ISSN 2395-1621

CFD analysis and Experimental Investigation of Heat Transfer Enhancement of Cross Flow Heat Exchanger with Hybrid Nanofluid as a Coolant

#1 Tushar S.Gaidhane, #2 Sameer.Y.Bhosale

[1]tushargaidhane804@gmail.com
[2]sybmodern@gmail.com

#12 Mechanical Engineering Department,MCOE, Savitribai Phule Pune University ,pune,Maharashtra, India..

ABSTRACT

The demand for more powerful engines in smaller hood spaces has created a problem of insufficient rates of heat dissipation in cross flow heat exchanger (automotive radiators). Upwards of 33% of the energy generated by the engine through combustion is lost in heat. To minimize the stress on the engine as a result of heat generation, automotive radiators must be redesigned to be more compact while still maintaining high levels of heat transfer performance. Base fluids (water, ethylene glycol and glycerol) have been used as conventional coolants in cross flow heat exchanger (automobile radiator) for many years; however, these offered low thermal conductivity, which has prompted researchers to find fluids that offer higher thermal conductivity compared to that of conventional coolants. Nanofluids have been considered as a new-type heat transfer fluid because of their substantial increase in liquid thermal conductivity, liquid viscosity, and heat transfer coefficient.

Proposed work concentrates on developing experimental system to investigate the heat transfer enhancement of cross flow heat exchanger with hybrid nanofluid as a coolant and its CFD analysis.

Keywords— Nanofluid, cross flow heat exchanger, heat transfer coefficient.

ARTICLE INFO

Article History

Received : 28th April, 2015

Received in revised form :

30th April, 2015

Accepted : 4th May, 2015

Published online :

14th May 2015

I. Introduction

Nanofluids are formed by suspending metallic or non-metallic oxide nanoparticles in traditional heat transfer fluids. These so called nanofluids display good thermal properties compared with fluids conventionally used for heat transfer and fluids containing particles on the micrometer scale. Nanofluids are the new window which was opened recently and it was confirmed by several authors that these working fluid can enhance heat transfer performance. Another application is implementation of nanofluids instead of the conventional fluids in cross flow heat exchanger (radiator).The Cross flow heat exchanger is an important accessory of vehicle engine.

Normally, radiator used as a cooling system of the engine and generally water is heat transfer medium. The current research studies show that application of nanofluids instead of water enhances thermal performance of the automobile cooling system

II. Literature Survey

Related current research studies and their results are explained below,

S. Choi et al. [1] reported a project to target fuel savings for the automotive industries through the development of energy efficient nanofluids and smaller and lighter radiators. A major goal of the nanofluids project is to reduce the size and weight of the vehicle cooling systems by greater than 10% despite the cooling demands of higher power engines.

Nanofluids enable the potential to allow higher temperature coolants and higher heat rejection in the automotive engines. It is estimated that a higher temperature radiator could reduce the radiator size approximately 30%. This translates into reduced aerodynamic drag and fluid pumping and fan requirements, leading to perhaps a 10% fuel savings. It is interesting idea in these years which humans involved in the energy and fuel shortage crisis. According to this idea, scarce experimental and theoretical studies were performed to analyse the application of nanofluids in the car radiator.

K.Y.Leong et al. [2] attempted to investigate the heat transfer characteristics like overall heat transfer coefficient and heat transfer rate of an automotive car radiator using ethylene glycol based copper nanofluids numerically. Thermal performance of an automotive car radiator operated with nanofluids has been compared with a radiator using conventional coolants.

He varied volume concentration of CuO nanofluid with variation 0.15 %, 0.4 % and 0.65 %. It was observed that heat transfer characteristics like overall heat transfer coefficient increased with the usage of nanofluids with ethylene glycol as base fluid.

Ravikanth Vajjha et al. [3] have been numerically studied a three-dimensional laminar flow and heat transfer with two different nanofluids, Al_2O_3 and CuO, in the ethylene glycol/water mixture circulating through the flat tubes of an automobile radiator to evaluate their superiority over the base fluid. Convective heat transfer coefficient in the developing and developed regions along the flat tubes with the nanofluid flow showed considerable improvement over the base fluid. prandtl number, Reynolds number and nusselt number are the functions of thermo physical properties and this numbers strongly influences the convective heat transfer coefficients.

M.G. Khan et al. [4] have experimentally studied forced convection cross-flow heat transfer of hot air over an array of cold water carrying elliptic tubes. Their experimental investigation was restricted to water as the coolant. He observed in elliptical geometry of cross flow heat exchanger their was a significant change in the properties of the fluid and heat transfer enhancement observed.

S. M. Peyghambarzadeh et al. [5] have recently investigated the application of Al2O3/water nanofluids in the car radiator by calculating the tube side heat transfer coefficient. They have recorded the interesting enhancement of 45% comparing with the pure water application under highly turbulent flow condition. Five different concentration of nanofluids in the range of 0.1% - 1% has been prepared by the addition of aluminium oxide(Al_2O_3) nanoparticles into the water. Liquid flow rate also varied in the range of 2-5 LPM to have the fully turbulent regime. Also varied nanofluid inlet temperature in the range 37– 49^0 c

They observed that fluid circulating rate can improve the heat transfer performance while the fluid inlet temperature also improves the heat transfer rate. Low concentration of nanofluid improves heat transfer efficiency upto 45% comparison with the pure water.

In the other study, S.M. Peyghambarzadeh et al. [6] have been used different base fluids including pure water, pure ethylene glycol, and their binary mixtures with Al_2O_3 nanoparticles and once again it was proved that nanofluids improves the cooling performance of the car radiator extensively. In the two latter studies, tube side heat transfer coefficient was calculated according to the temperature measurement at the thin walls of the radiator flat tubes. It is very hard to accurately measure the temperature at the wall and therefore, the data may have not adequate accuracy. They have been observed heat transfer performance of the automobile radiator evaluated experimentally by calculating overall heat transfer coefficient with effectiveness NTU method. They added copper oxide (CuO) and iron oxide (Fe_2O_3) and to the base fluid / water at three concentrations 0.15% , 0.4% and 0.65 % . also liquid side Reynolds number varied 500and 700 and inlet temperature of nanofluids of 50 , 65 and 80 ^{0} c.

They observed the effects of this variables that both the nanofluids show greater overall heat transfer coefficient in comparison with water up to 9%.

III. PROBLEM STATEMENT

To experimentally investigate heat transfer enhancement using hybrid nanofluid as coolant in cross flow heat exchanger (car radiator) and its validation with CFD.

IV. PROJECT OVERVIEW

Proposed work concentrates on developing the system to study "Experimental investigation of heat transfer enhancement of cross flow heat exchanger with hybrid nanofluid as a coolant and analysis with CFD software "this includes the phases as under.

Phase I :- Study Of literature review
Phase II :- Selection of nanopowder material
Phase III :- Development of experimental system to achieve stated objectives below
Phase IV :- Preparation of nanofluid and Experimentation.
Phase V :- Validation of experimental results with CFD
Phase VI :- Results and Discussion.

V. PROJECT LAYOUT

Proposed work concentrates on developing the system to study "Experimental investigation of heat transfer enhancement of cross flow heat exchanger with hybrid nanofluid as a coolant and its CFD analysis" this includes the detail phases as under.

Phase-I :-This phase involves the detail study of heat transfer enhancement techniques of cross flow heat exchanger with particular attention towards the passive heat transfer enhancement techniques with nanofluids. Effect of properties related to the nanofluid on heat transfer enhancement will be further analysed in this phase. Additionally idea behind the mixing of two nanoparticle materials in the base fluid to form the hybrid nanofluid will also be studied.

Phase-II :-On the basis of the concluding remarks from the literature review it is decided to proceed in the same direction towards the investigation of thermal performance the cross flow heat exchanger with hybrid nanofluid.

Accordingly the experimental system will be designed and

Nanofluid Number	Nanoparticles material	Base fluid	Nano particles size	Variation in concentration of Hybrid Nanofluid by volume fraction %
I	CuO + Fe_2O_3	Manufacturer recommended coolant (Green color)	60/60 nm	0.5
II	CuO + Fe_2O_3			1.0
III	CuO + Fe_2O_3			1.5

manufactured to investigate the proposed title

The experimental system to be developed includes flow lines, a reservoir tank, heater, a centrifugal pump, flow meter, a forced draft fan, a temperature controller, five RTD's with Six channel temperature indicator to measure the wall temperature and two RTD's with two channel temperature indicator to measure the inlet and outlet fluid temperature in a cross flow heat exchanger.

The test section is a cross flow heat exchanger (an automobile radiator) and forced draft fan. Nanofluid passes through the vertical tubes with stadium-shaped cross section. The fins and the tubes are made with aluminium. For cooling the liquid, a forced draft fan is to be installed close and face to face to the cross flow heat exchanger. Consequently air and water have indirect cross flow contact and there will be heat exchange between hot water flowing in the tube-side and air across the tube bundle.

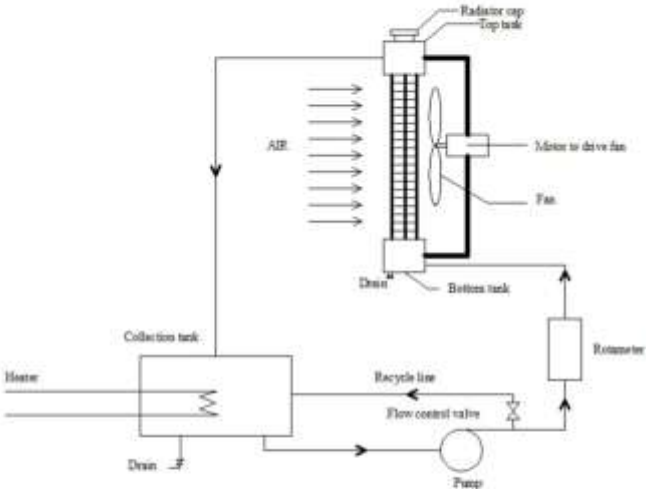

Fig.No.1:- Schematic drawing of the proposed experimental setup.

Phase III :- Additionally to evaluate the accuracy of the measurements, experimental system is to be tested and validated with distilled water before running the experiments with hybrid nanofluids.

Phase IV :- This phase aims to prepare the hybrid nanofluid of required volume concentration with conventional coolant as mentioned. The volume of nanoparticles to be added in the decided quantity of base fluid will be decided on the basis of volume concentration. The characterization of nanofluid will also be done in this phase only.

Hybrid Nanofluid preparation:- Hybrid Nanofluid is to be prepared with following specification

Table.No.1:-Hybrid nanofluid preparation

Phase V :- By using the hybrid nanofluid prepared in the above phase, experimentation will be carried out on proposed system with variation in inlet temperature, flow rate and volume concentration of nanofluid. The corresponding observations will be noted in the respective conditions which will be further utilized to draw conclusions.

Phase VI :- In this phase the effect of the parameters on thermal performance of the cross flow heat exchanger will be represented graphically to see the variation and come out with some results.

VI. NANOPARTICLE

COPPER OXIDE NANOPARTICLES (CUO)

CuO Nanoparticles Purity: 99%
CuO Nanoparticles Color: black
CuO Nanoparticles APS: <80 nm
CuO Nanoparticles SSA: >18 m^2/g
CuO Nanoparticles Morphology:SPHERE
CuO Nanoparticles Bulk Density: 0.79 g/cm^3
CuO Nanoparticles True Density: 6.4 g/m^3

It is a brownish-black powder, 40nm, with 99% purity and 6.3-6.49 g/cm^3 density and melting point of 1326 ℃.

IRON OXIDE NANOPOWDER (FE2O3, ALPHA)

Nanopowder (Fe_2O_3) Purity: 98+%
Nanopowder (Fe_2O_3) :- 20-40 nm
Nanopowder (Fe_2O_3) : -: 40-60 m^2/g
Nanopowder (Fe_2O_3) Color: red brown
Nanopowder (Fe_2O_3) Morphology: spherical
Nanopowder (Fe_2O_3) pH-value: 5-7
Nanopowder (Fe_2O_3) Bulk Density: 1.20 g/cm^3
Nanopowder (Fe_2O_3) True Density: 5.24 g/cm^3

VII. FIGURE & TABLE

Fig.No.1:- Schematic drawing of the proposed experimental setup.
Table.No.1:-Hybrid nanofluid preparation

VIII. CONCLUSION

Addition of nanoparticles to a base fluid increases the viscosity significantly and the thermal conductivity moderately. the overall heat transfer coefficient decreases with increasing inlet temperature of the nanofluid. The overall heat transfer coefficient increase with enhancing volumetric flow rate of the nanofluid significantly.

IX. ACKNOWLEDGEMENT

Authors take opportunity to express their deep sense of gratitude to their guide, for his continuous guidance and encouragement during this study. Without valuable suggestion and encouragement this would not have been possible. It is because of guide experience and wonderful knowledge Author can fulfil the partial requirement of completing the review paper within the stipulated time.

authors acknowledge with thanks, the assistance provided by departmental staff, central library and computer faculty staff. Authors find themselves spellbound to acknowledge thanks to my father and mother for their silent support, patience, encouragement and affection without which this work would never have been possible and thank all colleagues for their valuable co-operation and coordinate which was available time to time.

REFRENCES

[1] S. Choi, Nanofluids for improved efficiency in cooling systems, in: Heavy Vehicle Systems Review, Argonne National Laboratory, April 18-20, 2006.

[2] K.Y. Leong, R. Saidur, S.N. Kazi, A.H. Mamun, Performance investigation of an automotive car radiator operated with nanofluid-based coolants (nanofluid as a coolant in a radiator), Appl. Therm. Eng. 30 (2010) 2685-2692.

[3] R.S. Vajjha, D.K. Das, P.K. Namburu, Numerical study of fluid dynamic and heat transfer performance of Al2O3 and CuO nanofluids in the flat tubes of a radiator, Int. J. Heat Fluid Flow 31 (4) (2010) 613-621.

[4] M.G. Khan, A. Fartaj, D.S.K. Ting, An experimental characterization of cross flow cooling of air via an in-line elliptical tube array, Int. J. Heat Fluid Flow 25 (2004) 636-648.

[5] S.M. Peyghambarzadeh, S.H. Hashemabadi, M. Seifi Jamnani, S.M. Hoseini, Improving the cooling performance of automobile radiator with Al2O3/water Nanofluid, Applied Thermal Engineering 31 (2011) 1833-1838.

[6] 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, International Journal of Applied thermal engineering 52 (2013) 8-16.

