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An Overview of Nanofluids: A New Media Towards Green Environment

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ABSTRACT

Recent advancements in nanotechnology have originated the new emerging heat transfer fluids called nanofluids. Nanofluids are prepared by dispersing and stably suspending nanometer sized solid particles in conventional heat transfer fluids. Past researches have shown that a very small amount of suspending nanoparticles have the potential to enhance the thermo physical, transport and radioactive properties of the base fluid. Due to improved properties, better heat transfer performance is obtained in many energy and heat transfer devices as compared to traditional fluids which open the door for a new field of scientific research and innovative applications. The aim of this paper is to present the broad range of nanofluid based current and future applications. Some barriers and challenges are also focused for implementing these new class of working fluids. At last future opportunities in nanofluid research are identified and directions are given so that the vision of nanofluid can be completed

Keywords: **Nanomaterials, Nanofluids, Properties, Heat Transfer Enhancement.**

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I. INTRODUCTION

Rapid increase in energy demand of worldwide for more efficient energy storage materials and inherently low thermal conductivity engender the strong need in many industrial field to intensifying heat transfer process and reducing energy loss by developing advanced heat transfer fluid with high thermal conductivities than are presently available[2]. Nanotechnology provides new area of research to process and produce materials with average crystallite sizes below 100 nm called nanomaterials. The term “nanomaterials” encompasses a wide range of materials including nanocrystalline materials, nanocomposites, carbon nanotubes and quantum dots. Xuan and Li (2000) explained that due to its nanostructural features, nanomaterials exhibit enhanced properties (mechanical, thermal, physical, chemical), phenomenon and processes than conventional materials[1]. In general, there are four types of nonmaterial’s: Carbon based nanomaterials (e.g.: Carbon nanotubes), Metal based nanomaterials (metal oxides such as aluminium oxides), Dendrimers (nanosized polymers) and Composites (nanosized clays)[4].

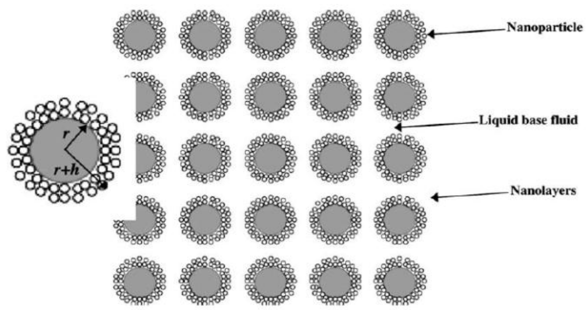

Fig 1: Schematic cross section of nanofluid structure

When these nanoparicles are suspended in conventional fluids (water, oil, ethylene glycol) called "nanofluids". Nanofluids clearly 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 nonmaterial's[5].

I. PREPARATIONS OF NANOFLUIDS

There are two methods for preparation of nanofluid.

One step method

One step method was developed by Eastman et al to reduce aggregation of nanoparticles.The one step method consists of making and dispersing the nanoparticles in the base fluid at the same time.. Many steps like drying, storage, transportation and dispersion of nanoparticles are done away within this process; this reduces the agglomeration considerably and increases the stability of the nanofluid. One step method is highly successful in dispersing the nanoparticles uniformly and provides greater stability. One step method has not been successful in preparing nanofluid on a big scale and the production costs are also high as of now. Novel methods are being conceived now to make one step method industrially feasible and phase transfer method is one of them[6].

Two-step method

The most common method used for the preparation of nanofluid is two step method. Nanomaterials are made into a dry powder using physical or chemical means. The next step involves the dispersion of nano sized powder into a base fluid using magnetic force agitation, ultrasonic agitation, high shear mixing, homogenizing and ball milling. This is the most economic method for the preparation of nanofluids because industrial production is already underway. Nanoparticles have the tendency to agglomeration owing to the large surface area and surface activity. Surfactants are used to prevent this and the behavior of the surfactants at high temperature also comes into play[6].

II. BENIFITS 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[6].
2. The suspended nanoparticles increase the surface area and the heat capacity of the fluid due to the very small particle size[6].
3. The suspended Nanoparticles enhance the thermal conductivity which results improvement in efficiency of heat transfer systems[2].
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[2].
5. The mixing fluctuation and turbulence of the fluid are intensified[3].
6. The dispersion of nanoparticles flattens the transverse temperature gradient of the fluid[3].
7. To make suitable for different applications, properties of fluid can be changed by varying concentration of nanoparticles[4].

IV. LIMITATIONS OF USING NANOFLUIDS

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 vender walls interactions so the suspension is not homogeneous[1].

Increased pressure drop and pumping power

Pressure drop development and required pumping power during the flow of coolant determines the efficiency of nanofluid application [8]. 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 [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].

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[7].

V.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[5]. **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[5].

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 [4].

Industrial Cooling Applications

Routbort et al. (2010) employed nanofluids for industrial cooling and showed great energy savings and resulting emission reductions. They showed that replacement of cooling and heating water with nanofluids has the potential to conserve about 300 million kWh of energy for industries [4]. 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 [5].

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. Otanicar et al. (2010) demonstrated efficiency improvements of up to 5% in solar thermal collectors by utilizing nanofluids as the absorption mechanism [5]. The experimental and numerical results demonstrate an initial rapid increase in efficiency with volume fraction, followed by a leveling off in efficiency as volume fraction continues to increase. For domestic hot water system, Golden and Otanicar (2009) resulted that the nanofluid based solar collector has a slightly longer payback period but at the end of its useful life has the same economic savings as a conventional solar collector[6]. The nanofluid based solar collector has a lower embodied energy 9% and approximately 3% higher levels of pollution offsets than a conventional collector[2].

I. CONCLUSION

This paper presents overview about nanofluid, an exciting new class of heat transfer fluid, in terms of application, barriers and further research. It is concluded that nanofluids are important because they can be considered as a potential candidate for numerous applications involving heat transfer and their use will continue to grow. It was also found that the use of nanofluids appears promising, but the development of the field faces several challenges. Nanofluid stability and its production cost are major factors in using nanofluids. The problems of nanoparticle aggregation, settling, and erosion all need to be examined in detail in the applications. We can say that once the science and engineering of nanofluids are fully understood and their full potential researched, they can be reproduced on a large scale and used in many applications. It is also suggested that further research still has to be done on the synthesis and applications of nanofluids so that they may be applied as more efficient and compact heat transfer systems, maintaining cleaner and healthier environment and unique applications.

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