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Graphene based nanofluids as Heat transfer Fluid

Abstract

European Energy set plan states that "The development and uptake of innovations which substantially reduce the energy cost of industry must be prioritized, for energy intensive industries and Small and Medium Enterprises (SME). European energy intensity industries are those that have a high dependence on resources (energy, utilities and raw materials.) Main representative processes of this type of industries are: steel makers, foundries, ceramic, chemical, cement, food & beverages and paper industries).

Taking into account the needs to reduce energy consumption, the aim of this research is the synthesis of graphene based nanofluids to apply in an industrial manufacturing company. The goal is to reuse in other applications the energy that is waste during different plant processes.

Heat transfers fluids (HTFs) are compounds specifically manufactured for the purpose of transmitting heat from one system to another, to store heat, and to prevent excess heating of any thermal device. These fluids are used to transport energy in the form of heat from the point of generation of heat (burners, nuclear reactors, solar fields, etc.) The most commonly used thermal fluids are water, ethylene glycol, thermal oils, and molten salts. A Common feature to all of them is its low thermal conductivity, which limits the efficiency of heat exchange systems. With the aim to enhance the thermal conductivity of HTF the scientific community is researching on a new concept. Nanofluids. Nanofluids are a new class of fluids engineered by dispersing nanometer-sized material smaller than 100nm (nanoparticles, nanofibers, nanotubes, nanowires, nanorods, nanosheet, or droplets) in base fluids [1]. Considerable researches have been carries out on this topic and it has been noticed that most authors agreed that nanofluids provide higher thermal conductivity compared to base fluids [2]. Its value increases with particles concentration. Temperature, particle size, dispersion and stability do play an important role in determining thermal conductivity of nanofluids.

There are several techniques to disperse nanoparticles o other nanomaterials in a host fluid. These techniques are divided in two groups: One step technique and two step technique. In this case two step technique is applied, the graphene was added into the host fluid. There are different techniques to improve the dispersion of nanoparticles in a host fluid such as nanoparticles modification, pH modification or dispersant addition. In this work the third option has been applied, dispersant addition. Dispersants are employed to increase the contact of two materials, sometimes known as wet ability [3]. In a two-phase system, a dispersant tends to locate at the interface of the two phases, where it introduces a degree of continuity between the nanoparticles and fluids. A repulsion force between suspended particles is caused by the zeta potential which will rise due to the surface charge of the particles suspended in the base fluid. The figure 1 illustrate effect of stable dispersion and aggregation.

Heat transfer fluids can be divided according to their working temperature range; low temperature range (glycol/water mixtures) and medium temperature range (mineral oils) and high temperature range (synthetic organic fluids, silicones, molten salt, liquid metal). The figure 2 shows some examples of these different heat transfer fluids. In this research silicone-based heat transfer fluids have been selected. These fluids are very stable at high temperature.

Synthesized nanofluids were characterized measuring different thermo-physical parameters, such as thermal conductivity, viscosity, density, etc. The results have shown that at 0.5% of Graphene has increased the thermal conductivity in 9%. These results indicate that graphene it could be very useful material to increase the properties of the heat transfer fluids.

Reference

[1] R.Saidur, et al. Renewable and Sustainable Energy Reviews 15 (2001) 310-323

[2] Haoran Li, Applied thermal Engineering Available online 27 October 2014.

[3] Double Wallet Carbon Nanotube dispersion via surfactant substitution. Journal of material Chemistry. Issue 18. 2009

Figures

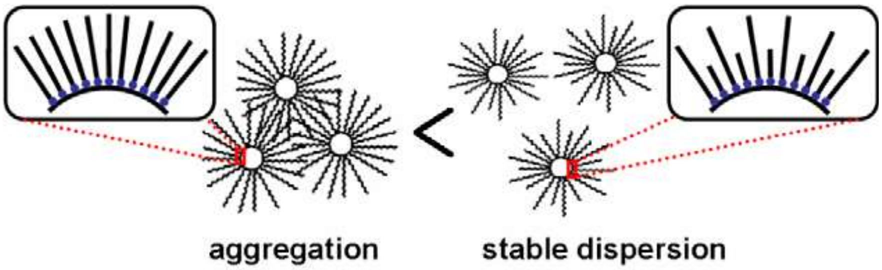


Figure 1: Effect of stable dispersion and aggregation.

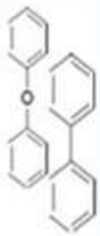
FLUID TYPE	GLYCOL	WATER	MINERAL OILS (HOT OILS)	ORGANIC FLUIDS	SILICONES	MOLTEN SALTS	LIQUID METAL
FLUID COMMUN STRUCTURE	HO, OH	H H O			[CH_3 -Si-O- CH_3]$_n$	NaNO3 KNO3	Na Bi Ga
Temperature working range (ºC)	-73_150	1_100	-25-315	-60_400	-90_400	100-600	800

Figure 2: HTF classification according working temperature