Journal of Mines, Metals and Fuels, *72(5): 509-513; 2024. DOI: 10.18311/jmmf/2024/43750*

Print ISSN : 0022-2755

Journal of Mines, Metals and Fuels

Contents available at: *www.informaticsjournals.com/index.php/jmmf*

Performance Analysis of Aluminium and Copper Helical Coils in SHCTHE Using Cu-Ni Hybrid Nanofluid Under Laminar Flow Regime

Dangeti Sarath Chandra*, Kuruva Krishna Murthy and Valiveti Sivaramakrishna

VNRVJIET, Pragathinagar, Nizampet, Hyderabad - 500090, Telangana, India; sarathchandra7@gmail.com

Abstract

Experiments are conducted under laminar flow conditions. The sol-gel method is used for preparations of copper (Cu) and nickel (Ni) nanoparticle. The prepared Cu-Ni nanoparticles are surface treated to lower the sedimentation after suspending these nanoparticles in pure water. The impact of pitch (0.032, 0.042 and 0.052m), mass flow rate, coil material Aluminium (Al) and Copper (Cu), and volume concentration (0.02, 0.04 and 0.06) on heat transfer rate is computed. Reynolds number (Re), Nusselt number (Nu) are computed to evaluate thermal performance of counter flow helical coil heat exchanger. The overall heat transfer coefficient in case of a 12 turn copper coil is increased by 43.71, 52.196 and 60.782% for 0.02, 0.04 and 0.06 % vol respectively compared to distilled water at reynolds number equals to 2224. In this study the best optimal condition to operate shell and helical coil heat exchanger is 0.006% vol at Re=2224. This is due to mass flow rate and reduction in sedimentation of Cu-Ni nanoparticles in distilled water. This is due to flow ate and thermal conductivity of coil material.

Keywords: *Coil Material, Flow Rates, Nanofluids, Overall Heat Transfer Coefficient, Pressure Drop*

1.0 Introduction

Shell and helical coil heat exchangers are single-phase or two-phase heat exchangers. In case of single-phase heat exchangers, the fluids do not undergo any phase change through out the heat exchange process. It means hot and cold fluids remain in the samephase of matter at which they entered the heat exchanger[1]. For example, in water-to-water heat transfer applications, the warmer water loses heat which is then transferred to the cooler water and neither change to a gas or solid. One of the great benefits of utilizing a single-phase counter flow shell and helical coil heat exchanger is very good to pressure[2].

And uses at different ranges of pressure functions in various industries. The flow direction of fluids in heat exchanger and material of the coil are the important parameters in improving heat transfer rate in shell and helical coil heat exchanger[3]. It is higher for counter flow of fluid in helical coil compared to parallel flow direction. This is due to increase in time of contact between two fluids and it occupies less space compared to parallel flow heat exchanger. The coil material shows an impact on heat transfer rate between cold and hot fluids with minimum heat losses.

Apart from this the position of the shell and helical coil system is also having its influence on overall heat transfer coefficient. Among horizontal and vertical positions, vertically positioned shell and helical coil heat exchanger gives the maximum heat transfer rate. But it is difficult to control the head losses without reducing pressure

*Author for correspondence

drop to minimum. The pressure drop can be reduced by increasing inflow rate and reducing the density of the nano particles in base fluid[4].

The stability of dispersed nanoparticles is based on the preparation technique applied and thermo-physical properties of nanoparticles. There are certain challenges that require being resolved before using nanofluids in shell and helical coil heat exchanger[5]. The operational performance and stability of nanoparticles in base fluid are the main challenges of using nanofluids in heat exchangers. Nanofluids stability is one of the crucial parameters in order to maintain their thermo-physical properties for long duration after production[6]. There are different types of stability enhancement methods are used to prevent the agglomeration of nano particles in nanofluids. Addition of surfactants and Surface treatment techniques are best methods to improve the stability of nano particle. Surface treatment and ultra sonication techniques are used to treat the prepared nanoparticle to reduce the agglomeration in base fluid. The metals, oxides and carbides are the typical nanoparticles utilized for fabrication of nanofluids.

2.0 Experimentation

The photo of the shell and helical coil heat exchanger is shown in the Figure 1. Experimentations using Cu-Ni-hybrid nanofluid are conducted by varying coil material, flow rates, and pitch of the coil.

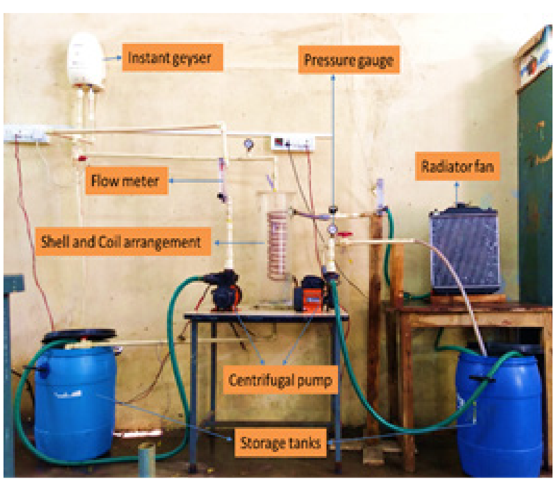

Figure 1. Photographic view of shell and helical coil tube heat exchanger.

2.1 Test Methodology

2.1.1 Methodology

The methodology adopted in this study is shown in Figure 1.

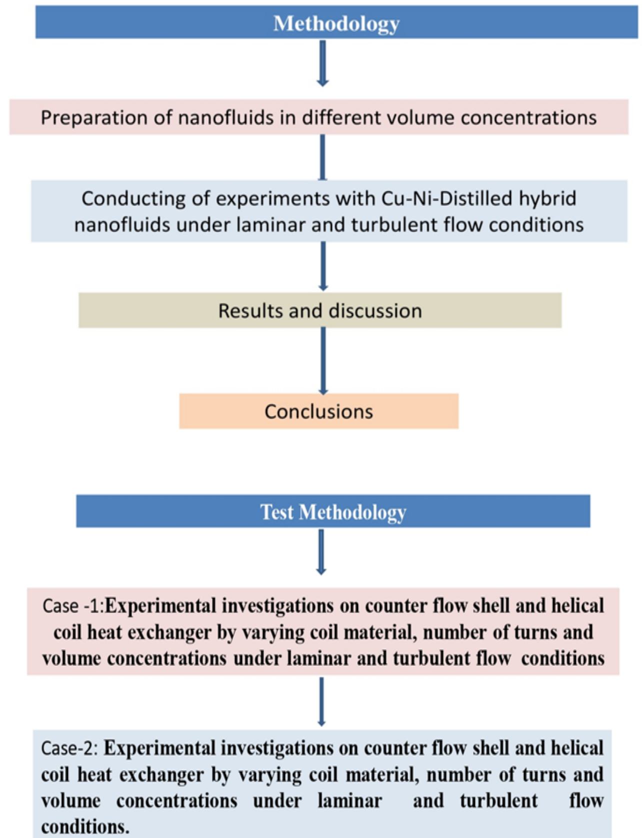

Figure 2. The methodology adopted for the study.

3.0 Results Discussion

Figure 3, Figure 4 and Figure 5 shows the variation in Nusselt number (Nu) with respect to Reynolds number (Re) under laminar flow regime. The volume concentrations considered in this work are 0.02, 0.04 and 0.06. All these experiments conducted for 8, 10 and 12 turns. From the Figure 3 it is observed that 8 turn Aluminium (Al) coil shows the 21.32, 26.99 and 32.28 % increase in Nusselt number (Nu) at 0.02,0.04 and 0.06% volume concentration of Cu-Ni-Distilled water compared with only distilled water. The maximum nusselt number obtained at 0.06%vol. When aluminium coil compared

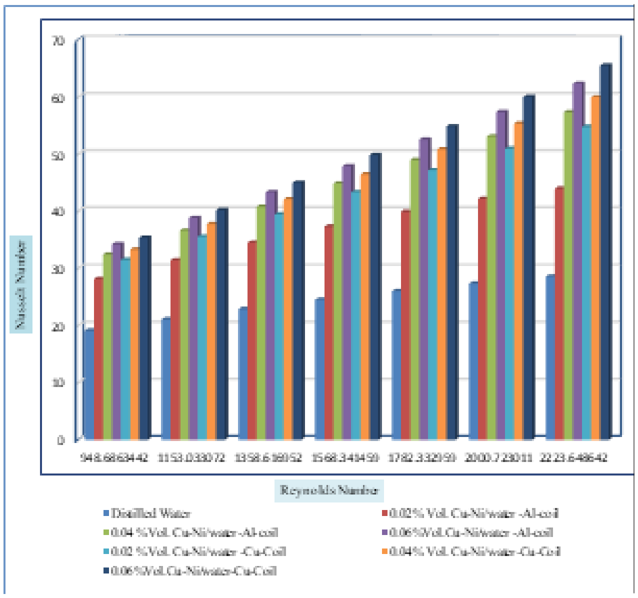

Figure 3. Variation in Nusselt number with respect to Reynold Number for aluminium and copper coils with 8 turns under laminar flow conditions.

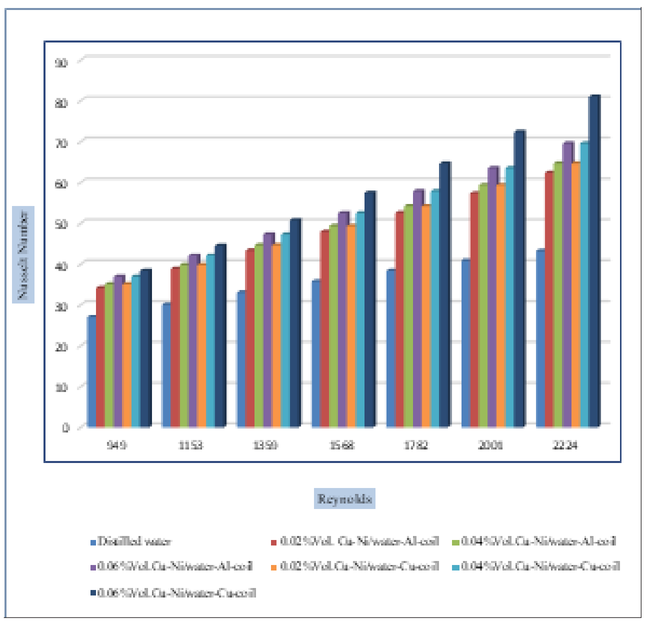

Figure 4. Variation in Nusselt number with respect to Reynold Number for aluminium and copper coils with 10 turns under laminar flow conditions.

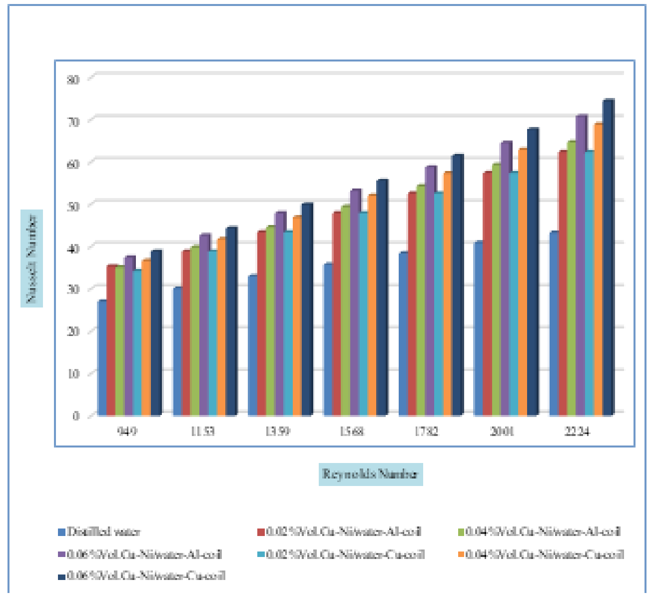

Figure 5. Variation in Nusselt number with respect to Reynold Number for aluminium and copper coils with 12 turns under laminar flow conditions.

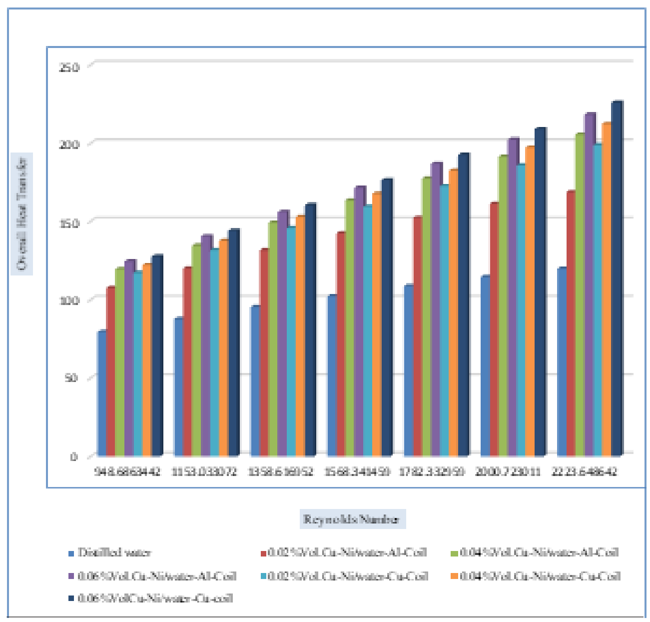

Figure 6. Variation in overall heat transfer with respect to Reynold number for aluminium and copper coils with 8 turns under laminar flow conditions.

with copper coil it shows 7.6% lesser Nu. Similarlly for 10 and 12 turns copper coil for 0.06% vol compared to Aluminium coil increased by 18.23% and 40.14 %. This is due to increase in volume concentration in base fluid and counter flow of nanofluid in the coil.

Variation in overall heat transfer (U) with respect to Reynold number for aluminium and copper coils with

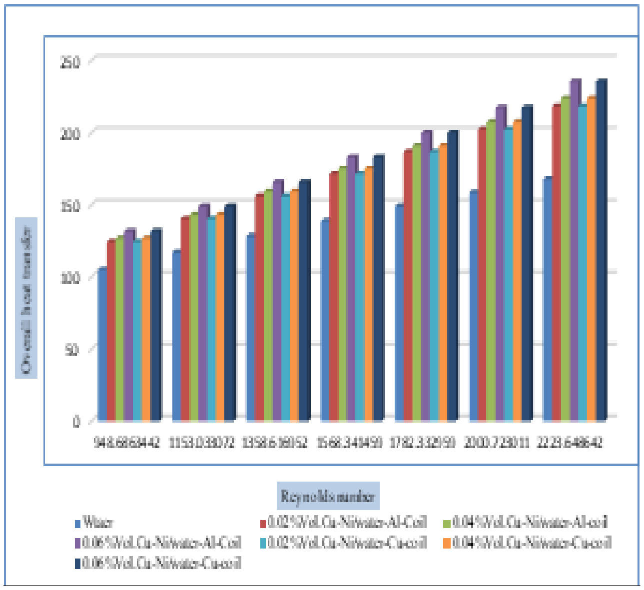

Figure 7. Variation in overall heat transfer with respect to Reynold number for aluminium and copper coils with10 turns under laminar flow conditions.

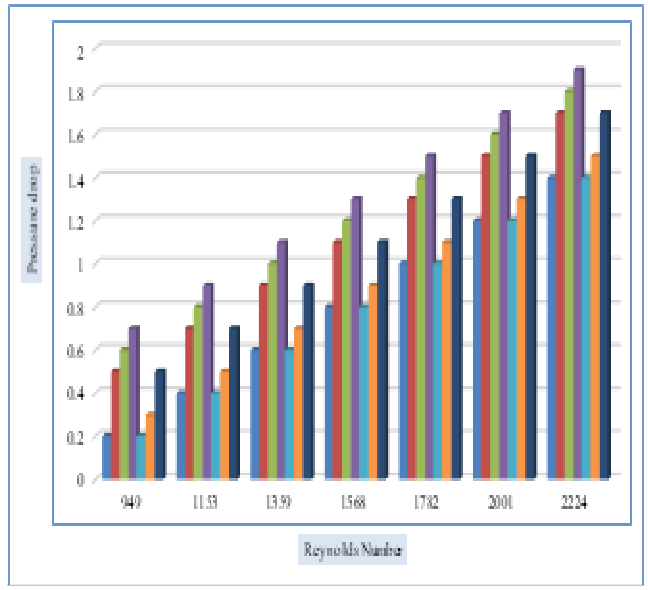

Figure 9. Variation in pressure drop with respect to Reynolds number for aluminium and copper coils with 8 turns under laminar flow conditions.

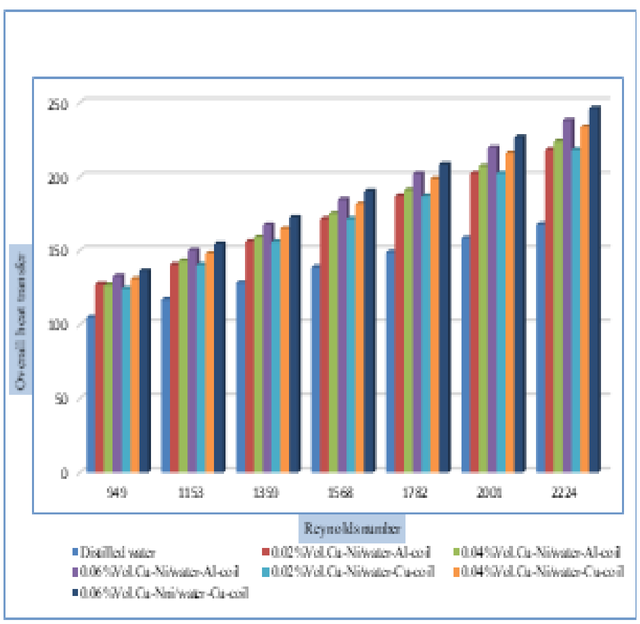

Figure 8. Variation in overall heat transfer with respect to Reynold number for aluminium and copper coils with 12 turns under laminar flow conditions.

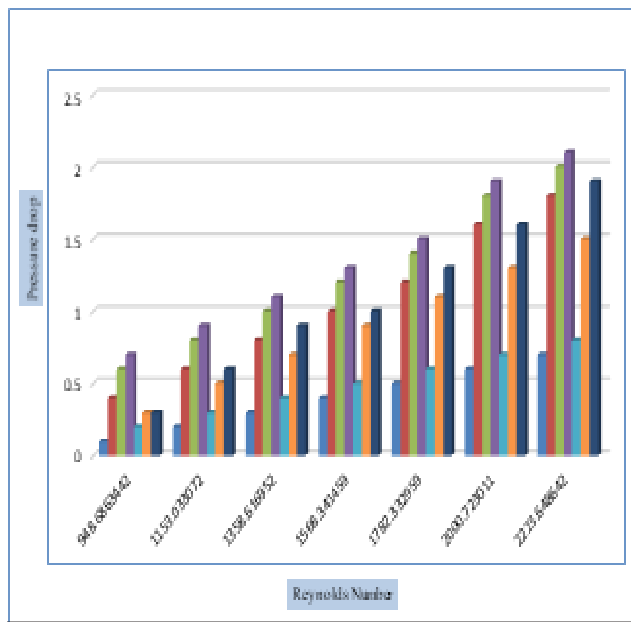

Figure 10. Variation in pressure drop with respect to Reynolds number for aluminium and copper coils with 10 turns under laminar flow conditions.

8,10 and 12 turns under laminar flow conditions is shown in Figure 6, Figure 7 and Figure 8 respectively. In case of 8 turn coil with 0.02 volume concentration flows in counter flow direction in which maximum overall heat transfer coefficient obtained at 2224 is 37.06% compared with distilled water using aluminium coil and copper is 2.58% higher than the aluminium coil. This is due to increase in mass flow rate and nusselt number. From the Figure

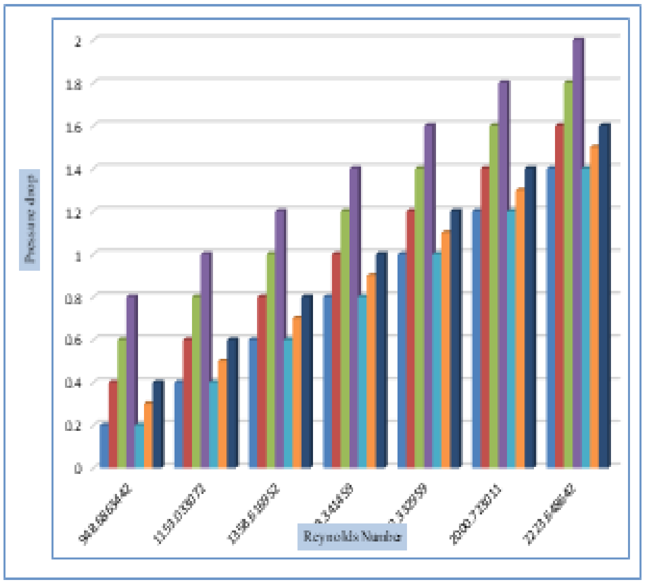

Figure 11. Variation in pressure drop with respect to Reynolds number for aluminium and copper coils with 12 turns under laminar flow conditions.

6 it is observed that the maximum %U obtained using alunimium coil is 38.61% for 0.06%vol Cu-Ni-hybrid nanofluid. Bloo2+ut it 14.20% less when fluid flowing through copper coil. Among all three different turns and two different coil materials 12 turn copper coil with 0.06% vol Cu-Ni-hybrid nanofluid gives the highest overall heat transfer *i.e* 79.88% and it is 25.88% higher than aluminium coil. This is due to decrease in pith of the coil and flow direction. When pitch decrease nanoparticles flows near the internal wall of the coil for long longer time.

4.0 References

1. Zhu W, Bartos PJ, Porro A. Application of nanotech-nology in construction: Summary of a state-of-the-art report. *Mater Struct*. 2004; 37(9):649-658. https://doi.org/10.1007/BF02483294
2. Ahmed AA. Nanotechnology in civil engineering construction. Int J Struct Civ Eng Res. 2022; 9(1). https://doi.org/10.18178/ijscer.9.1.87-90
3. Al-Ajmi F, Abdalla H, Abdelghaffar M, Almatawah J. Strength behavior of mud brick in building construction. Open Journal of Civil Engineering. 2016; 6(3):482-94. https://doi.org/10.4236/ojce.2016.63041
4. Abdalkhaliq Hasan S. The use of nanotechnology in construction sector. *Al-Qadisiyah J. Eng. Sci*. 2014; 7:1.
5. Madurwar M, Mandavgane SA, Ralegaonkar RV. Use of sugarcane bagasse ash as brick material. Curr Sci. 2014; 117(6): 1044-1051.
6. Mathew T, Sujatha U. Utilization of sugarcane bagasse ash and red mud in the manufacture of compressed earth blocks. Int. J Adv Res Trends Eng Technol. 2017; 4(22):6-10.