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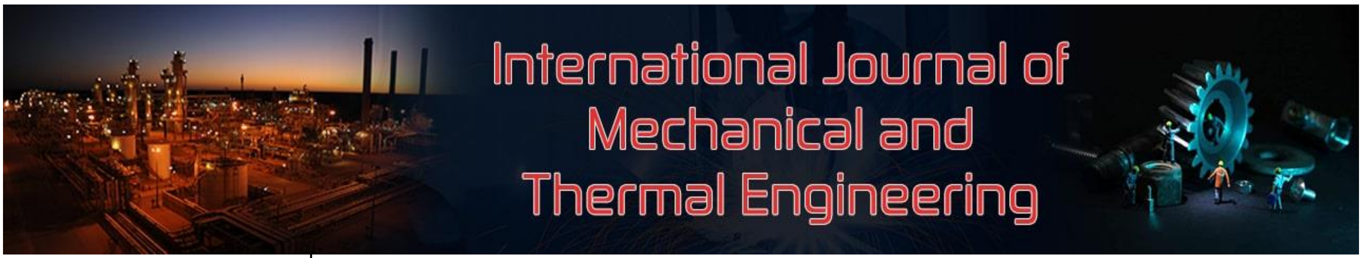

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Comparative thermal performance of helical and serpentine tube heat exchanger

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Abstract
Nowadays heat transfer is having wide application in areas like automobile, food processing power plant electronic devices etc. The system is used to enhance heat transfer between hot and cold fluid is heat exchanger and at present the requirement of heat exchanger is that it should be compact and efficient. The turbulence in the flow increaser rate of heat transfer and aim of present research work is to compare thermal performance of helical tube heat exchanger with serpentine tube heat exchanger to understand the effect of tube shape on thermal performance.

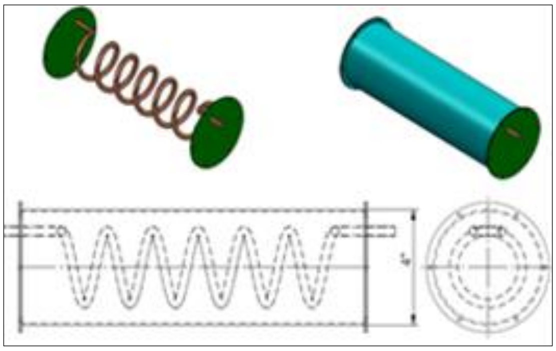
Keywords: Helical heat exchanger, serpentine heat exchanger, thermal performance, counter flow, parallel flow, heat transfer

1. Introduction

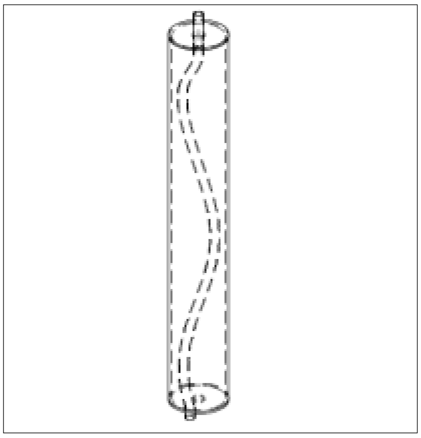
Thundil Karuppa Raj R *et al.* [1] attempted to study the effect of different baffle inclination angles on the fluid flow and heat transfer characteristics of a shell and tube heat exchanger for three different inclination angles of the deflectors, namely 0°, 10° and 20°. Vindhya Vasiny Prasad Dubey *et al.* [2] focused on in-depth thermal analysis of the effect of extreme loading conditions on heat exchanger performance. Chérif Bougriou and colleagues [3] were interested in a new type of heat exchanger, which is a double concentric shell and tube heat exchanger. Andre' L.H. Costa *et al.* [4] presented a study on design optimization of shell and tube heat exchangers. O. García-Valladares [5] developed detailed one-dimensional transient and steady-state numerical simulations of the thermal and hydrodynamic properties of a concentric three-tube heat exchanger. Abdalla Gomaa *et al.* [6] investigated experimental and numerical studies on concentric three-tube heat exchangers, paying special attention to twin-tube heat exchangers. Hinge [7] studied the design and performance of a single-section shell-and-tube heat exchanger by considering vertical and parallel baffle plates. Girish *et al.* [8] used fluent software to study the pressure drop inside a shell-and-tube heat exchanger by considering different baffles. Haran *et al.* [9] studied thermal analysis in the case of shell and tube heat exchangers considering both water type and oil type, which are most used in heating, refrigeration and air conditioning industries. Air, Pranita *et al.* [10] studied shell and tube exchangers by considering the influence of baffle types considering thermal performance and pressure loss. Petinin *et al.* [11] studied shell and tube heat exchangers by considering different variations of tube designs such as triangular, revolving triangular and combined shell and tube heat exchangers. Kaushik [12] studied the optimal design of shell and tube heat exchanger considering various parameters such as outer diameter, pitch, length, spacing and baffle shear etc. Yang *et al.* [13] studied the properties of heat exchangers by changing the fluid. Flows into the shell in the case of a shell-and-tube heat exchanger with spiral baffles. Kahya *et al.* [14] studied a shell-and-tube heat exchanger by comparing simulation results with analytical calculations using heat transfer studies. Amirtaraj *et al.* [15] studied a shell-and-tube heat exchanger with inclined baffles to achieve higher heat transfer efficiency and lower pressure drop. Oguz *et al.* [16] studied the thermal design of a shell-and-tube heat exchanger using an intelligent coordinated harmonic algorithm. Yanzhong [17] studied improving heat transfer by installing a sealing ring into the ring. They closed the gap between the bulkhead and the hull with putty. Tsjuwang *et al.* [18] investigated a shell-and-tube combined multi-way heat exchanger with spiral baffles to improve heat transfer characteristics and simplify the manufacturing process. Pramod S. Purandare *et al.* [19] conducted a study on the heat transfer phenomenon in a conical coil heat exchanger with a taper angle of 900 M.

Ghazikhani *et al.* [20] investigated the effect of a wedge-shaped tetrahedral VG (vortex generator) on a gas-liquid tube heat exchanger and Mohanty *et al.* [21], statistical analysis is used as a valuable tool to study the performance of shell-and-tube heat exchangers under fouling conditions. AI Zinkevich *et al.* [22] studied that the non-uniform distribution of fluid flow between the tubes of a shell-and-tube device needs to be taken into account to determine the heat transfer efficiency and analyze its influence on the heat transfer intensity. LIU Wei *et al.* [23] focused on improving the heat transfer in the central flow and analyzing the turbulence mechanism of longitudinal flow. Seong Yeon Yoo *et al.* [24] studied the heat transfer rate of the outer surface of the heat exchanger tube for a closed wet cooling tower and can be divided into sensible and latent heat transfer rates. Kozeki *et al.* [25] studied HE spiral wrapping with stainless steel pipes. Desai *et al.* [26] studied the fluid vibration inside HE provided by fins. He discovered that the fine networks are very stable, which contributes to the stability of the HE body. Dang *et al.* [27] presented a study on the HE heat storage capacity provided by fins and found that fins play a major role in thermal energy storage. Quach *et al.* [28] proposed a design module for HE to reduce the volume of the heat exchanger, aiming to reduce manufacturing costs. Vuong *et al.* [29] are currently doing research related to modeling and optimization of multilayer heat exchangers. Figley *et al.* [30] studied the structure of HE using numerical simulation and found a great influence of the structure on the behavior of HE. Zheng *et al.* [31] developed a new channel with a new form of EO to study the effectiveness. A transient flow is discovered by the new design. Ma *et al.* [32] numerically studied the inclination of the new HE design and the pressure drop. Andre' L.H. Costa *et al.* [33] presented a study on design optimization of shell and tube heat exchangers. O García-Valladares [34] developed detailed one-dimensional transient and steady-state numerical simulations of the thermal and hydrodynamic properties of a concentric three-tube heat exchanger. The literature review was performed from [35-41] Patel Anand *et al.* [42] Thakre, Shekhar *et al.* for heat exchanger [43-47] Anand Patel *et al.* for hybrid combination systems- heat exchanger with solar heater, hybrid car with renewable system and solar heater with electric car; [48] Patel Anand *et al.* for cooling tower; [49-54] Anand Patel *et al.* for Solar Heater by optimizing the design and material improvement performing thermal performance analysis to enhance the heat transfer efficacy which will be useful to perform the current study.

2. Experimental Construction



a. Helical Heat Exchanger



b. Serpentine Heat Exchanger

Fig 1: CAD Model of Experimental set up

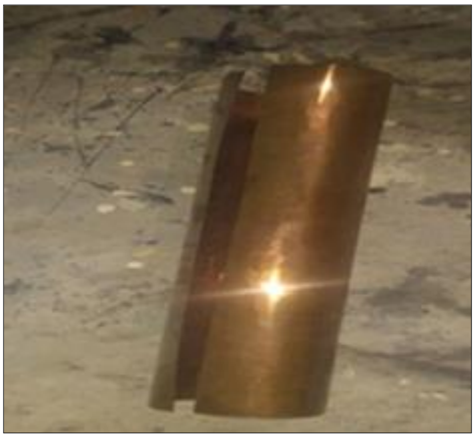


Fig 2: 4" Cylindrical pipe

Fig 3: Serpentine pipes

Fig 4: Helical Heat exchanger pipe

Fig 5: Helical and Serpentine Heat exchanger

In the present work in the first phase from copper sheet of 20 gauges the 4” diameter two cylindrical pipes of 0.23 m and 0.8 m length are fabricated using brazing process. Inside the cylindrical pipe the ½” diameter and above mention lengths helical pipe and serpentine pipe are inserted in shapes respectively. The outer cylinder is closed from both ends and inlets and outlets are provided on cylinder and inner pipes also. The K type thermocouples are used for temperature measurement purpose and 20 liter tank with tape is used to supply cold and hot water in the heat exchanger. The asbestos tape is wrapped around 4” cylinder to avoid heat transfer. Total four thermocouples and two measuring flasks are used to measure water flow and temperature at various locations of both heat exchangers, respectively.

3. Results and Discussion

Table 1: Observation Table

Helical Counter Flow			
Hot		Cold	
Tin	Tout	Tin	Tout
60	53.9	33	43.5
50	45.8	33	40.4
Helical Parallel Flow			
Tin	Tout	Tin	Tout
60	55.2	33	45.6
50	45.3	33	43.1
Serpentine Counter Flow			
Tin	Tout	Tin	Tout
60	55	33	41
50	46.5	33	38
Serpentine Parallel Flow			
Tin	Tout	Tin	Tout
60	56.1	33	41.8
50	47	33	39

Table 2: Result Table

ε counter flow Helical
0.23
0.25
ε parallel flow Helical
0.18
0.28
ε counter flow Serpentine
0.19
0.21
ε parallel flow Serpentine
0.14
0.18

Table 1 and Table 2 represent the observations and results in case of helical and serpentine heat exchanger for parallel and counter flow heat exchanger. In case of helical heat exchanger better thermal performance is observed as due to shape more surface area is available for heat transfer and more turbulence in the flow can be achieved which enhances heat transfer and so better effectiveness can be obtained in parallel and counter flow both.

4. Conclusion

In case of shell and tube heat exchanger the pipe shape plays a vital role to improve the thermal performance also heat exchanger becomes compact.

5. References

1. Thundil KRR, Srikanth G. Shell side numerical analysis of a shell and tube heat exchanger considering the effects of baffle inclination angle on fluid flow using CFD.
2. Vindhya VPD, Raj RV, Piyush SV, AK Srivastava. Performance Analysis of Shell & Tube Type Heat Exchanger under the Effect of Varied Operating Conditions IOSR Journal of Mechanical and Civil Engineering; c2014. Volume 11.
3. Cherif B, Khireddine B. Shell-and-double concentric-tube heat exchangers Heat Mass Transfer; c2010.
4. Andre´ LH Costa, Eduardo M. Queiroz Design optimization of shell-and-tube heat exchangers, Applied Thermal Engineering; c2008. Volume 28.
5. O García-Valladares. Numerical simulation of triple concentric-tube heat exchangers International Journal of Thermal Sciences; c2004. Volume 43.
6. Abdalla Gomaa, MA Halim, Ashraf Mimi Elsaid, Experimental and numerical investigations of a triple concentric-tube heat exchanger; c2015. Volume 15,
7. SS Deshpande, SA Hinge. Design and performance study of shell and tube heat exchanger with single segmental baffle having perpendicular & parallel-cut orientation, Int. J. Eng. Res. Technol; c2014. Volume 3.
8. D Gireesh, JB Rao. Design and analysis of heat exchanger with different baffles, Int. J. Mag. Eng. Technol. Manag. Res; c2017. Volume 4.
9. V Hari Haran, G Ravindra Reddy, B Sreehari. Thermal analysis of shell and tube heat ex-changer using C and Ansys, Int. J Computer Trends Technol; c2013. Volume 4.
10. P Bichkar, O Dandgaval, P Dalvi, R Godase, T Dey. Proc. Manufacture; c2018. Volume 20.
11. MO Petinin, AA Dare. Performance of shell and tube heat exchangers with varying tube layouts, Br. J. Shell Tube Heat Exchangers Varying Tube Layouts; c2016. Volume 12.
12. AK Prasad, K Anand. Design and analysis of shell and tube type heat exchanger, Int. J. Eng. Res. Technol; c2020. Volume 9.
13. YS Son, JY Shin. Performance of a shell-and-tube heat exchanger with spiral baffle plates, KSME Int. J; c2011. Volume 15.
14. AH Cahya, R Permatasari. Design of shell and tube heat exchanger for waste water using heat transfer research INC, Int. J Adv. Sci. Technol; c2020. Volume 29.
15. PSP Amirtharaj, S Allaudinbasha, M Janagan, R Karthikeyan, S Muthukumar. Design and analysis of shell and tube heat exchanger with inclined baffles, Int. J Sci. Eng. Dev. Res; c2016. Volume 1.
16. OE Turgut, MS Turgut, MT Coban. Design and economic investigation of shell and tube heat exchangers using improved intelligent tuned harmony search algorithm, Ain Shams Eng. J; c2014. Volume 5.
17. SW Wen, Y Li. An experimental investigation of heat transfer enhancement for a shell-and-tube heat exchanger, Appl. Thermal Eng; c2009. Volume 29.
18. Q Wang, Q Chen, G Chen, M Zing. Numerical investigation on combined multiple shell-pass shell-and-tube heat.
19. Purandare PS, Lele MM, Gupta RK. Experimental investigation on heat transfer analysis of conical coil

heat exchanger with 90 degree cone angle, Heat Mass Transfer; c2014. Volume 46.

20. M Ghazikhani, I Khazaee SM, S Monazzam, J Taghipour. Experimental Investigation of the vortex generator effects on a gas liquid finned tube heat exchanger using irreversibility analysis Arab J Sci Eng; c2013.
21. Mohanty DK, Singru PM. Numerical method for heat transfer and fouling analysis of a shell and tube heat exchanger using statistical analysis Korean J Chem. Eng; c2012.
22. Zinkevich VN, Sharifullin, AV Sharifullin. Analyzing the Effect on Heat Transfer due to Non uniform Distribution of Liquid Flow among the Tubes of a Shell and Tube Heat Exchanger Thermal Engineering; c2010.
23. Wei L, ZhiChun L, Shuang WY, SuYi H. Flow mechanism and heat transfer enhancement in longitudinal flow tube bundle of shell and tube heat exchanger, Sci China Ser E-Tech Sci; c2009.
24. Yoo S, Kim J, Han K. Thermal performance analysis of heat exchanger for closed wet cooling tower using heat and mass transfer analogy, Journal of Mechanical Science and Technology; c2010. Volume 24.
25. Kozeki M, Nariai H, Furukawa T, Kurosu K. A study of helically-coiled tube once-through steam generator. Bulletin of JSME; c1970. Volume 13.
26. Desai SR, Kengar RV. Experimental analysis of fluid elastic vibrations in rotated square finned tube arrays subjected to water cross flow. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science; c2019. Volume 233.
27. Deng S, Nie C, Wei G, Ye WB. Improving the melting performance of a horizontal shell-tube latent-heat thermal energy storage unit using local enhanced finned tube. Energy and Buildings; c2019. Volume 183.
28. Guo K, Zhang N, Smith R. Optimization of fin selection and thermal design of counter-current plate-fin heat exchangers. Applied Thermal Engineering; c2015. Volume 78.
29. Wang Z, Li Y. Layer pattern thermal design and optimization for multi stream plate-fin heat exchangers - A review. Renewable and Sustainable Energy Reviews; c2016. Volume 53.
30. Figley J, Sun X, Mylavarapu SK, Hajek B. Numerical study on thermal hydraulic performance of a Printed Circuit Heat Exchanger. Progress in Nuclear Energy; c2013. Volume 68.
31. Zheng Z, Fletcher DF, Haynes BS. Transient laminar heat transfer simulations in periodic zigzag channels. International Journal of Heat and Mass Transfer; c2014. Volume 71.
32. Ma T, Li L, Xu XY, Chen YT, Wang QW. Study on local thermal–hydraulic performance and optimization of zigzag-type printed circuit heat exchanger at high temperature. Energy Conversion and Management; c2015.
33. Andre LH Costa, Eduardo M. Queiroz, Design optimization of shell-and-tube heat exchangers, Applied Thermal Engineering; c2008. Volume 28.
34. O García-Valladares. Numerical simulation of triple concentric-tube heat exchangers International Journal of Thermal Sciences; c2004. Volume 43.
35. Patel AK, Zhao W. Heat Transfer Analysis of graphite foam embedded vapor chamber for cooling of power electronics in electric vehicles. Proceedings of the ASME 2017 heat transfer summer conference. volume 1: aerospace heat transfer; computational heat transfer; education; Environmental Heat Transfer; Fire and Combustion Systems; Gas Turbine Heat Transfer; Heat Transfer in Electronic Equipment; Heat Transfer in Energy Systems. Bellevue, Washington, USA; c2017 July. p. 9-12. V001T09A003. ASME. https://doi.org/10.1115/HT2017-4731
36. Anand P. Thermal Performance Investigation of Twisted Tube Heat Exchanger, International Journal of Science and Research (IJSR). 2023 June;12(6):350-353. https://www.ijsr.net/getabstract.php?paperid=SR23524161312. DOI: 10.21275/SR23524161312
37. Patel A. Performance Analysis of Helical Tube Heat Exchanger, TIJER - International Research Journal. ISSN: 2349-9249. 2023 July;10(7):946-950. www.tijer.org Available: http://www.tijer.org/papers/TIJER2307213.pdf.
38. Patel A. Effect of pitch on thermal performance serpentine heat exchanger. International Journal of Research in Aeronautical and Mechanical Engineering (IJRAME). 2023 Aug;11(8):01-11. https://doi.org/10.5281/zenodo.8225457.
39. Patel A. Advancements in heat exchanger design for waste heat recovery in industrial processes. World Journal of Advanced Research and Reviews (WJARR). 2023 Sep;19(03):137-52. DOI: 10.30574/wjarr.2023.19.3.1763.
40. Patel AK. Investigation of a Novel vapor chamber for efficient heat spreading and removal for power electronics in electric vehicles, thesis, May 2017; Denton, Texas. University of North Texas Libraries, UNT Digital Library, Accessed September 11, 2023, https://digital.library.unt.edu, DOI: 10.13140/RG.2.2.28847.10402 https://digital.library.unt.edu/ark:/67531/metadc98420
41. Patel A. Heat Exchanger Materials and Coatings: Innovations for improved heat transfer and durability. International Journal of Engineering Research and Applications (IJERA). 2023 Sep;13(9):131-42. DOI: 10.9790/9622-1309131142.
42. Thakre S, Pandhare A, Malwe, Prateek D, *et al.* Heat transfer and pressure drop analysis of a micro channel heat sink using Nano fluids for energy applications Kerntechnik; c2023. https://doi.org/10.1515/kern-2023-0034.
43. Patel A. Comparative analysis of solar heaters and heat exchangers in residential water heating. International Journal of Science and Research Archive (IJSRA). 2023;09(02):830-843. https://doi.org/10.30574/ijsra.2023.9.2.0689
44. Patel A. Enhancing Heat Transfer Efficiency in Solar Thermal Systems Using Advanced Heat Exchangers. Multidisciplinary International Journal of Research and Development (MIJRD). 2023;02(06):31-51. https://www.mijrd.com/papers/v2/i6/MIJRDV2I60003.pdf.
45. Patel A. Optimizing the Efficiency of solar heater and heat exchanger integration in hybrid system, TIJER - International Research Journal (www.tijer.org), ISSN: 2349-9249. 2023 Aug;10(8):270-b281, Available: http://www.tijer.org/papers/TIJER2308157.pdf

46. Patel A. Solar heater-assisted electric vehicle charging Stations: A Green Energy Solution. Hangkong Cailiao Xuebao/Journal of Aeronautical Materials. ISSN: 1005-5053, 2023;43(02):520-534. www.hkclxb.cn/article/view/2023/2-520.html.
47. Patel A. Enhancing Sustainability: A Review of hybrid vehicle technologies powered by renewable energy. Yantu Lixue/Rock and Soil Mechanics. ISSN: 1000-7598. 2023;44(06):386-400. https://doi.org/10.5281/zenodo.8056589.
48. Anand P. The Effect of moisture recovery system on performance of cooling tower. International Journal for Modern Trends in Science and Technology. 2023;9(07):78-83. https://doi.org/10.46501/IJMTST0907013.
49. Patel A. Integrating solar heaters into renewable energy Systems: A Case Study. China Petroleum Processing and Petrochemical Technology. 2023;23(2):1050-1065. http://zgsyjgysyhgjs.cn/index.php/reric/article/view/2-1050.html
50. Patel A. Efficiency enhancement of solar water heaters through innovative design. International Journal of Science and Research Archive (IJSRA). 2023;10(01):289-303. https://doi.org/10.30574/ijsra.2023.10.1.0724.
51. Anand KP. Technological Innovations in Solar Heater Materials and Manufacturing. United International Journal for Research & Technology (UIJRT). 2023;4(11):13-24.
52. Patel A. Optimizing solar heater efficiency for sustainable renewable energy. Corrosion and protection. ISSN: 1005-748X. 2023;51(2):244-258, www.fsyfh.cn/view/article/2023/02-244.php.
53. Anand P. Thermal Performance Analysis of Wire Mesh Solar Air Heater. Eduzone: International Peer Reviewed/Refereed Multidisciplinary Journal. 2023;12(2):91-96. Retrieved from: https://www.eduzonejournal.com/index.php/eiprmj/article/view/389
54. Patel A. Thermal performance analysis conical solar water heater. World Journal of Advanced Engineering Technology and Sciences (WJAETS). 2023;9(2):276-283. https://doi.org/10.30574/wjaets.2023.9.2.02286