International Journal of Modern Developments in Engineering and Science
Volume 1, Issue 6, June 2022
https://www.ijmdes.com | ISSN (Online): 2583-3138

CFD Analysis of Natural Convective Heat Transfer in Helical Coiled Heat Exchanger

Nikita V. Sonare[1*], Ajay W. Mahore[2]

[1]Student, Department of Mechanical Engineering, P. R. Pote Patil College of Engineering and Management, Amravati, India

[2]Associate Professor, Department of Mechanical Engineering, P. R. Pote Patil College of Engineering and Management, Amravati, India

***Abstract*: This paper focuses on the CFD analysis of flow of fluid through a helical coil heat exchanger. Also, on the enhancement in convective heat transfer in between the fluid and the surrounding surface in these helical coils which has been a major topic of study as reported by many researchers. As helical coil has compact size and higher heat transfer coefficient, they are widely used in industrial applications such as power generation, nuclear industry, process plant, refrigeration, food industry, etc. In this study, an attempt has been made to study the stagnant hot fluid inner chamber as a bath and outer cold fluid flow, which are separated by copper surface in a helical coil heat exchanger. The temperature contours, velocity vectors, total pressure contours, total heat dissipation rate from the wall of the tube were calculated and plotted using ANSYS 18.2. Copper was used as the base metal pipe and the fluid was taken as cold water for inner flow and soap solution and CMC as a bath.**

***Keywords*: Helical coil, Natural convection, Heat exchanger.**

1. Introduction

Natural convection is a process or type of heat transfer, in which the fluid motion is caused by density differences in the fluid occurring due to temperature gradients. Here the fluid which surrounds a heat source receives heat, becomes less dense and rises. The fluid that is surrounding the hot fluid is cooler and then moves in to replace it. Then further that cooler fluid gets heated and the process continues, forming convection current. The driving force for this process is buoyancy, a result of difference in the fluid density. Natural convection has attracted a great deal of attention from researchers because of its presence both in nature and engineering applications.

2. Geometry Creation and Mesh Generation

The setup was modeled for only entire fluid domain was used. It is logical to assume part of fluid domain instead of whole domain that saves computation time. Domain has to build by considering inside fluid volume only.

Table 1
Range of parameter studied

Systems Studied	Flow rate Kg/s
Water	0.01-0.1
Soap solution (1%)	0.01-0.1
Soap solution (1.5%)	0.01-0.1
CMC solution	0.01-0.1

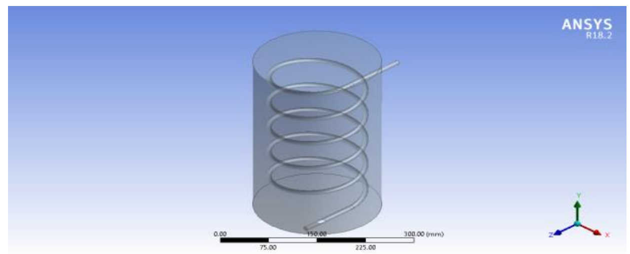


Fig. 1. Geometry creation in Ansys Design modeler

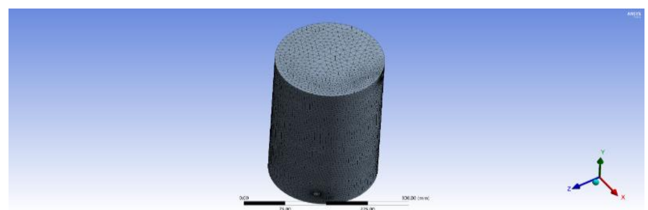


Fig. 2. Mesh bath geometry

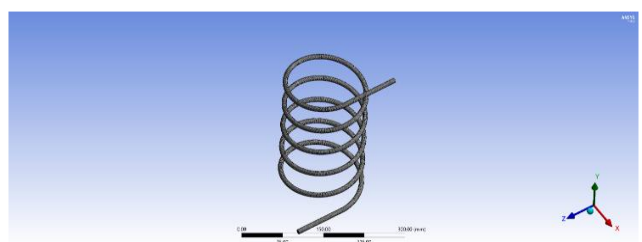


Fig. 3. Mesh helical coil

3. Data Analysis

The overall heat transfer is calculated with heat transfer obtained as under

$$Q = m^{\circ}\, Cp\, \Delta T$$

Where m^{o} is mass flow rate of coolant; C_p is the heat capacity of water and $\Delta T = T_o - T_i$.

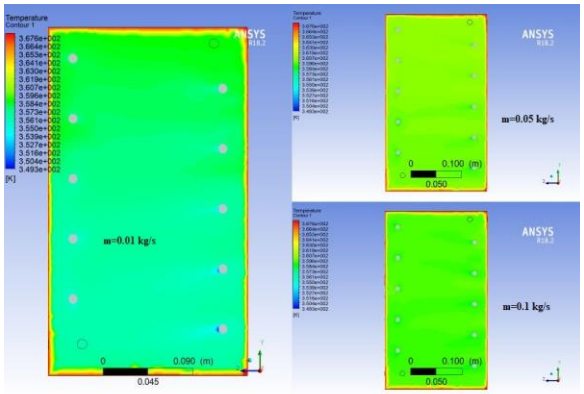
The coil side heat transfer coefficient is calculated from following equation,

$$h_{coil} = Q/(A\,\Delta T)$$

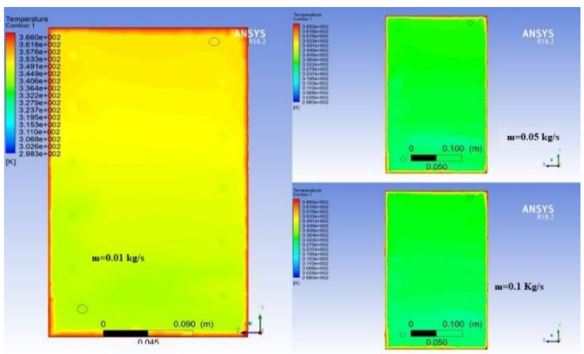
*Corresponding author: niki20sonare@gmail.com

4. Result and Discussion

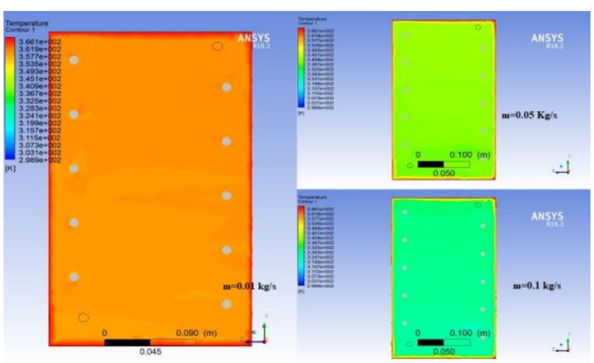
A. Temperature profile inside the bath



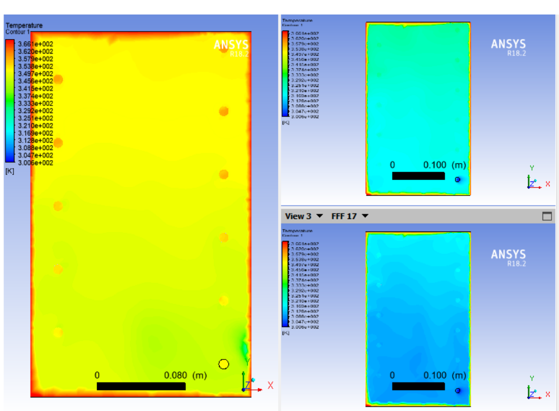
(a)



(b)



(c)



(d)

Fig. 4. Temperature distribution in bath at X=0 (a) water (b) 1% Soap (C) 1.5% Soap solution (d) CMC

Temperature contour inside the bath is shown in figure 4 for 0.01 kg/s,0.05kg/s and 0.1 kg/s for only water 1% Soap and 1.5% soap respectively. From the analysis it is found that bathe temperature reduced by 12% to 40 % from its initial temperature. The maximum temperature inside the bath was found to be 84^{O}C whereas minimum temperature found to be 56 ^{O}C.

B. Effect of bath solution on natural convection coefficient

Fig. 5 shows the effect of bath solution on the natural heat transfer coefficient. It shows that the maximum heat transfer coefficient found in water as compared to the soap solution and CMC solution.

Whereas when we compared a soap solution and CMC the CMC is the better option for bath solutions.

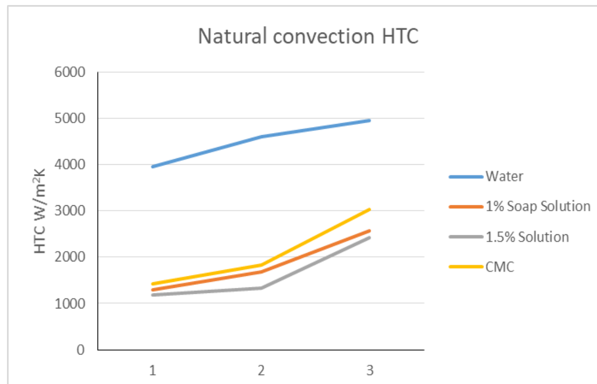


Fig. 5. Effect of Soap and CMC solutions on natural HTC

C. Reynold number v/s force convection coefficient

Fig. 6 shows that plot between Reynold number verses force convection coefficient for helical coil. It shows that heat transfer coefficient increases with rise in Reynold number and mass flow rate. Maximum heat transfer coefficient found in mass flow rate of 0.1 Kg/s for all category of bath solutions.

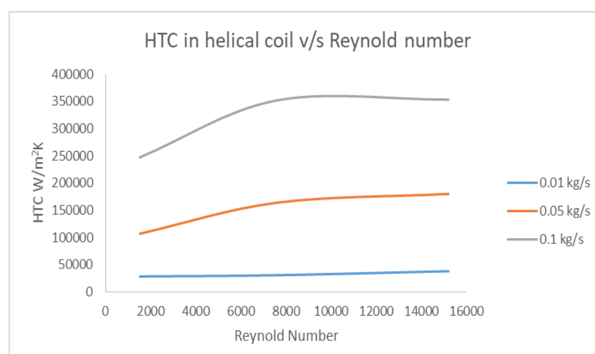


Fig. 6. Reynolds number v/s HTC in helical coil

5. Conclusion

Following conclusion are drawn:

1. Maximum natural heat transfer coefficient found in water bath and in Soap solution and CMC heat transfer coefficient is less this due to surface tension occurs in soap and CMC solution.
2. Maximum heat transfer occurs in a coil when bath

contain CMC solutions this happened because of the surface temperature of coil.

3. Fig. 6 shows natural convection heat coefficient increases with increase in Reynolds number.

References

[1] Aravind, G.S., Arun, Y, Sunder, R S, Subrahmaniyam S, "Natural Convective Heat Transfer in Helical Coiled Heat Exchanger", IE (I) Journal CH, vol. 84, 2003.
[2] and Square Coiled Pattern by Jayakumar, J. S., Mahajani, S. M., Mandal, J. C., Iyer, K. N., & Vijayan, P. K., "CFD analysis of single-phase flows inside helically coiled tubes," Computers & chemical engineering, vol. 34, no. 4, pp. 430-446, 2010.
[3] Heat Transfer Analysis of Helical Coil Heat Exchanger with Circular Ashok B. Korane, P.S. Purandare, K.V. Mali, IJESR, vol. 2, no. 6, June 2012.
[4] Daniel Flórez-Orrego, "Experimental and CFD study of a single-phase cone-shaped helical coiled heat exchanger: an empirical correlation," ECOS, June 26-29, 2012.
[5] Noble, M. A., Kamlani, J. S., and Mc Ketta, J. J., "Heat Transfer in Spiral Coils," Petroleum Engineer, pp. 723, April 1952.
[6] K. E. Reby Roy, "Numerical analysis of forced convection heat transfer through helical channels,", IJEST, vol. 4, July 2012.
[7] Minton P. E., Designing Spiral Tube Heat Exchangers, Chemical Engineering, pp. 145 May 1970.