Al_2O_3 NANOPARTICLES SYNTHESIS WITH SOL-GEL PROCESS TO IMPROVE COOLING ENGINE PERFORMANCE

Oki Maulana Rosadi[1], M. Ramdlan Kirom, S.Si, M.Si [2],

Dr. Abrar , S.Si, M.Sc [3] Dr. Dani Gustaman Syarif, M.Eng [4]

[1,2,3]Engineering Physics, Electric Engineering Faculty, Telkom University
[4]Nuclear Technology Center for Materials and Radiometry BATAN Bandung
[1] okimrs@gmail.com, [2]jakasantang@gmail.com, [3]abrarselah@gmail.com
[4]danigustamansyarief@gmail.com

Abstract

In this research will be to learn about one of the applications of nanotechnology, one of which is the application of making nanoparticle material. Nanoparticles have advantages could bring properties such as carrier particles, the number and have improved properties when compared with nano-particles with a size above. Alumina (Al_2O_3) is used as the base material of aluminum, has thermal properties that could make these materials as a conductor of heat and a heat sink. If used in nano size, is expected to be mixed with other materials, for use in everyday life. Suppose that can be applied in engine cooling system, in which the alumina nanoparticles to be mixed with the lubricant that will be called nanofluids, to improve the performance of the cooling engine.

Characteristics thermal properties of Al_2O_3 nanoparticles will be learned. Al_2O_3 nanoparticles derived from the Sol-Gel process which will be carried out on the research. The final result of compounds Al_2O_3 to be made into a nano size. XRD test and SAM (Surface Area Meter) is performed to determine whether the compound has nano-sized Al_2O_3 and know the content of what is contained in the Al_2O_3 compound. Further characterization of thermal properties of nanoparticles Al_2O_3 to be implemented on a heat transfer system.

Keywords :nanotechnology, nanoparticles, nanofluids, Alumina, Sol-Gel Method, Thermal Conductivity

1. Introduction

In the engine cooling system not only refrigerant that works, there is also a lubricant. Lubricant flows from the refrigerant compressor and returned to the compressor (reversible). Refrigerant oil consumption function is to avoid friction in the cooling engine system. Lubricant with refrigerant flows in the cooling engine used by researchers to try increasing the performance of the cooling engine.

Researchers use a lubricant with nanoparticles to increase performance of cooling engine. Nanoparticles used because it can increase the thermal conductivity of the working fluid cooling engine [1]. The increasing of thermal conductivity due to the nanoparticles have a larger surface area than microparticles so it can absorb heat more optimal. Beside of that nanoparticles have characteristics that can not precipitate in a long time. Beacause of the nanoparticles have a very small size, so it will not be affected by the gravitational force causes the particles to precipitate [2].

One of the studies use lubricant with TiO_2 nanoparticles to analyzing the vibration of the compressor. The results of these studies showed that the nanofluids could save 26.1% electric energy consumption and reduce 0.1% the vibrations of the compressor [3].

Nanofluids is a new invention of the nanotechnology that has high thermal performance characteristics and very promising for thermal engineering applications. A good cooling system is a system that can increased thermal conductivity, viscosity, and the fluid density, along with increasing volume of fluid in the cooling system. Nanofluids can be applied in the refrigeration system because it has the ability to improve the thermal conductivity of a working fluid, so the process of cooling and heating is more efficient.Because of that factors, in this study the researchers try to mix lubricant with Al_2O_3 nanoparticles in a purpose to increase the performance of the cooling engine.

2. Synthesizing $AlCl_3$ with Sol-Gel method to obtain Al_2O_3 nanoparticles

At the beginning $AlCl_3$ obtained from import purchases of the company Yixing Cleanwater Chemicals Co., Ltd. based in China with 95%-98% purity. Furthermore $AlCl_3$ powder processed by Sol-Gel treatment. Where the sol-gel treatment, $AlCl_3$ powder mixed with sucrose ($C_{12}H_{22}O_{11}$) or with starch ($C_6H_{10}O_5$) is used as a binder in the sol-gel treatment.

This mixture of $AlCl_3$ with sucrose, then the process will be gradual heating until 900^oC. The results of that process is Al_2O_3 nanoparticles was just to make sure to do the leaching process using a mortar.

Al_2O_3 (alumina) nanoparticles resulting from the synthesis of Sol-Gel with organic mixing using sucrose will then be tested by XRD (X-Ray Diffraction). In Figure 2.1 shows the results of XRD of calcined Al_2O_3 nanoparticles until 900^oC gradually within 7 hours.

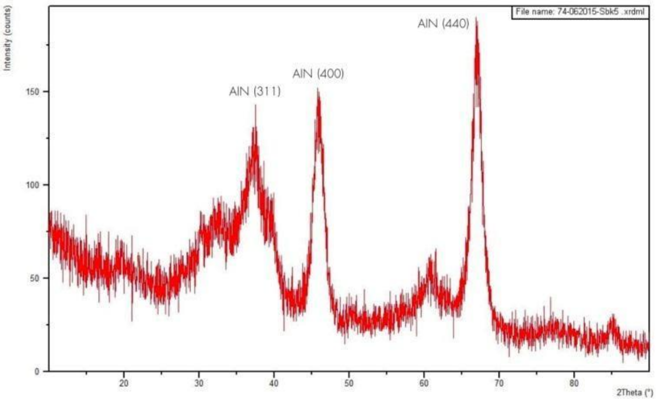

Figure 2.1. Results of XRD Al_2O_3

From the XRD results, it is known that the peak position 2 theta of Al_2O_3 nanoparticles contained in point 67, 46 and 38, where the 2theta point is the point of Al. Beams emitted form the diffraction peaks are high and small angle, it indicates if the nanoparticles shaped crystals.

Quantitative analysis of the XRD chart, can be determined by XRD software, but to use the software XRD analysis can not be done in this experiment, then do the review analysis. The review that used in this experiment is 10-0425 JCPDS database, the database has become reference to determine the structure of crystals and the concentration of Al_2O_3 nanoparticles.

After knowing the structure of the material using XRD test, then do the Surface Area Meter test to determine the size of the material that has been synthesized. Surface area measurement can be obtain using an instrument Quanthachrome NovaWin version 11.03. From these measurements it would be known how much surface area of the material being measured. Surface area measured is the surface area in the field of volume.

BET summary	
Slope =	14.141
Intercept =	3.317e-01
Correlation coefficient, r =	0.999989
C constant=	43.636
Surface Area =	240.624 m²/g

Figure 2.2 Results of Surface Area Meter Test

From the results of measurements of surface area, it is known that the large surface area of the Al_2O_3 is 260.624 m2 / gram. From the surface area measurement can be calculated how much the diameter of the particle. To determine the diameter of particles, can be done with approximation of diameter equivalent by measuring the specific surface area. Measuring the specific surface area can be obtain by Brunauer-Emmett-Teller (BET) methods [21]. The average particle diameter is obtained assuming the particles is spherical according to the equation :

.....……………………………………………………………………………………….…(1)

Where :
ρ = Density of Al2O3 (gram/cm3)
As = Surface Area of Al2O3 (m2/gram)

Using the equation (1), we can determine the average diameter of the Al_2O_3 particles were tested. Since the density of Al2O3 (3.97 g / cm3) was known and surface area (260.624 m2 / g), the results of the calculation of the average particle diameter is 6.26 nm. From these calculations, it is known that the diameter of the material can be categorized as nanoparticles, because the particle diameter ≤ 100nm.

3. Comparison of Thermal Conductivity Nanofluids with Three Concentration

Effective thermal conductivity is a way to calculate how much the conductivity of nanofluids. Effective thermal conductivity can be known if we have the conductivity data of the nanoparticles and the base fluid. If you already know the thermal conductivity of the base fluid and nanoparticles, then we can use the equation:

…………………………………………………………...……….………..(2)

Where :
Keff = Effective Thermal Conductivity
Kf = Thermal Conductivity of base fluids (Lubricant)
Kp = Thermal conductivity of Al_2O_3 (90% purity)
α = k/(1+k) ; k = Concentration ratio between the volume of base fluid and nanoparticles Al2O3.

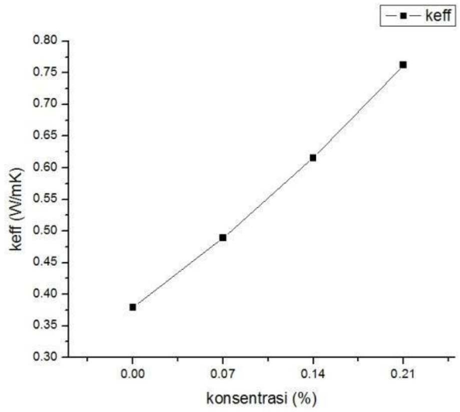

Figure 3.1. Calculation Graph of Effective Thermal Conductivity

On Figure 3.1 shows a different value of effective thermal conductivity for every concentration. The increasing effective thermal conductivity is directly proportional with the concentration of the nanoparticles. This is because the Al_2O_3 nanoparticles is one of the manifold metal material.The thermal conductivity of Al_2O_3 nanoparticles is 35 W / mK, so that when mixed with the lubricant will increase the thermal conductivity of the nanofluids than before.

The increasing of nanofluids thermal conductivity can also affect the cooling engine system, because the greater thermal conductivity of a material, the greater the material's ability to conduct heat.

4. Application Usage Nanofluids on Engine Cooling

The performance of the cooling engine, were tested using some variation of the concentration of the nanofluids. Nanofluids which is a mixture of base fluid in the form of compressor oil cooling machine were added with Al_2O_3 nanoparticles with several different concentrations.

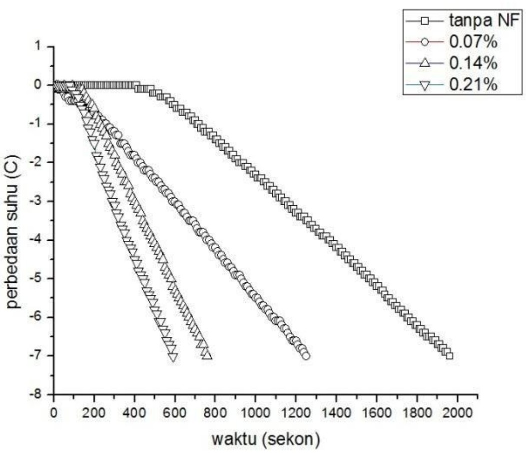

Figure 4.1 Graph Cooling With Various Concentrations

From the Figure 4.1, it is known that there are differences between the cooling time nanofluids with several different variations. Experiment in figure 4.1 was taken as much as 3-4 times per nanofluids with different variations. Each nanofluids, when compared to a standard lubricant, can accelerate the cooling is directly proportional to the addition of nanoparticles in a fluid base. Acceleration of the cooling caused by changes in the physical properties of the refrigerant, the effect of using of nanofluids can be seen when the system with the same condition comparing lubricant and using nanofluids, the same refrigerant input pressure, the use of nanofluids could make the freezing point of the refrigerant changes. It can be seen by comparing the time of decreasing temperature, between using nanofluids and pure lubricant.

Table 4.1. Electric power used for each experiment

Experiment / Data	I (0%)	II (0.07%)	III (0.14%)	IV (0.21%)
Electric Power (kWH)	0.0613	0.032	0.0211	0.0183

In Table 4.1 is known how much power is needed in the cooling cycle using nanofluids with several different concentrations. This data is obtained by measuring the electric power that goes into the engine cooling system by using a Watt Meter (electrical power measuring device). Because of the required electrical power is directly proportional to the time, the more time is required in the cooling cycle, the less electrical power is needed.

In all four experiments, the entire system on the cooling engine is on identical condition, ranging from the type of refrigerant, refrigerant pressure, loads of heat inside, load heat is cooled, the type of fluid-cooled (water), the volume of fluid that is cooled. Differences in each experiment is using nanofluids containing concentrations varied, so that it can be seen the effect of accelerating the use of nanofluids in cooling engine system.

Table 4.2. The data generated from performance measurement cooling engine

Percobaan / Data	I (0%)	II (0.07%)	III (0.14%)	IV (0.21%)
ΔT (°C)	7	7	7	7
Waktu(Jam)	0.547222	0.288889	0.2111111	0.1722222
Kalor jenis air (J/kg°C)	4200	4200	4200	4200
Massa air (kg)	1.5	1.5	1.5	1.5

From table 4.2 can be calculated from the cooling engine performance using nanofluids with some variated concentration. To calculate the performance of the cooling engine, using the equation :

……………………………………………………………………………… (3)

On each trial, the temperature difference (ΔT), the specific heat of water and the mass of water all the same conditioned. Which becomes the difference is the time taken for each experiment to cool the water, where the greater concentration of nanofluids, the faster it is also cooling.

Table 4.3. Performance of cooling engine with several concentrations

Percobaan / Data	I (0%)	II(0.07%)	III (0.14%)	IV (0.21%)
(W/W)	393.6786	398.125	441.23223	415.02732

Table 4.3 shows the performance calculation results of the cooling engine, but the performance that counted in this experiment is the comparison between the electric power coming into the system, with thermal power out of the system. Calculation of the thermal performance of a cooling engine is actually a calculation of the thermal power that goes into the engine, the thermal power released by the engine. But the comparison results in Table 4.3 is sufficient to show the general performance of the cooling engine. Performance calculation results in table 4.3 indicate if any increase in the concentration of nanofluids, the greater value of the performance of the engine coolant. It also can be the optimum point to a concentration that has the highest performance value is the concentration of 0:14% nanofluids.

5. Conclusions

The results of the research that has been done is as follows:

1 Al_2O_3 nanoparticles is a good materials in heat transfer applications, because it has been tested on the cooling engine .

2. The thermal conductivity of a material not necessarily affect the thermal properties of a material, because the thermal properties of the material can also be influenced by the density and specific heat.
3. The use of nanofluids affect the rate of cooling fluid in the cooling engine. The more concentration of nanoparticles in nanofluids mixture, will speed up the cooling of refrigeration.

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