International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Performance Enhancement of an Automotive Radiator Using Ethylene Glycol and Al_2o_3 Nanofluid as a Coolant

K. Sirisha[1], Dr. P. Vijaya Kumar[2]

[1]P.G.student, Department of Mechanical Engineering, LBR College of Engineering, Mylavaram

[2]Professor, Department of Mechanical Engineering, LBR College of Engineering, Mylavaram

Abstract: ***In this study, a new model of predicting effective thermal conductivity for Al_2O_3 and ethylene glycol (EG) and water as a new generation of heat transfer fluids, attracted the attention of researchers over the past few years and found its applications in heat exchangers of chemical plants, automotive cooling, building heating, etc. As a reference case, pure water is mixed with glycol at standard proportions 70:30, 60:40 and 50:50 mixture is used in an automotive radiator and its performance was studied. The performance comparison will be made between pure water and ethylene glycol tested in an automotive radiator. Finally the recommendations are made and conclusions are drawn based on the improved performance of ethylene glycol in an automotive radiator. All parameters like thermal conductivity, friction factor and heat transfer rate are also better values obtained.***

Keywords: heat transfer, ethylene glycol (EG), water, thermal conductivity, Al_2O_3

1. Introduction

Heat transfer fluids such as water, minerals oil and ethylene glycol play an important role in many industrial sectors including power generation, chemical production, air-conditioning, transportation and microelectronics. The performance of these conventional heat transfer fluids is often limited by their low thermal conductivities. According to industrial needs of process intensification and device miniaturization, development of high performance heat transfer fluids has been a subject of numerous investigations in the past few decades. It is well known that at room temperature, metallic solids possess an order-of magnitude higher thermal conductivity than fluids. For example, the thermal conductivity of copper at room temperature is about 700 times greater than that of water and about 3000 times greater than that of engine oil. Therefore, the thermal conductivities of fluids containing suspended solid metallic or nonmetallic (Metallic oxide) particles would be expected to be significantly higher than those of conventional heat transfer fluids.

Heat transfer enhancement in fluids can be effected primarily by two techniques viz. passive heat transfer technique and active heat transfer technique. Passive heat transfer techniques can be employed by provision of rough and extended surfaces tubes and creation of swirl in the flow using inserts of certain geometrical shape. Active heat transfer techniques include applying of electric/magnetic fields, inducing vibrations in the heated surface, injection and jet impingement of fluids etc. The above techniques can hardly meet the requirements of high heat transfer performance desired by present day modern heat exchanger. Compact heat exchangers with higher performance demand fluids having better heat transfer capabilities. Such devices results in material saving, energy conservation and hence low cost of heat exchangers. Ethylene glycol improve thermal conductivity of host fluids and now become important area of research attracting the attention of many researchers across the world. The ethylene glycol will quench the thirst of investigators who are in quest to engineer better heat transfer fluids.

Heat transfer coefficient and friction factor are two important parameters associated with thermos fluids. Many experimental as well as theoretical investigations have been carried out to study heat transfer and pressure drop characteristics of pure fluids. Use of two phase ethylene glycol for heat transfer enhancement has boosted the research interest among many research groups across the globe. Literature confirmed that ethylene glycol give higher heat transfer coefficient compared to the base fluid. The investigation results on ethylene glycol indicated that heat transfer coefficient increases with the increase of nanoparticle concentration in the base fluid.

Most of the research works done so far on ethylene glycol are experimental studies and confined either to laminar or turbulent flow conditions. The host or base fluid is water in majority of the cases. In severe cold climatic conditions glycols are added to water in different proportions to reduce the freezing point of heat transfer liquids. Glycol based fluids are used in base board heaters, automobile radiators and process plants particularly in cold countries where the ambient temperatures are below zero degree Celsius.

2. Experimental Setup of Automotive Radiator

In the performance evaluation of radiator a test apparatus is prepared which consists of a radiator, fan, flow meter, heating element, pump, two thermocouples, tank are used. In the test apparatus the heating element will be acting as a source of heat which will act just like an engine in an automobile. This heating element will heat up the coolant to a temperature range of 60ºC - 80ºC. After heating, the hot water is pumped with the help of a pump in to the radiator. At the outlet of the pump a flow meter is installed to measure the mass flow rate of the hot coolant. The flow to flow meter is controlled by a controlling valve, which helps in obtaining different mass flow rate of the hot coolant.

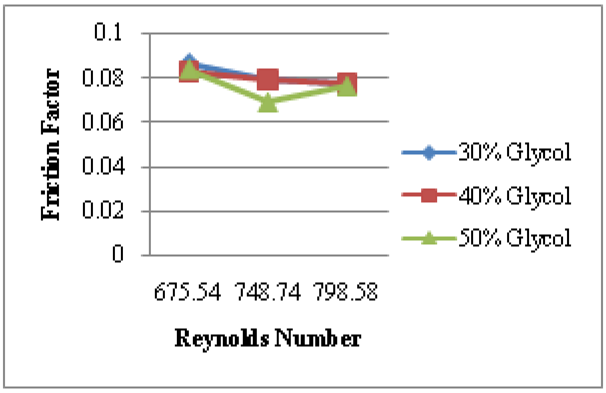
Figure 1: Fabricated model of experimental setup

3. Results and Discussions

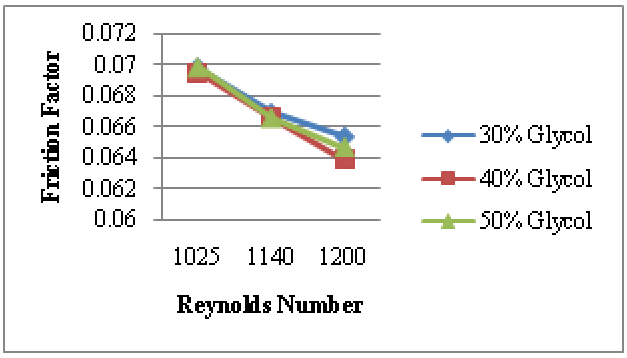
The experiments are conducted on fabricated model of experimental setup by using water as base fluid, 30%, 40%, 50% of ethylene glycol and Al2O3 nanofluids as test fluids. The obtained results are recorded. The parameters like Nusselt number (Nu), Reynolds number (Re), friction factor, heat transfer enhancement are recorded.

4. Performance of Friction Factor at Different Reynolds Numbers

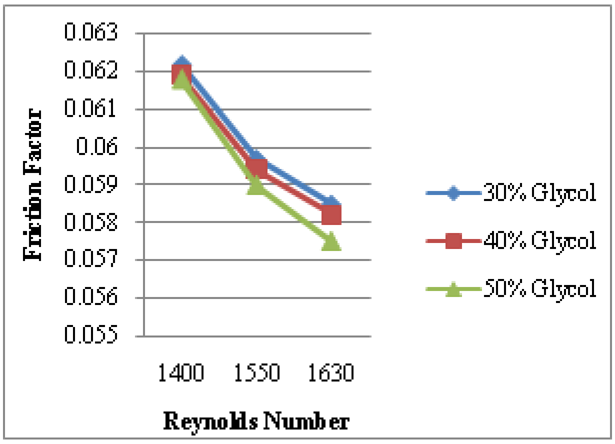
The results obtained for the friction factor at different Reynolds number and nanofluid volume concentration is shown in graphs 1 to 3. It appears that the friction factor decreases with increasing in Reynolds number and nanofluid volume concentration. The figures illustrate the effect of inlet temperature on the friction factor. It seems that slightly effect of inlet temperature and nanofluid volume concentration on the friction factor. Areas on related to the slow flow are generated high friction factor. The friction factor at Reynolds number less than 1000 has been given the maximum deviation but after that the deviation is less.



Graph 1: Variation of Friction factor for different Reynolds number at 4lts/min



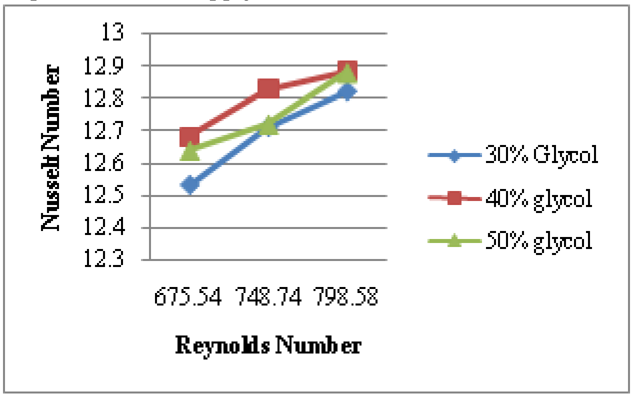
Graph 2: Variation of Friction factor for different Reynolds number at 6lts/min



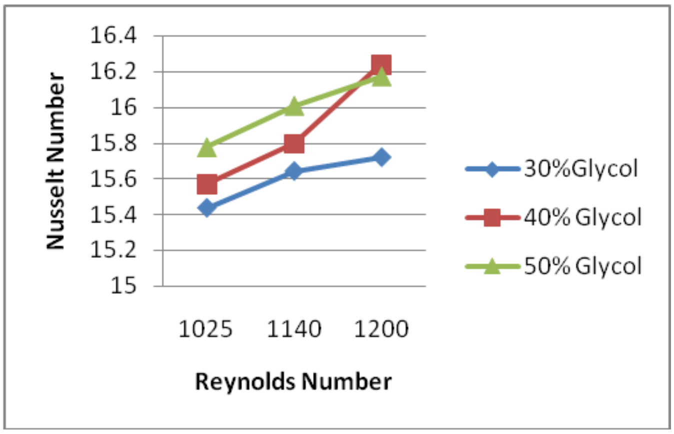
Graph 3: Variation of Friction factor for different Reynolds number at 8lts/min

5. Performance of Nusselt Number at Different Reynolds Numbers

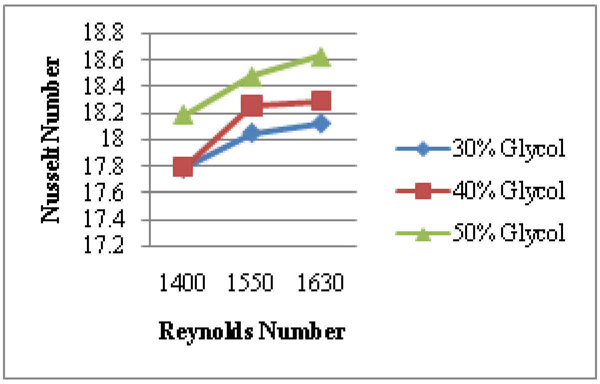
The Nusselt number increases with increasing of Reynolds number and ethylene glycol volume concentration. The deviation is high when adding the ethylene glycol on base fluid (pure water).It demonstrates the effect of inlet radiator temperature on Nusselt number. The highest values of Nusselt number found at inlet temperature 80ºC followed by at 70ºC and finally at 60ºC inlet temperature. The maximum values of Nusselt number are 19.35, 19.80 and 21.21 at 4lts/min, 6lts/min and 8lts/min respectively. This refers to high heat transfer from the radiator when high inlet temperature would apply.



Graph4: Variation of Nusselt number for different Reynolds number at 4lts/min



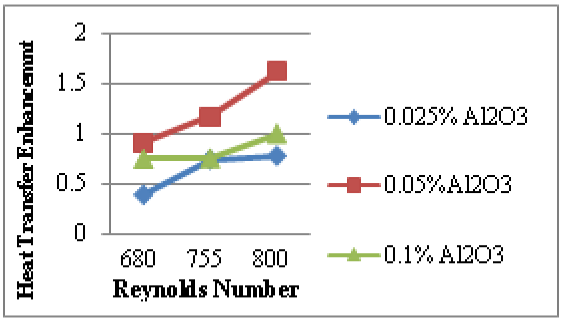
Graph 5: Variation of Nusselt number for different Reynolds number at 6lts/min



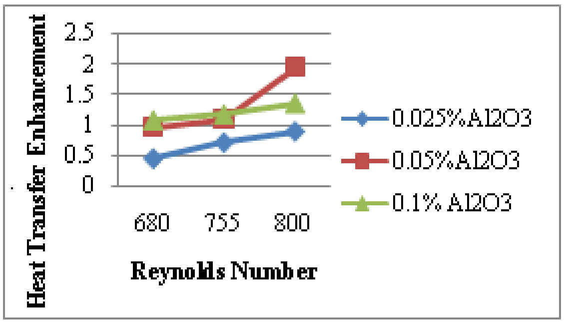
Graph 6: Variation of Nusselt number for different Reynolds number at 8lts/min

6. Effect of Reynolds Number on Heat Transfer Enhancement

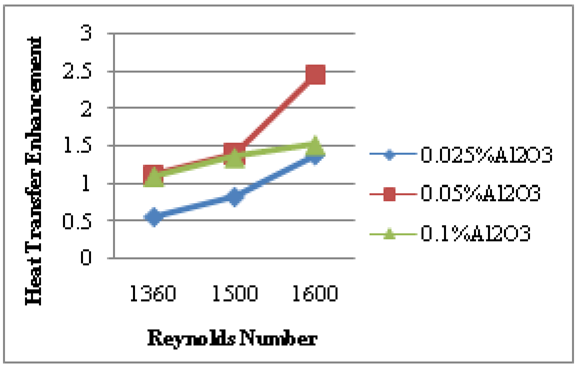
Effects of the Reynolds number, nanoparticle volume fraction and fluid inlet temperature on enhancement in heat transfer are shown in graphs 7 to 8. The enhancement in heat transfer has increased by augmentation in the concentrations of nanoparticle, Reynolds number and fluid inlet temperature. For the water based nanofluid it is obvious that *E* increases with Reynolds number and in higher concentrations of nanoparticle the effect of Reynolds number becomes pronounced. Improvement in the heat transfer rate when ϕ = 0.1% and the E value is about 4.56% for 0.025% Al_2O_3 nanofluid at 80ºC and this value is about 12.4% for 0.1% Al_2O_3 nanofluid at 80ºC.



Graph 7: Effects of the Reynolds number on heat transfer enhancement at 4lts/min



Graph: Effects of the Reynolds number on heat transfer enhancement at 6lts/min



Graph: Effects of the Reynolds number on heat transfer enhancement at 8lts/min

7. Conclusions

The convective heat transfer performance and flow characteristics of ethylene glycol flowing in an automotive radiator have been experimentally investigated. Significant increase in heat transfer was observed with the used different volume concentrations of nanoparticles mixed with water. The results showed that the variation of the friction factor and Nusselt number of the ethylene glycol were highly depended on the volume concentration and Reynolds number. The friction factor decreases with increasing of volume flow rate and the inlet temperature of ethylene glycol.The experimental results have shown that theNusselt number behavior of the ethylene glycol was highly depended on the volume concentration and the volume flow rate. The heat transfer enhancement was about 4.56% for 0.025% ethylene glycolat 80ºC and this is about 12.4% for 0.1% ethylene glycolat 80ºC.The results have shown that ethylene glycolhas a high potential for hydrodynamic flow and heat transfer enhancement in an automotive radiator.

References

[1] M. Ebrahimi, M.Farhadi, K.Sedighi, S.Akbarzade "Experimental investigation of force convection heat transfer in a car radiator filled with SiO 2-water nanofluid", IJE TRANSACTIONS B: Applications Vol. 27, No. 2, (February 2014) 333-340.

[2] 2.Vlassov, V. V., de Sousa, F. L. and Takahashi, W. K., "Comprehensive optimization of a heat pipe radiator assembly filled with ammonia or acetone",International Journal of Heat and Mass Transfer , Vol. 49, No. 23, (2006), 4584- 4595.

[3] Adnan M. Hussein, R.A. Bakar, K. Kadirgama “Study of forced convection nanofluid heat transfer in the automotive cooling system”, case studies in Thermal Engineering 2 (2014) 50-61.
[4] Pantzali, M., Mouza, A. and Paras, S., "Investigating the efficacy of nanofluids as coolants in plate heat exchangers (PHE)", Chemical Engineering Science , Vol. 64, No. 14, (2009), 3290-3300.
[5] Kakaç, S. and Pramuanjaroenkij, A., "Review of convective heat transfer enhancement with nanofluids", International Journal of Heat and Mass Transfer , Vol. 52, No. 13, (2009), 3187- 3196.
[6] Leong, K., Saidur, R., Kazi, S. and Mamun, A., "Performance investigation of an automotive car radiator operated with nanofluid-based coolants (nanofluid as a coolant in a radiator)", Applied Thermal Engineering , Vol. 30, No. 17, (2010), 2685