# Enhancement of heat transfer rate using MgO nanofluid in heat exchanger

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**Abstract –**

Energy conservation, conversion, and recovery are vital thinking among people due to environmental issues. The effectively way to save energy of materials and facilities in which heat exchanger plays a significant role. Mostly in industries uses heat exchangers for enchantment of heat transfer. The common used heat transfer fluids are water, ethylene glycol and propylene glycol as base fluids in heat exchanger. Dispersion of Nano particles in a base fluid shows solution in problems such as high pressure loss, erosion of material. The thermal conductivity of the base fluid increases by adding Nano particle which in turn increases the heat transfer rate. In this paper heat exchanger performance is analyzed by adding Magnesium oxide with base fluid (a mixture of Distilled water and propylene glycol). The thermal property i.e. overall heat transfer coefficient of heat exchanger is calculated and compared with base fluid. Experiments were conducted for various volume concentration 0.1%,0.3% and 0.5% and observed that the addition of manganese oxide nanoparticles enhances the thermal performance. The maximum enhancement in the convective heat transfer is observed at 0.5% volume concentration. Experiments will be conducted by varying the inlet temperature, nanoparticle volume concentration and fluid flow rate. Heat transfer coefficient, thermal conductivity and nusselt number of MgO nano particles are selected as performance assessment parameters.

**Key Words:** Heat transfer rate, heat exchanger, Manganese Nanoparticle Nusslet number.

## 1. INTRODUCTION

Most industrial processes involve heat transfer and more often, it is required that these heat transfer processes be controlled. Heat transfer is the term used for thermal energy from a hot to a colder body. Heat transfer always occurs from a hot body to a cold one, as a result of the second law of thermodynamics. Where there is a temperature difference between objects in proximity, heat transfer between them can never be stopped but can only occur through threeways which are conduction, convection and radiation. Though study has also shown that phase change is accompanied with thermal energy transfer.

**Mohammad Hossein Aghabozorg et al. [1],** experimentally studied the overall heat transfer coefficient of an automobile radiator using graphene nanoplatelets based coolant with the volume fractions of 0.1-0.5% and the nanofluid flow rates of 12.5g/s-62.5g/s. They also variedthe ambient air velocity and the nanofluid inlet temperatures from 1-5 m/s and 35 to 45 respectively. Their results stated that the overall heat transfer coefficient enhanced up to 104%at 0.5% volume fraction, 62.5g/s flow rate and 5 m/s ambient air velocity compared to thebase fluid and 39% enhancement in pressure drop was recorded at the highest mass flow rateof 62.5g.

**T Aseer Brabin1 et al. [2],** conducted the experiments on an automobile radiator with ethylene glycol based Cu nanofluids. They varied the volume fraction of the nanoparticles in the range of 0-2% and observed that 3.8% of heat transfer enhancement with the dispersion 2% MgO nanopowder at the Reynolds number of 6000 and 5000 for air and coolant respectively. **K.Karimullah Khan et al. [3],** experimentally studied the overall heat transfer coefficient of CuO/water nanofluid in a car radiator. Their results show that the overall heat transfer coefficient increases with the volume fraction of the nanoparticles and the maximum enhancement in overall heat transfer coefficient up to 8% obtained at 0.4% concentration in comparison with the base fluid.

**M. Raja.R.M. Arunachalam. et al. [4],** investigated thermal conductivity and dynamic viscosity of TiO2-SiO2 nanofluids in PG+water mixture. The experiments were performed with the volume fractions of 0.5-3.0% and the temperatures from 30°C-80°C. The resultsstated that the maximum thermal conductivity of nanofluids was enhanced up to 22.8% for 3.0Vol% and temperature of 80°C. Meanwhile, the highest average relative velocity was obtainedfor 3.0Vol% with 62.5% increment.

**Kishan H. Maheshwari. et al. [5],** experimentally studied rheological behaviour of water-EG coolant dispersed with MgO-MWCNTs hybrid nanomaterials with the volume fractions of 0.025-0.8%. The experiments were performed at various shear rates within the temperatures from 25-60°C. The results showed that nanofluid samples had Newtonian behaviour and nanofluid viscosity decreased with the increasing temperature and augmented with increasing the volume fraction. The grater changes in the relative viscosity occurred by increasing the ratio of particles with volume fraction of 0.8% to almost 80%.

**Kallalu Harika., Tummala.Likhitha et al. [6],** experimentally studied heat transfer characteristics of Al2O3/water based nanofluids in an automobile radiator with the volume fractions of 0.1%,0.5%,1.5%,2%. The experiments done at different heat load (16,12,8 kw) and coolant and air flow rate conditions. The Maximum percentage increase of the coolant heat transfer rate, coolant heat transfer coefficient, and coolant Nusselt number is 14.79,14.72, and 9.51, respectively, which occurs at maximum load and at 0.1 Vol%. The maximum values of air side heat transfer coefficient and Nusselt number also occur at the same load and concentration and have 14.45% and 13.94% increase over that of the base fluid, respectively.

**I.M. Shahrul., I. M. Mahbubul et al. [7],** experimentally studied pressure drop and heat transfer performance of CuO/Ethylene Glycol (60%)-Water (40%) nanofluid in a car radiator. They conducted the experiments with the volume fractions of 0.05%-0.8% and flow rates of 4-8 l/min, and at different inlet fluid temperatures (34°C,44°C,54°C). The results demonstrated that that the presence of nanoparticles caused an increase in nanofluid pressure drop, which was intensified by increasing nanoparticle concentration as well as decreasing temperature of inlet fluid.

**K.Y. Leong., R. Saidur et al. [8],**experimentally studied laminar convective heat transfer coefficient of a TiO2-CNT hybrid nanofluid through the shell and tube heat exchanger. They conducted the experiments with 0.1-0.2 wt% of nanopowder and at various temperatures (25°C,32°C,38°C). The heat transfer coefficient strongly depends on nanoparticle concentration and temperature, which revealed an increase from 1,861.46 to 2,516.86 by increasing temperature from 25°C to 32°C and an increase from 2,246.46 to 2,516.86 by increasing NPs concentration from 0.1 to 0.2 wt%. Furthermore, comparison of the results by CNT demonstrated that the same load of hybrid NFs has 3% lower thermal conductivity compared to the CNT, which in turn, results in a 5% lower heat transfer coefficient. But the amount CNT used for preparing hybrid nanopowder was less which in turn reduce the cost andstability of the nanofluids.

**M. Sarafraz., F. Hormozi et al. [9],** Numerically studied heat transfer characteristics of a car radiator using Cu/water based nanofluid with different nanoparticle sizes (10,50,100 nm) and various volume concentrations of 1-10 Vol%. The results stated that Cu/Water nanofluid thermal conductivity is increased significantly with nanoparticle volume fraction of 1 % to 10

% but decreasing with the increment of particle size. The convective heat transfer coefficient of nanofluid enhanced significantly up to 92% compared to base fluid

**Hassan Hajabdollahi.et al. [10],** experimentally studied pressure drop and heat transfer performance of CuO/Ethylene Glycol (60%)-Water (40%) nanofluid in a car radiator. They conducted the experiments with the volume fractions of 0.05%-0.8% and flow rates of 4-8 l/min, and at different inlet fluid temperatures (34°C,44°C,54°C). The results demonstratedthat that the presence of nanoparticles caused an increase in nanofluid pressure drop, which was intensified by increasing nanoparticle concentration as well as decreasing temperature of inlet fluid

## 3. METHODOLOGY:

A. Cooling water at room temperature is allowed to flow through shell inlet

B. Temperature reading is noted at the shell inlet

C. A total volume of 17 litres(water+nano fluid) is used in this experiment.

D. For every 1000ml of water, 20ml of Mgo oxide nanofliud is mixed through.

E. The above prcoos is repeated for the whole 17 litres.

F. This mixture is pumped to the geyser using re-circulating pump

G. The fluid is heated in the geyser and then the hot fluid is allowed to pass through thetube inlet.

H. As the heat exchanger used in this experiment is 1-Shell 2-tube pass heatexchanger, the hot fluid passes through the tubes in both the directions.

I. Baffles plates are used to change the direction of the fluid.

J. Both shell and tube outlet temperature readings are noted.

K. Flow rates is calculated manually b using a measuring flask and stop watch.

L. Now, the overall heat transfer coefficient is calculated using the obtainedtemperature reading and other parameters

## 4. EXPERIMENTAL SETUP AND EXPERIMENTATION

**Figure:** Photographic view of experimental setup

**Components:**

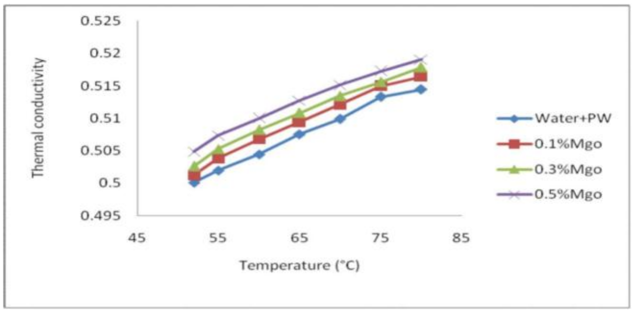
- Shell and tube heat exchanger
- Heater
- Thermocouples
- Cold water tank and hot water tank
- Pipes (0.5 inch)

**Figure**: Mechanical stirrling and sonication bath

## 5. RESULTS & DISCUSSIONS

The thermal conductivity of MgO/water nanofluid was significantly higher than that of waterand strongly dependent on temperature of the fluid. It exhibit that the experimental values of thermal conductivity of nanofluid increased significantly with the fluid temperature. The reason is that, fluid temperature strengthens the Brownian motion of nanoparticles and also drops the viscosity of the base fluid. With a strengthened Brownian motion, the influence of micro convection in heat transport rises and in consequence increased enhancement of the thermal conductivity of nanofluids. Results obtained at different concentrations 0.1 %, 0.3%and 0.5% compared to base fluid.

Fig1: Variation of heat transfer coefficient with different heat inputs for various volume fractions




Figuer 1: Variation of Thermal Conductivity of MgO/water nanofluids withtemperature

thermal conductivity of base fluid and, MgO nanofluids at different concentrations (0.1%,0.3%,0.5%) and temperatures (40°C- 80°C). From Fig 3.4, it is observed that thermal conductivity increases with increase of volumetric concentration and temperature .At 0.5 Vol%, 0.6% and 0.75% enhancement in thermal conductivity

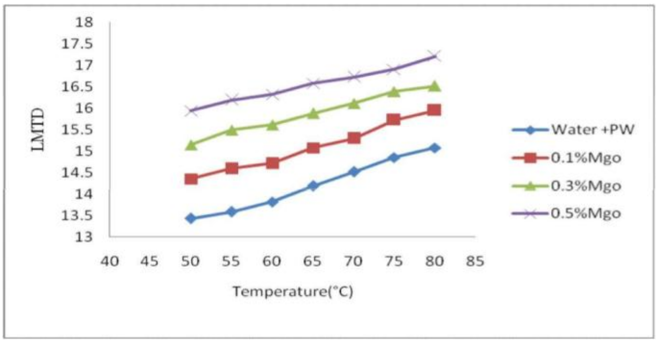



Fig2: Influence of LTMD with Temperature and particle volume concentrations

LMTD of base fluid and, MgO nanofluids at different concentrations (0.1%,0.3%,0.5%) and temperatures (40°C-80°C). From Fig 3.4, it is observed LMTD increases with increase of volumetric concentration and temperature .

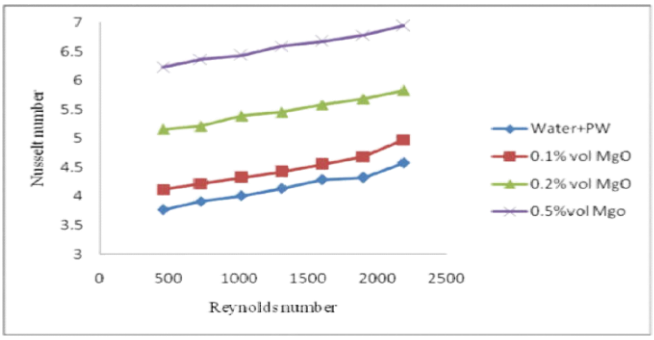



Fig3: Influence of LTMD with Temperature and particle volume concentrations

The variation of the nusselt number with Reynolds number the of the nano fluid. At 0.5 Vol% MgO nanofluid, 24.1% enhancement in nusselt number was compared to base fliud.

## 6. CONCLUSIONS

A. The performance of the shell and tube exchanger using MgO/Water + PG, based nanofluids was experimentally investigated.

B. Experiments work performed using distilled water 0.1%vol 0.3%vol and 0.5%vol Concentration MgO/water nanofluid as hot fluid flowing the tubes.

C. Nusselt number of hot fluid was increased with Reynolds number of hot fluid and nanoparticles volume concentration

D. The maximum enhancement in Overall heat transfer coefficient is recorded as 33.51% with 0.5 Vol% and 6lit/min and 12lit/min flow rate and compared to base fluid while using nanofliuds.

E. The maximum enhancement in Overall heat transfer coefficient is recorded as 37.71% with 0.5 Vol% and 10lit/min and 20lit/min flow rate and compared to base fluid while using nanofliuds.

F. Dynamic viscosity and Thermal conductivity of nanofluids were increased with increase of the volumetric concentration of nanoparticles and dynamic viscosity decreases with increasing the working fluid temperatures.

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