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Performance Test on Flat Fin Automotive Radiator using Nano Fluids

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Abstract : In this paper experimental investigation performed on automobile radiator using water and water based Nanofluids (Al_2O_3/CuO). Two Nanofluids of concentrations0.5 & 1% by volume were taken to conduct experiments. The sizes of the Nano particles used in this present work approximately 50-100nm. Fluid inlet temperature and velocities were varied to study the Heat Transfer Rate using water and water based Nano fluids. From the results it is clear that Nanofluids enhances the heat transfer rate compared to pure water. By varying the fluid temperature and velocities enhancement in heat transfer rate observed both in pure water and Nanofluids. Comparision also done between two Nanofluids Al_2O_3&CuO. CuO shows slight increase in heat transfer rate compared to Al_2O_3.
Key words : Nano fluid, Radiator, Heat transfer.

Introduction:

A Nano fluid is a fluid containing Nanometer-sized particles, called Nanoparticles. These fluids are engineered colloidal suspensions of Nanoparticles in a base fluid. The Nanoparticles used in Nanofluids are typically made of metals, oxides, carbides, or carbon Nanotubes. Common base fluids include water, ethylene glycol and oil.Nanofluids have novel properties that make them potentially useful in many applications in heat transfer, including microelectronics, fuel cells, pharmaceutical processes, and hybrid-powered engines, engine cooling/vehicle thermal management, domestic refrigerator, chiller, heat exchanger, in grinding, machining and in boiler flue gas temperature reduction.Knowledge of the rheological behavior of Nanofluids is found to be very critical in deciding their suitability for convective heat transfer applications. However, almost all of new academic papers, use two-phase assumption.

In car radiator Al_2O_3Nanoparticles dispersed into water to find the thermal conductivity, viscosity, density, and specific heat. With increase of volume concentrations thermal conductivity, viscosity, and density of the Nanofluid increases but specific heat decreases. Optimum temperature was found to be 10-50^{0}C. 8.3 % highest thermal conductivity at 1% vol. of Al_2O_3–RC Nanofluid[1]. In a shell and tube heat exchanger ϒ-Al_2O_3/water and TiO_2/water Nanofluids heat transfer behavior was investigated experimentally. From the experimental results heat transfer characteristics of both Nanofluids improve with Peclet number. Different optimum volume concentration for both Nanofluids in which maximum enhancement in heat transfer characteristics[2].CuO/water Nanofluid pressure drop and convective heat transfer performance investigated experimentally while flowing through a circular tube. A 25 % increase in heat transfer coefficient observed compared to pure water. For 0.03% volume concentration 20% maximum increase in pressure drop[3]. The effect of Nano fluid and tube geometry on heat transfer is reviewed. Higher heat transfer performance attained with flat tubes. But lower pressure drop and wall shear showed by circular tube[4]. Recently for many researchers enhancement of heat transfer using Nanofluids becomes the center of interest. Studies performed in conventional numerical methods as well as the new Lattice Boltzmann Method (LBM) areas reviewed and summarized. Increase in heat transfer taken place by thermophoresis or Dufour effect slip mechanisms. The effect of Brownian motion is to be investigated more on the thermal behavior of Nanofluids. The flow of Nanofluid in different geometries, the modeling can be done by Lattice Boltzmann Method (LBM)[5]. Performance and function of Plate Heat Exchangers using Nanofluids are reviewed. The main abstains of the wider use of Nanoparticles are greater pumping power and the high cost of Nanofluids.For application in different types of heat exchangers the scientific community agreed that Nanofluids have great potential for heat transfer enhancement. Better alternative to conventional coolants are Nanofluids[6]. In geometry, boundary conditions, and types of fluids, the effects of several parameters were extensively introduced and investigated.It is found that in future space limitation, many technological problems by other ordinary coolants are going to be solved by using Nanofluids[7].Theperformance of an air-cooled radiator heat dissipation enhanced by adopting an alumina (Al_2O_3) and titania (TiO_2) Nano-coolant (NC). The relationship between pumping power by using the efficiency factor and heat dissipation capacity evaluated. Efficiency factor and heat dissipation capacity of NC higher than EG/W and TiO_2 NC is higher than the Al_2O_3 NC. The maximum enhanced heat dissipation capacity is 25.6%[8]. The effect of internal aluminum fins on the heat transfer enhancement in a counter flow heat exchange inestigated.12–51% increase in heat transfer observed compared to plain tube[9]. Impact of interfacial Nanolayer on Nanofluid thermal conductivity was investigated and effects of thermal conductivity ratio, Nanoparticle size, Nanolayer thickness and volume fraction have been discussed. Increases in effective thermal conductivity with an increase in Nanolayer thickness and decrease of particle size[10]. Improvement in viscosity of base fluid and thermal conductivity could be with the suspension of solid Nanoparticles[11]. Nanofluids thermal conductivity enhancement with temperature investigated experimentally. Over a temperature range of 21°C to 51°C increase in thermal conductivity enhancement of Nanofluids 2 to 4 fold. This finding makes attractive for Nanofluids used in cooling application[12]. Radiator of the vehicle filled with different concentrations of Al_2O_3 water Nanofluid and experimental investigation done on forced convection heat transfer.Experiments have been performed in three cases, coolant flow rate, air flow rate and different heat load in order to simulate the engine cooling system. From the results Heat transfer is gradually increased with the concentration and the optimum is 1% by volume and maximum percentage is 14.79%[13]. Under laminar flow regime experiments were conducted in a car radiator using CuO/water Nanofluids. From 0.15-0.4 % vol. concentration of Nanofluid heat transfer enhanced and increasing the inlet temperature of Nanofluid from 50-80^0 C heat transfer decreases[16].Multiwalled carbon Nanotubes (MWCNTs) Nano-coolant (NC)filled in the radiator and the maximum enhanced heat exchange ratio was found to be 12.8%[17].

Experimental Set Up:

The schematic of the experimental system used in this research is shown in Figure 1. It includes a reservoir tank, a feed pump, an electrical heater, a flow meter, a forced draft fan, a temperature controller, two thermocouples and an automobile radiator. The test section of the radiator was placed in front of the forced draft fan and its configuration is the flat fin-and-tube type. Nanofluid was allowed to pass through the 40 vertical tubes.The fins and the tubes are made with aluminum.

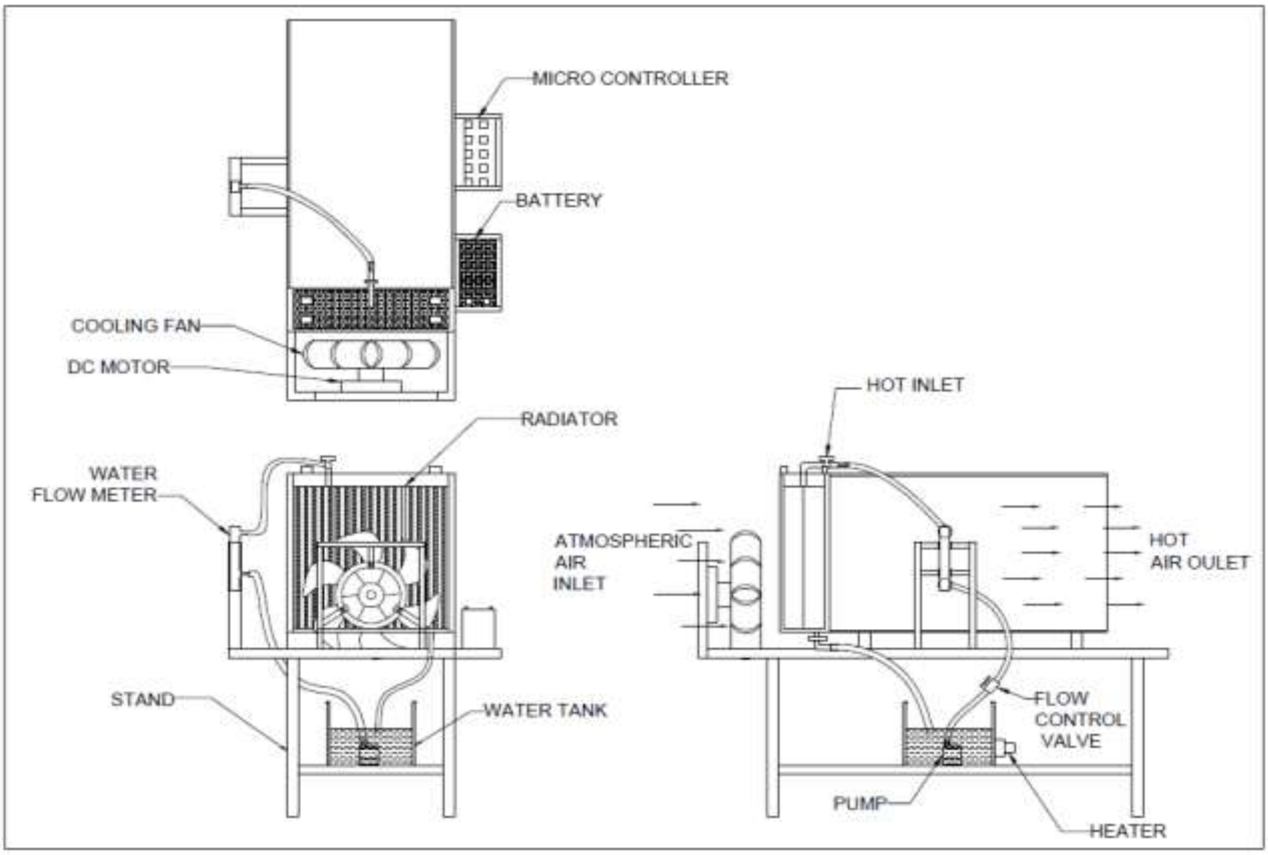

Figure 1. 2D Diagram of experimental setup

For cooling the liquid, a forced draft fan (Almonard 1440 rpm) which is capable of producing air delivery of 270 m^3/hr was installed facing the radiator core. The inlet air temperature was about 33°C in the whole experiments. The pump was driven at constant speed to deliver a constant flow rate of 0.24 m^3/h, and the flow rate for the test section was being regulated by using an appropriate flow meter.The reservoir tank is having the storage capacity of approximately 15L in which, the working fluid, always fills 62.5% of storage capacity. The connecting lines were covered with insulating materials to reduce heat loss to the surroundings.A flow meter (RMS Controls India) was used to control and manipulate the liquid flow rate with high precision. For heating the working fluid, an electrical heater (3000 W) and a temperature controller were used to vary the temperature between 35 and 59°C. Two K type thermocouples were implemented on the flow line to record the radiator fluid inlet and outlet temperatures. The temperatures from the thermocouples were measured by using a digital multimeter (RMS Controls India) with an accuracy of 0.1°C.

Working Principle:

The radiator fin fan cooling system consists of the control unit, battery, micro controller, flow meter, frame stand, cooling fan and the water storage tank. The Nano fluids are mixed with the normal cooling system and then it is used as the coolant in this system.Single Pump Single Loop (SPSL) systems are common in smaller to mid-size generator applications. Operation of this system as follows:

- Engine starts, direct drive pump is driven and fan clutch is rotating.
- The engine reaches operating temperature, coolant thermostat opens and fan clutch engages.
- Coolant is supplied to the engine block and cylinder head internal components, such as oil cooler and intercooler.
- Air is pulled through the radiator.
- Return coolant flow is directed to the radiator.

Figure 2.Experimental set up

Calculation of Heat Transfer Coefficient:

For heat transfer coefficient and corresponding Nusselt number, the following procedure has been performed. According to Newton's cooling law:

$Q=hA\Delta T=hA(T_b-T_w)$...(1)

Heat transfer rate can be calculated as follows:

$Q=mC_p\Delta T=mC_p(T_{in}-T_{out})$...(2)

Results and Discussion:

In order to check the accuracy and reliability of the experimental set up, some experiments were conducted with pure water as coolant prior to the usage of Nanofluids in the radiator. These experiments were conducted at a constant flow rate and varying inlet temperature of the water.The results were shown in the Figures 3 to 7. The experimental runs were extended to the usage of Nanofluids in the radiator, but with different concentrations of Nanofluids.The concentration of Nanofluids used in these experiments was 0.5 % and 1 % Al_2O_3 and CuO in Water (Vol %). While the flow rate was maintained 0.03 kg/s the inlet temperature was varied from 35°C to 56°C in these runs.

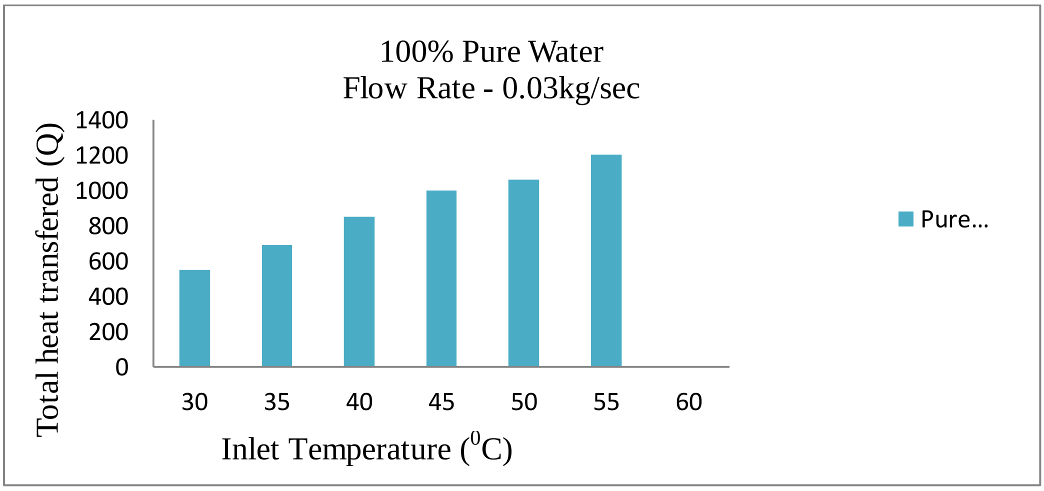

Figure 3: Pure Water: Inlet temperaturevs Total heat transfer

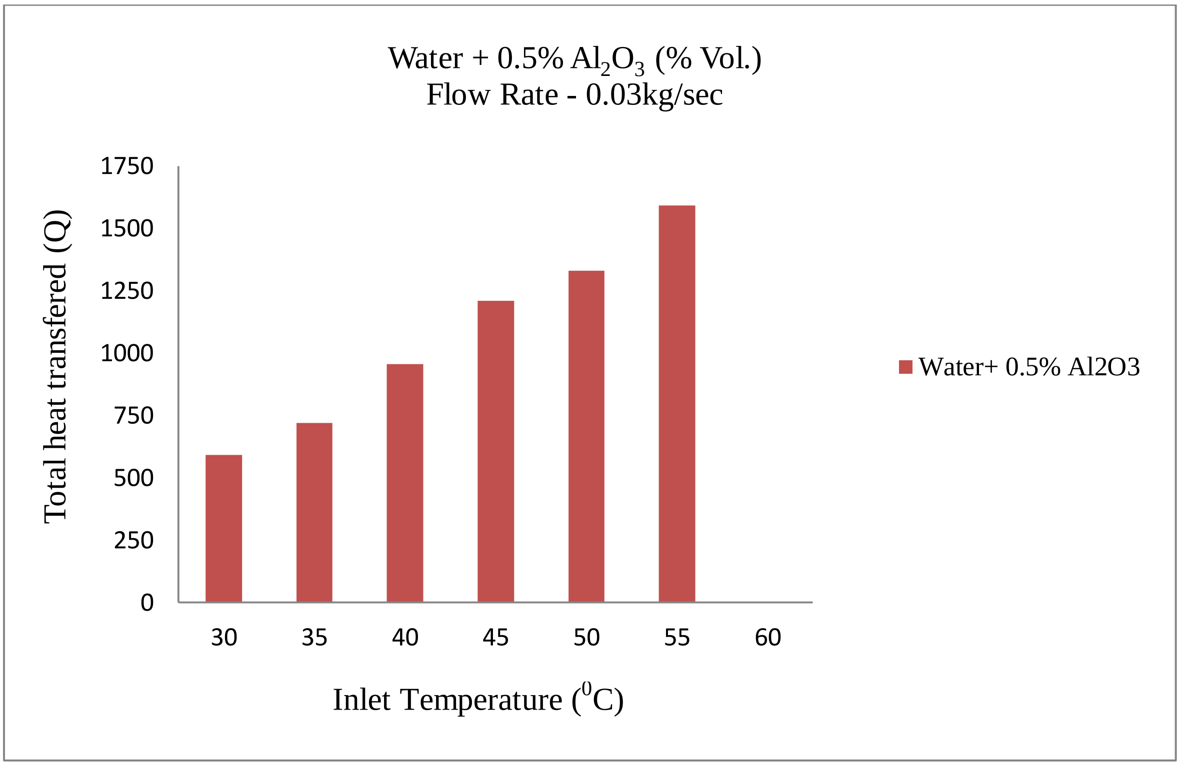

Figure 4: Water+Al_2O_3Nano fluid (0.5% Vol.): Inlet temperature vs Total heat transfer

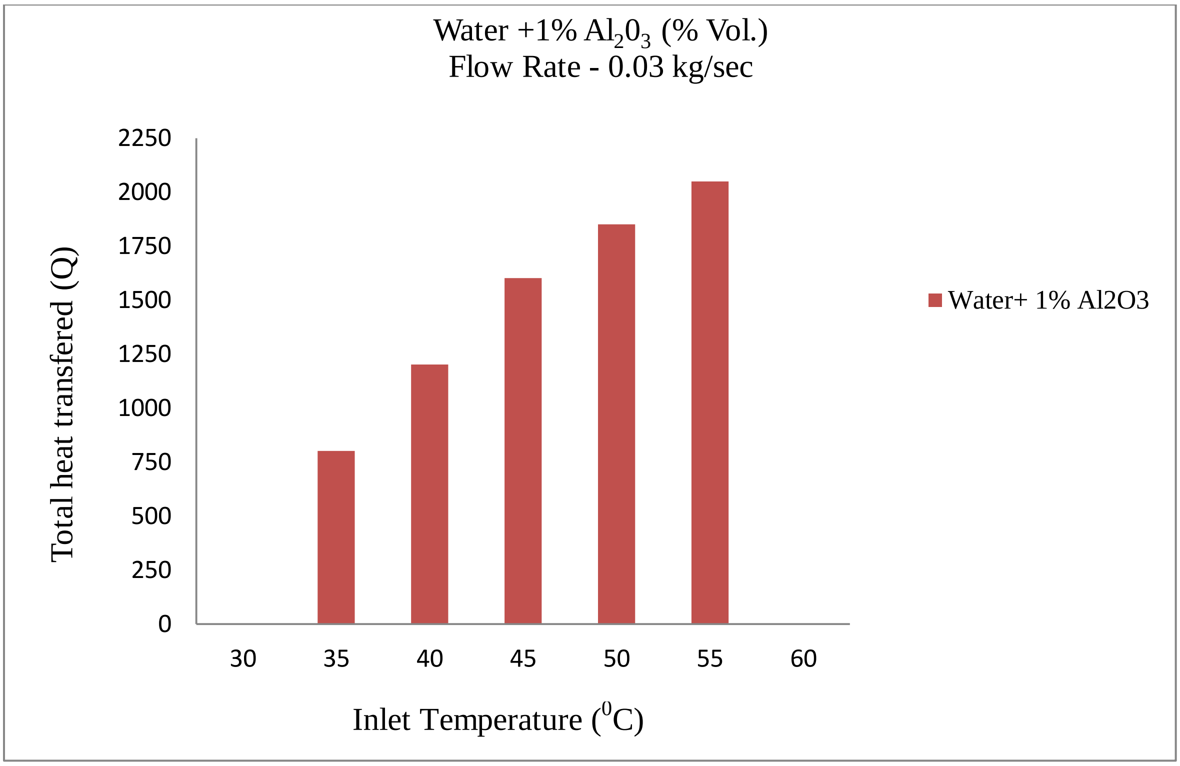

Figure 5:Water+Al_2O_3Nano fluid (1% Vol.): Inlet temperature vs Total heat transfer

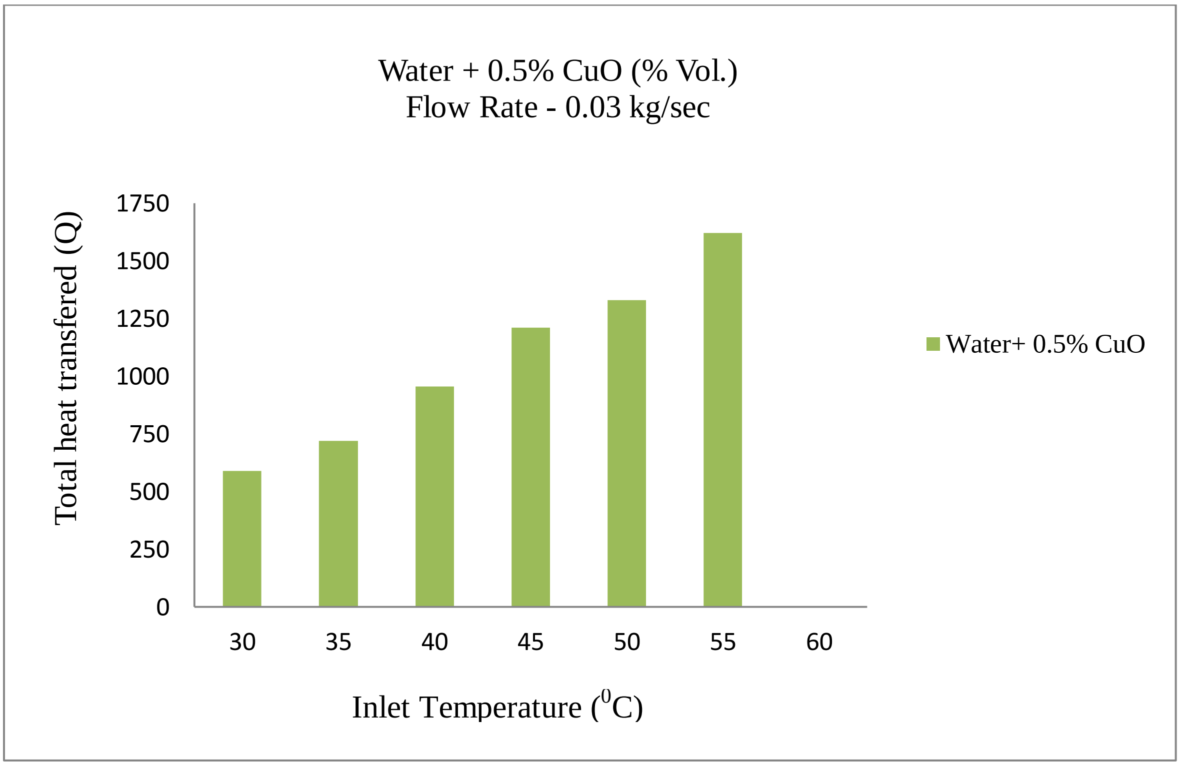

Figure6:Water+CuONano fluid (0.5% Vol.): Inlet temperature vs Total heat transfer

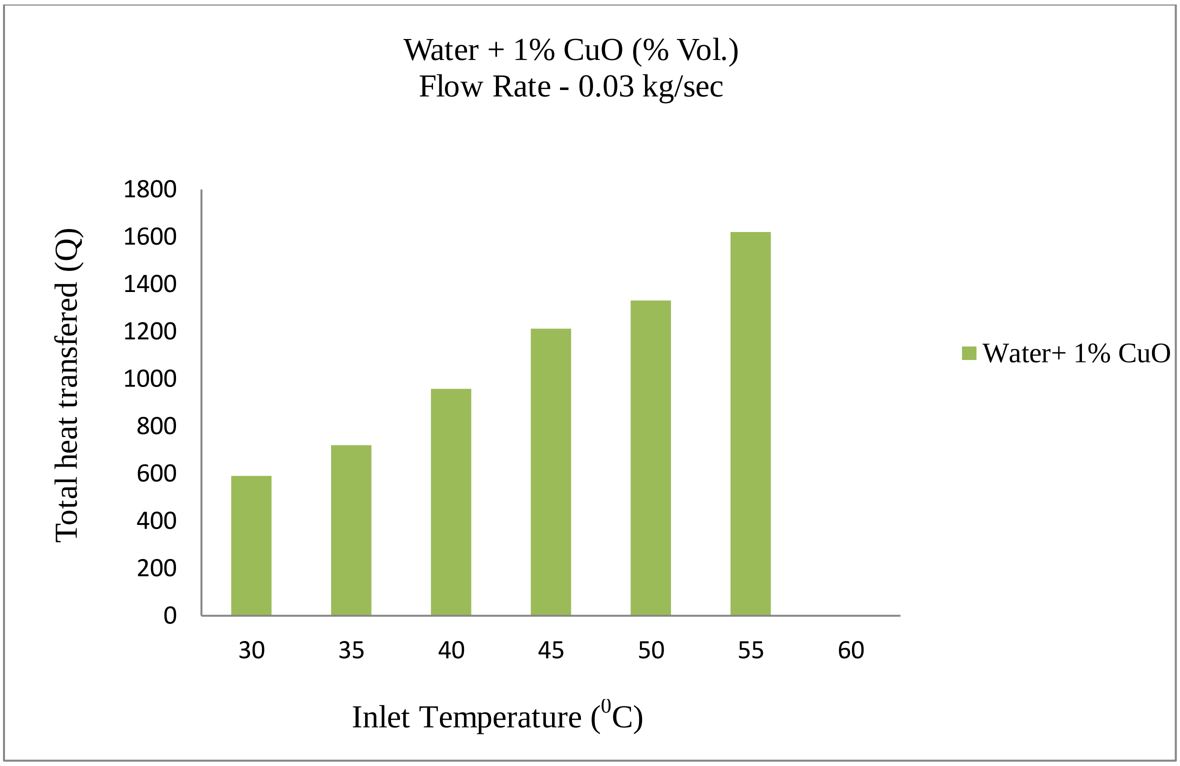

Figure 7: Water+CuONano fluid (1% Vol.): Inlet temperature vs Total heat transfer

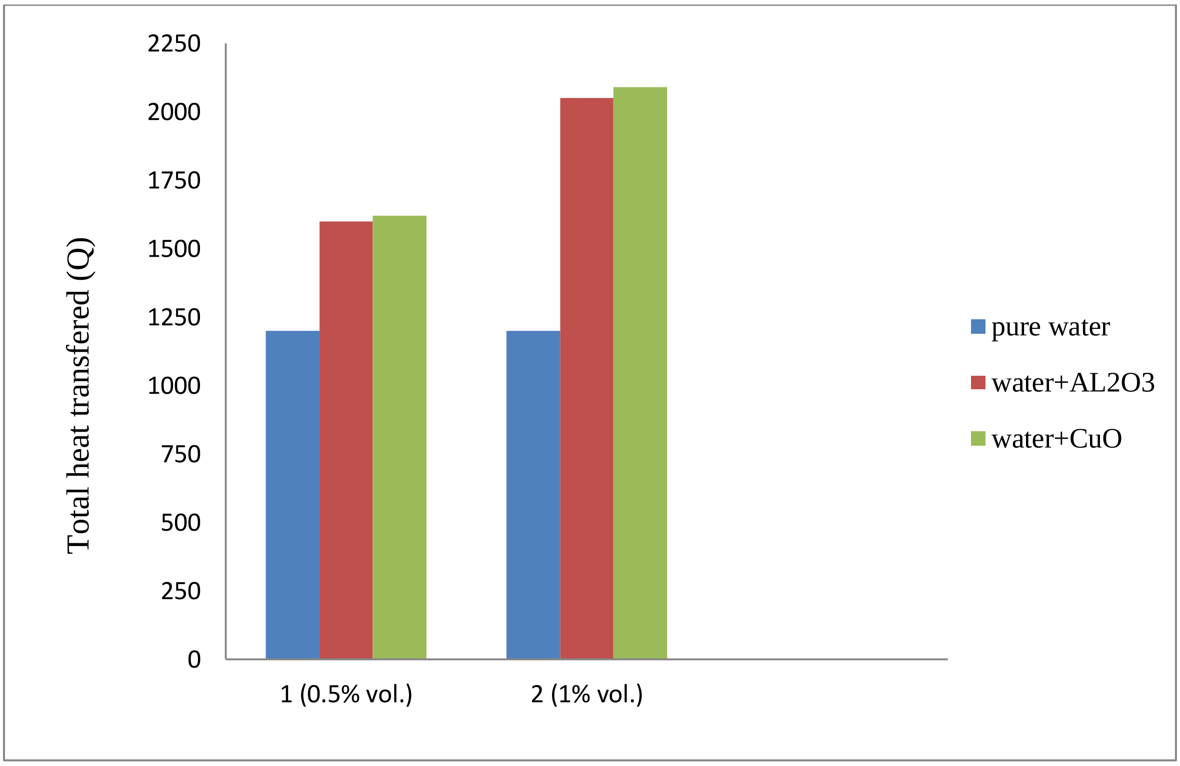

Figure 8:Comparison in total heat transfer(Q) between pure Water,Al_2O_3 and CuO

Here experiments were done to increase the heat transfer rate in automotive flat fin radiator by using Nanofluids and also we compare the heat transfer rate between Al_2O_3 and CuO to achieve better results.From the above graphs we observed that the heat transfer rate is increased by using Nano fluids instead of pure water .The experiment was done at a constant flow rate of 0.03kg/sec and varying Nano fluid concentration(%vol.) respectively 0.5% and 1%. The results are positively obtained and the comparison between Al_2O_3 and CuO ,we got slight increase of heat transfer rate with CuO .

Conclusion:

In this experiment, heat transfer coefficients in the automobile radiator have been measured with two distinct working liquids: pure water and water based Nanofluids (small amount of Al_2O_3/CuONanoparticles in water) at different concentrations and temperatures and the following conclusions were made.

1. The presence of Al_2O_3/CuONanoparticles in water can enhance the heat transfer rate of the automobile radiator. The degree of the heat transfer enhancement depends on the amount of Nanoparticle added to pure water. Ultimately, at the concentration of 1 vol.%, the heat transfer enhancement of 45% compared to pure water was recorded. Similar results obtained in [14].
2. Increasing the flow rate of the working fluid (or equally Re) enhances the heat transfer coefficient for both pure water and Nanofluid considerably while the variation of fluid inlet temperature of the radiator (in the range tested) has slightly changes the heat transfer performance. Similar trend followed in [15].
3. Comparison between Al_2O_3 and CuO has been done,we observed that CuONano particles gave slightly higher heat transfer rate than Al_2O_3.Similar results observed in [18].

References:

1. M.M. Elias, I.M. Mahbubul, R. Saidur, M.R. Sohel, I.M. Shahrul, S.S. Khaleduzzaman, Sadeghipour S. Experimental investigation on the thermo-physical properties of Al_2O_3 Nanoparticles suspended in car radiator coolant. International Communications in Heat and Mass Transfer, 2014, 54: 48-53.
2. B. Farajollahi, S.Gh. Etemad, M. Hojjat. Heat transfer of Nanofluids in a shell and tube heat exchanger. International J of Heat and Mass Transfer, 2010, 53: 12-17.

3. S.M. Fotukian, M. Nasr Esfahany. Experimental study of turbulent convective heat transfer and pressure drop of dilute CuO/water Nanofluid inside a circular tube. International Communications in Heat and Mass Transfer, 2010, 37: 214-19.
4. H.W. Chiam, W.H. Azmi, N.M. Adam, M.K.A.M. Ariffin. Numerical study of Nanofluid heat transfer for different tube geometries - A comprehensive review on performance.International Communications in Heat&Mass Transfer, 2017, 86: 60-70.
5. A. Kamyar, R. Saidur, M. Hasanuzzaman. Application of Computational Fluid Dynamics (CFD) for Nanofluids. International Journal of Heat and Mass Transfer, 2012, 55: 4104-115.
6. Vikas Kumar, Arun Kumar Tiwari, Subrata Kumar Ghosh. Application of Nanofluids in plate heat exchanger: A review. Energy Conversion and Management, 2016, 105: 1017-36.
7. H.A. Mohammed, A.A. Al-aswadi, N.H. Shuaib, R. Saidur. Convective heat transfer and fluid flow study over a step using Nanofluids: A review. Renewable and Sustainable Energy Reviews, 2011, 15: 2921– 39.
8. Hwa-Ming Nieh, Tun-Ping Teng, Chao-Chieh Yu. Enhanced heat dissipation of a radiator using oxide Nano-coolant. International Journal of Thermal Sciences, 2014, 77: 252-61.
9. Leonard D. Tijing, Bock Choon Pak, Byung Joon Baek, Dong Hwan Lee. A study on heat transfer enhancement using straight and twisted internal fin inserts. International Communications in Heat and Mass Transfer, 2006, 33: 719–26.
10. Huaqing Xie, Motoo Fujii, Xing Zhang. Effect of interfacial Nanolayer on the effective thermal conductivity of Nanoparticle-fluid mixture. International Journal of Heat and Mass Transfer, 2005, 48: 2926–32.
11. Ningbo Zhao, Shuying Li, Jialong Yang. A reviewonNanofluids: Data-driven modeling of thermal physical properties and the application in automotive radiator. Renewable and Sustainable Energy Reviews, 2016, 66: 596–616.
12. Das SK, Putra N, Thiesen P, Roetzel W. Temperature dependence of thermal conductivity enhancement for Nanofluids. ASME J Heat Transfer, 125, 2003: 567–74.
13. Ali M, El-Leathy AM, Al-Sofyany Z. The effect of Nanofluid concentration on the cooling system of vehicles radiator. Advances in Mechanical Engineering, 2014, Article no. 962510.
14. S.M. Peyghambarzadeh, S.H. Hashemabadi, M. Seifi Jamnani, S.M. Hoseini. Improving the cooling performance of automobile radiator with Al_2O_3/waterNanofluid. Applied Thermal Engineering, 2011, 31: 1833-38.
15. S.M. Peyghambarzadeh, S.H. Hashemabadi, M. Naraki, Y. Vermahmoudi. Experimental study of overall heat transfer coefficient in the application of dilute Nanofluids in the car radiator. Applied Thermal Engineering, 2013, 52: 8-16.
16. M. Naraki, S.M. Peyghambarzadeh, S.H. Hashemabadi, Y. Vermahmoudi. Parametric study of overall heat transfer coefficient of CuO/water Nanofluids in a car radiator. International Journal of Thermal Sciences, 2013, 66: 82-90.
17. Tun-Ping Teng, Chao-Chieh Yu. Heat dissipation performance of MWCNTs Nano-coolant for vehicle. Experimental Thermal and Fluid Science, 2013, 49: 22–30.
18. M. Hatami, M. Jafaryar, J. Zhou, D. Jing.Investigation of engines radiator heat recovery using different shapes of Nanoparticles in H_2O/ $(CH_2OH)_2$ based Nanofluids International journal of hydrogen energy, 2017: 1-10.

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