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"ANALYSIS OF HELICAL COILS OF DIFFERENT MATERIALS IN HEAT EXCHANGER USING CFD"

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ABSTRACT

Now-a-days with every increasing power applications have created a demand for heat exchangers of high heat transfer co-efficient that often exploit coil's highly complex design architectures. Architectures of coils are the very important functional blocks in heat exchanger unit as the performance of system depends on the dynamics associated with fluid flow within the coils. In this thesis, we present comparative analysis off helical design of the coil as it offer an enhanced heat and mass transfer co-efficient than most existing and commonly used coil designs. Method for solving CFD analysis of helical coil heat exchanger would be carried out using "ANSYS 14.0" while the feasibility of model is analyzed via CAD model Generation of 3D model by using "CATIA VER 5.0".

Keyword*:* CFD, CATIA, ANSYS, Heat exchanger, Coils, heat transfer.

I. Introduction

Heat exchange is an operation where in heat is transferred from mass to fluid which is commonly exploited in heating and cooling based operation throughout the world. In typical sense, a heat exchanger can be defined as a gadget or mechanical setup utilized for procedure of heat trades between two or more liquids that are at various temperature. Helical coil heat exchangers are of great use in industrial applications such as power generation, nuclear industry, process plants, heat recovery systems, refrigeration, food industry, etc due to its compact structure and high heat transfer coefficient. Helical coils of circular cross section have been used in wide variety of applications due to simplicity in manufacturing. Flow in curved tube is different from the flow in straight tube because of the presence of the centrifugal forces. These centrifugal forces generate a secondary flow, normal to the primary direction of flow with circulatory effects that increases both the friction factor and rate of heat transfer.

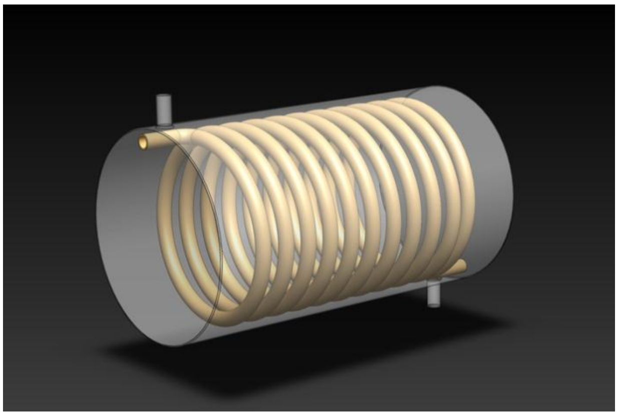

Fig.1

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BASIC CLASSIFICATION OF HEAT EXCHANGERS

- Parallel-flow heat exchangers
- Counter-flow heat exchangers:
- Cross-flow heat exchangers

II. METHODOLOGY

CFD is a sophisticated computationally-based design and analysis technique. CFD software gives you the power to simulate flows of gases and liquids, heat and mass transfer, moving bodies, multiphase physics, chemical reaction, fluid-structure interaction and acoustics through computer modeling. This software can also build a virtual prototype of the system or device before can be apply to real-world physics and chemistry to the model, and the software will provide with images and data, which predict the performance of that design. CFD analysis of helical coil heat exchanger using Ansys 14.0, Cad model Generation of 3D model by using CATIA Ver 5.0 and exporting to the IGES. and then import in ANSYS fluent 14.0.

Fig.1

- ➢ **PRE PROCESSING**:

  Create geometry and mesh for solving problem

- ❖ **CAD model**
- ✓ Generation of 3D model by using CATIA ver 5.0
- ❖ **FVM approach:-**

  By this method we can solve algebraic equation to get initial solution.

- ✓ Set the transportation equation that need to be solved. This can be solved by using ANSYS Fluent 14.0 in Fluent setup
- ✓ Set the fluid property
- ✓ Set the boundary conditions
- ✓ Set the Source term (Pressure)
- ➢ **<u>SOLUTION:</u>**

  Solution Method

- ❖ **Pressure Velocity coupling scheme**

  For 2D Problem we use Stream Function Vortices approach.

  For 3D Problem we use Primitive variable approach.

  Collocated grid should be used to solve pressure velocity coupling scheme.

- ❖ **Turbulence Modeling:-**

  K-ε turbulence model for turbulent flow equation Momentum second order Turbulence Kinetic energy second order (K) Turbulence dissipation rate second order (ε)

- ➢ **SOLUTION INITIALIZATION:-**

  Initialized the solution to get the initial solution for the problem. By using SIMPLE solver (Semi – implicit method for pressure linked equation).

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- **RUN SOLUTION:-**

Run the solution by giving 300 no of iteration for solution to converge.

- **POST PROCESSING:-**

Post Processing:- For viewing and interpretation of Result, the result can be viewed in various formats like graph, value, animation etc.

Table.1 Geometry Dimentions

S.No.	Dimensional parameters	Dimensions
1	Pitch coil diameter (D)	40 mm
2	Tube diameter (d)	10 mm
3	Pitch (p)	17 mm
4	Tube Length (L)	1000 mm

III. MODELING & SIMULATION

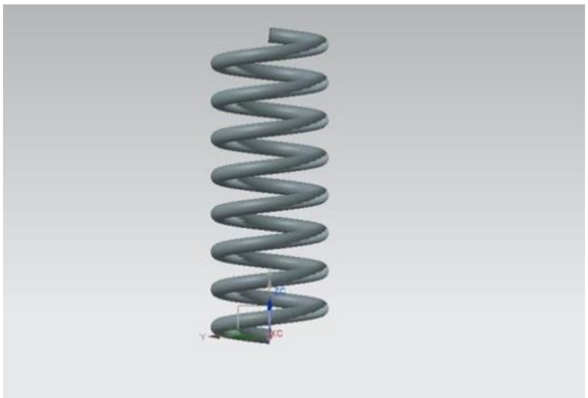

Fig.3 CAD Model Helical Tube

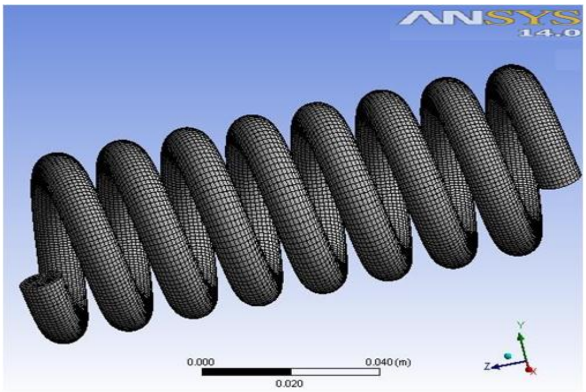

Fig.4 Meshing of coil

Table.2 Fluid Properties

Type of fluid	Water
Density	999.2 kg/m3
Viscosity	.0010003kg/m3
Specific heat Cp	4182 jule/g.kal
Thermal Conductivity ,k	0.6 watt/kal

Table. 3 Boundary Conditions for flow rates (i.e. 0.02kg/s)

Temperature	332 k
Mass flow rate	0.02 kg/s
Turbulence intensity ratio	0.5%
Turbulence viscosity ratio	10%
Wall temperature	293k
Outlet	Out pressure
Operation condition pressure	101325 Pa

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IV. RESULT & DISCUSSION

All the simulation result and synthesis report of the all the implemented heat exchangers over different materials and flow rates. CFD computations were done for mass flow rate of water 0.02 kg/s for Different Materials like Aluminum, Bronze and Copper for helical coil heat exchanger. In our study, there is constant length and number of turns. Performance parameters and dimensions adopted for comparison are different helical tube materials, Nussle number and pressure drop in cases.

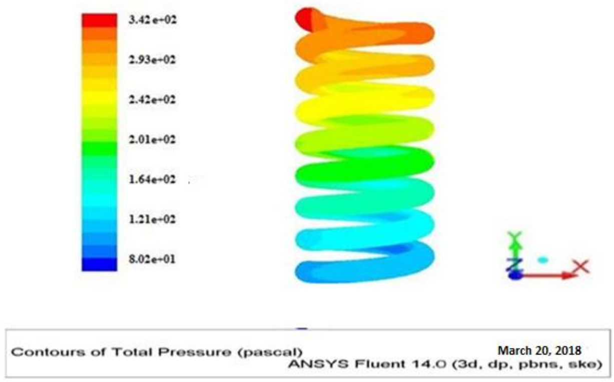

Fig.5 Pressure drop copper tube

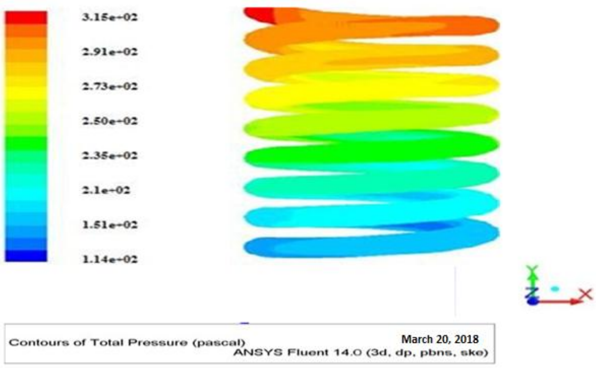

Fig.6 Pressure drop Bronze tube

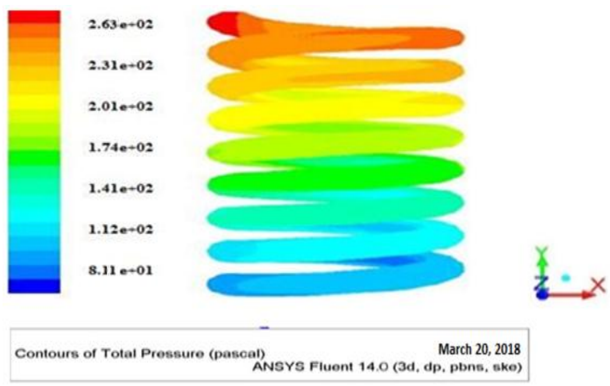

Fig.7 Pressure drop Aluminum tube

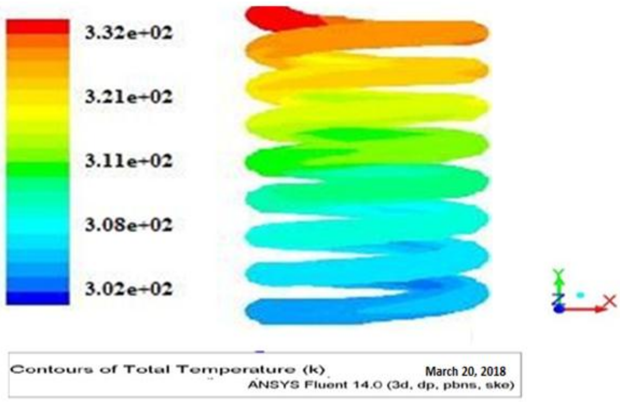

Fig.8 Temperature changes Copper tube

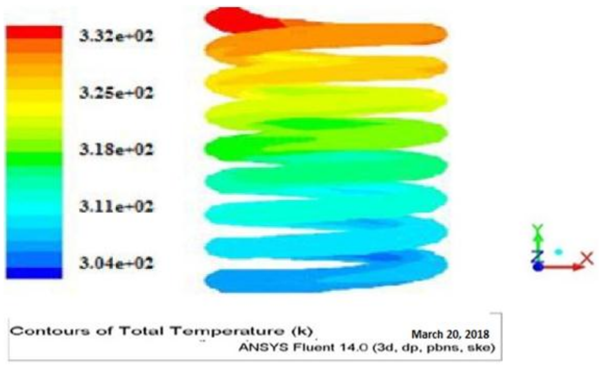

Fig.9 Temperature changes Bronze tube

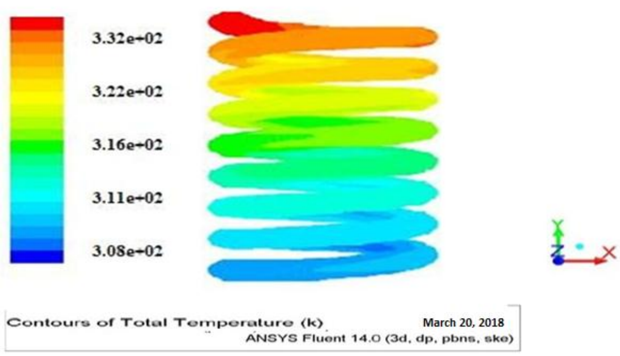

Fig.10 Temperature changes Aluminium tube

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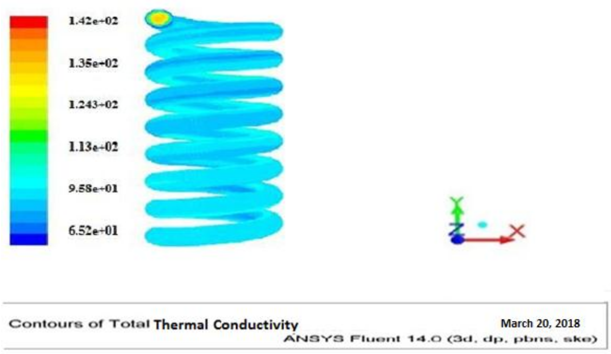

Fig.11 Thermal Conductivity for Copper

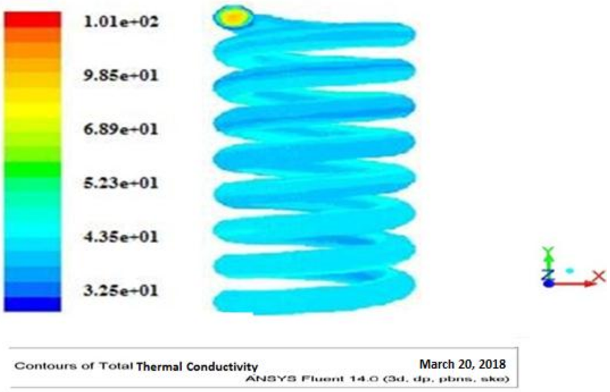

Fig.12 Thermal Conductivity for Bronze

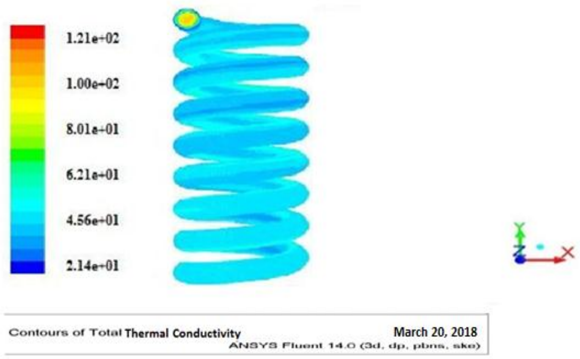

Fig.13 Thermal Conductivity for Aluminum

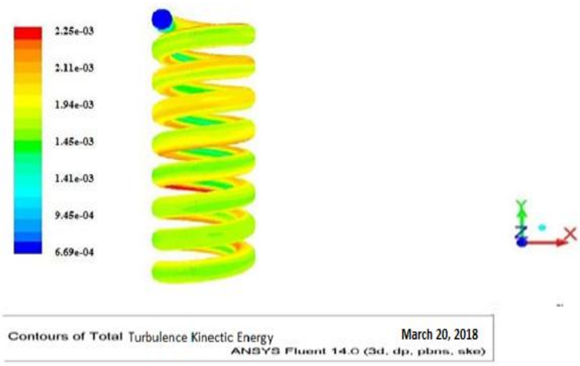

Fig.14 Turbulence Kinetic Energy, Copper

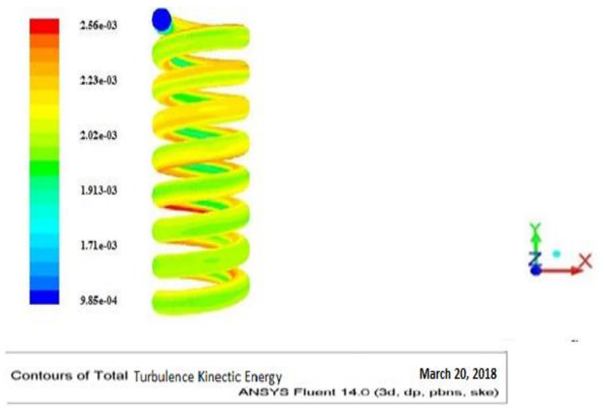

Fig.15 Turbulence Kinetic Energy, Bronze

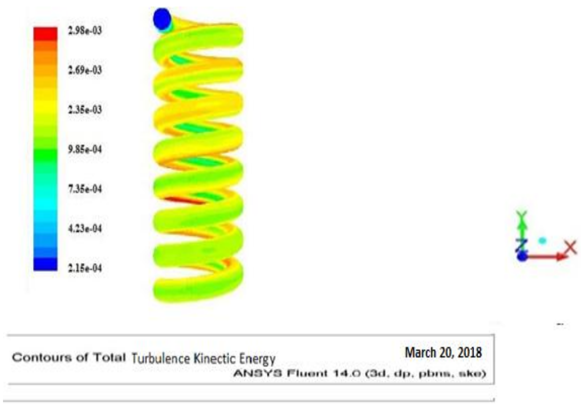

Fig.16 Turbulence Kinetic Energy for Aluminum

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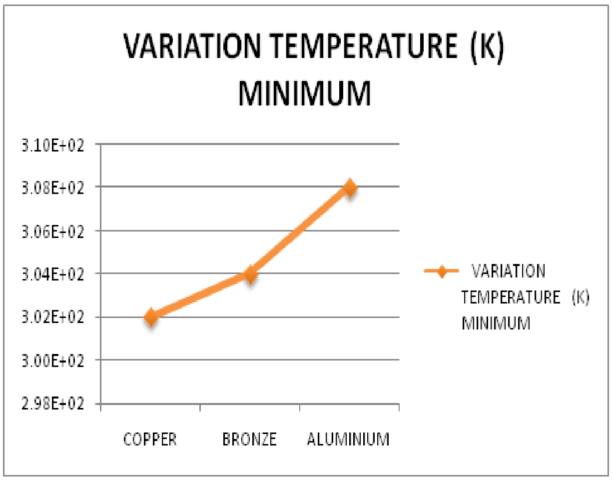

Fig.17 Variation in Temperature

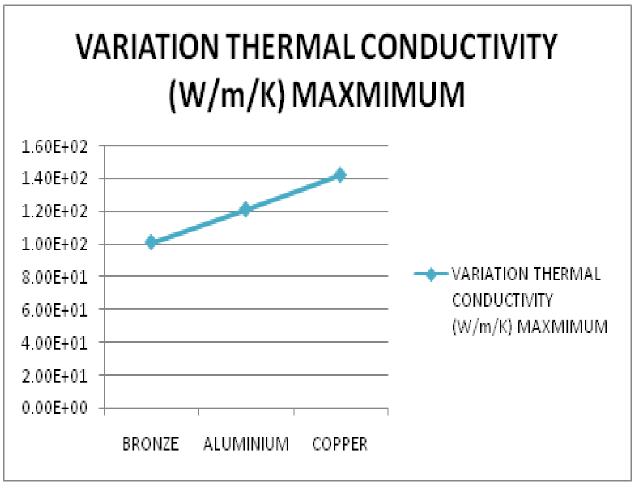

Fig.18 Variation in Thermal Conductivity

Table .4 Result Summary

PARAMETER	MATERIAL	VARIATION	
		MAX	MIN
PRESSURE	I. Copper II. Bronze II. Aluminum	3.43e+02 3.15+02 2.63e+02	8.02e+01 1.14e+02 8.11e+01
TEMPERATURE	I. Copper II. Bronze II. Aluminum	3.32e+02 3.32e+02 3.32e+02	3.02e+02 3.04e+02 3.08e+02
THERMAL CONDUCTIVITY	I. Copper II. Bronze II. Aluminum	1.42e+02 1.01e+02 1.21e+02	6.52e+01 3.25e+01 2.14e+01
TURBULENCE KINETIC ENERGY	I. Copper II. Bronze II. Aluminum	2.25e-03 2.56e-03 2.98e-03	6.69e-04 9.85e-03 2.15e-04

V. CONCLUSION

In this thesis, comparisons of various heat transfer parameter of helical coil heat exchanger has been carried out for different material (like Aluminium, Bronze and Copper) for constant mass flow rate of fluid (water). Here different design implementations of helical coil heat exchanger have been introduced with inlet and outlet flow of the fluid. Method for solving CFD analysis of helical coil heat exchanger has been carried out using “ANSYS 14.0” while CAD three dimensional model is being created by using “CATIA V5.0”.

The important feature of the thesis is to provide a comprehensive analysis associated with heat exchanger in terms material, pressure temperature, thermal conductivity, maximum heat transfer rate with a suggested design of helical coil type.

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Simulation results shows that for different materials pressure drop is increasing from Aluminium to Bronze and Bronze to Copper and Temperature drop is decreases so the thermal resistance is decreased hence the heat transfer rate is also increased. Heat transfer coefficient, pressure drop and corresponding rate are higher in case of Copper in identical conditions. Finally, the heat transfer increase for the copper material compared to another material but with increase in pressure drop the corresponding thermal resistance decreases which allows the improved heat transfer rate and the rate increases from Aluminium to Bronze to Copper. With the drop in temperature the thermal resistance is reduced which enhances the heat transfer rate. The simulations results show that the copper has high heat transfer co-efficient than Aluminum and Bronze while operating in identical conditions.

It is observed that the heat transfer of the copper material is enhanced in comparison with other material (Aluminium and Bronze), whereas thermal resistance is reduced with increase in pressure drop. Helical architecture are often designed with a clear motive of compact size and also address high heat transfer co-efficient and other ancillary attributes in efficient and effective manner.

To validate our research these computational results are compare with a previous research 24and it is found that with same design parameters and other operating conditions pressure drop in copper material is high. From this previous work it is validated that the suggested deign and materials used in this thesis have better existence with the pressure drop of 342 Pa as compare to 706 Pa in the earlier results found by others

Finally this research work concluded that for industrial applications of heat transfer, helical coil heat exchanger using copper material gives better performance as compare to other materials i.e.

. VI. CONCLUSION

Present study can be extended by taking following variables in future:

- Investigation can be done with different mass flow rate.
- Study with different geometrical and design parameters like PCD, Pitch and Pipe diameters.
- with different kinetic energy

REFERENCES

1. Ayare A.A., Anjarlekar S.D.,Tagare M.N. and Wamane S.S.(2017),""Experimental Study on Helical Coil Heat Exchanger**"** International Journal of Scientific and Research Publications, **2017,** Volume 7, Issue 5, May

2. Banka H,ReddyV.V.,Radhika M., "CFD Analysis of Shell and Tube Heat Exchanger using Titanium Carbide, Titanium Nitride and Zinc Oxide Nanofluid" International Journal of Innovations in Engineering and Technology, **2016** Special Issue, Page 315-322

3. David C. Denkenberger, Michael J. Brandemuehl, Joshua M. Pearce, and John Zhai, Expanded microchannel heat exchanger: design, fabrication and preliminary experimental test, *Proceedings of the Institution of Mechanical Engineers – Part A: Journal of Power and Energy*, **2012**, 226, 532-544 DOI: 10.1177/0957650912442781

ISSN : 2455-9679
Impact Factor : 2.015

4. Denkenberger D.,ParisiM.,Pearce J.M., Towards Low-Cost Microchannel Heat Exchangers: Vehicle Heat Recovery Ventilator Prototype. *Proceedings of the 10th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics*(HEFAT), July **2014,** 14–16, Orlando, FL,USA.

5. Flórez-OrregoD.,"Experimental and CFD study of a single phase cone- shaped helical coiled heat exchanger: an empirical correlation" ECOS, **2012** June 26- 29.

6. Jayakumar J.S.,MahajaniS.M.,Mandal J.C. ,Vijayan P.K., and Bhoi R. "Experimental and CFD estimation of heat transfer in helically coiled heat exchangers" **2008**, Chemical Engineering Research and Design 221-232.

7. Judy, J., Maynes, D., and Webb, B.W., "Characterization of frictional pressure dropfor liquid flows through micro-channels", International Journal of Heat and Mass Transfer,**2002.**

8. K. Abdul Hamid, W. H. Azmi, RIzalmanMamat, N. A. Usri and GohalamhassanNajafi, "Effect of Titanium Oxide Nanofluid Concentration on Pressure drop" ARPN Journal of Engineering and Applied Sciences, **2015** Volume 10, Page 7815-7820.

9. Kee, Robert J., et al. "The design, fabrication, and evaluation of a ceramic counter-flow microchannel heat exchanger." Applied Thermal Engineering ,**2011,** 2004-2012.

10. Kumar S., K VasudevKaranth, "Numerical analysis of a Helical Coiled Heat Exchanger using CFD" International Journal of Thermal Technologies, **2013**, Volume 3, Page 126-130.

11. Moallem, E., Padhmanabhan, S., Cremaschi, L., & Fisher, D. E. Experimental investigation of the surface temperature and water retention effects on the frosting performance of a compact microchannel heat exchanger for heat pump systems. International journal of refrigeration, **2012**, 35(1), 171-186.

12. Nawras H. Mostafa, Qusay R. Al-Hagag"Structural and Thermal Analysis of Heat Exchanger with Tubes of Elliptical Shape" IASJ, **2012**,Vol-8 Issue-3

13. Northcutt, B., &Mudawar, I. Enhanced design of cross-flow microchannel heat exchanger module for high-performance aircraft gas turbine engines. Journal of Heat Transfer, **2012**, 134(6),061801.

14. Patil S, Patel s. , Vavhal P, Rahate H , (2018), "Design & Development of Tube in Tube Helical Coil Heat Exchanger" Int. Res. J. of Science & Engineering, **2018**; Special Issue A2 : 245-250

15. Peng, X.F. and Peterson, G.P., "Effect of thermo fluid and geometrical parameters onconvection of liquids through rectangular micro-channels", International Journal of Heat andMass Transfer, **1995**, Vol.38(4)

16. Peng, X.F., Peterson, G.P., and Wang B.X., "Heat transfer characteristics of waterflowing through micro channels", Experimental Heat Transfer, **1994**

17. Rehman U. "Heat Transfer Optimization of Shell-and-Tube Heat Exchanger through CFD Studies" **2011,**

 ISSN : 2455-9679
Impact Factor : 2.015

Chalmers University of Technology.

18. Sadik K. and Hongtan Liu Heat Exchangers: Selection, Rating and Thermal Design .,**2002**. CRC Press. ISBN 0-8493-0902-6.

19. Sharma R and Thakur K. K., "Comprative study of a Helical Coil Heat ExchangerBy Using CFD……..IJSRD – international journal for scientific research & development |vol. 2, issue **11,2015**|IISN(online):2321-0613

20. Sharp K.A. "Structure And Properties Of Water,ER Johnson Research Foundation University Of Pennsylvania,PhiladelphiaPennsylvania,USA 2007

21. Timothy John Rennie, "Numerical and Experimental Studies of a Double pipe Helical Heat Exchanger" Dept. of Bio-resource Engg. McGill University, Montreal August **2004**.

22. Tuckerman, D.B. and Pease, R.F.W., "High-performance heat sinking for VLSI", IEEE Electron Device Letters,**1981.**

23. Tushar A. Sinha, Amit Kumar, Nikhilesh Bhargava and Soumya S Mallick, "An Experimental Investigation into the Thermal Properties of Nano Fluid" Applied Mechanical Engineering, **2014**, Volume 4, Issue 1.

24. Xu, B., Shi, J., Wang, Y., Chen, J., Li, F., & Li, D. Experimental Study of Fouling Performance of Air Conditioning System with Microchannel HeatExchanger, **2014**

25. Balamurugan M, Kumar S,MudaliK.U,Joshi JB CFD simulation on helical coil to understand the effect of different design parameters by pressure drop measurement**.2014**