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Comparison Study of Mechanical Properties of Al-Si Alloy with and without Nanoreinforce Iron Oxide (Fe_2O_3)

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ABSTRACT

Nanoreinforce materials such as ZnO, eggshell, Al_2O_3, TiO_2, and ZrO_2 have been shown to improve the mechanical properties of Al-Si alloy. Nanomaterial Fe_2O_3 has many applications as catalysts reaction in electronic devices, for example, semiconductor materials, paint formulations, lithium rechargeable batteries, and is often applied in industrial fields. It is known that Fe_2O_3 can be synthesized through the stirring process on machine and method used will involve several steps that relatively take a long time. In this study, Al-Si alloy reinforced by using nanomaterial Fe_2O_3 which sintered at a temperature of 600°C for 3 hours aimed to improve mechanical and morphological properties of Al-Si alloy. The method used was stir casting, where this method was known as flexible, simple, and economic. The result of reinforcing Al-Si alloy by using nanomaterial Fe_2O_3 had affected on the hardness level of Al-Si alloys as evidenced by the fracture morphology that was brittle and had a light reflection.

Keywords: *Fe_2O_3, Al-Si, Mechanical Properties, Morphology.*

I. Introduction

Fe_2O_3 is included into iron oxide material which has the same crystal structure as magnetite and also includes spinel ferrite and parts of ferromagnetic. Fe_2O_3 has optical properties that can be understood based on the width of the band gap by using the principle of light absorption. In the industrial sector, Fe_2O_3 has a potential application in catalysts reaction in electronic devices [1][2]. This study will apply Fe_2O_3 that sintered at a temperature of 600°C for 3 hours to reinforce Al-Si alloy. Al-Si itself is an alloy that has many applications in the industrial field, one of which is used for making piston. The increasing of Al-Si alloy usage in vehicles should be balanced by the increasing in the quality of these alloys, one of which is reinforced by using Fe_2O_3 which sintered at 600°C for 3 hours to improve its mechanical and morphological properties [3]-[5]. The method used is stir casting because this method is known to be economical and maximum during the process of stirring quickly [6][7].

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II. Materials and Methods

This study used stir casting method with the addition of Fe_2O_3 which sintered at a temperature of 600 °C for 3 hours as nano reinforced material with the composition of 0.05% in Al-Si alloys. The beginning of the process is to melt the Al and Si alloys in the furnace type T150/120-90 at 950°C. Then 0.05% of the Fe_2O_3 nanomaterial sintering 600°C 3 hours was mixed in the Al-Si alloy which had melted, and the quick stirring process could be carried out for 30 seconds using a GBM 350 hand drill with a stirrer with a stirring speed of 500 rpm. After that, the mixture of nanomaterial Fe_2O_3 sintering 600°C 3 hours and Al-Si alloy is poured into a permanent mold made of steel, where the pouring process must be done quickly to avoid hardening and minimize the occurrence of porosity defects. After the process is complete, the Al-Si alloy is removed from the permanent mold, and then the hardness test is done using the MM 0054 Micro Hardness tool by using a major load of 100 kg, indentor Steel Ball 1/16, both surfaces of the test material must be flat, and the length of the surface pressing for 5 seconds.

The tensile strength test using the Tokyo Testing Machine tool which has a maximum loading of 50 kN and before testing the test material must be measured at the initial length and then mounted on the test equipment by clamping the material in a tight condition so that it is not released when pulled. The measuring needle set on the indicator is shaped like a clockwork consisting of two needles, the first needle is red, and the second needle is black. Then the withdrawal is done by giving loading until the test material is cut off. After the material is cut off the needle on the indicator will show the value of the tensile strength of the test material, then calculate the strain that occurs in the test material. Microstructure observed with metallurgical microscope Olympus type PME3-111B/-312B by placing the material on the preparation table then adjusting the objective lens to fit the target and adjusting the focus of the microscope to clarify the image seen from the eyepiece lens. When the object's shadow has been found, increase the size by replacing the lens according to the desired size and in accordance with the microscope specifications, and macrostructure using a Canon EOS 1200D DSLR camera the material is placed in a flat place and not exposed to vibration, then directs the camera to the object that has been set.

III. Results and Discussions

A. Tensile Strength Analysis

Figure 1 shows the resulting diagram of tensile test of raw Al-Si alloy and Al-Si alloy reinforced nanomaterial Fe_2O_3 sintered at a temperature of 600 °C for 3 hours. The tensile test results of Al-Si raw material showed a tensile strength of 24.76 kg/mm² and Al-Si alloys reinforced by nanomaterial Fe_2O_3 showed tensile strength of 7.53 kg/mm². The nanomaterial of Fe_2O_3 cannot strengthen the tensile strength of Al-Si alloys. Although the nanomaterial Fe_2O_3 is soluble in Al-Si alloys, nanomaterial Fe_2O_3 has very little solubility in solids. So that the Fe_2O_3 nanomaterials tend to join with other elements to form intermetallic phase particles of various types of elements, and the phases formed in this case are Al_8Fe_2Si (α phase) and Al_5FeSi (β phase) [8][9]. The tensile strength can also be influenced by the level of porosity and the small size of the porosity level, which affects the tensile strength of Al-Si alloys. Porosity occurs because the flow of interdendritic fluid is inhibited during the pouring process, so it cannot spread evenly [10]-[12].

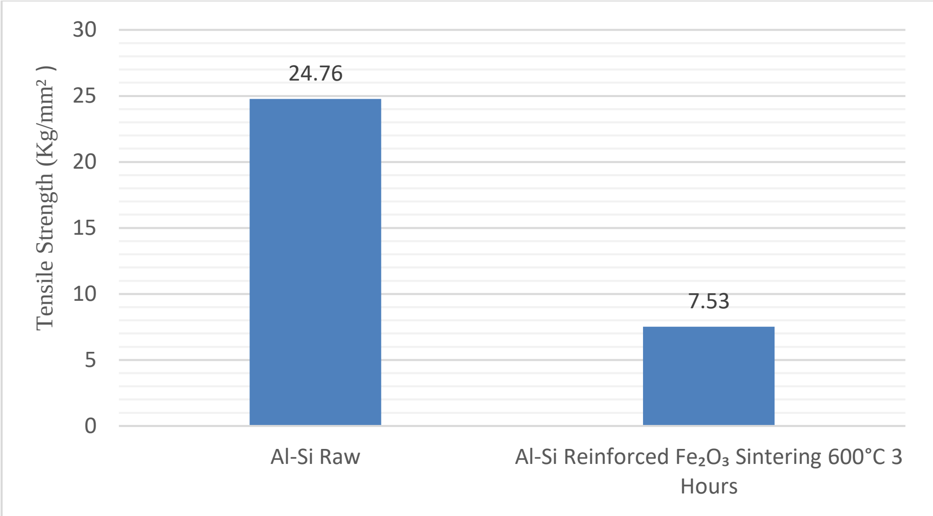

Fig 1. Comparison of the tensile strength of Al-Si alloy

B. Hardness Analysis

Figure 2 shows the resulting diagram of hardness test of raw Al-Si alloy and Al-Si alloy reinforced nanomaterial Fe_2O_3 sintered at a temperature of 600°C for 3 hours. Al-Si alloy reinforced by nanomaterial Fe_2O_3 affecting the hardness of Al-Si alloys. There was an increase in the value of Al-Si raw hardness 108.83 HV to 118 HV after adding Fe_2O_3 sintering 600 °C 3 hours nanomaterials. When the level of Fe_2O_3 increases, the tenacity of the Al-Si alloy will consistently decrease, and there will be an increase in the hardness. This occurs accompanied by a decrease in tensile strength and general yield strength, which remains unaffected by the Fe_2O_3 sintering 600 °C for 3 hours nanomaterial [8][9][13].

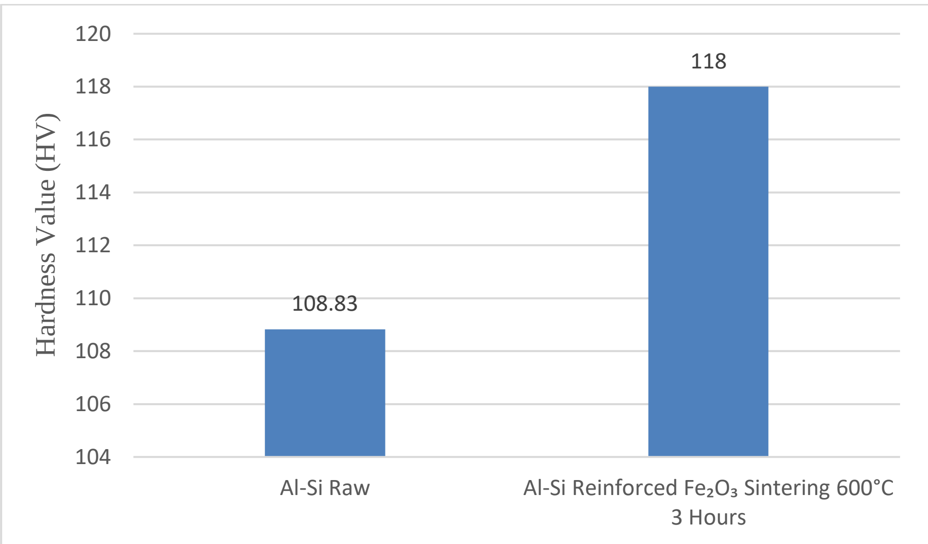

Fig 2. Comparison of the hardness of Al-Si alloy

C. Microstructure Analysis

The following is the result of testing photos of Al-Si alloys micro alloys, and Al-Si alloys reinforced Fe_2O_3 sintered at a temperature of 600 °C for 3 hours.

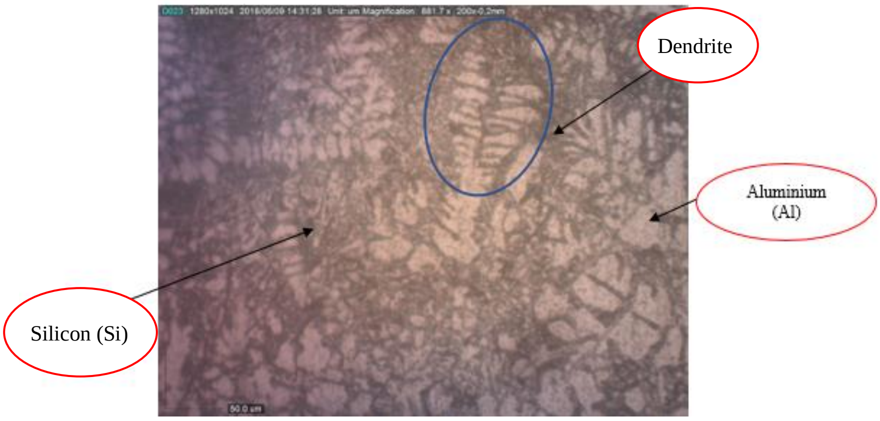

Fig 3. The microstructure of Al-Si raw material

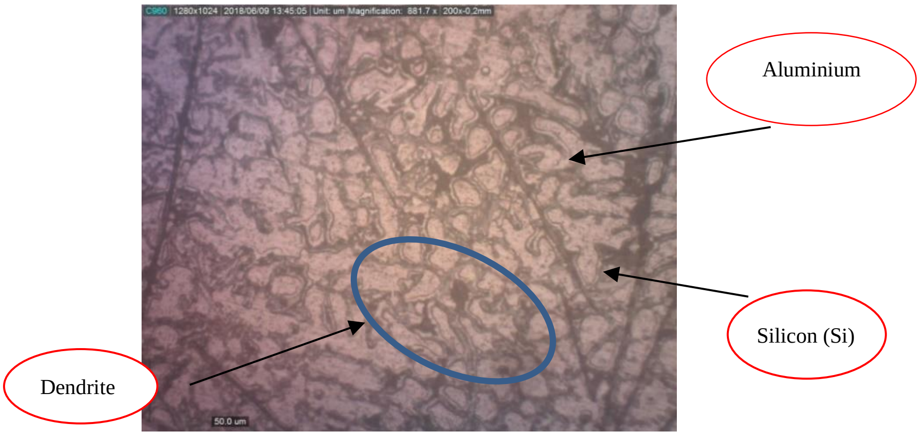

Fig 4. The microstructure of Fe_2O_3 sintering 600 °C 3 hours

Figure 3 showed the microstructure of an Al-Si raw alloy where grain size appears small, grain distribution appears evenly distributed, and dendrites appear small compared to Fe_2O_3. Figure 4 showed the microstructure of the Al-Si alloy reinforced Fe_2O_3 where grain size appears small, grain distribution appears evenly distributed, and dendrites appear larger than Al-Si raw alloy. Other because the cooling and compaction process looks perfect and faster. The intermetallic phase in the process of compaction and cooling is formed before the process of forming dendrites and grows freely in the liquid. Al-Si dendrite alloy reinforced by Fe_2O_3 appears larger than Al-Si raw alloy due to compaction rate and cooling of Al-Si raw alloy faster [9][11][12].

D. Analysis of Macrostructure

The result of a macrostructure observation on raw Al-Si alloys and Al-Si alloys reinforced by Fe_2O_3 is shown in Figure 5 and Figure 6.

Fig 5. Morphology of raw Al-Si alloy faults

Fig 6. Morphology of Al-Si alloy reinforced by Fe_2O_3

Figure 5 Al-Si raw alloys seen the fracture appear brittle, fracture surfaces that appear flat, and provide reflective power. Figure 6 showed the fracture of Al-Si alloy reinforced by Fe_2O_3 appear brittle, provide reflected light power, and appear to have considerable porosity. This is due to the presence of a substance trapped at the point of porosity so that the compaction and cooling process seems imperfect [14][15].

IV. Conclusions

Reinforcing Al-Si alloy by using Fe_2O_3 which sintered at a temperature of 600°C for 3 hours, cannot increase its tensile strength and conversely, its process can increase the hardness of Al-Si alloys. Reinforcing Al-Si alloy by using Fe_2O_3 increased the hardness of the Al-Si alloy from 108.83 HV to 118 HV. The microstructure showed that dendrites of Al-Si raw alloys were smaller than Al-Si alloys that reinforced by Fe_2O_3. The results of fracture morphology of raw Al-Si alloys and Al-Si alloys that reinforced by Fe_2O_3 seemed brittle, and there was a considerable degree of porosity in Al-Si alloy.

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