NANOFLUIDS

1. Introduction

Nanotechnology provides new area of research to process and produce materials with average crystallite sizes below 100 nm called nanomaterials. **In general, there are four types of nanomaterials**: Carbon based nanomaterials (eg: Carbon nanotubes), Metal based nanomaterials (metal oxides such as aluminium oxides), Dendrimers (nanosized polymers) and Composites (nanosized clays).

When these nanoparicles are suspended in conventional fluids (water, oil, ethylene glycol) the solutions thus obtained are called "nanofluids". The nanolayer works as a thermal bridge between the liquid base fluid and the solid nanoparticles. So a nanofluid consists of the liquid base fluid, the solid nanoparticles and the nanolayers.

Nanofluids exhibit improved thermo-physical properties such as
thermal conductivity
thermal diffusivity
viscosity and
convective heat transfer coefficient.

The property change of nanofluids depends on the volumetric fraction of nanoparticles, shape and size of the nanomaterials.

Due to novel properties of nanofluid it can be widely used for various heat transfer applications of engineering including, automotive and air conditioning cooling, solar and power plant cooling, cooling of transformer oil, improving diesel generator efficiency, in nuclear reactor and defense and space.

Although the use of nanofluids will improve the overall properties and heat transfer characteristics of base fluid even then the **development and applications of nanofluids may be limited by several factors due to use of very small size solid particles with very small concentration.**

2. Preparation of nanofluids

To prepare nanofluids by suspending nanoparticles into base fluids, some special requirements are necessary such as even suspension, durable and stable suspension, low agglomeration of particles and no chemical change of fluid.

There are three general methods used for preparation of stable nanofluid:
(1) Addition of acid or base to Change the pH value of suspension
(2) Adding surface active agents and/or dispersants to disperse particles into fluid
(3) Using ultrasonic vibration.

2. 1 Benefits of use of nanofluids

Nanofluids possess the following advantages as compared to conventional fluids which makes them suitable for various applications involving heat exchange.

1. Absorption of solar energy will be maximized with change of the size, shape, material, and volume fraction of the nanoparticles.
2. The suspended nanoparticles increase the surface area and the heat capacity of the fluid due to the very small particle size.

3. The suspended Nanoparticles enhance the thermal conductivity which results improvement in efficiency of heat transfer systems.
4. Heating within the fluid volume, transfers heat to a small area of fluid and allowing the peak temperature to be located away from surfaces losing heat to the environment.
5. The mixing fluctuation and turbulence of the fluid are intensified.
6. The dispersion of nanoparticles flattens the transverse temperature gradient of the fluid.
7. To make suitable for different applications, properties of fluid can be changed by varying concentration of nanoparticles.

3. Applications of Nanofluids

Nanofluids can be used in broad range of engineering applications due to their improved heat transfer and energy efficiency in a variety of thermal systems. The following section gives a brief idea of different areas of nanofluid applications based on available literatures.

3.1 Applications in automotive

In automobile arena, nanofluids have potential application as engine coolant, automatic transmission fluid, brake fluid, gear lubrication, transmission fluid, engine oil and greases.

3.1.1 Nanofluid as coolant

The use of nanofluids as coolants would allow for smaller size and better positioning of the radiators. There would be less fluid due to the higher efficiency, coolant pump could be shrunk and truck engines could be operated at higher temperatures allowing for more horsepower

3.1.2 Nanofluid in Fuel

It was shown that the combustion of diesel fuel mixed with aqueous aluminum nanofluid increased the total combustion heat while decreasing the concentration of smoke and nitrous oxide in the exhaust emission from the diesel engine. It is due to the high oxidation activity of pure Al which allows for increased decomposition of hydrogen from water during the combustion process.

3.1.3 Nanofluid in Brake Fluids

During the process of braking, the produced heat causes the brake fluid to reach its boiling point, a vapour lock is created that retards the hydraulic system from dispersing the heat caused from braking. It will create a brake malfunction and poses a safety hazard in vehicles. Nanofluids with enhanced characteristics maximize performance in heat transfer as well as remove any safety concerns.

3.2 Applications of nanofluid in domestic refrigerator

Now a days, in refrigeration equipment HFC134a is used as a refrigerant. Traditional mineral oil is avoided as a lubricant due to the strong chemical polarity of HFC134a in refrigeration equipment. POE (Polyol-ester) oil as a lubricant also has the problems of flow choking and severe friction in the compressor. So nanoparticles can be used to enhance the working fluid properties and energy efficiency of the refrigerating system associated with reduction in CO2 emission.

3.3. Industrial Cooling Applications

Replacement of cooling and heating water with nanofluids has the potential to conserve about 300 million kWh of energy for industries. For the electric power industry using nanofluids could save about 3000-9000 million kWh of energy per year which is equivalent to the annual energy consumption of about 50,000-150,000 households. The associated emission reductions would be approximately 5600 million kg of carbon dioxide, 8.6 million kg of nitrogen oxides and 21 million kg of sulfur dioxide.

3.4. Solar Devices

Direct absorption solar collectors have been proposed for a variety of applications such as water heating; however the efficiency of these collectors is limited by the absorption properties of the working fluid.

4. Limitations of using nanofluids

The use of nanofluids seems attractive in a broad range of applications as reported in the previous section. But the development in the area of nanofluid application is hindered by many factors in which long term stability of nanofluid in suspension is major reason. The following are the most pressing issues.

4.1 Poor long term stability of suspension

Long term physical and chemical stability of nanofluids is an important practical issue because of aggregation of nanoparticles due to very strong vander walls interactions so the suspension is not homogeneous. Physical or chemical methods have been applied to get stable nanofluids such as (i) an addition of surfactant; (ii) surface modification of the suspended particles; (iii) applying strong force on the clusters of the suspended particles.

4.2 Increased pressure drop and pumping power

Pressure drop development and required pumping power during the flow of coolant determines the efficiency of nanofluid application. It is known that higher density and viscosity leads to higher pressure drop and pumping power. There are many studies showing significant increase of nanofluids pressure drop compared to base fluid.

4.3 Lower specific heat

An ideal heat transfer fluid should possess higher value of specific heat so the fluid can exchange more heat. Previous studies show that nanofluids exhibit lower specific heat than base fluid. It limits the use of nanofluid application.

4.4 High cost of nanofluids

Nanofluids are prepared by either one step or two step methods. Both methods require advanced and sophisticated equipments. This leads to higher production cost of nanofluids. Therefore high cost of nanofluids is drawback of nanofluid applications.