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Experimental Evaluation of Relation of Reynolds Number and Pressure Drop in a Blood Vessel for Optimized Injection of Drug

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Abstract

The authors investigate the thermal and dynamic performance of zinc oxide nanofluid on the heat pipe with 0.2 in length and 0.006 in diameter in this paper. Moreover, the knowledge of the amount of heat transfer and fluid mechanic of nano fluid are as two fundamental parameters. So, the thermal and kinematics properties of nano fluid in heat pipe are investigated in this research. The experimental results show, higher pressure drops are obtained in high concentrations of nano particles. Hence, the average amounts of pressure drop increase 0.2%, 0.3%, 0.6% and 0.8% at 1, 10, 50 and 100 concentrations of nano particles compared with the pure fluid.

Keywords : Pressure Drop; Thermal Resistance; Reynolds Number; Heat Pipe; Nano Fluid

Abbreviations : TEM: Transmission Electron Microscopy; XRD: X-Rays Diffractometer; SEM: Scanning Electron Microscopys

Introduction

Generally, attempts of humans during the industrial history have been tended to higher heat transfer rates and making heat exchangers in smaller size [1]. Although the metallic particles suspended in the fluids have higher thermal conductivities and had been proposed to heat transfer augmentation in the heat exchangers, but they also are responsible of erosion corrosion, pressure drop and pipe blockage [2]. Therefore, adding particles in millimetres or even micrometre size, have encountered problems. The suspensions with millimetre, micro and nano sized particles are known to cause severe problems in heat transfer apparatus. However, particles in large size tend to quickly settle out of suspension and cause to severe clogging by passing through micro channels. Thereby, the pressure drop increases severely [3]. Furthermore, the abrasive actions of these particles make the erosion of pipelines and industrial equipment. Nowadays, developing technology represents the utilization of nano fluids as working fluids in heat transfer equipment's. 'Nanotechnology'' is one of the important branches which uses substances in nano size in many revolutionary variations that can significantly improve device performance, which relates to engine cooling systems, petroleum and chemical plants, the technology of communication, resistor materials, sensor applications, drug delivery, pharmaceutical industries and several areas of practical importance [4].

With the rapid development of this area of science, nano materials have been used into the heat transfer subfields as nano fluids which are produced by dispersing nano particles of metals in the working fluids [5]. Heat pipes are utilized in cooling purposes in several fields of technology, excessively. Since these parts are low in cost so they are named highly reliable equipment's. Their usage in high power, cooling applications is limited to the custom applications requiring either low thermal resistance and/or having a severely limited enclosure field. The thermal performance of a heat pipes as one type of highly effective heat transfer part of the heat exchange apparatus can be improved by using nano fluids [3]. There are different methods for providing the zinc oxide nanoparticles, which are briefly as

i. Dissolving zinc salt in the deionized water to make a precursor solution

ii. Heating deionized water

iii. Adding solid alkali, salt to the precursor solution to make a dispersion of ZnO nanoparticles

iv. Separating the zinc oxide nanoparticles through solid-liquid separation and washing them with deionized water.

Highly pure, crystalline zinc oxide nanoparticles with spherical appearance and size distribution of 10 to 50 nm can be prepared quickly and at large scale and very low-cost application of inexpensive materials via a stable low-temperature process, without using a dispersion [5-7]. The associated low-temperature, normal-pressure process produces fewer harmful materials and may be easily employed for preparing of zinc oxide nanoparticles. Surely, nano fluid is a new type of heat working fluid, which is made by adding nano-level substances such as metallic, non-metallic or polymeric solid particles into the liquid in a certain method and ratio [1-3]. So, the experiments are conducted with ZnO nano fluid. The ZnO is an environmentally friendly material. Also, ZnO nano particles in cooling water of heat pipe appear to reach an enhancement power criterion as high as that of water compared with other nano metal oxide [5,6]. In this paper, two kinds of zinc oxide nanoparticles in different sizes are used. The average size of one kind is 35 nm and the other one is 55 nm. Experimental investigations of thermal resistance and dynamic properties of water-based nano fluids containing concentrations of ZnO nanoparticles are surveyed, in the present study. Also, the experiments are performed to investigate the effect of ZnO nano fluid on the thermal yield of a heat pipe. The temperature distribution and thermal resistance are measured at different positions of heating pipe. Moreover, pressure drop, and pumping power are considered in this study. The mentioned parameters are measured for pure water and nanofluids. Finally, the comparison between the measured properties of pure water and nano fluids is done. So, the thermal and dynamic characterization of pure fluid and also nano fluid are evaluated in this work.

Materials and Methods

Properties of Zinc Oxide

The zinc oxide nanoparticle is a usual element with a vast variety of applications. The zinc is an essential mineral at various concentration and is nontoxic in low concentration, undoubtedly. Data shows a good relation between healthy and suitable concentration of zinc oxide (Table 1).

Table 1: The physical properties of zinc oxide.

Properties	ZnO
The lattice parameters at 300 Kelvin	
— a_0 (nm)	0.32495
— c_0 (nm)	0.52069
— c_0 / a_0	1.602(1.633*)
Density (g/ cm^3)	5.606
Stable phase at 300 K	Wurtzite
Melting point (^{o}C)	1975
Thermal conductivity ($W m^{-1} {}^{o}C^{-1}$)	0.6, 1-1.2
Linear expansion coefficient (^{o}C)	$a_0 : 6.5\ cm^{3} \times 10^{-6}$
	$c_0 : 3.0\ cm^{3} \times 10^{-6}$
Static dielectric constant	8.656
Refractive index	2.008
Band gap (RT)	3.370 eV
Bands gap (4 K)	3.437 eV
Exciton binding energy (meV)	60
Electron effective mass	0.24
Electron Hall mobility at 300 K (cm^2 /Vs)	200
Hole effective mass	0.59
Hole Hall mobility at 300 K (cm^2 /Vs)	5-50

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Method of Preparation of Zinc oxide Nano Particle

The nano fluids are used in this empirical study is prepared in two steps. At the beginning the nano powder of zinc oxide is made and then the produced powder is mixed with the water as basic fluid. The zinc metal is applied to make a solution containing one molar Zn^{2+} ion. So, at the first, the Zn^{2+} solution sis purified, and then a type of surface-active reagent 0.05 M and also, approximately 10 per cent of ethanol is mixed with Zn^{2+} solution under the ultrasonic conditions. The produced solution is shacked in the certain time periodic. Then the same reagents are mixed with Na_2Co_3, 1M solution under the same conditions. Then two produced aqueous solutions are mixed, proportionally. The mixed solution is shacked for half hour under the ultrasonic condition. Sequentially, adding another surface-active reagent and mixing for half hour again, filtering and washing several times with pure water and ethanol alternately under the ultrasonic conditions. The synthesized substance is prepared to dry for fifty minutes at 80 Centigrade degree. At the next step, the synthesized substance is roasted at 450 Centigrade degree for 1 hour to obtain zinc oxide nanoparticles. So, in this process such as other process, many parameters may affect the quantity and quality of synthesized nano particles [8].

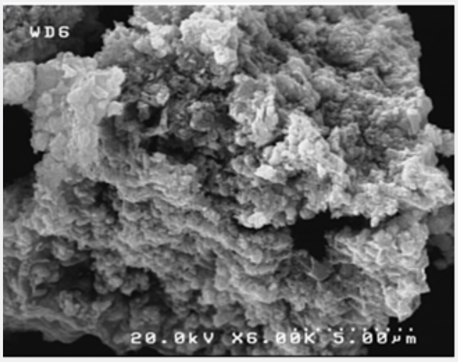

Figure 1: SEM Photographs of zinc oxide nanoparticles with 5 scales.

The basic parameters such as temperature, amplitude and time of sonication, pH and concentrations of material affect the growth and produced zinc oxide nano particle size. Finally, the synthesis of nano zinc oxide is carried out with the scan reader and is confirmed by X-Rays Diffractometer (XRD). The graphs of the zinc oxide nanoparticles are evaluated through the Transmission Electron Microscopy (TEM) and also are confirmed by Scanning Electron Microscopy (SEM). The morphology, size and figuration of nano particles with 35 nm and 55 nm is determined by SEM, TEM and XRD analysis. Finally, the spherical particles with the average size of 30 to 60 nm in diameter is shown, approximately. So, two groups of zinc oxide nano particles with the average size of 35 nm and the other one, 55nm is prepared, separately. The produced zinc oxide nanoparticles are mixed with pure water which passes through heating pipe. Figure 1 shows SEM photos of nano particles in two different visions a) in the scale of 5 μm.

Description of Heat Pipe

The mixed solution is shacked for half hour under the ultrasonic condition. Sequentially, adding another surface-active reagent and mixing for half hour again, filtering and washing several times with pure water and ethanol alternately under the ultrasonic conditions. The synthesized substance is prepared to dry for fifty minutes at 80 Centigrade degree. At the next step, the synthesized substance is roasted at 450 Centigrade degree for 1 hour to obtain zinc oxide nanoparticles. So, in this process such as other process, many parameters may affect the quantity and quality of synthesized nano particles. The basic parameters such as temperature, amplitude and time of sonication, pH and concentrations of material affect the growth and produced zinc oxide nano particle size. Finally, the synthesis of nano zinc oxide is carried out with the scan reader and is confirmed by X-Rays Diffractometer (XRD). The graphs of the zinc oxide nanoparticles are evaluated through the Transmission Electron Microscopy (TEM) and also are confirmed by Scanning Electron Microscopy (SEM). The morphology, size and figuration of nano particles with 35 nm and 55 nm is determined by SEM, TEM and XRD analysis. Finally, the spherical particles with the average size of 30 to 60 m in diameter is shown, approximately. So, two groups of zinc oxide nano particles with the average size of 35 nm and the other one, 55nm is prepared, separately. The produced zinc oxide nanoparticles are mixed with pure water which passes through heating pipe. Figure 1 shows SEM photos of nano particles in two different visions a) in the scale of 5 μm (Figure 2).

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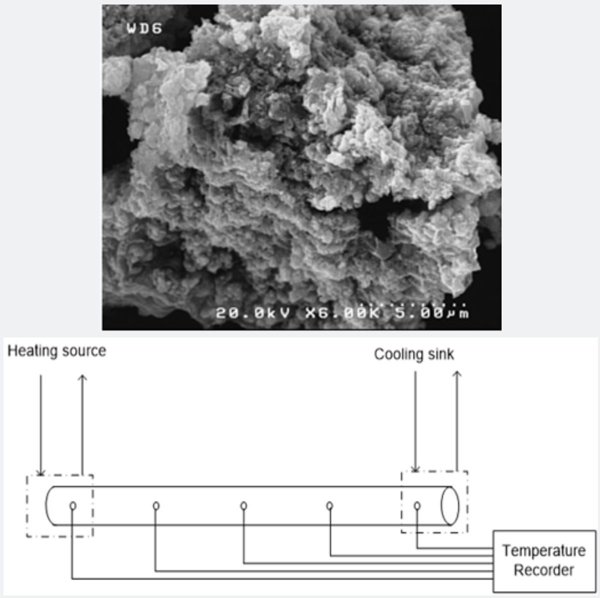

Figure 2: Experimental heat pipe.

Results and Discussion

The knowledge of the amount of heat transfer and fluid mechanic of nano fluid are as two fundamental parameters. So, the thermal and kinematic properties of nano fluid in heat pipe are investigated in this research.

The Effect of Particle Size and Reynolds Number on the Pressure Drop

Figures 3 & 4 emphases on the effect of the size variations of nano particles and the Reynolds number on the development of the pressure drop in the heat pipes. Pressure drop is an important operational parameter which affects the performance of the heat transferring equipment's. So, predicting and measuring of pressure drop is always considered as a key parameter in designing. Tube geometry, friction factor and fluid flow rate change the amount of pressure drop. Hence, different Reynolds number and different concentrations of two types of nano particles with 35 nm and 55 nm in diameter are considered in this work.

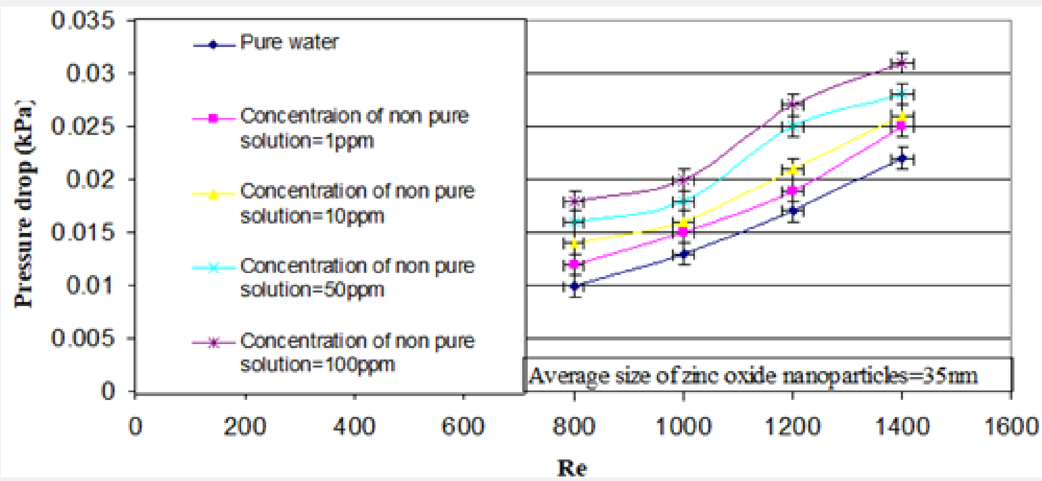

Figure 3: Nano fluid pressure drop versus different Reynolds number at different concentration of 35   particles.

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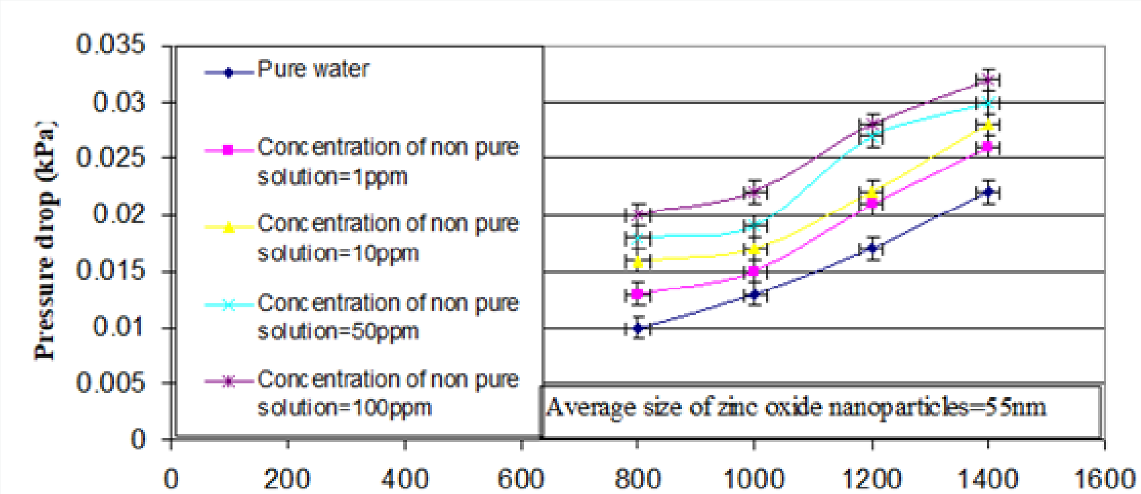

Figure 4: Nano fluid pressure drop versus different Reynolds number at different concentration of 55 particles..

The Figure 3 shows the pressure drop distribution related to Reynolds number in cooling fluid which contains 35 nm particles in 1, 10, 50 and 100 ppm concentrations. Increasing the concentration of nano particles decreases the fluid viscosity so augments the Reynolds number. Higher pressure drops are obtained in high concentrations of nano particles. Hence, the average amounts of pressure drop increase 0.2%, 0.3%, 0.6% and 0.8% at 1, 10, 50 and 100 ppm concentrations of nano particles compared with the pure fluid.

The Figure 4 shows the pressure drop distribution related to Reynolds number in cooling fluid which contains 55 *m* particles in 1, 10, 50 and 100 ppm concentrations. So, with dispersing the 55 nm in diameter of nano particles, the average amounts of pressure drop increase 0.3%, 0.5%, 0.8% and 1% at fluid concentrations of 1, 10, 50 and 100 ppm compared with the pure fluid, respectively. Although, Figures state that larger diameter of nano particles develops higher pressure drop in the heat pipes but using zinc oxide nano particles doesn't show such a severe pressure drop, in this work.

Conclusion

The knowledge of the amount of heat transfer and fluid mechanic of nano fluid are as two fundamental parameters. So, the thermal and kinematics properties of nano fluid in heat pipe are investigated in this research. The experimental results show, higher pressure drops are obtained in high concentrations of nano particles. Hence, the average amounts of pressure drop increase 0.2%, 0.3%, 0.6% and 0.8% at 1, 10, 50 and 100 ppm concentrations of nano particles compared with the pure fluid.

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