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# A REVIEW ON HEAT TRANSFER AUGMENTATION IN COUNTER FLOW SHELL AND TUBE HEAT EXCHANGER

**Harshal Chothe[1], K. B. Bokankar[2], K. A. Rajput[3]**

[1]*P.G. Student, Department of Mechanical Engineering, MIT, Aurangabad, MS (India)*

[2]*Professor, Department of Mechanical Engineering, MIT, Aurangabad, MS (India)*

[3]*Asst. Prof. Department of Mechanical Engineering, SYCET, Aurangabad, MS (India)*

## ABSTRACT

*Many industrial application including power plants, chemical, refrigerator and air conditioning systems use heat exchangers to remove excess generated heat out of the system. Recent technologies are uses shell and tube counter flow type heat exchanger to enhance heat transfer coefficient. Helical coil heat exchanger is wide range of applications because of small space with large heat transfer area using passive techniques of heat transfer enhancement. Now day's nanofluid has numerously used in the heat exchanger due to its higher heat carrying capacity. It also found that CNT coating increase heat transfer due to its high thermal conductivity. This paper presents a review of published works on the heat transfer enhancement by active and passive methods especially in helical coil tube heat exchanger. This review can be indicated by the status of the research in this area which is important.*

***Keywords: CNT Coating, Heat Transfer Augmentation, Helical coil heat exchanger, Shell and Tube Heat Exchanger***

## I. INTRODUCTION

A heat exchanger is a device used to transfer heat between one or more fluids. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment. The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the incoming air, due to increased demands by industry for heat exchange equipment that is less expensive to build and operate than standard heat exchange devices.Recently, large numbers of attempts have been made to develop enhancement techniques to reduce the size and costs of heat exchangers in order to improve the overall performance of heat exchangers. An extensive literature survey of research on all types of enhancement technique is given in Webb and Bergles. Generally, enhancement techniques can be classified in three broad categories [1]:

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(a) Active method: Active augmentation, which has been studied extensively, involved some external power input to bring about the desired flow modification for enhancement and has not shown much potential owing to complexity in design. Furthermore, external power is not easy to provide in several applications.

(b) Passive method: Passive methods do not require external power but make use of a special surface geometry or fluid additive which cause heat transfer enhancement. The majority of commercially interesting enhancement techniques are passive ones. Tube insert devices including twisted tape, wire coil, extended surface and wire mesh inserts are considered as the most important techniques of this group; in which, twisted tape and wire coil inserts are widely applied than others.

(c) Compound method: a compound method is a hybrid method in which both active and passive methods are used in combination. The compound method involves the complex designs and hence it has limited applications.

The flow through a curved pipe has been attracting much attention because helical coiled pipes are widely used in practice as heat exchangers and chemical reactors. The fluid flowing through curved tubes induces secondary flow in the tubes. This secondary flow in the tube has significant ability to enhance the heat transfer due to mixing of fluid. The intensity of secondary flow [2, 3] developed in the tube is the function of tube diameter (Di) and coil diameter (*D*). Due to enhanced heat transfer in helical coiled configuration the study of flow and heat transfer characteristics in the curved tube is of prime important. The several studies have indicated that helical coiled tubes are superior to straight tubes when employed in heat transfer applications. The centrifugal force due to the curvature of the tube results in the secondary flow development which enhances the heat transfer. This phenomenon can be beneficial especially in laminar flow regime. Naphon [3] investigated the thermal performance and pressure drop of a shell and helical coiled tube heat exchanger with and without helical crimped fins. Naphon et al. [4] summarized the phenomenon of heat transfer and flowcharacteristics of single-phase and two-phase flow in curvedtubes including helically coiled tubes and spirally coiled tubes.

Helical coils offer advantageous over straight tubes due to their compactness and increased heat transfer coefficient.

The increased heat transfer coefficients are a consequence of the curvature of the coil, which induces centrifugal forces to acton the moving fluid, resulting in the development of secondary flow. Fluid from the inside of the tube is thrown through the center of the tube towards the outer wall and then returns to the inner wall via the wall region. This secondary flow enhances heat transfer and temperature uniformity due to increased mixing, especially in laminar flow (Ruthven 1971). However, the required pressure gradient to obtain a given mass flux is increased compared to a straight tube. Both the increased heat transfer rates and temperature uniformity can be advantageous for food processing. The main aim of researchers to enhance heat transfer coefficient in heat exchanger by using passive techniques with saving in materials and space.

## II. LITERATURE REVIEW

The shell and tube counter flow type heat exchanger most common used in industries. Researchers takes interest to find most effective method of heat transfer enhancement by analysis of heat exchanger. The LMTD method can be readily used when the inlet and outlet temperatures of both the hot and cold fluids are known. When the outlet temperatures are not known, the LMTD can only be used in an iterative scheme. In this case the

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effectiveness-NTU method can be used to simplify the analysis. The choice of heat exchanger type directly affects the process performance and alsoinfluences plant size, plant layout, length of pipe runs and the strength and size of supporting structures. The most commonly used type of heat exchanger is the shell-and tube heat exchanger, the optimal design of which is the main objective of this study.

**Prabhanjan et al. 2002[5]** Authors found that many industries use helical coil tube heat exchanger due to its higher heat transfer coefficients than straight tube heat exchanger due to increased buoyancy effects. A comparative study was undertaken to determine heat transfer coefficient. Flow rate did not affect the heat transfer coefficient, most likely from the fact that the flow was turbulent and increasing the flow rate does not greatly change the wall effects. Author also found that the temperature rise of the fluid was found to be effected by coil geometry and by the flow rate.

**Salimpour 2009 [6]** He investigated experimentallythe heat transfer coefficients of shell and helically coiled tube heat exchangerswith different coil pitches were selected as test section for both parallel-flow and counter-flow configurations. It was found that Nusselt numbers increase with Reynolds number.It was revealed that the correlation for constant temperature boundary conditionis quite in agreement with the present data in low Dean numberregion. From the results of the present study, Author was found out thatthe shell-side heat transfer coefficients of the coils with largerpitches are higher than those for smaller pitches. Finally, basedon the results of this study, two correlations were developed topredict the inner and outer heat transfer coefficients of the coiledtube heat exchangers.

**Nasser Ghorbani et al. 2010 [7]**Author studied an experimental investigation of the mixed convection heat transfer in a coil-in-shell heat exchanger was reported for various Reynolds and Rayleigh numbers, various tube-to-coil diameter ratios and dimensionless coil pitch and found that the mass flow rate of tube-side to shell-side ratio was effective on the axial temperature profiles of heat exchanger.The results also indicate that the ε−NTU relation of the mixed convection heat exchangers was the same asthat of a pure counter-flow heat exchanger and it find that the mass flow rate of tube-side to shell-side ratio (Rm) was found to beeffective on the axial temperature profiles of heat exchanger. Author also shows with increasing mass flow rate ratio the logarithmic mean temperature difference was decreased.The modified effectiveness decreased with increasing mass flow rateratio.An equation was found to correlate the modified effectiveness data to the mass flow rate ratio for $0.15<Rm<5$. The ε−NTU relationof the mixed convection heat exchangers was same to those of a purecounter-flow heat exchanger.

**Mandar et al 2012 [8]** In this paper parametric analysis was taken by different researchers are summarized for helical coil heat exchanger and found that for low *Re*, the graphs of *Nu* Vs*Re*and *hi* Vs *Re* is steeper than that at high *Re.* Itindicates that helical coils are efficient in low *Re.* Theanalysis also shows that, as tube diameter (*d*) increaseswith constant coil diameter (*D*), the curvature ratio (*δ*) increases, which increases the intensity of secondariesdeveloped in fluid flow. The increase in the intensity ofsecondaries developed in fluid flow increases *Nu*. Henceit is desirable to have small coil diameter (*D*) and largetube diameter (*d*) in helical coil heat exchanger, for largeintensities of seconderies in tube.

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**Sujith Kumar C 2012 [9]** This work deals on the experimental investigation on the heat transfer and pressure drop characteristics of CNT coating on a stainless steel substrate in a rectangular macro channel with water as the working fluid. The experiments were conducted under both laminar and turbulent flow conditions with Reynolds number varying from 500-2600. The result of CNT coatings on the surface enhances the heat flux, surface area, the increase in the roughness and without much increase in the pressure drop.

**R. Senthilkumar2012[10]** In this paper rectangular aluminium fins were preferred for analysis and coated by carbon nano tubes using PVD to enhance the heat transfer rate of fins. Experimentally the temperature distribution for coated and non coated fins was observed and optimized using Taguchi method and ANOVA analysis. Hereby it is confirmed that the coating is efficient in enhancing natural convection while considering the thermal properties of carbon nano tubes, the expected degree of increase in natural convection rate is governed and controlled by diffusion force and viscous force.

**B. ChinnaAnkanna et al. 2014 [11]** This paper author focus on an increase in the effectiveness of a heat exchanger and analyze variousparameters that affect the effectiveness of a heat exchangerand also deals with the performance analysis of heatexchanger by varying various parameters like number ofcoils, flow rate and temperature. The results found that

a) High rate of heat transfer due to greater surface area.

b) Heat transfer coefficient of helical coil heat exchanger is 0.35 times of straight tube heat exchanger.

c) The effectiveness of pipes either helical or straight in counter flow is greater than parallel configuration.

**M.Balachandran 2015 [12]** he investigate by experimentally convective heat transfer coefficient of cold fluid (Cuo-water nano fluid) flowing in helical coil was reported for various Reynolds numbers. It observed once the steady state has passed. The volume flow rate of both fluids is maintained below as laminar and in that the flow rate of cold fluid (Cuo-water nano fluid) by keeping constant while that of hot fluid (water) is changed. It is inferred that nano fluid coolant can absorb heat better than water as coolant at low flow rate. Author concludes that the performance of the helical coil heat exchanger using nano fluid is comparatively higher than that of water as a coolant.

## V. CONCLUSION

From the above literature survey it is conclude that

a) Helical coil has higher heat transfer rate than straight tube due to greater surface area.
b) Heat transfer coefficients of the helical coils with largerpitches are higher than those for smaller pitches.
c) With increasing diameter of tube with curvature ratio increase heat transfer
d) Heat transfer coefficient was increase by additives in heat exchanger like nano fluid.
e) CNT Coating on substrate enhance in heat flux, surface area, increase in the surface roughness and without increase in the pressure drop.

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## REFERENCES


[1] A. E. Bergles, R. L. Webb, Heat transfer enhancement: second generation technology, Proceedings from the Sixth Annual Industrial Energy Technology Conference Volume I, Houston, TX, April 1984, 15-18.

[2] Dravid, A. N., Smith., K. A., Merrill, E.A., and Brian, P.L.T.,Effect of secondary fluid motion on laminar flow heat transfer in helically coiled tubes, AIChE Journal, Vol.17(5), 1971, 1114-1122.

[3] Naphon, P., Thermal performance and pressure drop of the helical-coil heat exchangers with and without helically crimped fins, Int.Communication of Heat Mass Tran, Vol.34 (3), 2007, 321–330.

[4] Naphon, P., and Wongwises, S., A review of flow and heat transfer characteristics in curved tubes, Renew. Sust.Energ. Rev. 10, 2006, 463–490.

[5] D. G. Prabhanjan, G. S. V. Ragbavan and T. J. Kennic, Comparison of heat transfer rates between a straight tube heatexchanger and a helically coiled heat exchanger, lnt. Comm. Heat & mass Trans. Vol. 29. No. 2. 2007, 185-191.

[6] M.R. Salimpour Heat transfer coefficients of shell and coiled tube heat exchangers,Experimental Thermal and Fluid Science 33, 2009, 203–207.

[7] Nasser Ghorbania, HessamTaherian b, MofidGorji b, HessamMirgolbabaei c An experimental study of thermal performance of shell-and-coil heat exchangers,International Communications in Heat and Mass Transfer 37, 2010, 775–781.

[8] Pramod S. Purandare, Mandar M. Lele, Rajkumar Gupta, Parametric Analysis of Helical Coil Heat Exchanger, International Journal of Engineering Research & Technology (IJERT)Vol. 1 Issue 8, October, 2012, 2278-0181.

[9] Sujith Kumar C. S, S. Suresh, Rajiv K, Heat Transfer Enhancement by Nano Structured Carbon Nanotube Coating,International Journal of Scientific & Engineering Research Volume 3, Issue 6, June, 2012, 2229-5518.

[10] R. Senthilkumar , A. J. D. Nandhakumar, S. Prabhu Analysis of natural convective heat transfer of nano coatedaluminium fins using Taguchi method, Heat Mass Transfer DOI 10.1007/s00231-012-1063-1.

[11] B. ChinnaAnkanna, B. Sidda Reddy Performance Analysis of Fabricated Helical Coil Heat Exchanger, International Journal of Engineering Research, Volume No.3 Issue No: Special 1, 2014, 33-39.

[12] M. Balachandran Experimentaland CFD study of a helical coil heat exchanger using water as fluid, Proceedings of 22nd IRF International Conference, 29th March 2015, Chennai, India, ISBN: 978-93-82702-83-2.