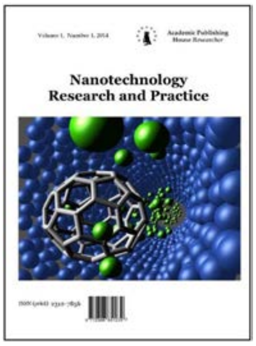
Published in the Russian Federation
Nanotechnology Research and Practice
Has been issued since 2014.
ISSN: 2312-7856
Vol. 6, Is. 2, pp. 68-71, 2015

DOI: 10.13187/ejnr.2015.6.68
www.ejournal13.com



UDC 532.529:541.182

Investigation of Dynamics of Nanofluid

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Abstract

Experimental work is held to investigate how nanoparticles affect the hydrodynamic properties of the fluid. Nano zinc oxide (ZnO) particles with different diameters are produced with using the ultrasonic method using different time duration. In this research the thermal conductivity enhancement, the viscosity changes, heat capacity, shear rate and density of nanofluid are compared with those ones in water base fluid.

Keywords: dynamics, nanofluid, density, viscosity.

Introduction

In recent years, development in the miniaturization technologies results in fabrication of micro-scale electronic devices which is used in various industries such as aerospace and automotive. For maximum performance of these micro devices which is known as MEMS (Micro Electromechanical Systems), the temperatures should be within a certain range. Microchannels [1] as compact and efficient cooling devices have been developed for the thermal control of MEMS. Utilizing nanofluid as working fluid could improve the cooling and heating performance. Because of more stable nature of nanofluid compared with its pioneer generation (including micro and millimeter size particles) and exceptional thermal conductivity of nanoparticles, it could considerably enhance the convective heat transfer coefficient in microchannels.

During the last decade, many studies on convective heat transfer with nanofluids have been considered [2–6]. Pak and Cho [2] revealed that the heat transfer coefficients of the nanofluids increase with increasing the volume fraction of nanoparticles and the Reynolds number. Mirmasoumi and Behzadmehr [7] studied the laminar mixed convection of Al_2O_3/water nanofluid in a horizontal tube numerically using a two-phase mixture model. They showed that the nanoparticle concentration did not have significant effects on the hydrodynamics parameters, but its effects on the thermal parameters were important for the fully developed region. Izadi et al. [8] considered the laminar forced convection of Al_2O_3/water nanofluid flowing in an annulus. Their results indicate that the friction coefficient depends on the nanoparticle concentration while the order of magnitude of heating energy is much higher than the momentum energy. Thermal transport of nanofluid flow in microchannels has also attracted a few investigators [9–15] due to its promising applications. In a study by Jang et al [11] the cooling performance of the microchannel was significantly improved by the significant reduction in the temperature difference between the heated wall and the nanofluids. Ho et al. [12] experimentally assessed forced convective cooling and heating performance of a copper microchannel heat sink with Al_2O_3/water nanofluid as a coolant. Their results show that the nanofluid cooled heat sink outperforms the water-cooled one, having significantly higher average heat transfer coefficient and thereby markedly lower thermal resistance and wall temperature at high pumping power, in particular. Meanwhile, in an experiment [14] using SiO_2–water nanofluids in an aluminum heat sink consisted of an array of 4 mm diameter circular channels with a length of 40 mm. The experimental results showed that dispersing Al_2O_3 and SiO_2 nanoparticles in water significantly increased the overall heat transfer coefficient while the thermal resistance of heat sink was decreased up to 10%. Also they numerically investigated corresponding configuration. The results revealed that the channel diameter, as well as heat sink height and number of channels in a heat sink have significant effects on the maximum temperature of heat sink. Regarding numerical aspects, Kosar [16] demonstrated when the commonly used assumption of constant heat flux boundary condition is applicable in heat and fluid flow analysis in microfluidic systems. Also a general Nusselt number correlation for fully developed laminar flow was developed as a function of two dimensionless parameters, namely, the Biot number and relative conductivity, to take the conduction effects of the solid substrate on heat transfer into account. Kalteh et al. [17] numerically and experimentally studied the thermal characteristics of an alumina-water nanofluid flow inside a wide rectangular microchannel. In their study, a two-phase method was adopted. Their comparison shows that two-phase modeling results have better concordance with experimental data than the homogeneous (single-phase) approach. Few researches on characteristics of nanofluids which experimentally behave as non-Newtonian have been performed. For example Hojjat et al. [18] prepared three kinds of nanofluids by dispersing Al_2O_3, CuO, ZnO and TiO_2 nanoparticles in a solution of carboxymethyl cellulose (CMC). They proposed a new correlation to predict successfully the Nusselt number of non-Newtonian nanofluids as a function of the Reynolds and the Prandtl numbers. In most of the cases, heat transfer in micro channels is connected with conduction effects of substrate. Most of researches are performed Regardless the substrate material and thickness under the assumption of constant heat flux boundary condition. For cases where thick and low thermal conductivity (such as polymers) substrates are utilized commonly used constant heat flux boundary condition may not be valid. Thus many researchers have been performed studies on single-phase flow in micro-heat sinks to investigate their thermal performances and the conjugate effects [19].

This paper aims to consider the hydrodynamic and thermal properties of the Al_2O_3- and ZnO-nanofluid in a channel. According to the literature reports [20–25], in micro scale systems, large channel length to hydraulic diameter ratios brings about large velocity and as a result thermal energy generation due to viscous dissipation effects. Thus, this paper studied some attributes of nanofluids flow performance in the above described configuration.

Experimental set up

After preparing nanoparticle in two steps process, the determined amount of nano particle is fed into the experimental set up to prepare nanofluid and experiments running.

Results and Discussion

1. The effect of the time of ultra-sonic on the synthesized nano particles

Figure 1 illustrates the size of produced nanoparticles versus time of ultra-sonic. According to this Figure the size of produced nanoparticles is decreasing versus increasing the time of ultra-sonic. The increasing the time can broke the structure of macro molecule.

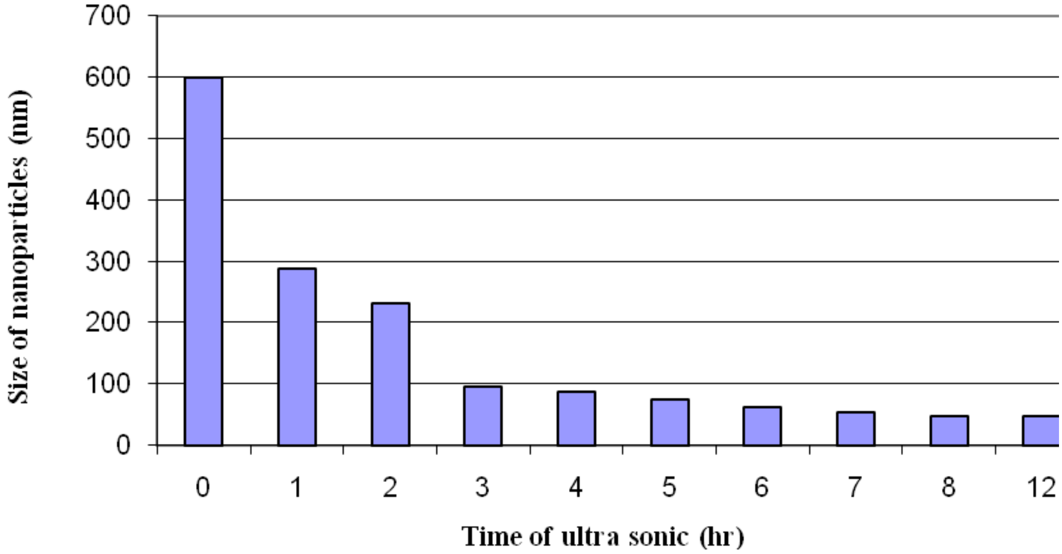

Figure 1. Size of particle versus time of ultrasonic.

1.1. Average temperature and average velocity distribution

Figure 2 shows the temperature changes through the pipe with different amounts of nanoparticles. Also, this Figure compares the experimental data with the calculated data from the mathematical model. The increase in the amount of nanoparticle increases the average temperature of nanofluid at the constant heat flux. This is clearly due to the increase in the amount of thermal conductivity and also heat of capacity of the fluid. The decreasing trend of temperature is obtained through the non adiabatic tube.

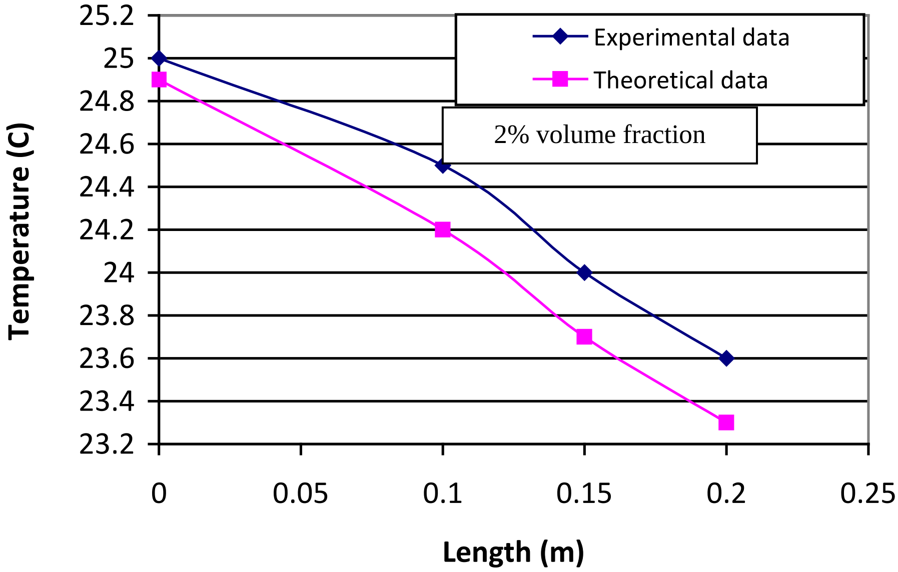

Figure 2. Average temperature versus length (2 % volume fraction nanoparticle)

Conclusions

This work investigates the effect of nanoparticles on the rheological parameters of fluid, experimentally and mathematically. Experiments are held to measure the viscosity, shear rate, shear stress, heat capacity, density and enhancement in amount of thermal conductivity of nano fluid in a pipe with 0.025 m and 0.2 m in diameter and length, respectively.

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