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Research Paper

ANALYSIS OF NANOFLUIDS

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A colloidal mixture of nano-sized particles in a base liquid called nanofluid, which is the new generation of heat transfer fluid for various heat transfer applications with enhanced thermo physical properties and heat transfer performance can be applied in many devices for better performances. Specific application of nanofluids in engine cooling, solar water heating, cooling and heating in buildings and cooling of heat exchanging devices have been discussed. Moreover, challenges and future directions of other applications of nanofluids have been presented in this paper.

Keywords: Nano fluids, Nano sized particles

INTRODUCTION

To take care of growing demand of energy density, the miniaturized devices as well as large devices require more efficient cooling systems with greater cooling capacities and decreased sizes. Thus heat transfer capacity needs to be increase and this need must be met in two ways: introducing new designs, such as microchannels and introducing extended surface heat exchanger, and enhancing the heat transfer capability of the fluid itself. Successful employment of nanofluids will support the current trend toward component miniaturization. The thermal conductivities of the particle materials are typically an order-of-magnitude higher than those of the base fluids such as water, ethylene glycol, and light oils, and nanofluids, even at low volume concentrations, resulting in significant increases in thermal performance. Properly engineered nanofluids possess the following advantages: (i) High specific surface area and therefore more heat transfer surface between particles and fluids. (ii) High dispersion stability with predominant Brownian motion of particles, (iii) Reduced pumping power as compared to pure liquid to achieve equivalent heat transfer intensification, (iv) Reduced particle clogging as compared to convention slurries, thus promoting system miniaturization, (v) Adjustable properties, including thermal conductivity and surface wettability, by varying particle concentrations to suit different applications. The above potentials provided

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the thrust necessary to begin research in nanofluids, with the expectation that these fluids will play an important role in developing the next generation of cooling technology. Nanofluids have the potential to reduce thermal resistances, and industrial groups that would benefit from such improvement, include transportation, electronics, medical, food, and manufacturing.

APPLICATIONS OF NANOFLUIDS

Engine Cooling

Vehicle thermal management is a crosscutting technology because it directly or indirectly affects engine performance, fuel economy, safety and reliability, aerodynamics, driver/ passenger comfort, materials selection, emissions, maintenance, and component life. The heat rejection requirements of automobiles and trucks are continually increasing due to trends toward more power output. An ethylene glycol and water mixture, the nearly universally used automotive coolant, is a relatively poor heat transfer fluid compared to water alone. Engine oils perform even worse as a heat transfer medium. The addition of nanoparticles to the standard engine coolant has the potential to improve automotive and heavy-duty engine cooling rates. Smaller coolant systems result in smaller and lighter radiators, which in turn benefit almost every aspect of car and economy. This may reduce the coefficient of drag and thus resulting in less fuel consumption. Alternatively, improved cooling rates for automotive and truck engines can be used to remove more heat from higher horsepower engines with the same size of coolant system.

Heat Exchanger

Cooling is one of the important challenges faced by many industries. The conventional way to increase cooling rates is increasing the heat transfer area. There is a balance between pumping costs and heat transfer. Further increase of heat transfer area requires increasing the size of thermal management system.Nanotechnology may help accelerate the development of energy-efficient central heating. When added to water, CNTs disperse to form a nanofluid. Researchers have developed Nanofluids whose rates of forced convective heat transfer are four times better than the norm by using CNTs. When added to a home’s commercial water boiler, such Nanofluids could make the central heating device 10% more efficient . The new experimental data concerning the use of Nanofluids in a commercial heat exchanger confirmed that, besides the physical properties, the type of flow (laminar or turbulent) inside the heat exchanging equipment plays an important role in the effectiveness of a nanofluid. When the heat exchanging equipment operates under conditions that promote turbulence, the use of nanofluids is beneficial if and only if the increase in their thermal conductivity is accompanied by a marginal increase in viscosity, which seems very difficult to be achieved. On the other hand, if the heat exchanger operates under laminar conditions, the use of nanofluids seems advantageous, the only disadvantages so far being their high price and the potential instability of the suspension. In conclusion, in industrial heat exchangers, where large volumes of Nanofluids are involved and turbulent flow is usually developed, the substitution of conventional fluids by Nanofluids seems inauspicious. However, in micro-scale equipment with increased thermal duties, where also volume is a matter, and especially in laminar flow, the use of a nanofluid instead of a conventional fluid seems advantageous. In each case the nanofluid properties should be defined carefully in order to evaluate its efficacy in a specific heat exchanger. The benefits of nanofluid cooling are clear, including dramatic enhancement of cooling rates while operating the advanced cooling system at room temperature. Furthermore, the possibility of thermal distortion and flow-induced vibration will be eliminated by passing the Nanofluids through micro channels within the silicon mirror itself. Future experimental work on the nanofluid cooled microchannel heat exchanger will advance the art of cooling high-heat-load X-ray monochromators.

CHALLENGES OF NANOFLUIDS

The use of Nanofluids in a wide variety of applications appears promising. But the development of the field is hindered by:

- Lack of agreement of results obtained by different researchers.
- Poor characterization of suspensions.
- Lack of the mechanisms responsible for changes in properties.

Long Term Stability of Nanoparticles Dispersion

Preparation of homogeneous suspension remains a technical challenge since the nanoparticles always form aggregates due to very strong vander Waals interactions. To get stable Nanofluids, physical or chemical treatment have been conducted such as an addition of surfactant, surface modification of the suspended particles or applying strong force on the clusters of the suspended particles.

Generally, long term stability of nano particles dispersion is one of the basic requirements of nanofluids applications. Stability of nanofluids have good corresponding relationship with the enhancement of thermal conductivity where the better dispersion behavior, the higher thermal conductivity of Nanofluids.

Higher Viscosity

The viscosity of nanoparticles-water suspensions increases in accordance with increasing particle concentration in the suspension. So, the particle mass fraction cannot be increased unlimitedly.

CONCLUSION

It has been found that the improved thermal conductivities of nanofluids are the one of the driving factors for better performance in different applications. It was observed that there are inconsistencies in the results published in open literature by many researchers. Few researchers' reported the inconsistencies between model and experimental results of thermal conductivity of nanofluids. The proper physical mechanism of heat transfer enhancement has not been established till date. It is clear that the increase of thermal conductivity might be offset by the increase of viscosity, the decrease of effective specific heat of nanofluid.

Nanofluids stability and its production cost are major factors that hinder the commercialization of Nanofluids. By solving these challenges, it is expected that nanofluids can make substantial impact as coolant in heat exchanging devices.

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