Heat Transfer Enhancement by Using Nano-Fluid

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ABSTRACT

In this paper the experimental analysis of the thermal behaviour of the single phase flows through an automobile radiator. In advance technological development in automotive industries has increased the demand for high efficiency engines. A high efficiency engine is not only based on its performance but also for better fuel economy and less emission. One of the important elements in car cooling system is the radiator. Radiator plays an important role in heat exchange. In this paper the experimental analysis of the thermal behaviour of the single phase flows through an automobile radiator. Heat transfer enhancement studies can help in the design of lighter and more compact radiators for the same given load, which in turn can improve the fuel economy of the automobile. The thermal performance of a radiator operated with Nano fluids is compared with a radiator using conventional coolant. In this study, effect of adding Al2O3 nanoparticle as a base fluid in radiator will be investigated experimentally. Forced convective heat transfer of water and ethylene glycol based Nano fluid will be compared experimentally with water, water + ethylene glycol (60:40), water+ethylene glycol+ nanoparticles have been carried out. The experimental results show that Al2O3 based coolant show better heat transfer as compared to other coolants. Nano fluids have the capacity to transfer heat more efficiently than conventional coolant like water. Due to high thermal conductivity, MWCNT is a better coolant amongst CuO and water.

Keywords: *Automobile Radiator, Heat Transfer Enhancement, engine coolant ethylene glycol, Nano fluids, alumina, MgO etc.*

1. INTRODUCTION

In advanced engineering technology optimization process is very important. In automobile weight reduction one of them has been a major focus for manufacturers in recent years to improve the fuel economy and minimizing the running cost. The advancement in technology in the automotive industry has increased the need for high performance engines. The engine performance is based on the fuel economy and high average. Reducing the vehicle weight by optimizing design and size of a radiator. By using the Nano fluid high thermal conductivity coolant increase the performance more 50% compared to conventional coolant. In an automobile, fuel and air produce power within the engine through combustion. Only a portion of the total generated power is actually supplied to the automobile and the rest is wasted in the form of exhaust and heat. If this excess heat is not removed by the engine, temperature becomes too high which results in overheating and decrease viscosity of lubricating oil, weakening the metal of engine parts. A cooling system is used to remove this excessive heat. Most automotive cooling systems consist of radiator, water pump, electric cooling fan, radiator pressure cap, and thermostat. In which radiator is the most prominent part of the system because heat exchange. As coolant travels through the engine's cylinder block, it accumulates heat. Addition of fins is one of the approaches to increase the cooling rate of the radiator. It provides greater heat transfer area and enhances the air convective heat transfer coefficient as the coolant flows through the tubes of the radiator. Heat is transferred through the fins and tube walls to the air by conduction and convection the radiator. Heat transfer fluids at air and fluid side such as water, ethylene glycol and mixture of ethylene glycol +water (50:50) combination exhibit very low thermal conductivity Normally, it is used as a cooling system of the engine and generally water is the heat transfer medium.

2. LITERATURE SURVEY

The presence of nanoparticles in the base fluids contributes better flow of mixing and higher thermal conductivity compared to pure fluid. Heat transfer coefficient can be improved up to 50% compared to the original coolant by Nor Azwadi et al [1]. The revealed that the dispersion of γ-A12O3particles at 4.3 vol% can increase the effective thermal conductivity of water by almost 30%.Since then, many studies have been carried out to investigate the enhancement of thermal conductivity with different nanoparticle volume fractions, materials and dimensions in several base fluids. Eastman et al. [4] reported that the thermal conductivity of ethylene glycol Nano fluids containing 0.3% volume fraction of copper particles can be enhanced up to 40% compared to that of ethylene glycol base fluid. Most of the findings show that thermal conductivity of Nano fluids is higher than the base fluids by Adithya Choure [2]. In demonstrated that oxide ceramic Nano fluids consisting of CuO or Al2O3 nanoparticles in water or ethylene-glycol exhibit enhanced thermal conductivity. For example, using Al2O3 nanoparticles having mean diameter of 13 nm at 4.3% volume fraction increased the thermal conductivity of water under stationary conditions by 30%. On the other hand, larger particles with an average diameter of 40 nm led an increase of less than 10%.In research paper investigated the thermal conductivity enhancement of three different Nano fluids CuO, ZnO2 and Al2O3 Nano fluids. Also, thermal conductivity increases within creasing temperature and volume concentration. In another paper Author predict the thermal conductivity theoretically under dynamic and static processes taking into account the effect of Brownian motion, particle size, nano layer and particle surface. They concluded that thermal conductivity is due to both static and dynamic mechanisms. In a different study, reported a nonlinear model of thermal conductivity enhancement of18% at volume fraction of 0.05 vol% using Fe-ethylene glycol Nano fluids. Author compared the thermal conductivity between Cu-ethylene glycol Nano fluid and pure ethylene glycol.

3. CORE CONTENT

3.1 Nano fluid

A Nano fluid is a fluid containing nanometer-sized particles of MWCNT and copper oxide, called nanoparticles. These fluids are engineered colloidal suspensions of nanoparticles in a base fluid. The nanoparticles used in Nano fluids are typically made of metals, oxides, carbides, or carbon nanotubes i.e., multiwall carbon Nano fluid. Common base fluids include water. The presence of nanoparticles in the base fluids contributes better flow and higher thermal conductivity compared to pure fluid. Nanotechnology has opened new ways to look at the energies. Nanotechnology plays an essential role in heat transfer. These are known for their good thermos-physical properties. Due this, they find application in many areas where heat transfer is concerned. Nano fluids have novel properties that make them potentially useful in many applications in heat transfer fuel cells, pharmaceutical processes, hybrid-powered engines, engine cooling vehicle, domestic refrigerator, chiller, heat exchanger and in machining. They exhibit enhanced thermal conductivity and the convective heat transfer coefficient compared to the base fluid.

Fig.3.1 Nano fluid

3.2 Radiator

Radiators are heat exchangers used to transfer thermal energy from one medium to another for the purpose of cooling and heating. The majority of radiators are constructed to function in automobiles, buildings, and electronics. The radiator is always a source of heat to its environment, although this may be for either the purpose of heating this environment, or for cooling the fluid or coolant supplied to it, as for engine cooling. Despite the name, most radiators transfer the bulk of their heat via convection instead of thermal radiation. Spacecraft radiators necessarily must use radiation only to reject heat.

3.3 Fan

The fans do not work alone. They are part of a larger overall cooling system in the vehicle. All of the parts need to be working correctly for the fan to be able to do its job and cool the engine. When the engine is cool or even at normal operating temperature, the fan clutch partially disengages the engine's mechanically driven radiator cooling fan, generally located at the front of the water pump and driven by a belt and pulley connected to the engine's crankshaft.

3.4 Temperature Sensors

A temperature sensor is a device, typically, a thermocouple or RTD that provides for temperature measurement through an electrical signal. A thermocouple (T/C) is made from two dissimilar metals that generate electrical voltage in direct proportion to changes in temperature.

3.5 Flow Sensor

The potential difference is sensed by electrodes aligned perpendicular to the flow and the applied magnetic field. The physical principle at work is Faraday's law of electromagnetic induction. The magnetic flow meter requires a conducting fluid and a nonconducting pipe liner.

Fig. 3.2 Flow Sensor

3.6 Heating Coil

An electric heater is an electrical device that converts electric current to heat. The heating element inside every electric heater is an electrical resistor, and works on the principle of Joule heating: an electric current passing through a resistor will convert that electrical energy into heat energy.

3.7 Flow Control Valve

Flow control valve. A flow control valve regulates the flow or pressure of a fluid. Control valves normally respond to signals generated by independent devices such as flow meters or temperature gauges. The altitude valve will remain open while the tank is not full and it will close when the tanks reaches its maximum level.

3.8 Arduino UNO

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output pins that may be interfaced to various expansion boards and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler tool chains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project.

Fig. 3.3 Arduino UNO

3.9 Pump

Pump is device that moves fluids, sometimes slurries, by mechanical action. Pumps operate by some mechanism and consume energy to perform mechanical work by moving the fluid. Pump can run with the help of electricity, engines etc.

4. OBJECTIVE OF PAPER

1) The main objective of this project is design and simulation of shell and tube heat exchanger with segmental baffle using CFD and measuring the thermal performance that is heat transfer, temperature variation, velocity etc.

2) Also doing the CFD analysis for plane tube with circular fins over the tubes along with baffle.

3) Comparing these results for both the case with and without fins and finding which is effective for improving the performance of heat exchanger.

5. SYSTEM DEVELOPMENT

In this experiment devices are arranged like pump, radiator, Nano fluids, piping, sensors and all placed over the wooden base as shown in figure. In which Nano fluids is a working fluids which is stored in tank and with the help of pump it has circulate radiator through piping, temperature sensor will placed at inlet and outlet of radiator to check the temperature. Radiators are heat exchangers used to transfer thermal energy from one medium to another. Flow control valve are used to control the flow rate and with the help of flow sensor check the flow rate. Heating coil is used to heat the Nano fluid liquids so we check the heat transfer rate while passing the fluid from radiators.

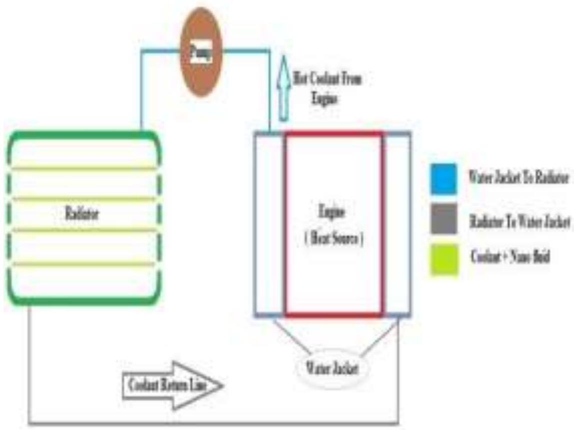

Fig 4.1 Conceptual Design

Fig. 4.2Actual Design

7. RESULT AND CONCLUSION

Tests were taken on two different flow rates as flow rates play an important role in heat transfer. Coolants used were water, CuO and MWCNT Nano fluids concentration 1% by volume. Following are the results in the form of graphs.

1. Flow rate= 71.5 lpm

a. Temp vs. Total Time

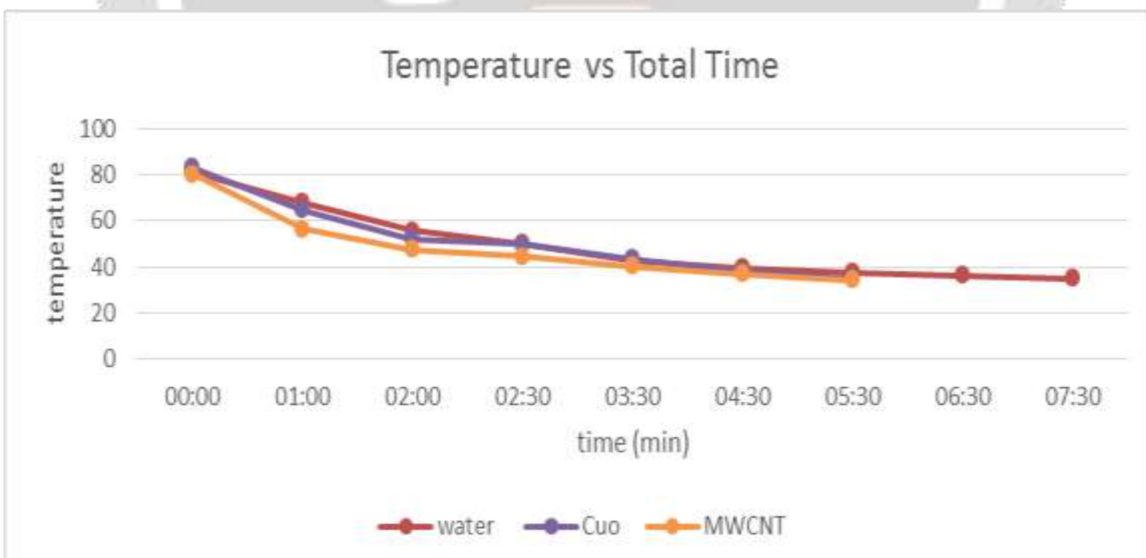

Fig 6.1 Total Time vs. Temperature at FL= 71.5 lpm

b. Time vs. Temp difference.

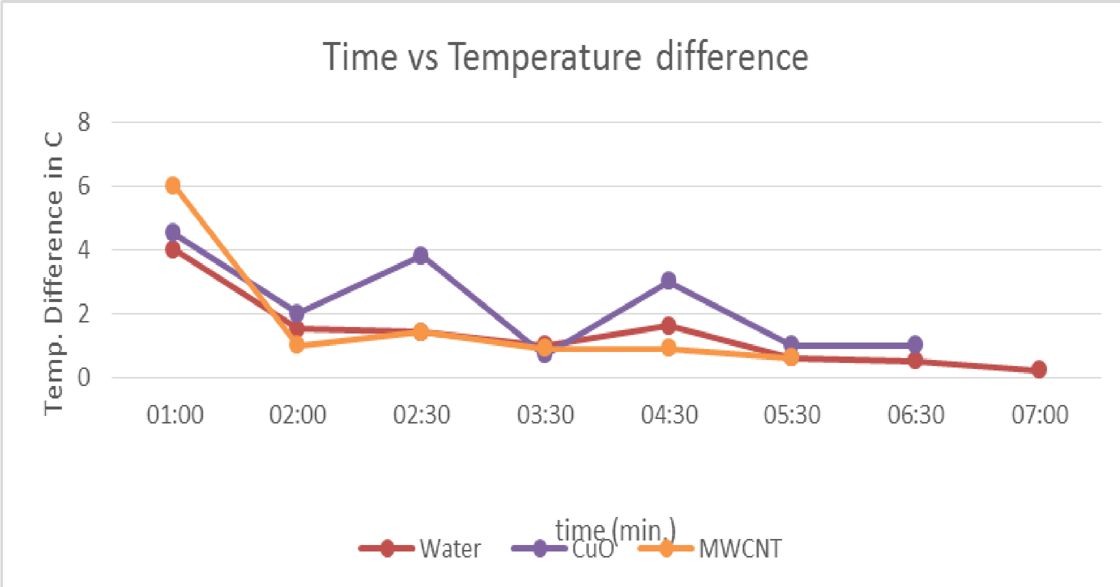

Fig. 6.2 Time vs. Temperature difference at FL- 71.5 lpm

Initial temperature was about 80 degree centigrade. Then after the circulation started, temperature started to drop. According to the result, water took around more than 8 min to cool down to ambient temperature where CuO and MWCNT Nano fluids took 5 min and 4.5 min to cool down. Considering the temperature difference in all the three fluids, MWCNT is a better coolant.

2. Flow rate = 56.1 lpm

a. Temperature vs. Total Time

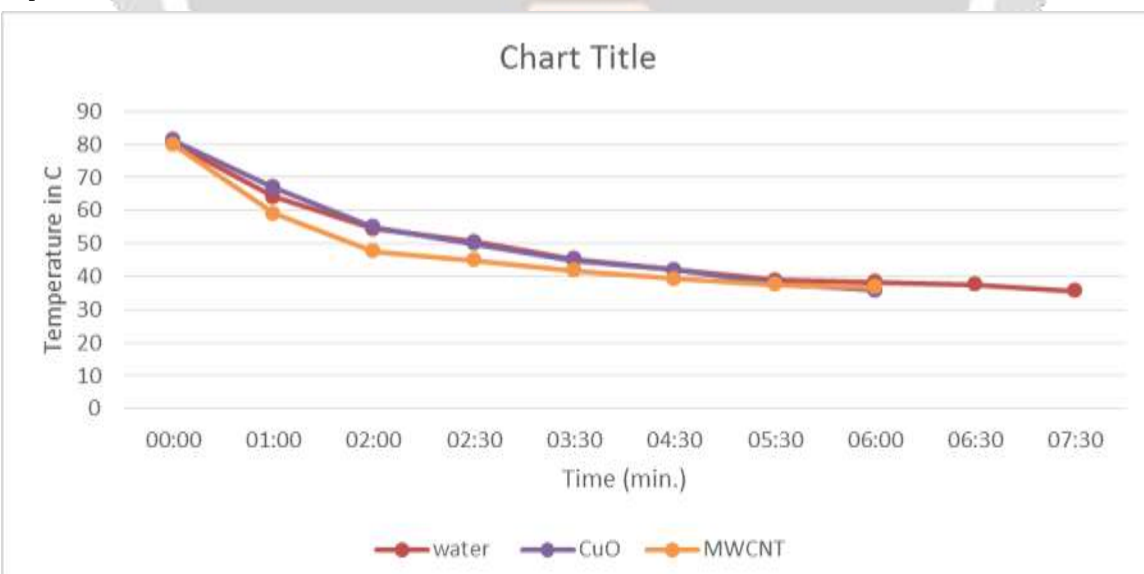

Fig 6.3 Temperature vs. Total time at FL= 56.1 lpm

b. Temperature difference vs. time

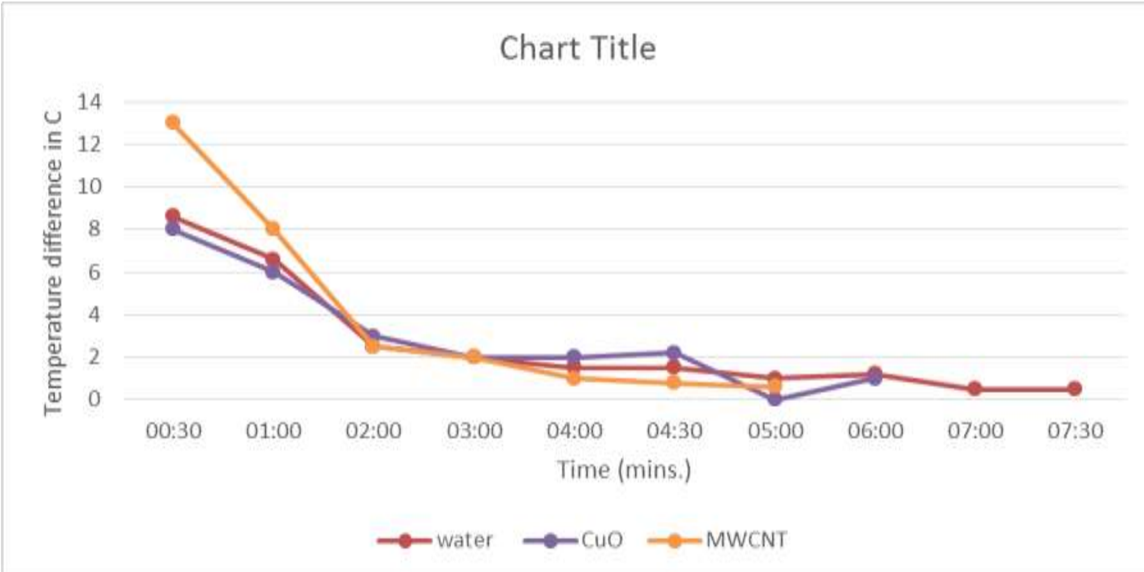

Fig 6.4 Temperature difference vs. time at FL= 56.1 lpm

As the flow rate was decreased the temperature difference was increased. Water cooled down from 80 degree centigrade to 34 in 8.40 min. CuO and MWCNT cooled down with greater temperature differences. Combining all the data together, considering the heat transfer capacity of all the three fluids, MWCNT has the highest efficiency amongst all. In this project Nano fluids are used as a coolant in radiator because it has a high thermal conductivity due to its surface area as compared to other coolants such as water and ethylene glycol. Following conclusions can be made from this project**.**

1. Nano fluids have the capacity to transfer heat more efficiently than conventional coolant like water.
2. With the decrease in flow rate, the coolant gets more time to absorb heat and hence it boosts heat transfer.
3. Due to high transfer rate of Nano fluid, size of the radiator can be reduce to some extent which will lead to be better fuel economy in vehicle.
4. Due to high thermal conductivity, MWCNT is better coolant amongst CuO and water.

Table 6.1 Comparative Properties in between Water and Nano fluid

Properties	**Water**	**Nano fluid**
Thermal conductivity	low	high
Viscosity	low	high
Density	low	high
Efficiency	low	high
Stability	high	low
Preparation	does not require	required

8. ADVANTAGES AND DISADVANTAGES

8.1 Advantages

- High heat capacity
- High thermal conductivity
- Reduces the pumping power consumption
- High specific surface area
- High efficiency in heat transfer

8.2 Disadvantages

- Chemical stabilizers are required
- Clustering of nanoparticles in Nano fluids
- Careful handling is required
- Government authorization is required for proper disposal
- Erosion may take place due to solid particles.

9. FUTURE SCOPE

Further research on a thermal conductivity mechanism of Nano fluids is focused on theoretical and experimental studies to answer the question of effect of particle size on its conductivity. Researchers are building a structural model that can help to explain the thermal conductivity of Nano fluids. Another major task is analyzing the microscopic motion in Nano fluids and understanding their contribution to energy transport. The knowledge of heat transfer at micro and Nano scale is still limited so further research have more scope. Another main task to known Nano fluids behaves over time at elevated temperatures. Thermal conductivity is not a critical issue but the mechanism behind this is still unknown to this date. A better understanding of this mechanism can lead to application of these Nano fluids in engineering for industrial applications. Nano fluids can be used in HVAC and refrigeration systems, automobile engineering and will apply for machining in production process for cooling and so on where heat transfer is concerned.

10. REFERENCES

[1] Nor Azwadi Che Sidik "Recent Advancement of nanofluid in engine cooling system" International Journal of Thermal Sciences (2016)

[2] Aditya choure, Ravibala patil, Kishor dolare, "Performance investigation of automobile radiator using AL2O3 as base Nanofluid" International Journal of Thermal Sciences (2016)

[3] D.P. Kulkarni, R.S. Vajjha, D.K. Das, D. Oliva, "Application of aluminum oxide nanofluids in diesel electric generator as jacket water coolant", Applied Thermal Engineering 28 (14-15) (2008) 1774-1781.

[4]. J.A. Eastman, S.U.S. Choi, S. Li, W. Yu, L.J. Thompson, "Anomalously increased effective thermal conductivities of ethylene glycol-based nanofluids containing copper nanoparticles", Applied Physics Letters 78 (6) (2001) 718-720.

[5]. Y. Hwang, J.K. Lee, C.H. Lee, Y.M. Jung, S.I. Cheong, C.G. Lee, "Stability and thermal conductivity characteristics of nanofluids", Thermochimica Acta 455 (1-2) (2007) 70-74.

[6]. J.-H. Lee, K.S. Hwang, S.P. Jang, B.H. Lee, J.H. Kim, S.U.S. Choi, "Effective viscosities and thermal conductivities of aqueous nanofluids containing low volume concentrations of Al2O3 nanoparticles", International

Journal of Heat and Mass Transfer 51 (11- 12) (2008) 2651-2656.

[7]. W. Yu, H. Xie, L. Chen, Y. Li, "Investigation of thermal conductivity and viscosity of ethylene glycol based ZnO nanofluid", Thermochimica Act a 491 (1-2) (2009) 92-96.

[8]. H.A. Mintsa, G. Roy, C.T. Nguyen, D. Doucet, "New temperature dependent thermal conductivity data for water-based nanofluids", International Journal of Thermal Sciences 48 (2) (2009) 363-371.

[9]. Navid Bozorgan, MostafaMafi and Nariman Bozorgan, "Performance Evaluation of Al2O3/Water Nanofluid as Coolant in a DoubleTube Heat Exchanger Flowing under a Turbulent Flow Regime", Hindawi Publishing Corporation Advances in Mechanical Engineering Volume 2012, Article ID 891382, 8 pages doi:10.1155/2012/891382.

[10]. P.K. Namburu, D.K. Das, K.M. Tanguturi, R.S. Vajjha, "Numerical study of turbulent flow and heat transfer characteristics of nanofluids considering variable properties", International Journal of Thermal Sciences 48 (2) (2009) 290-302.

[11]. Y. Ding, H. Chen, Y. He, A. Lapkin, M. Yeganeh, L. Siller, "Forced convective heat transfer of nanofluids", Advanced Powder Technology 18 (6) (2007) 813-824.

[12]. H.S. Zeinali, M. Nasr Esfahany, S.G. Etemad, "Experimental investigation of convective heat transfer of Al2O3/water nanofluid in circular tube", International Journal of Heat and Fluid Flow 28 (2) (2007) 203-210.

[13]. W. Yu, D.M. France, D.S. Smith, D. Singh, E.V. Timofeeva, J.L. Routbort, "Heat transfer to a silicon carbide/water nanofluid", International Journal of Heat and Mass Transfer 52 (15-16) (2009) 3606-3612.

[14]. D. Kim, Y. Kwon, Y. Cho, C. Li, S. Cheong, Y. Hwang, "Convective heat transfer characteristics of nanofluids under laminar and turbulent flow conditions", Current Applied Physics 9 (2) (2009) e119e-e123.
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