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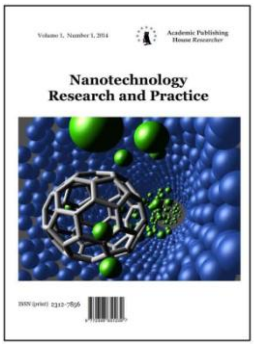


## Experimental Study of Heat Pipe

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**Abstract**

Nowadays, developing technology represents the utilization of nanofluids as working fluids in heat transfer equipment's. Today's, the application of heat pipes in electronic cooling applications has increased dramatically, primarily in notebook computers. This paper investigates thermal performance of nanofluid which contains composition of aluminium and ferric oxide in the heat pipe with 2 $m$ in length and 0.006 $m$ in diameter.

**Keywords**: Novel; thermal; Heat performance; Heat pipe.

### Introduction

Argonne National Laboratory has developed the concept of a new class of heat transfer fluids which is called "Nanofluids," which are engineered by suspending ultrafine metallic or nonmetallic particles of nanometer dimensions in traditional fluids such as water, engine oil and ethylene glycol [1 and 2]. Nowadays, developing technology represents the utilization of nanofluids as working fluids in heat transfer equipment's [3 and 4]. '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, technology of communication, resistor materials, sensor applications, drug delivery, pharmaceutical industries and several area of practical importance[5 and 6]. With the rapid development of this area of science, nano materials have been used into the heat transfer subfields as nanofluids which are produced by dispersing nano particles of metals in the working fluids. Some experimental studies have revealed that the nanofluids have severely higher thermal conductivities and greater heat transfer characteristic than those of conventional pure fluids [7]. A theoretical model and an experimental are proposed to describe the heat transfer performance of nanofluid flowing in a tube. Generally, the experimental results illustrate that the thermal conductivity of nanofluids remarkably increases with the volume fraction of ultra-fine particles [8]. Heat pipes are utilized in cooling purposes in several fields of technology, excessively [9]. Since these parts are low in cost so they are named highly reliable equipments [10]. Their usage in high power cooling applications has been limited to custom applications requiring either low thermal resistance and/or having a severely restricted enclosure field.

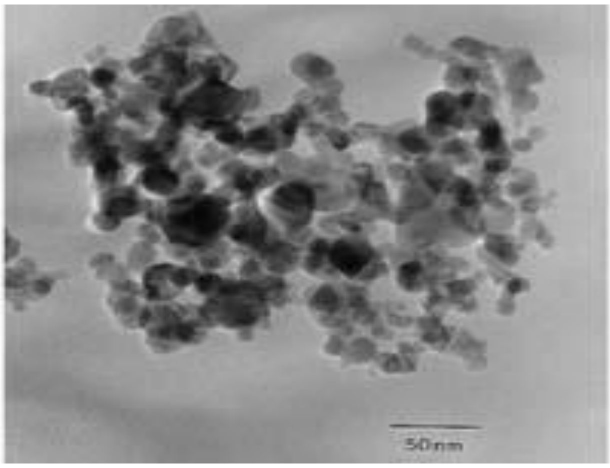
## Materials and Methods

### 1. Synthesis of Aluminum oxide nano particles

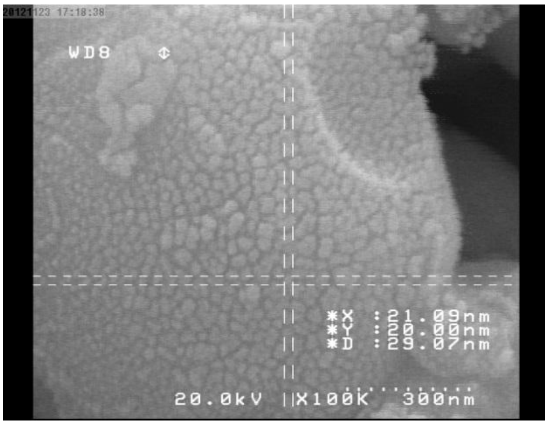
The two precursors used in the synthesis of Al2O3 by sol-gel method were of different chemical nature: inorganic – aluminium chloride (AlCl3) and organic– aluminium triisopropylate (C3H7O)3Al. a). In the case of AlCl3 (p.a., Fluka) as precursor, the sol-gel synthesis consisted in the preparation of a 0.1 M AlCl3 ethanolic solution (p.a., Chemical Company). By adding a 28% NH3 solution (p.a. Fluka) a gel was formed. The gel was let to maturate for 30 hours at room temperature and then dried at 100 $^{o}C$ for 24 hours. b). For C9H21AlO3 (p.a., Fluka) used as precursor, the sol-gel synthesis consisted in the preparation of a 0.1 M (C3H7O)3Al ethanolic solution (p.a., Chemical Company). A 28% NH3 solution (p.a., Fluka) was added in order to form a gel. Mild shaking at 90 $^{o}C$ for10 hours was utilised. The gel was let to maturate at room temperature for 24 hours, and then dried at 100 $^{o}C$ for 24 hours. The resulting gels were calcined in a furnace for 2 hours (heating rate 20 $^{o}C$ /min.), at temperature values of 1000 $^{o}C$ and 1200 $^{o}C$ [2].

### 2 Synthesis of Iron oxide nano particles

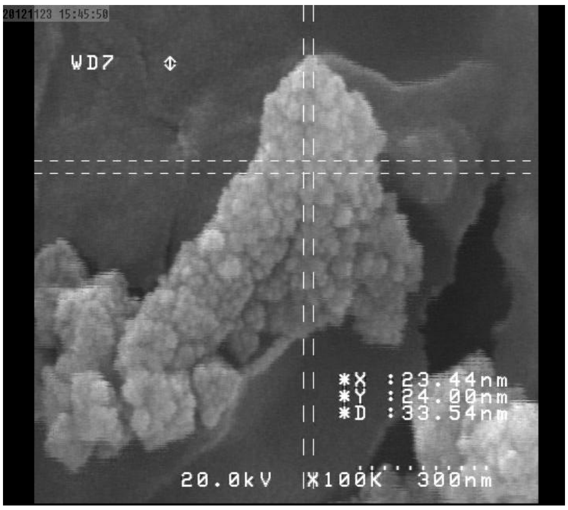
Low dimensional iron oxide NPs have been synthesized by adding uni-molar concentration of ferric chloride and urea into hydrothermal cell (Teflon line autoclave). FeCl3 and urea were slowly dissolved into the de-ionized water separately to make 0.5 M concentration at room temperature. Then the solution was mixed gently and stirred until mix properly. The solution pH was slowly adjusted using ammonia solution drop wise to approximately 9.66. Then the mixture was put in hydrothermal cell (Teflon line autoclave) to put in the oven for 6 hours heated up and maintained at 150oC. Then the solution was washed with acetone and kept for drying at room temperature. The as-grown iron oxide products were characterized in detail in terms of their structural and optical properties. The development of Fe2O3 nanoparticles can be well explained stranded on the chemical reactions concerned and crystal growth behaviors of iron oxide. For the synthesis of Fe2O3 nano particles, ferric chloride (FeCl3) and NH4OH (in presence of urea) were mixed under continuous stirring at 150oC. During the reaction method, the NH4OH performs in major rules, like control the pH value of the solution as well as resource to supply hydroxyl ions to the solution. The FeCl3 reacts with NH4OH and forms FeOOH, which, upon heating, further produce into Fe2+ and OH- ions, which consequently assists in the development of Fe2O3 ions. The FeOOH finally, however dissociates to the formation of Fe2O3 nuclei. The initially formed Fe2O3 nuclei perform as building blocks for the development of final products. With reaction time under the appropriate heating conditions in hydrothermal method, the Fe2O3 nuclei concentration enlarges which escorts the construction of desired nanoparticle products. As the Fe2O3 NPs are prepared by the well accretion of low dimensional particles, therefore it is supposed that the fu undamental entity for the configuration of Fe2O3 structure is nano particles. The obtained produced substance can been characterized by XRD and TEM. Produced spherical particles with the average diameter of 30-40 $nm$ in size are observed approximately. The produced aluminium and ferric oxide nano particles are added to pure water which passes through heating pipe. Figure 1 show the photos of nano particles which are taken by electron microscopy. a) A composition of aluminium and ferric oxide mixed in water, b) SEM photos of produced combined nano particles.




a).




b-1).




b-2).

Figure 1. a). A composition of alumium and ferric oxide mixed in water, b-1 and b-2). SEM pictures

The experimental heat pipe which is used in this study is shown in the Figure 2. Temperature distribution is measured in different length of heating pipe by thermometers. Thermal resistance can be calculated by knowing the power value and difference temperature. Pressure values are measured by pressure gauges which are installed on the heating pipe. The head loss and required energy can be calculated from the amounts of pressure in different positions of pipe.

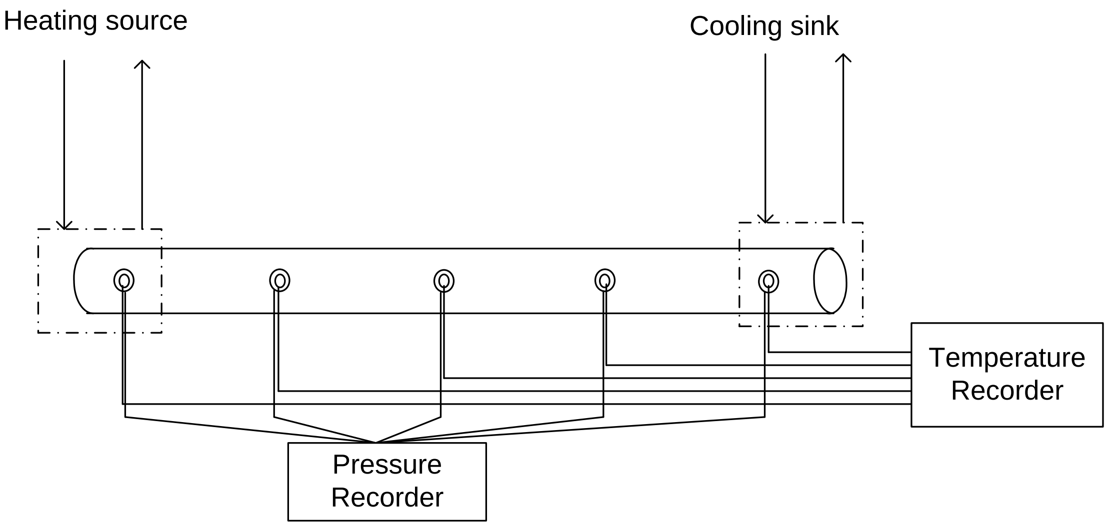



Figure 2. Schematic of heat pipe

## Results and Discussions

### 1. Temperature distribution of the tube wall

Temperature distributions are measured in different lengths of heating pipe for one kinds of aluminium and ferric oxide nanoparticles. The average size of this group is 35 $nm$. In this paper 35 Watt, 45 Watt, 55 Watt and 65 Watt are selected as input power to pipe.

### 1.1. Solutions contain 35 nm Zinc oxide particles

The temperature values of pipeline wall which produced nanofluid passes through it is shown in Figures 3, 4, 5 and 6. In these experiments, the nano particles with 35 $nm$ in diameter are added into pure water and passes through a pipe which is exerted by different values of power adjusted in 35 W, 45 W, 55 W and 65 W.

The obtained results state the higher dispersion of nano particles in pure water make the higher convective heat transfer coefficient and lower temperature distribution for the pipeline wall, finally.

Experiments show the higher power cause to the higher convective heat transfer and the lower temperature profile, ultimately. More details are achieved in the following Figures.

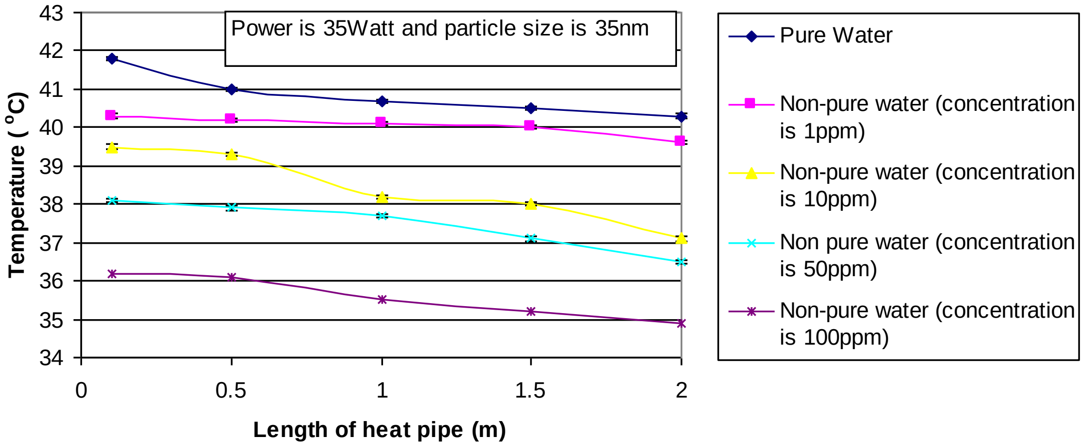



Figure 3. Variation of wall temperature during the length of heat pipe (input power is 35Watt)

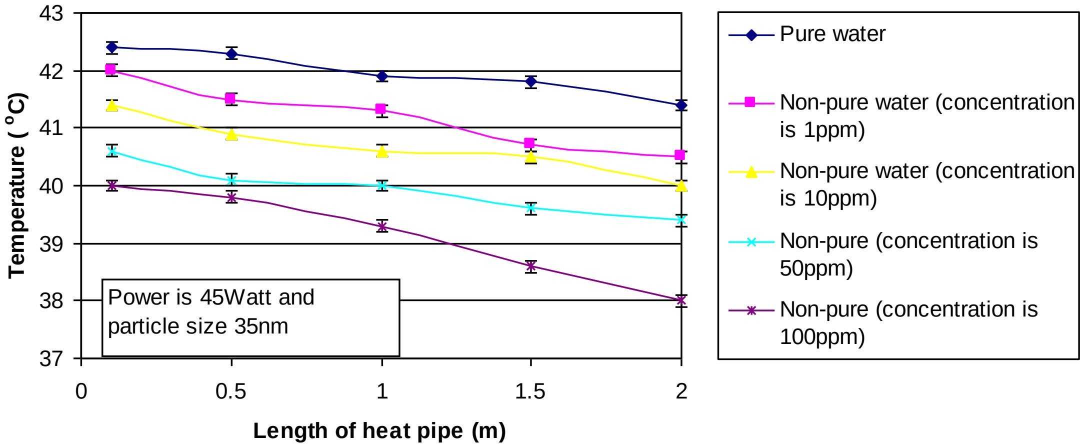



Figure 4. Variation of wall temperature during the length of heat pipe (input power is 45Watt)

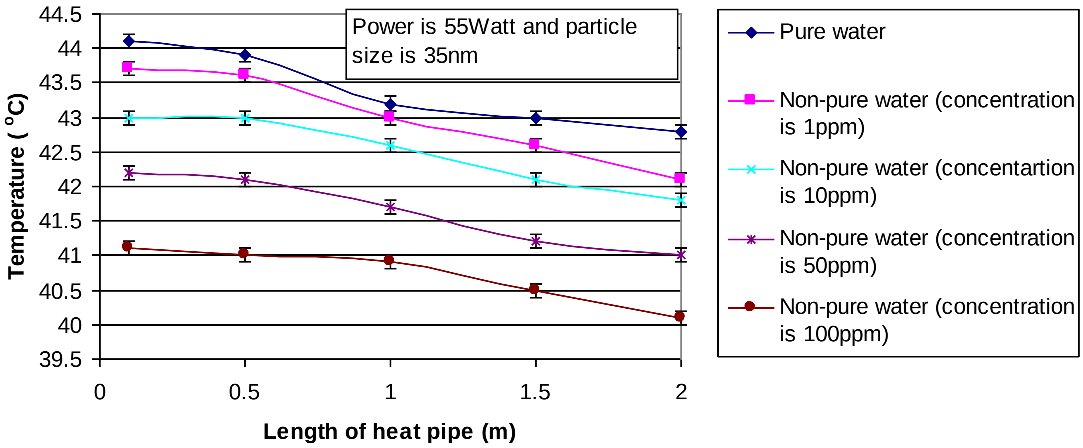



Figure 5. Variation of wall temperature during the length of heat pipe (input power is 55Watt)

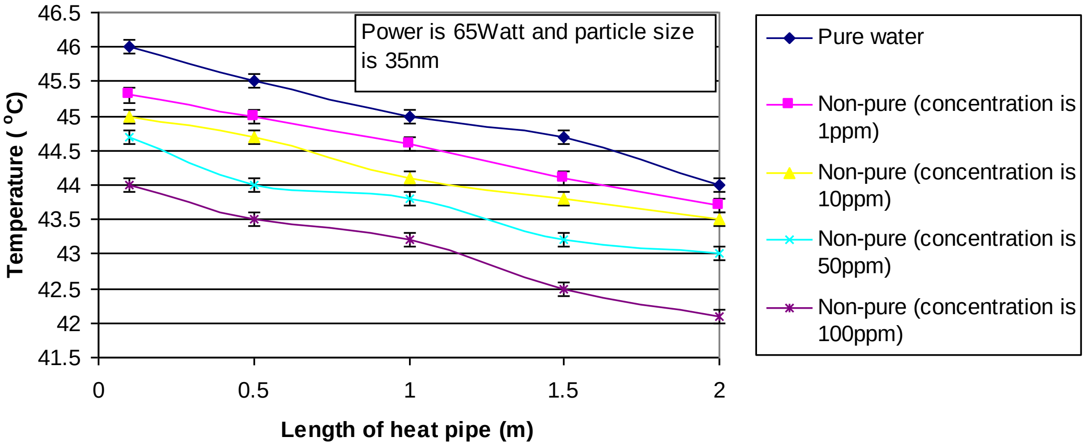



Figure 6. Variation of wall temperature during the length of heat pipe
(input power is 65Watt)

Figures 3, 4, 5 and 6 show the temperature distribution profiles for concentrations of 1, 10, 50 and 100 *ppm* of nano partocles in various powers. In addition, the temperature profile of pure water is illustrated in these Figures.

Figures 3, 4, 5 and 6 show the wall temperature of pipeline decreases slightly during the length of heat pipe. In addition, increasing the concentration of nanoparticles increases the convective heat transfer coefficient at the same power but temperature distribution decreases. According to the Figures 3, 4, 5 and 6 the temperature distribution of pipeline that contains 100 *ppm* nanoparticles is same approximately with the wall temperature profile of the pipe that contains 50 *ppm* nanoparticles. Therefore, the effective concentration of nano zinc oxide is 50 *ppm*.

For 45 watt power, the results show the partly same trend of temperature decreasing as for 35 watt. Although, increasing the nano- material concentration from 1 *ppm* to 50 *ppm* augments the convective heat transfer coefficient and retards the pipeline temperature but temperature profile in 100 *ppm* is observed higher than the profile related to 50 *ppm* concentration of zinc oxide. Due to Figure 4, dispersing 50 *ppm* of nano composition in the pure water reduces the temperature distribution about 5% in lower values comparing with ones in the pure water.

According to Figure 5, the temperature values are reduced by increasing nano particles dispersion in pure water when the pipe exposed to 55 *Watt* powers. Effective experimental results are obtained in 50 *ppm* concentrations with about 4% average reduction in temperature values of pipeline compared to the pure water. However, the observed temperature data of pipe contains 100 *ppm* nano- particles are same approximately to the results of that with 50 *ppm* concentrations. Data shows also, decreasing in wall temperature of pipe which contains 1, 10, 50 and 100 *ppm* nano-particles and also when the pipe contains sample pure water and exerted to power of 65 *Watt*. The effective concentration is 50 *ppm* with the average temperature reduction of 3% from the pure water.

Therefore, solution containing 50 *ppm* particles with 35 *nm* in diameter is the most effective cooling fluid in the used heat pipe according to the results.

## Conclusion

Investigations about the performance of heat pipes contain nano zinc oxide are done experimentally, in this wok. At the first, the nano zinc oxide is made and nano fluid utilizes by dispersing the particles in nano size in pure cooling water. The effects of size and quantity of nano particles that are dispersed in the cooling water are surveyed on the operational parameters such as temperature distribution of the pipe wall, heat pipe thermal resistance, pressure drop and the input pumping power. Different nano fluids contain 1, 10, 50 and 100 *ppm* nano zinc oxide with both 35 *nm* and 55 *nm* in diameter of particle are used in the experiments. In addition, different powers of 35, 45, 55 and 65 watt are applied in each experimental runs. Results are compared with ones obtained for pure cooling water.

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