reliability of heat transmission and outlet temperatures has been validated. Researchers discovered that hiTRAN wire matrix inserts give a significant improvement inside the laminar flow zone."

Deshmukh et al. [20] analyzed the thermal–hydraulic properties of air flow within a circular tube using various tube inserts using numerical simulations. Researchers evaluated Reynolds numbers spanning from 2300 to 8800. In a concentric tube heat exchanger, the swirling flow devices were full-length helical tape even without centered-rod. Researchers found that using several types of helical tape structures improved the heat transmission rate significantly.

“In contrast to the plain tube, the maximum mean Nusselt number reported by that of the researchers was 160 percent for such full-length helical tape including centered-rod and 150 % for the full-length helical tape without rod. Researchers indicated that increased heat transmission might be due to whirling flow caused by secondary fluid flows.”

Yadav et al. [21] “the heat transfer enhancement properties of air flow inside a circular tube with just a partially declining & partly swirl flow were investigated using CFD. The half-length upstream twisted-tape condition (HLUTT), the half-length downstream twisted-tape condition (HLDTT), the full-length twisted tape (FLTT), and also the plain tube (PT) have been investigated with 3 distinct twist parameters (0.27, and 0.38) in four various combinations of tube to twisted-tape inserts. They ran a grid independence test for the numerical model in the CFD code to evaluate their numerical results. Their findings indicated that the CFD solver approach was used. To simulate the numerical investigation separated solver techniques, a three-dimensional CFD interface with double precision was employed.

The friction factor & heat transfer value was tested in laminar flow within a circular pipe using twisted-tape. The heat transfer increase for such pipe with the twisted-tape inserts between 7% and 10% when compared towards the pipe without the twisted-tape inserts, according to the findings. In addition, when the Reynolds number climbed, the Nusselt number also boosted.”

III. CONCLUSION

Several experimental and computational approaches have been investigated to improve the quality of heat transfer technique through with a pipe fitted out with various sorts of inserts based on the above literature study. Unfortunately, no data on the properties of heat transfer and fluid field in a circular tube fitted with P-TT and V-Cut twisted tape inserts while utilizing water as even the working fluid was found.

The current research focuses on improving the twisted tape shape with the goal of lowering friction and increasing thermal performance. The impacts of various cut-out ratios here on friction factor, Nusselt number, & thermal enhancement factor of twisted tape inserts (P-TT and V-Cut) are investigated. The numerical simulations are run in an a turbulent regime with Reynolds numbers ranging from 4000 to 12,000 and a uniformly heat flux wall condition.

REFERENCES

[1] W.I. Aly, Numerical study on turbulent heat transfer and pressure drop of nanofluid in coiled tube-in-tube heat exchangers, Energy Convers. Manag. 79 (2014) 304–316.

[2] R.S. Khedkar, S.S. Sonawane, K.L. Wasewar, Heat transfer study on concentric tube heat exchanger using TiO2–water based nanofluid, Int. Commun. Heat Mass Tran. 57 (2014) 163–169.

[3] H.A. Mohammed, H.A. Hasan, M.A. Wahid, Heat transfer enhancement of nanofluids in a double pipe heat exchanger with louvered strip inserts, Int. Commun. Heat Mass Tran. 40 (2013) 36–46.

[4] Z. Dengliang, X. Hong, S. Yan, Q. Baojin, Numerical heat transfer analysis of laminar film condensation on a vertical fluted tube, Appl. Therm. Eng. 30 (10) (2010) 1159–1163. [5] Z. Zhnegguo, X. Tao, F. Xiaoming, Experimental study on heat transfer enhancement of a helically baffled heat exchanger combined with three-dimensional finned tubes, Appl. Therm. Eng. 24 (14–15) (2004) 2293–2300.

[5] M. Hatami, D.D. Ganji, M. Gorji-Bandpy, Experimental and numerical analysis of the optimized finned-tube heat exchanger for OM314 diesel exhaust exergy recovery, Energy Convers. Manag. 97 (2015) 26–41.

[6] E.J. Lee, N.H. Kim, Evaporation heat transfer and pressure drop in flattened microfin tubes having different aspect ratios, Int. J. Heat Mass Tran. 92 (2016) 283–297.

[7] S. Eiamsa-ard, S. Pethkool, C. Thianpong, P. Promvonge, Turbulent flow heat transfer and pressure loss in a double pipe heat exchanger with louvered strip inserts, Int. Commun. Heat Mass Tran. 35 (2) (2008) 120–129.

[8] P. Naphon, T. Suchana, Heat transfer enhancement and pressure drop of the horizontal concentric tube with twisted wires brush inserts, Int. Commun. Heat Mass Tran. 38 (2) (2011) 236–241.

[9] M.A. Akhavan-Behabadi, S.G. Mohseni, H. Najafi, H. Ramazanzadeh, Heat transfer and pressure drop characteristics of forced convective evaporation in horizontal tubes with coiled wire inserts, Int. Commun. Heat Mass Tran. 36 (10) (2009) 1089–1095.

[10] A. Al-Obaidi, Experimental and Numerical Investigations on the Cavitation Phenomenon in a Centrifugal Pump, University of Hudders field, 2018. Doctoral dissertation.

[11] A.R. Al-Obaidi, Monitoring the performance of centrifugal pump under single-phase and cavitation condition: a CFD analysis of the number of impeller blades, J. Appl. Fluid Mech. 12 (2) (2019) 445–459.

[12] M.P. Mangtani, K.M. Watt, Effect OF twisted-tape inserts ON heat transfer IN a tube-a review, International Journal of Mechanical Engineering and Robotics Research 4 (2) (2015) 97.

[13] S.N. Sarada, A.S.R. Raju, K.K. Radha, L.S. Sunder, Enhancement of heat transfer using varying width twisted-tape inserts, Int. J. Eng. Sci. Technol. 2 (6) (2010).

[14] P. Eiamsa-ard, N. Piriyarungroj, C. Thianpong, S. Eiamsa-ard, A case study on thermal performance assessment of a heat exchanger tube equipped with regularly-spaced twisted-tapes as swirl generators, Case Studies in Thermal Engineering 3 (2014) 86–102.

[15] S. Tamna, Y. Kaewkohkiat, S. Skullong, P. Promvonge, Heat transfer enhancement in tubular heat exchanger with double V-ribbed twisted-tapes, Case studies in thermal engineering 7 (2016) 14–24.

[16] A.R.S. Suri, A. Kumar, R. Maithani, Effect of square wings in multiple square perforated twisted-tapes on fluid flow and heat transfer of heat exchanger tube, Case Studies in Thermal Engineering 10 (2017) 28–43.

[17] S. Bhattacharyya, H. Chattopadhyay, A.C. Benim, Simulation of heat transfer enhancement in tube flow with twisted-tape insert, Progress in Computational Fluid Dynamics, an International Journal 17 (3) (2017) 193–197.

[18] W.G. Osley, P. Droegemueller, P. Ellerby, CFD investigation of heat transfer and flow patterns in tube side laminar flow and the potential for enhancement, in: Conference Chemical Engineering Transactions PRES, vol. 13, 2013, pp. 997–1002.

[19] K.P. Deshmukh, M.J. Dhanokar, N.S. Varkute, T.S. Kumar, Numerical simulation of enhancement of heat transfer in a tube with and without rod helical tape swirl generators, Int. J. Mech. Eng. Technol. 5 (6) (2014) 1–13.

[20] RJ Yadav, (2012), CFD Analysis for heat transfer enhancement, Journal of Thermodynamics 2012 (2012) 1–12, https://doi.0.1155/2012/58 0593, 2012, 580593.

[21] K. Sivakumar, K. Rajan, Experimental analysis of heat transfer enhancement in a circular tube with different twist ratio of twisted-tape inserts, International Journal of Heat and Technology 33 (3) (2015) 158–162.

[22] A. Bhosale, K. Karunamurthy, R. Sivakumar, CFD analysis on heat transfer enhancement and pressure drop reduction in tube fitted with rectangular cut twisted-tapes, in: International Conference on Technological Convergence for Information, Health, Food, Energy Security, CSIR-CLRI, 2015, 1-2 May 2015.

[23] N. "Mashoofi, S. Pourahmad, S.M. Pesteei, Study the effect of axially perforated twisted-tapes on the thermal performance enhancement factor of a double tube heat exchanger, Case studies in thermal engineering 10 (2017) 161–168.