Influence Of Heat Treatment on the Density and Surface Roughness Aluminium Alloy-Coal Bottom Ash Particle (5 Wt%) Composites for Bolts and Nuts Aplications

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Abstract. Metal composite or better known as Metal Matric Composite (MMC) is a combination of two or more materials, in which the metal as a matrix and ceramic as an amplifier to obtain the desired characteristics. To produce solid components and fine microstructure in its manufacture, the squezze casting process has an approximate capability. In the manufacture of Aluminium matrix composites, to obtain better mechanical properties such as: hardness and strength required existence of heat treatment process T6. The purpose of this research is to know the influence of pouring temperature and pouring time variation on squeeze casting process to density and surface roughness of 6061-coal bottom ash composite. The research method was done by casting aluminium 6061 to melt at 660^0C and then added coal bottom ash electroless plating and magnesium, the temperature was increased with variation of casting temperature 675^0C, 700^0C and 725^0C. Poured with 60 seconds, 90 seconds, 120 seconds and then pressed with a 20kg load. Then we got T6 heat treatment. The tests include density testing, surface roughness testing. The results of the research on the density test showed that the amount of density that occurred after the heat treatment T6, the value is greater. This shows the presence of expansion and shrinkage during the T6 heat treatment process. Based on the results of the surface roughness testing the added value of the roughness is greater than T6 between 5% - 10% of the initial roughness value before T6.

Keywords: Aluminium 6061, bottom-ash, composite, density squeeze casting, surface roughness, T6 heat treatment.

1. Introduction

Bolt and nut components are very widely used, because the function of the bolt is as a means of connecting or binding components with each other, in order to become a solid unity and formed according to the desires of the designer. Connection techniques using bolts and nuts are relatively safer, as they are easier to install and disassemble when necessary to do things like maintenance, repair and more. The choice of bolts and nuts as a means of attachment or binder in this case for bridge construction shall be done carefully and thoroughly to obtain the quality or strength of bolts and nuts corresponding to the

construction. Bolts and nuts for bridge construction shall have several conditions in order to be used that is to have high strength with low weight, corrosion resistance, wear resistance, and the direction of strength can be controlled, Then the eligible material is composite [1 – 3].

Material selection plays an important role in the quality of bolts and nuts. Bolts and nuts are made of composite metal material is one of the alternatives to consider. Metal composites are the most qualified to be applied in bridge construction. The use of Aluminium as a matrix is the most popular in the manufacture of metal composites, due to its lightweight and corrosion resistant properties. But in various applications such as transportation and construction has been limited due to low strength, stiffness and wear out resistance. The composite material is a material system composed of a combination of two or more different micro or macro elements in form, composition, chemical and essentially insoluble in each other, one of which is called a matrix and the other is a filler. The fill phase is embedded in the matrix to provide the desired characteristics. Aluminium 6061, Namely is 6xxx aluminium alloy containing magnesium and silicon as the main alloying element. Density is 2.7 gr/cm^3 and melts at a temperature of about 630^{0}C. The last two digits of Al 6061 identify that the different aluminium alloys are in the group [5, 7]. The second number shows the modification of the alloy. A second digit of zero indicates the original alloy and integers 1 through 9 indicate the modification of successive alloys. Coal bottom ash is one of the oxide materials composed of more than 70% coal bottom ash, SiO_2 and Fe_2O_3 which has a high hardness value and has a liquid point up to above 2000^{0}C. The main problem in the manufacture of reinforced composite materials with oxide materials is wettability. Therefore, to increase the wetness on the surface of coal base ash particles, it is necessary to add Mg to the wetting agent by going through the coating process of coal bottom ash powder using electroless plating method.

One method that can be used in making MMC is by squeeze casting method. There are several factors that influence the squeeze casting process such as casting temperature and cast time. but the results of squeeze casting process will affect the density and surface roughness of the bolts and nuts. Squeeze casting is also called liquid metal forging, a process whereby the metal in liquid condition is cooled and also given pressure. This process essentially combines the advantages of forging and casting processes.[4 – 7]

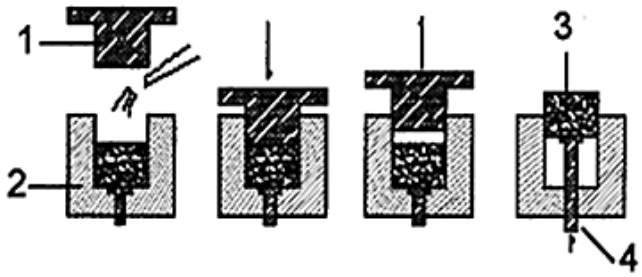

Fig. 1. Squeeze Casting Mechanism

In the manufacture of Aluminium matrixed composites, to obtain better mechanical properties such as: hardness and strength, a T6 heat treatment process is required. T6 heat treatment is a heat treatment process above the solvus line, then saturated for a while and continued by quenching. The T6 heat treatment process combines heating and cooling to solid

metal over a period of time in order to obtain certain mechanical properties. This heat treatment process depends on its usage, as it can be used to tighten, soften, remove residual stress, and to improve engine capability. The following steps are taken during the aging process: 1)Solution treatment at 530^0C for 120 seconds. 2)Quenching in water at 80^0C. 3)Stabilization at room temperature for 30 seconds. 4)Aging at 180^0C with different time variations starting from 120 seconds.

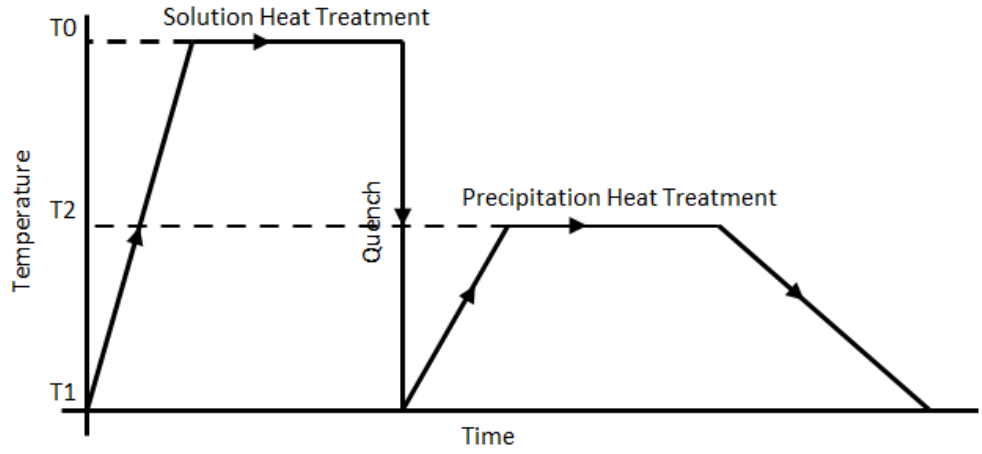

Fig. 2. T6 Heat Treatment mechanism

After quenching is done and then heated again to below the solvus line, the specimens is held for long periods of time and then the cooling treatment is slow in the air. However, the frequent constraints on the heat treatment process are distortion, dimensional changes (shape and size). The heat treatment of the material can change its dimensional shape and microstructure so that it will affect its mechanical properties. First, before the creation of specimens of nuts and bolts, it is necessary to review the experimental materials to be used in order to better.

1.1. Research Purpose

Effect of variation of temperature and time casting by squeeze casting process on density and surface roughness of nut and bolt made Aluminium 6061-coal bottom ash composite is studied. Aluminum 6061 as a matrix and coal bottom ash as a reinforcement.

1.2. Research Scope

At this study, we consider the following frameworks of the problem:

(i) Applied technology squeeze casting method in the manufacture of MMC Aluminium;
(ii) Applied technology of T6 heat treatment on Aluminium 6061-coal bottom ash composite to obtain effective mechanical properties;
(iii) Measurement and analysis of density before and after T6 heat treatment on Aluminium 6061-coal bottom ash composite;

(iv) Measurement and analysis of surface roughness level before and after T6 heat treatment on Aluminium 6061-coal bottom ash composite.

2. Research Method

2.1. Research Flowchart

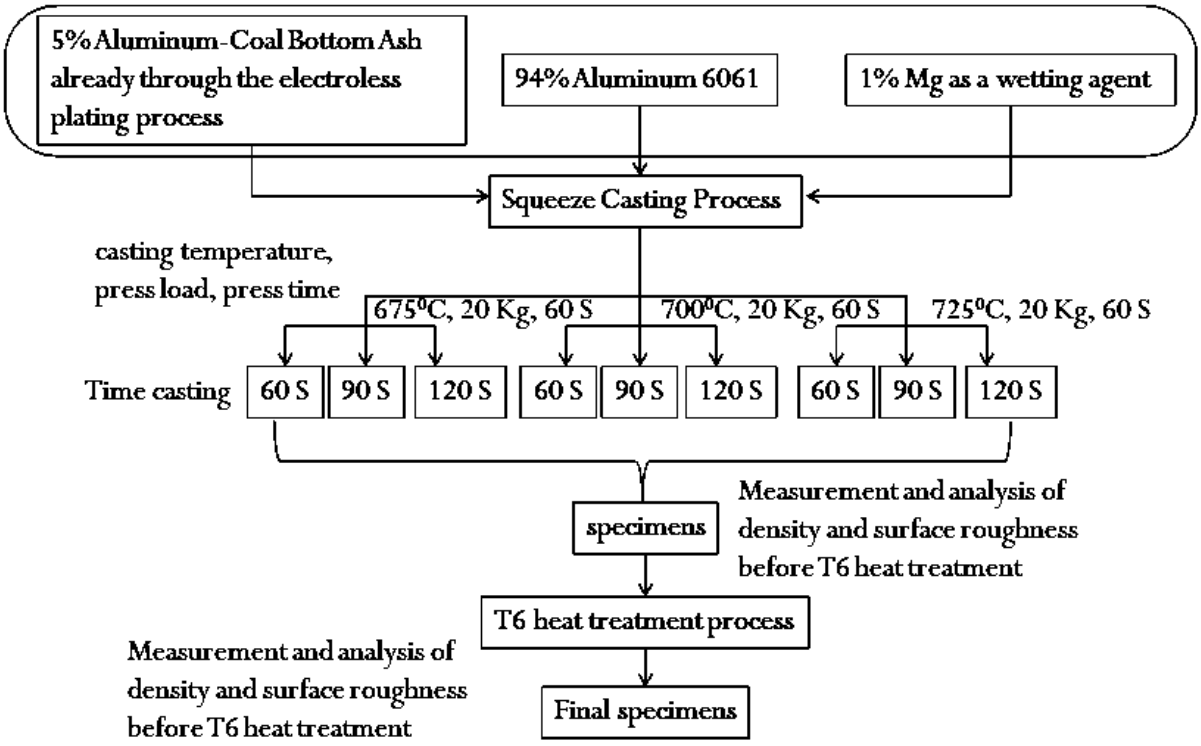

Fig. 3. Research Flowchart

2.2. Description of test / measurement

The density size of a substance is expressed by the amount of matter or mass per unit volume. Density is used in determining the type of substance. Each substance has a different density[1,3]. A substance with any mass regardless of its volume will have the same density. Any object submerged partially or completely into the fluid, tha will get an upward force of the weight of the fluid transferred by the object that is the Archimedes law. Things are immersed in water, there are three possibilities that will be experienced by the object, which is floating, being floated and drowned. The object is said to float in liquid when some of object is dyed and partly appear in the air, because the density of the object is less than the density of the liquid. In this experiment, the law of Archimedes applies so that the equations used to calculate the density are as follows:

$$\rho = \frac{\rho_{air} \times m_k \times \mathrm{g}}{\mathrm{W}_k - \mathrm{W}_b} \quad (1)$$

ρ is mass density (kg/m^3), ρ_{air} is the density of water (1000 kg/m^3), m_k is the dry mass of the specimen (kg), W_k is the dry weight of the specimen (N = kg.m/s^2), Wb is the weight of wet specimen (N = kg.m/s^2), and g is gravity acceleration (9.8 m/s^2)

In industry, the surface of the workpiece has a different surface roughness level, appropriate to the needs of the tool. Surface Roughness has a different quality (N). The surface roughness quality has been classified by ISO that the very small price is N1 which has a surface roughness (Ra) 0.025 μm and the highest is N12 which has a roughness 50μm.

Surface roughness measuring instrument used is Surface Roughness Mitutoyo, this tool can be used to observe or measure surface roughness with ISO standards. Some of the data that this Surface Roughness tool can show is the values of the surface roughness and graphs on the surface roughness. Surface roughness is defined by several parameters: 1) Total Roughness (Rt), is the distance between the reference line and the base line. 2) Roughness Grading (Rp), is the distance between the reference line and the measured line. 3) Roughness of Arithmetic Average (Ra), is the arithmetic value of the measured midline and line.

The working mechanism of the Surface Roughness Tester is to put the sensor needle (Styus) attached to the test equipment, then align the surface measuring instrument with the material to be tested. At the time of the process, the measuring instrument must not move because it will disturb the sensor in reading of surface roughness of the material. The measurement values obtained will appear on the display that is compatible with four standards including ISO world, SIN, ANSI and JIS, so no doubt the precision and accuracy in the measurement accuracy.

3. Results and Discussion

3.1. Density Testing

Table 1 presents the results of density testing before and after the T6 heat treatment process.

Table 1. The results of density testing before and after the T6 heat treatment process.

Squeeze Casting Process	Density (kg/m^3)		
	Before	After	Difference
675°C, 60 s	2637,09	2735,09	98
700°C, 60 s	2690,54	2752,91	62,37
725°C, 60 s	2708,36	2770,73	62,37
675°C, 90 s	2619,27	2699,45	80,18
700°C, 90 s	2663,82	2726,18	62,36
725°C, 90 s	2681,64	2744,01	62,37
675°C, 120 s	2592,54	2663,82	71,28
700°C, 120 s	2646,02	2681,64	35,62
725°C, 120 s	2654,91	2708,37	53,46

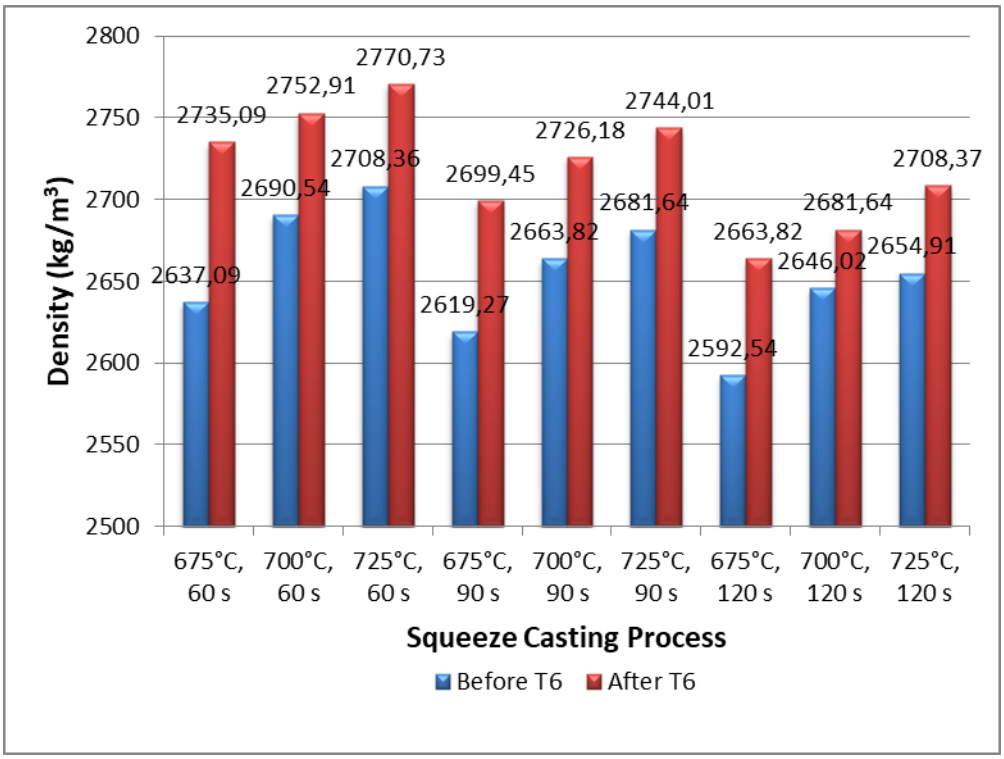

Fig. 4. Density graph before and after T6 heat treatment.

In Figure 4, it can be seen that there is a difference in the density of the specimen between before and after T6 heat treatment. It can be said that the T6 heat treatment affects the density of a specimen. In Figure 4, it can also be seen that the squeeze casting process variable greatly influences the density. The variables used are pouring temperature 675^0C, 700^0C, 725^0C and pouring time 60 seconds, 90 seconds and 120 seconds. Based on the pouring temperature variation and the time of pouring in the squeeze casting process, the density of the test specimen is greater after obtaining T6 heat treatment. The pouring temperature of 725^0C with the time of pouring 60 seconds after heat treatment T6 produces the largest density compared to the temperature variation of the pour and the time of pouring in the squeeze casting process after T6 heat treatment with the others. This is because the effectiveness of the time in pouring and the temperature that is far above the melting point of the specimen makes the castings solid when given a stress load during the squeeze casting process.

3.2. Surface Roughness Testing

Surface roughness testing is carried out in the upper part of the specimen. Table 2 presents the results of surface roughness before and after T6 heat treatment.

Table 2. The results of surface roughness before and after T6 heat treatment.

Squeeze Casting Process	Surface Roughness (μm)		
	Before	After	Difference
675°C, 60 s	2,87	3,49	0,62
700°C, 60 s	2,18	2,42	0,24

725°C, 60 s	1,69	1,79	0,1
675°C, 90 s	3,03	3,74	0,71
700°C, 90 s	2,32	2,84	0,52
725°C, 90 s	1,8	1,93	0,13
675°C, 120 s	3,26	3,83	0,57
700°C, 120 s	2,5	3,33	0,83
725°C, 120 s	2,08	2,33	0,25

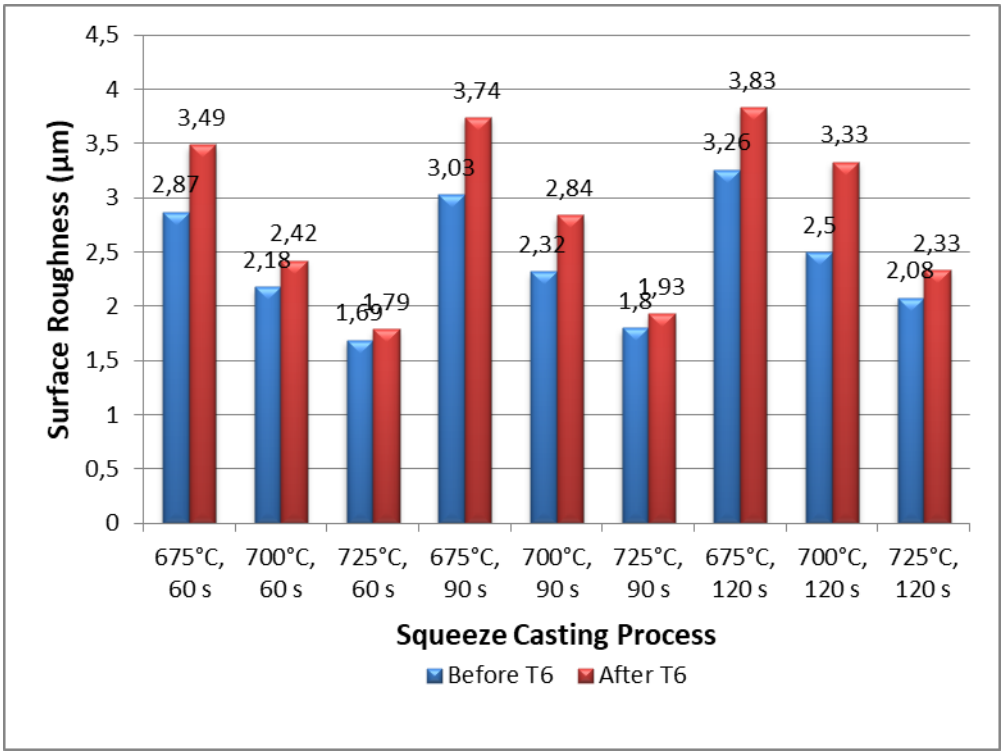

Fig. 5. Surface roughness graph before and after T6 heat treatment.

In Figure 5, it can be seen that there is a large difference in the surface roughness of the specimen between before and after T6 heat treatment. After heat treatment the T6 surface of the specimen becomes coarser. It can also be seen that the squeeze casting process variable greatly affects the amount of surface roughness. The variables used are pouring temperature 675^0C, 700^0C, 725^0C and pouring time 60 seconds, 90 seconds and 120 seconds. Based on the pouring temperature variation and the time of pouring in the squeeze casting process, the surface roughness of the test specimen increased after obtaining T6 heat treatment. pouring temperature of 725^0C with 60 seconds of pouring time before T6 heat treatment results in the smallest / smoothest surface roughness compared to the pour temperature variation and the time of pouring in the squeeze casting process before T6 heat treatment with the others. This is due to the effectiveness of the time in pouring and the temperature far above the melting point of the specimen. The faster pouring the less air that enters, so that a little air bubbles stick to the surface of the specimen and make the surface of the specimen smoother.

4. Conclusion

MMC Aluminum with Aluminum 6061 as a matrix and ash coal base as filler has formed. The results of the analysis showed a significant change in the density of the test specimens after the T6 heat treatment process. The largest density is 2770.73 kg/m3 for casting temperature at 7250C for 60 s. The results of the analysis showed an increase in surface roughness values in the test specimens after the T6 heat treatment process. Increased Surface Roughness after Heat treatment T6 is relatively the same, not too different. However, the smallest surface roughness is at the temperature of 7250C that is 1.69 μm and the largest surface roughness is at 6750C that is 3.83 μm.

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