The Comparative Study of Heat Transfer Enhancement of Automobile Radiator (Car) using Different Nanofluids

Krishna Mundada*[1] ,Kulkarni Durvesh *[2],Harsha Malbari*[3]
[1] *Mechanical Engineering, Smt. Kashibai Navale College of Engineering Pune*
durveshkulkarni55@gmail.Com

[2] *Mechanical Engineering, Smt. Kashibai Navale College of Engineering Pune*
krishnamundada951@gmail.com

[3] *Mechanical Engineering, Smt. Kashibai Navale College of Engineering Pune*
malbari60@gmail.com

ABSTRACT

In the development of the many modern technology the foremost challenge is thermal management. If we are looking towards the automobile sector the thermal management is the most difficult challenge. Nanofluids are suspension of metallic or nonmetallic nanoparticles in the base fluid. It can be used to increase the heat transfer rate of various applications such as internal cooling system for automobile engine. This paper contains the literature survey which gives the techniques to implementation of the different nanofluids in the car radiator for the cooling of engine and to enhance heat transfer of automobile radiator. Heat transfer in a Car radiator is carried out to cool circulating fluid which regulates water and a mixture of water and coolant materials like Ethylene glycol (EG), Al2O3,TiO2, etc. In this Comparative Experimental study presented, the mixture Ethylene glycol & water (50:50), combination of Al2O &water,TiO2,CuO nanoparticle were used in Car Radiator.

The test liquid flows through the regular radiator consisted of 34 vertical pipe with elliptical cross section and air makes a cross flow inside the tube bank with constant speed. Liquid flow rate will be changed in the range of 2 - 8 l/min. Additionally the effect of fluid inlet temperature of the radiator on heat transfer coefficient will also be analyzed by varying the temperature in the range of 40 - 90 0C.

Keywords: *Nanofluids, Car Radiator, Heat Transfer Enhancement, Magnetic Stirrer, Ethylene glycol, Aluminum oxide Nano particles. Nanofluid, Heat transfer coefficient*
TiO2, Radiator, Cooling performance.

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1. INTRODUCTION

New technological research and development in automotive industries has enhanced the demand for high- efficiency. There is a requirement for size and weight reduction in heat transfer systems in transport industries. Using variable fin types and microchannels, various tube arranged or irregular surfaces show some efforts made for increasing the cooling rate of radiators. The other way is changing the working fluid of radiators.

Using the conventional heat transfer fluid such as water, ethylene glycol (EG), engine oil individually diminish the performance as oil have relatively poor heat transfer performance. So, the high compactness of heat transfer systems is to require to achieve the required heat transfer. One method for increasing the heat transfer of car radiator fluids is adding small solid particles, in the range of nano, to the base fluids. These are called the nanofluids. However, nanofluids are different in shapes they can be round or elliptical.

Nanoparticles, the additives of nanofluids, play a worthy role in altering the thermal properties of nanofluids also they change the fluid features because thermal conductivity of the particles is higher than ordinary fluids. Scientist have studied the use of nanofluids by using the different combination of nanofluids. The investigations about nanoparticles mainly focus on the effects of their volume and mass fraction (including specific surface area, shape, and size of the nanoparticles). Heat transfer enhancement technology has been applied to heat exchanger applications in automobile, refrigeration, process in industries etc. The radiator used in this experiment has elliptical shaped curved tubes made from 0.1 to.03 mm aluminum sheet. The virtue of enhancement of heat transfer is to accommodate high heat fluxes. This result in decrease of heat exchanger size, which generally leads to less capital cost. Another profit is the reduction of temperature driving force, which reduces the entropy generation and enhances the second law efficiency. All these benefits have made heat transfer enhancement technology attractive in heat exchanger applications. As a heat exchanger becomes older, the resistance to heat transfer enhances owing to the scaling. These situation or problems are more common for heat exchangers used in mechanical and chemical industries and water based or marine applications. In this case the heat transfer rate can be enhanced by making a change in the fluid or in flow by different enhancement technologies i.e making laminar or turbulent. By suspending nanoparticles in heating or cooling fluids, the heat transport performance of the fluid can be significantly surpassed .

The main reasons may be listed as follows:

1) The suspended nanoparticles enhance the surface area and the heat capacity of the fluid.

2) The suspended nanoparticles enhance the effective (or apparent) thermal conductivity of the fluid.

3) The interaction and collision among particles, the surface of fluid and the flow passage are intensified.

2.CONTRIBUTION

Nanofluids seem to be valuable replacement of conventional coolants in engine cooling system. There have been enormous research findings superior heat transfer performances of nanofluids. .A decrease in energy consumption is possible by enhancing the performance of heat exchange systems and introducing various heat transfer enhancement techniques. Table 1 shows us the comparison of different concentration of nanofluids used for experiment.

SCIENTIST	FLOW	PERFORMED WITH	CONCENTRATION	%GAIN THAN BASE FLUIDS
WEN&DING	LAMINAR	AL_2O_3	0.6-1.6%	41
JUNG	LAMINAR	AL_2O_3&H_2O	1.8	32
YU	LAMINAR	ZnO+EG	0.3	26.5
EASTMAN	LAMINAR	CuO+H_2O	1-3.4	40
DURGESH CHAVAN	TURBULENT	Al_2O_3 +pureH_2O	1	45

TABLE 1: Contribution of Scientist in various fields.

Excellent mass features for the heat pipe radiator assembly arrangement for space application were investigated by Vlassov et al. In addition, heat transfer fluids such as water, ethylene glycol and a proportionate mixture of ethylene glycol &water (50:50) combination exhibit much less thermal conductivity. Therefore there is requirement for using the new heat transfer fluids for enhancing heat transfer rate in an automobile radiator .Yu et al. reported that about 15-30% of heat transfer enhancement can be achieved by using various types of nanofluids. Different types of tubes used would also contribute in increasing the heat transfer coefficient. As the surface area changes the heat convection also changes .Thus more the surface area more is the heat transfer coefficient. Coefficient of drag can be minimized and fuel consumption efficiency can be enhanced.

3.PREPARATION OF NANOFLUIDS

Formation of nanoparticles suspension is the important step in using nanofluid for heat transfer experiments. In this work the TiO2-water nanofluid , Al2O3- water nano fluids and CuO & water mixture is prepared by a two- step method. The TiO2,CuO, Al2O3,Fe3O4 nanoparticles of an average size have been provided. As the provided nanoparticles had a hydrophobic surface, and they are in clustered form and precipitated when dispersed in water in the absence of a surfactant as hydrophobic in nature. Moreover, addition of agent may change the fluid properties. The TiO2 nanoparticles were mixed with 1, 1, 1,3,3,3 hexamethyldisilazane (C6H19NSi2) in a mass fraction ratio of
2:1. The mixture which was available then was sonicated at 30 °C for 1-1.5h using ultrasonic vibration at sound frequency of 40 kHz. After that the hydrophilic ammonium were suspended on the TiO2 nanoparticles. The soaked nanoparticles were made to dry with a rotary evaporation apparatus. Specific quantities of these generated nanoparticles were mixed with pure distilled water as the base fluid to make nanofluids in particular volume (capacity) fractions. The suspensions were subjected to ultrasonic vibration at 415W and 24 kHz for 2–5 h to obtain uniform suspensions and break down the large

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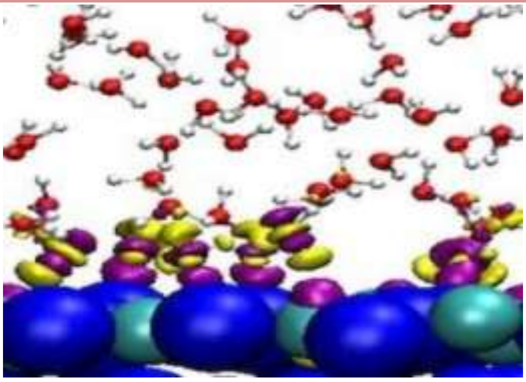

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Fig. 1: FESEM Image of Nanoparticles After Dispersion

Likewise the Al2O3 is prepare nanofluid by magnetic stirrer technique. A magnetic stirrer is a rotating magnetic field used to a stir bar (magnet) immersed in a liquid to spin fast and magnetic stirrer also heat the solution. The rotating field is created either by a rotating magnet. Placed the vessel with liquid in it. Glass does not affect a magnetic field and thus most chemical reactions take place in glass vessel. Magnetic stirrers can only be used for relatively small experiments. In magnetic stir technique cavitation does not occur..

Fig. 2: Magnetic Stirrer

4.EXPERIMENTAL SETUP

The experimental setup is shown in Fig.4 and is used to measure heat transfer coefficient and friction factor in the automotive engine radiator.This experimental setup includes a reservoir plastic tank, a centrifugal pump, a flow meter, tubes, valves, electrical heater, a fan, a DC power supply, Digital thermocouple type K for temperature measurement heat exchanger. An electrical heater (2000W)is inserted inside a plastic storage tank (40-45cm height and 30 cm diameter) heat the fluid .A voltage regulator (0–220 V) provided the power to keep the inlet temperature to the radiator from 50 to 80 C. A flow meter (0–30 LPM) and two valves were used to measure and also control the flowrate .The fluid flows through plastic tubes (0.1-0.3in.) by a centrifugal pump (0.5-0.8hp) from the tank to the radiator at the flow rate range 2–8 LPM. The total volume of the circulating fluid is 2.5 to 3l and constant in all the experimental steps. Two thermocouples (copper–constantan) types K were fixed for recording the inlet and outlet fluid temperatures. Digital thermocouples type K have been fixed to the radiator surface by ensuring more of surface area measurement. Two thermocouples type K also fixed in front of the fan and another side of radiator to measure air temperatures. A hand held (-35 ^{0} C to1000 ^{0}C) digital thermometer was used to read all the temperatures from thermocouples. The car radiator has 34 flat vertical Aluminium tubes with elliptical cross sectional area .The distances among the tube rows filled with thin perpendicular Aluminium fins .For the air side,an axial force fan (1400rpm) installed close on axis line of the radiator . For heating the working fluid an electric heater of capacity
2000 watt. Controller were used to maintain the temperature 40-80C.

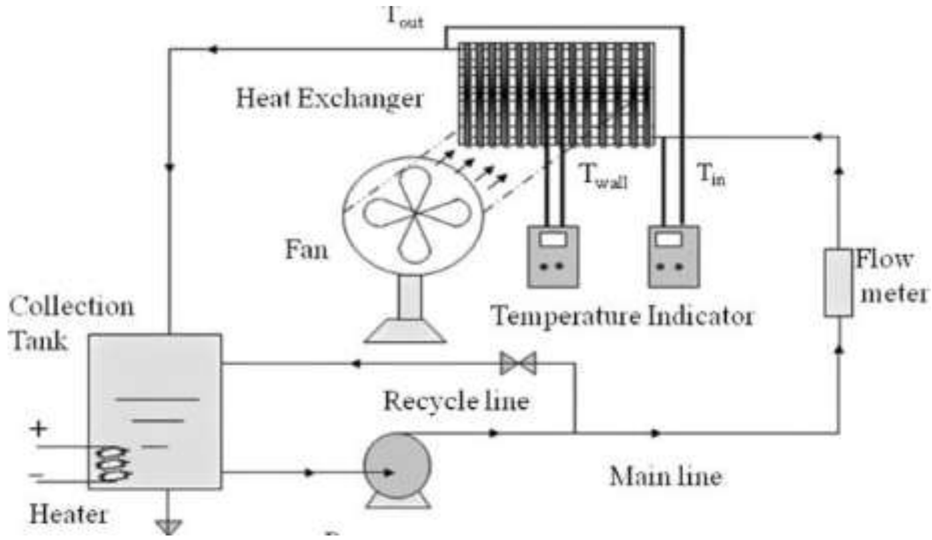

Fig.3: Experimental Setup

There was the heat exchange between the hot fluid flowing in the tube-side and air cross the tube bundle. Constant velocity and temperature of the air in the experiments were considered in order to clearly check the internal heat transfer. The design of the system allowed for filling the heat exchanger from up and down. Table 2 shows ranges of all the experimental parameters.

PARAMETER	Al2O3	TiO2	CuO
VOLUMETRIC FLOW RATE	3-5	2-5	4-8
CONCENTRATION (VOL%)	0-1	0-1	0-1
REYNOLD NUMBER	2000-20000	4000-18000	2000-8000
INLET TEMP.	$(40,45,50)^0$C	$(15,25,35)^0$C	$(35,45,54)^0$C

TABLE 2: Specification of Different Nanofluids

5.USES OF NANOFLUIDS NANOFLUID USED AS

LUBRICANT

1)Osorio et al. investigated the tribological properties of CuO suspended lubricant and concluded that the addition of CuO nanoparticles reduced friction with respect to base oil. Thus the nanoparticles could fill irregular cracks in a metal wall surface to reduce the coefficient of friction.

NANOFLUIDS USED AS ADDITIVES

1)Nanofluids Improve the fuel economy

2)It also Reduce the exhaust emissions.

3)It Enhance 15~25%combustion efficiency by adding 0.7% of aluminum nano- particles to a rocket's solid fuel. Also the combustion speed has been enhanced because of nanoparticle additives.

NANOFLUID USED IN SHOCK ABSORBER

1)Nanofluids , reduces the space and improve the performance of shock absorber by absorbing more vibrations.

2) Fluid is known as Magneto Rheological nano fluid or Electro Rheological nanofluid. Depending on the size of the nanoparticles, the magnetic fluid may be able to change its viscosity proportion to the strength of magnetic field applied to it.

3)It was observed that application of nanofluid with low concentration will enhance upto 44.5% heat transfer than base fluids.

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6.COMPARATIVE PROPERTIES OF NANOFLUIDS

NANOFLUIDS	MEAN DIA	DENSITY	THERMAL CONDUCTIVITY
AL2O3	20	3700	46
TiO2	10	3840	11.7
CuO	20	6510	18
Fe3O4	36	5180	80.4

Table 3: Specification of Different Nanofluids

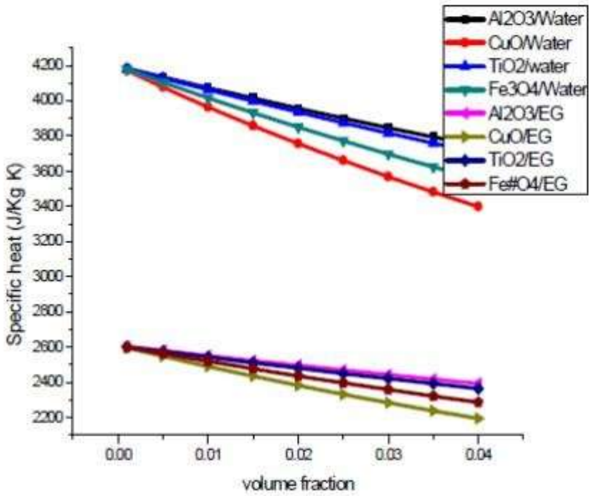

Fig.4: Specific Heat of Nano fluid with Base Fluid as water and Ethylene Glycol

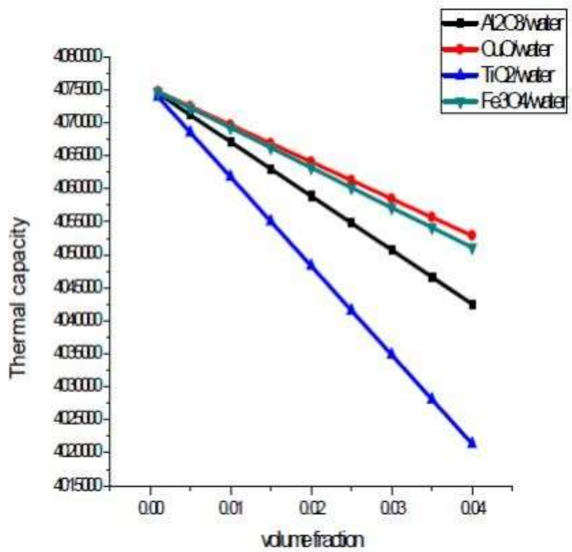

Fig.5: Thermal Capacity of Nanofluids with Water as Base Fluid

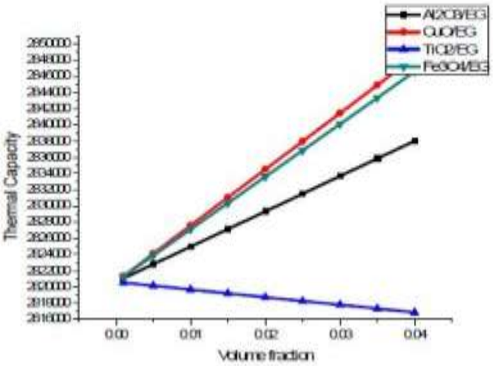

Fig.6: Thermal Capacity of Nano fluids with Ethylene Glycol as Base Fluid

The thermal capacity of the Nano fluids decreases with increase in volume fraction with having water as base fluids but in case of Ethylene Glycol as base fluids it increases for Al2O3, CuO,TiO2,Fe3O4 nanoparticles with different volume fraction.

7.RESULT:

1)Authors have found that the convective heat transfer coefficient of alumina nanofluids enhanced in correspondance to base fluids by 15-20% in laminar and turbulent flow respectively.
2)Using Al2O3 nanoparticles is more benefial than CuO nanoparticles based on the performance index for 1.5-2%vol. fraction
3)CuO at 54 degree Celsius with highest nusselt number and concentration was 0 .8% the convective heat transfer coefficient enhances upto 55%.
4)(EG+water) mixture and nanofluids enhances thermal conductivity almost upto 45%
5)In experimental study with Al2O3 in car radiator 64% enhance was seen at 5LPM constant flow rate and reyonald number (84389-41288).
6)Nanofluids are currently expensive.

8.CONCLUSION

In this review article, experimental heat transfer coefficients in the automobile radiator have been reviewed with 4 distinct working liquids: pure water,EG,Al2O3, CUO and water based nanofluid at different concentrations and different temperatures and the following conclusions were made.
1. The presence of TiO2 nanoparticle in water can enhance the heat transfer rate of the automobile radiator. The amount of the heat transfer enhancement depends on the amount of nanoparticles added to pure water.
2)Thermal conductivity of (Ethylene Glycol: water) mixture and nanofluid enhances almost linearly with temperature (25 to 45ºC). At a particular value of temperature corresponding enhancement in thermal conductivity is less in the volume concentration range from 0.2 to 0.5%.
3)Increasing the flow rate of working fluid (or equally Re) enhances the heat transfer coefficient for both pure water and nanofluid considerably while the change in the fluid inlet temperature to the radiator changes the heat transfer performance.
4)Brownian motion of nanoparticles may be one of the factors in the enhancement of heat transfer.

9.FUTURE POSSIBILITIES

Result shows us that heat transfer coefficient can be increase effectively with using the CuO as nanofluid. This nanofluids must be used in definite proportion so that desired characteristics can be obtained. The CuO nanofluid when mixed with ethylene glycol must give a enhancement of 14.8% in heat transfer coefficient and it increses with increase in temperature thus helping us to maintain the temperature of fluid flowing through the body.

Moreover the heat transfer also depend on the surface area of fluid flow thus as the surface area increases the rate of heat transfer alos increases.the area can be increase by twisting the sape of tube or by putting some twisted strip to avoid the flow i.e.to create the obstacle in the path of flow. We may achieve more efficiency if we use helical twisted tube along with nanofluid as CuO + ethylene glycol. Inspite of recent advances in the study of heat transfer with nanofluids, more experimental results and theoretical understanding of the mechanisms of the particle movements are needed to explain and examined heat transfer behavior of nanofluids. The experimental results showed that Nu number increase with enhancement in flow rate and volume concentration of nanofluid. Therefore, this provided promising ways for engineers to develop highly compact and effective radiators for cars. Reduction in weight

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of a cooling system can diminish the fuel consumption. Also, it can provide effective cooling and enhance the lifetime of pieces of an automotive.

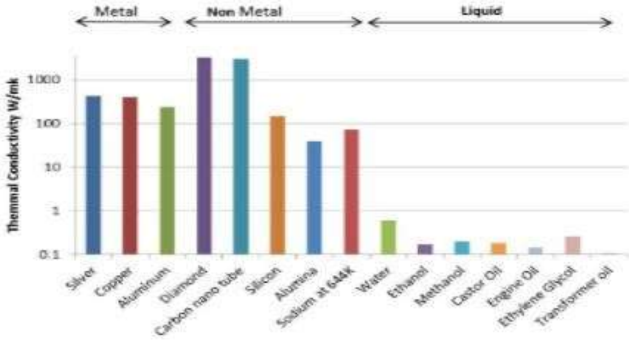

Fig.7: Materials which can be used in future for replacement of nanofluids used today

10.REFERENCES

[1] 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) pp. 3606-3612,2009.

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

[3] Wongcharee, K. and Eiamsa–ard, S. (2012) International Communications in Heat and Mass Transfer, 39: 251–257.

[4] Zeinali Heris, S. (2011) International Communications in Heat and Mass Transfer.

[5] S.H. Hashemabadi, S.G. Etemad, M. R. Golkar Naranji, J. Thibault, "Laminar flow of non- Newtonian fluid in right triangular ducts", International Communications in Heat and Mass Transfer 30 (1) (2003) 53-60.

[6] K. Yakut, B. Sahin, "Flow-induced vibration analysis of conical rings used for heat transfer enhancement in heat exchangers", Applied Energy 78 (3) (2004) 273-288.

[7] S. Laohalertdecha, S. Wongwises, "Effects of EHD on heat transfer enhancement and pressure drop during two- phase condensation of pure R- 134a at high mass flux in a horizontal micro-fin tube", Experimental Thermal and Fluid Science30 (7) (2006) 675-686.

[8] Choi S. U. S., Eastman J. A., Enhancing Thermal Conductivity of Fluids with Nanoparticles, ASME International Mechanical Engineering Congress & Exposition, USA, (1995).

[9] Lee S, Choi SUS, Li S, Eastman JA et al (1999) Measuring thermal conductivity of fluids containing oxide nanoparticles. Trans Am Soc Mech Eng 121:280– 289

[10] Wang X, Xu X, Choi SUS (1999) Thermal conductivity of nanoparticle–fluid mixture. Thermophys Heat Transf 13:474–480

[11] Xuan Y, Li Q (2003) Investigation on convective heat transfer and flow features of nanofluids. Int J Heat Transfer 125:151–155

[12] Murshed SMS, Leong KC, Yang C (2005) Enhanced thermal conductivity of TiO2–water based nanofluids. Int J Therm Sci44:367–373

[13] E. Ollivier, J. Bellettre, M. Tazerout and G. C. Roy, "De- tection of Knock Occurrence in a Gas SI Engine from a Heat Transfer Analysis," *Energy Conversion and Man- agement*, Vol. 47, No. 7-8, (2006), pp. 879-893.

[14] Nguyen C.T., Roy G., Gauthier C., Galanis N., Heat transfer enhancement using Al2O3-water nanofluid for an electronic liquid cooling system, Applied Thermal Engineering, Vol. 27, Iss. 8-9, (2007), pp. 1501-1506.

[15] Gherasim I., Roy G., Nguyen C.T., Vo-Ngoc D., Heat transfer enhancement and pumping power in confined radial flows using nanoparticle suspensions (nanofluids), International Journal of Thermal Sciences, Vol. 50, No. 3, (2011), pp. 369-377.

[16] Mohammed H.A., Bhaskaran G., Shuaib N.H., Saidur R., Influence of nanofluids on parallel flow square microchannel heat exchanger performance, International Communications in Heat and Mass Transfer, Vol.38, No. 1, (2011), pp. 1-9.

[17] Peyghambarzadeh S.M., Hashemabadi S.H., Hose-ini S.M., Seifi Jamnani M., Experimental study of heat transfer enhancement using water/ethylene glycol based nanofluids as a new coolant for car radiators, International Communications in Heat and Mass Transfer, Vol. 38, Iss. 9, (2011), pp. 1283-1290.

[18] Shafahi M., Bianco V., Vafai K., Manca O., An investigation of the thermal performance of cylindrical heat pipes using nanofluids, International Journal of Heat and Mass Transfer, Vol. 53, Iss. 1-3,(2012) , pp. 376-383