REVIEW PAPER ON ENHANCEMENT IN HEAT TRANSFER CHARACTERISTICS USING NANOFLUIDS

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***Abstract-** In many industries, such as power generation, chemical production, transportation, microelectronics and air conditioning we are using conventional heat transfer fluids such as water, mineral oil and ethylene glycol. However, the heat transfer efficiency decreases because of their low thermal conductivities. It has been found by researchers that the heat transfer rates (efficiency) of these conventional fluids can be amplified (increased) by suspension of metallic nanoparticles. The suspended metallic nanoparticles can change the heat transfer characteristics of the base fluid. The nanoparticles used are Cu, Ag, Al_2O_3 and TiO_2. Nowadays the experiments are conducted in concentric tube heat exchangers to study the heat transfer rates of Al_2O_3 -water nanofluids for variant flow rates. This review sum ups the development of nanofluids and gives the broad range of current and future applications in different fields like nuclear reactors, transportation, electrical energy, magnetic, mechanical, solar absorption and biomedical fields. However, there are some barricades and challenges that had been found in the industrial applications.*

***Index Terms** - Microelectronics, Heat transfer fluids, Thermal conductivity, nanoparticles, base fluid, concentric tube heat exchangers.*

I. INTRODUCTION

Nanofluids consist of a base fluid enriched with nano size particles (less than 100 nm). The base fluids which we use for enrichment of nanoparticles like Water, Ethylene Glycol or oil with nanoparticles like metals, oxides, carbides, carbon. Mostly common examples of nanofluids are TiO_2 in water, Al_2O_3 in water, CuO in water, ZnO in Ethylene glycol.

The heat transfer rates was lacking because low values of thermal conductivities of conventional cooling fluids. As a result there was a need to increase heat transfer rates with significantly increase in value of thermal conductivities. However, the micro sized particles are recline to sedimentation and clogging in micro channels. In contrast to that nanofluid is stable colloidal suspension of a low volume fraction of solid particles of nano size, dispersed in traditional heat transfer fluid, which is offering us enhancement of fluid thermal conductivity without sedimentation and clogging problems.

II. NEED OF NANOFLUIDS:

- Due to size of nano particles, pressure drop is minimum.
- Higher thermal conductivity of nano particles will increase the heat transfer rates.
- Successful employment of nanofluid can lead to shorter and smaller heat exchanger.
- Drastic change in the properties of base fluids.
- Nanofluids are most suitable for rapid heating and cooling systems.
- Increase in the rate of heat transfer due to large surface area of nanoparticles in base fluids.

Nowadays nanofluids have attracted much attention. The reason for this is their potential as high performance heat transfer fluids in electronic cooling and automotive. Effectiveness and high compactness of heat exchangers are obstructed the lower heat transfer properties of fluids as compared to solid. So it is more obvious that solid particles have high thermal conductivity (100times higher than fluids). In such case slurries have better thermal conductivities than fluid but it is not practical.

There are 2 primary preparation methods for nanofluids:

a) Two step method:
  - In which nanoparticles are 1st produced as dry powder
  - This dry powder is then dispersed into fluids

b) Single step method:
  - Using methods like direct evaporation, condensation, chemical vapour condensation and single step chemical synthesis
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There are other novel methods like micro fluidic microreactor to synthesize **copper** nanofluids

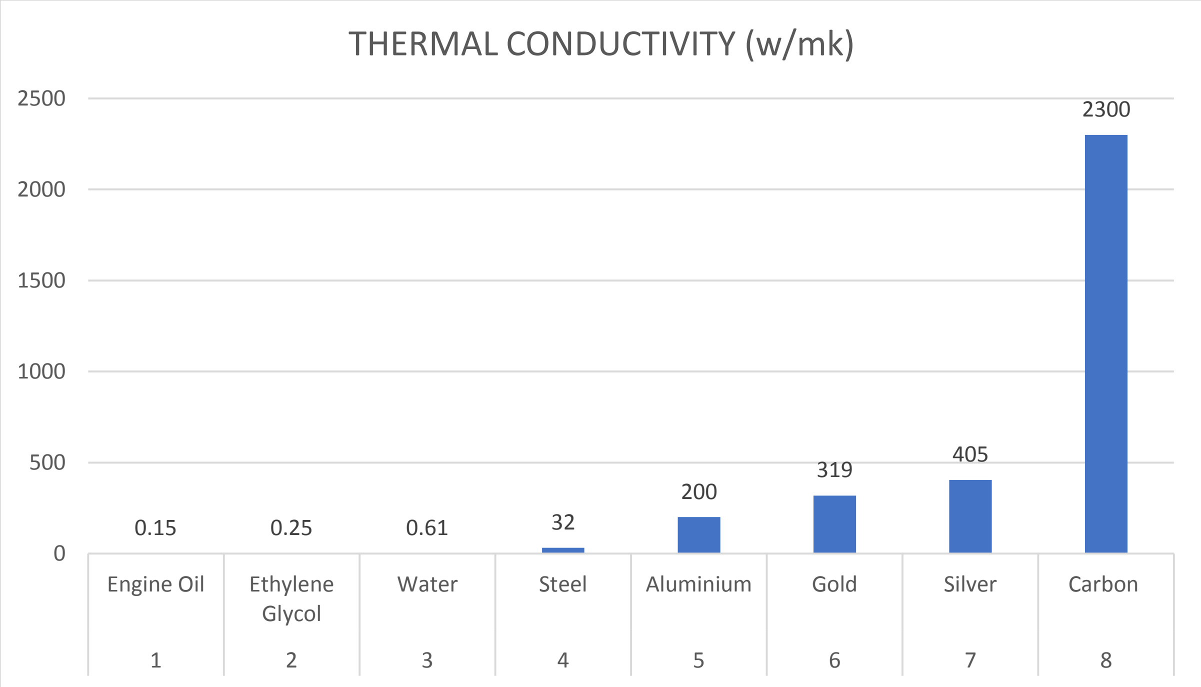


Fig 1- (Thermal conductivities of various material)

Solids have thermal conductivities that are orders of magnitude larger than those of conventional heat transfer fluids

Sr. No.	Material	Tthermal Conductivity (w/mk)
1	Engine Oil	0.15
2	Ethylene Glycol	0.25
3	Water	0.61
4	Steel	32
5	Aluminium	200
6	Gold	319
7	Silver	405
8	Carbon	2300

Notations

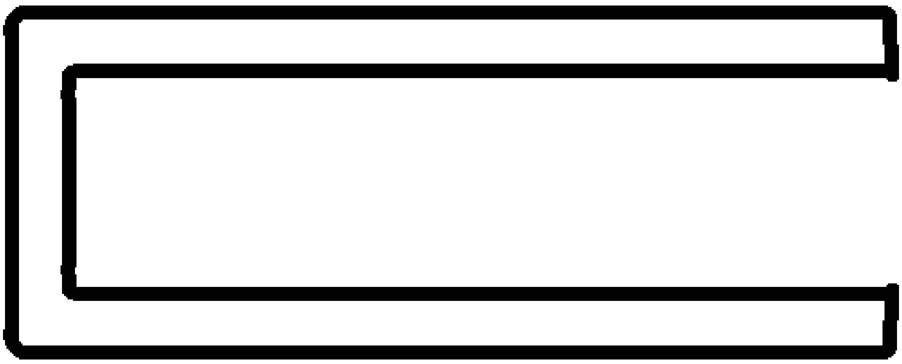
C – heat capacity, [J/kgK] D – diameter, [m]
k – thermal conductivity, [W/mK] Nu – Nusselt number
Pr – Prandtl number $\Re$ – Reynold's number
α – convective coefficient, [W/m^{2}K]

Fig.2- Al_2O_3 powder

III. LITERATURE REVIEW:

Nanofluids are important because they can be use d in numerous applications involving heat transfer. These nanofluids have unique features different from the traditional solid liquid mixtures. Due to their fascinating physical and chemical characteristics they can be used to enhance the heat transfer rate in many industrial process.

HEAT TRANSFER STUDY IN A COAIAL HEAT EXCHANGER USING NANOFLUIDS BY (RAZVAN-SILVIU LUCIU and THEODOR MATEESCU)[1] [1]:



DIMENSIONS: {L = 64cm; D = 20mm; d = 10mm}

Fig.3 Geometry of coaxial heat exchanger

Experimental Setup:

Experimentally tried to investigate the heat transfer rate in a coaxial heat exchanger using nanofluids. The nanofluid is circulated in the inner tube and treated as primary agent whereas the pure water is circulated in the outer tube and treated as secondary agent. Nanofluid used was composed of aluminium oxide Al_2O_3 particles dispersed in pure water in different concentrations and different inlet temperatures.

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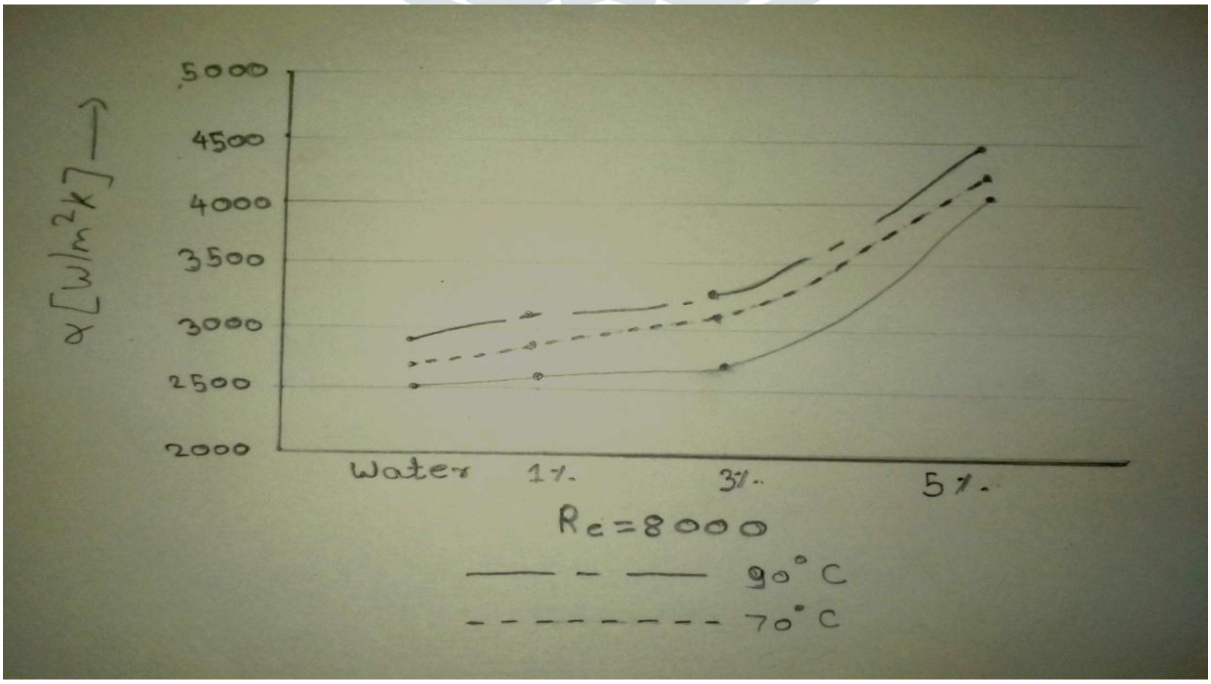

Fig.4 - graph of convective heat coefficients vs nanofluid concentration

Result and Discussion

A significant amount of increase (approximately 50% for convective heat transfer coefficient of nanofluid at concentration of 5% compared with water at 90^0C. The increase in heat transfer rate is directly proportional to increase in volume concentration of nanoparticles.

Synthesis, Applications and Challenges of Nanofluids- Review[2]

By Ramakoteswaa Rao.N[1], Leena Gahane[2] , Ranganayakulu S. V[3]

Result and Discussion:

This review paper summarizes the development of nanofluids and throws light on current and future application in various fields. A few barriers and challenges that have been identified due to size shape and temperature must be taken care off. Includes production of nanoparticles, application of nanofluids, challenges of nanofluids.

Experimental Investigation of Heat Transfer Enhancement by using Al_2O_3- Water Nanofluid in a Concentric Tube Heat Exchanger [3]

By V. Murali Krishna:

Experiment includes preparation of Al_2O_3 nanoparticles SOL-GEL method and Al_2O_3 water Nanofluid. The system consists of a double pipe heat exchanger. The inner tube is a made of copper and the outer tube is made of stainless steel. It consists of heating unit to heat the water, for temperature measurement system has 4 thermocouples, placed at the inlet and outlet of inner and outer tube. The hot water flows through the inner tube and the nanofluid flows through the annulus. Flow meters are installed in pipes carrying nanofluid.

The main switch is switched on. Cold water from reservoir is pumped to the heat exchanger at a constant flow rate while the hot water flow rate valve is kept open. Temperatures and flow rates of hot and cold water are noted down.

Fig.5 - Al_2O_3 before sintering

Fig.6- Al_2O_3 after sintering

IV. RESULT

The overall heat transfer coefficients are calculated experimentally and theoretically. The overall heat transfer coefficient is increased by 17% with the volume fraction 0.5% of Al_2O_3 nanoparticles compared with normal water.

Advantages:-

1) Higher thermal conductivity of nanoparticles will increase heat transfer rate.
2) They are most suitable for rapid heating and cooling system.
3) Less expensive.
4) Energy saving.
5) Microchannel cooling without clogging.

Application :-

1) Engine cooling.
2) Thermal storage.
3) Transportation.
4) Nuclear cooling system.
5) Petroleum industry.
6) In defence and space applications.

V. CONCLUSION

The research has clearly shown that the adding this new edition of particles in a base fluid produces a vast increase in heat transfer. The increase in rate of heat transfer is directly proportional the increase in volume concentration of nanoparticles and also increase in the pressure drop of nanofluids. When temperature increases, the value of coefficient of heat transfer also increases. Heat transfer rates is directly proportional to Reynolds number (R_e) of nanofluids. The increase in size of nanoparticles (diameter of nanoparticles) lead to decrease in heat transfer because area per unit volume decreases.

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