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Effects Of Peat Soil Carbon As Reinforcement On The Microstructure And Density In Recycled Aluminium Chips AA6061

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Abstract: The reinforcement materials on aluminium metal matrix composites are widely used in manufacturing sector due to lightweight, superior strength-to-weight ratio, better fracture toughness, and improved the mechanical properties. This study investigates the effect on composition of peat soil as reinforcement on AA6061 aluminium chip to physical properties of metal matrix composite. AA6061 aluminium chip reinforced with peat soil at various composition prepared by using cold compaction method were investigated. Due to the lower energies consumption and operating cost compared to conventional recycling by casting, this method was applied to study the physical properties of metal matrix composite samples. As a result, the addition of composition of peat soil shows improvement in term physical properties for composite compared to unreinforced AA6061 aluminium chip. The physical properties on density of metal matrix composites samples shows the increment up to 7.5 wt.% of peat soil, and then decreased at increasing mass fraction of peat soil. The addition of peat soil as reinforcement material shows the improvement on metal matrix composite samples.

Keywords: Aluminium, Peat, Recycling

1. Introduction

Aluminium is the most heavily consumed nonferrous metal in the world, with current annual consumption at 24 million tons[1]. In the 100 years since the first industrial revolution on aluminium production, worldwide demand for aluminium has grown to around 29 million tons per year. About 22 million tons are new aluminium, and 7 million tons are recycled aluminium scrap. The use of recycled aluminium is economically and environmentally compelling. It takes 14,000 kWh to produce 1 ton of new aluminium. Conversely, it takes only 5% of this to remelt and recycle one ton of aluminium [2].

About recycling, there are many notable difficulties to keep in mind, which are: metal loss owing to metal chips with high reactivity, noxious gases produced by the burning of oil emulsion that adheres

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to waste chips, and the impact on costs. Based on meticulous examination of recycling efficiency, energy consumption, expense, and environmental implications, the solid-state recycling process is a better option for converting scrap chips or turnings into bulk products and semi-products with higher mechanical qualities than remelting. Many studies have reported on the solid-state recycling of nonferrous metal chips (such as Mg, Ti, Cu, Al chips)[3]. Through recycling activities, new particle-reinforced metal matrix composites (high specific stiffness, specific strength, and high creep resistance) can be made. Metal-matrix composites are attractive possibilities for usage in aerospace, defense, and vehicle applications. Class-sensitive materials affect the mechanical behavior of metal matrix composites dramatically. hence, understanding the link between strengthening behavior and microstructure is crucial in designing improved metal matrix composites.[4]

Peat is defined as partially decaying vegetation that remains amassed under saturated surroundings and in the absence of oxygen. Peat in Malaysia is known as tropical woody peat, and consists of the semi-decomposed plant remains of tree stumps, roots, twigs, leaves, and roots [5]. In this study, peat particles will be mixed with aluminium chip and powder methodology containing cold pressing and sintering processes due to the ability to overcome all the disadvantages of recycling aluminium waste chips.

1.1 Problem statement

Kadir[6] mentioned using cold compaction and fabricated metal matrix composite, a method of solid-state recycling aluminium alloy has been developed. On paper, the recycled AA6061 aluminium chip and silicon carbide Al-SiC were demonstrated using various SiC and aluminium powder compositions. Because of its high compressive strength, adding SiC to solid-state recycling has become popular [7].

This material can be replaced by peat particles as high compression strength and low shear strength are shown in the research paper [8]. The use of peat soil for metal matrix composite as reinforcement and are rarely documented in recent literature. Thus, this study will be utilizing the cold compaction process due to low cost and time production. Therefore, peat soil will be used as a reinforcement in recycling AA6061 chips to investigate if percentage affecting the density of the composites.

1.2 Objective

The main objective of this research the suitability of peat soil carbon as reinforcement in aluminium chip A6061 composition and producing samples. This research analyses the microstructure and density of aluminium composites.

2. Materials and Methods

In this chapter, it will clarify more about the process undertaken in this research. The aim of all the process involved is to achieve the objective and to endure smooth of the research running in this study. The main objective of this research work is to investigate the microstructure and density of the samples.

2.1 Materials

The metal matrix material in this study was an aluminium AA6061 block with a theoretical density of 2.7 g/cm^3. This aluminium block was supplied by the Newspark Technology and Chengdu Best New Materials Co., Ltd., China. Aluminium chips were generated using a CNC milling machine of the type High-Speed Milling (SODICK – MC4301), with a feed rate of 1100 mm/min, a depth of cut of 1.0 mm, and a cutting velocity of 345.4 m/min. The peat particle can be obtained from the leftovers of dry peat soil that have been crushed and sieved to get 63 µm particle size using vibrator type apparatus in 30 minutes with an amplitude of 1.

2.2 Methods

The uniaxial hydraulic press machine Carver type 3851-0 was used for the compaction process. The AA6061 aluminium chips were mixed with 63µm of peat soil at appropriate composition as shown in Table 1, before being placed into the mould to shape the sample. The load compaction setting and compaction process holding duration were 9 tonnes and 20 minutes, respectively[9]. For easy sample removal, the surface of the die was cleaned by spraying it with a lubricant-saturated solution. The samples were then sintered at 552°C for 60 minutes, as illustrated in Figure 1.[9]

Table 1. Metal Matrix Composites Samples Preparation For Mixing Process

Samples	Composition of samples
1	AA6061 aluminium chip
2	AA6061 aluminium chip + 2.5 wt.% peat soil
3	AA6061 aluminium chip + 5.0 wt.% peat soil
4	AA6061 aluminium chip + 7.5 wt.% peat soil
5	AA6061 aluminium chip + 10.0 wt.% peat soil

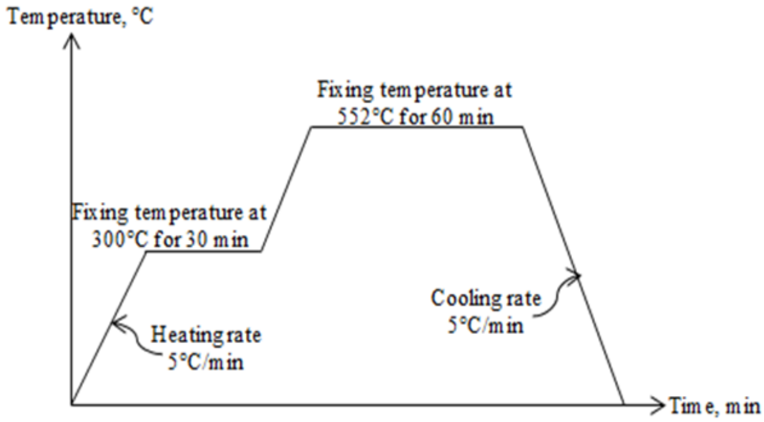

Figure 1: Sintering profile[9].

2.3 Microstructure and physical test

The Olympus BX60M optical microscopic is used to produce image microstructure up to micron scale. The picture was acquired between 50-100 times on the composite surface of the sample on a 100-micron scale. The physical test consists of measuring the density, porosity, and water absorption of metal matrix composites using the Archimedes Principle and an electronic balance from Mettler Toledo Germany.

3. Results and Discussion

This chapter discuss the outcome of the optical microscopy observation and density, porosity and water absorbability test.

While the compressibility of AA6061 chips and peat soil carbon is an essential factor in densification behavior, this behavior is prone to change based on the compressibility of the chips and peat soil carbon. Properly formed bodies yield proper results. Higher magnification was used to focus on the area on the body that contains both chip and peat soil carbon. Large chips can create a significant number of holes due of their varied sizes, ranging from 2mm to 4mm. Peat soil carbon was added in modest amounts gradually, and this caused the pore size to decrease and the formation of grain boundaries to rise as the proportion of peat soil carbon grew. As a result, the fine peat soil carbon was able to fill the huge pores in the contact zone of the AA6061 chips. The weight proportion of peat soil carbon is dependent on chip theoretical density. the peat soil carbon is spread evenly; the chip shapes and sizes lead to gaps and pores being apparent as per shown in Figure 2.

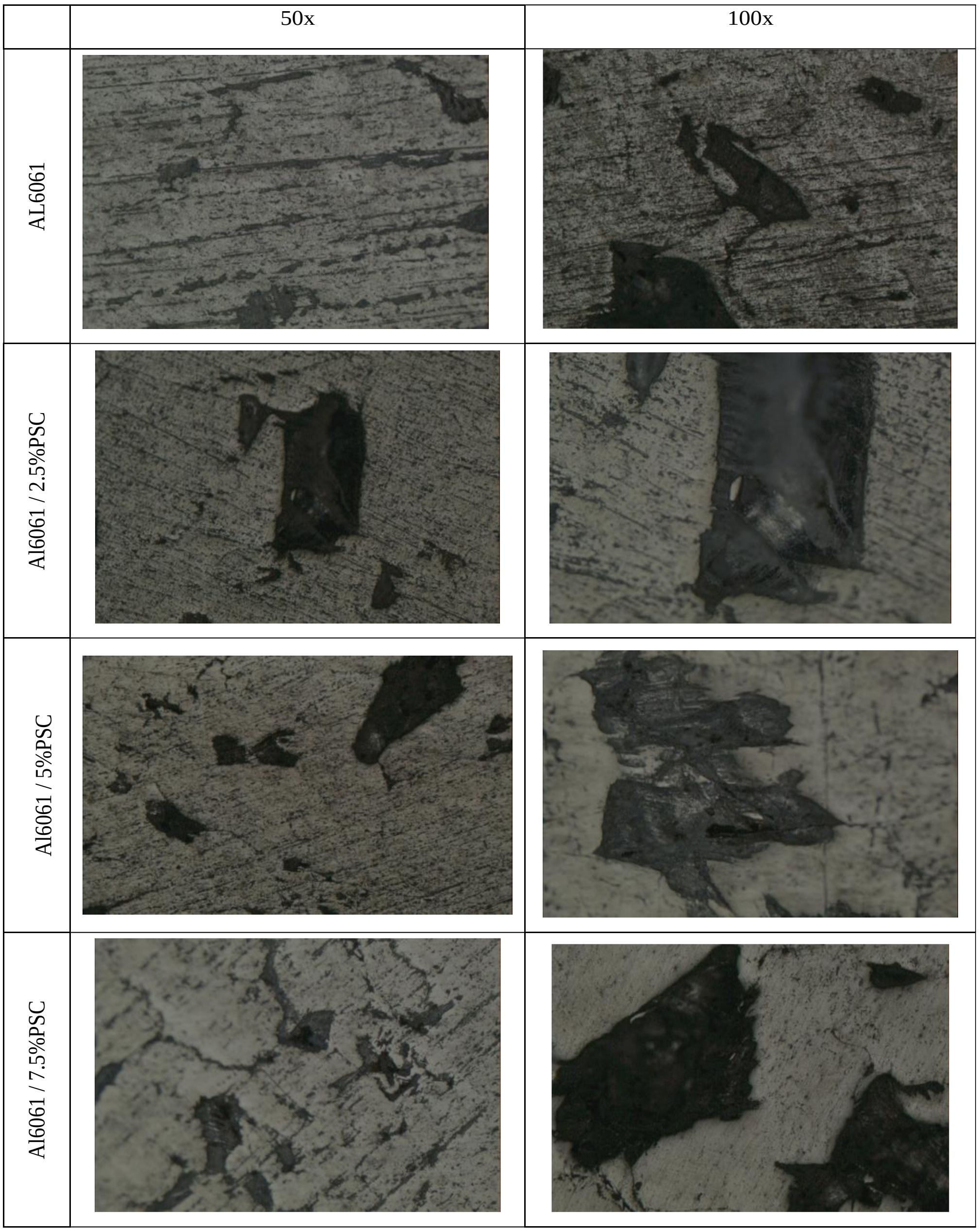

Figure 2 : Optical microscopy of different composition of peat soil carbon

According to the microstructural morphology of the recycled aluminium sample, the same process happened which also reported by Kadir et al[10] on the size of pores become smaller and forming boundary layers by using mixture of Al6061 with silicon carbide, SiC as shown in Figure 3.

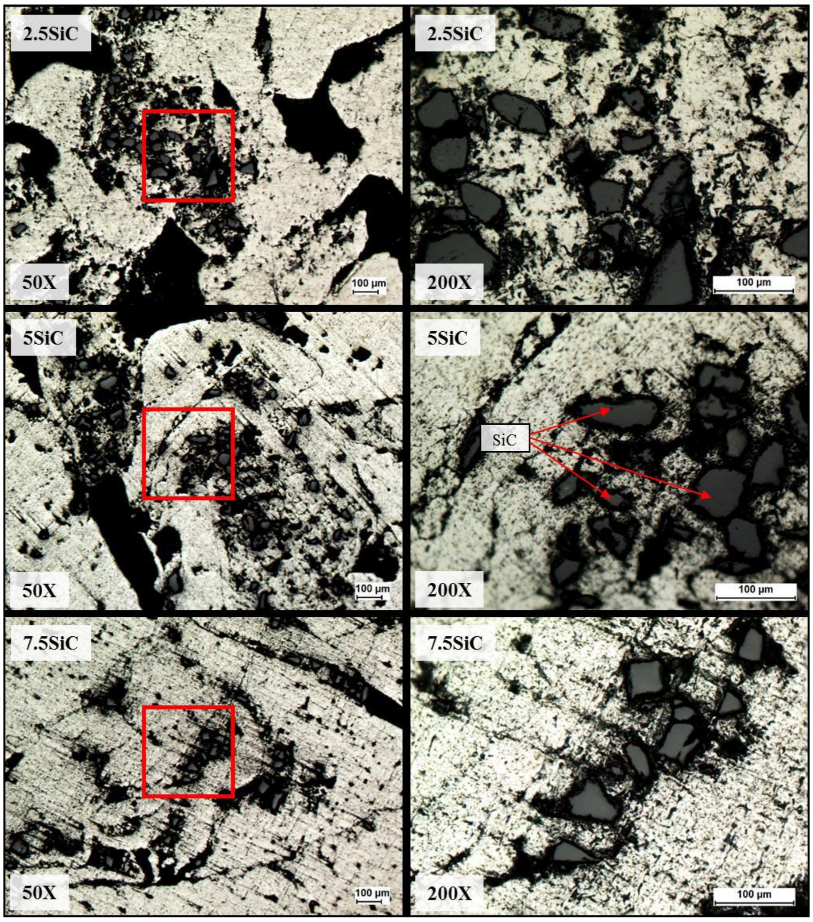

Figure 3 : Optical microscopy images of AA6061/10Al-(2.5, 5, and 7.5)SiC, with the red box indicating the image region magnified to 200 magnification.[10]

The Archimedes methodology was used to determine the relationship between the density, apparent porosity, and water absorption of metal matrix composites samples with different weight percentage of AA6061 aluminium chip and peat soil compositions. Density variations caused decreased porosity and water absorption in the sample body [11]. The density of the sample chips with peat soil carbon was the most closely matched to the theoretical density in the first two examples at 2.47 g/cm3 and 2.51 g/cm3. While the density increased as the peat soil carbon level increased, it peaked at 2.53g/cm3 at 5% peat soil carbon content as per Figure 4. The soil carbon content combination decreases in density after peak at the lowest levels at 10% peat soil carbon content. All composites have higher densities than unreinforced, hence adding more reinforcement to the composites will lead to an increase in density [12,13].

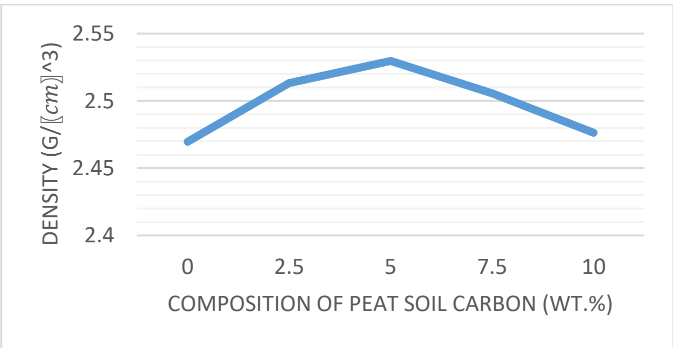

Figure 4 : Change in density

The apparent porosity of a porous material is always defined as the fraction or percentage of pores contained within the volume of the porous solid. As the peat soil carbon content increases, apparent porosity decreases. Clearly as per shown in Figure 5, the maximum porosity happens when the amount of Al chip is used in conjunction with no reinforcement of peat soil carbon. Increasing the amount of peat soil carbon in a composites mixture after it has been added will reduce the percentage in porosity.

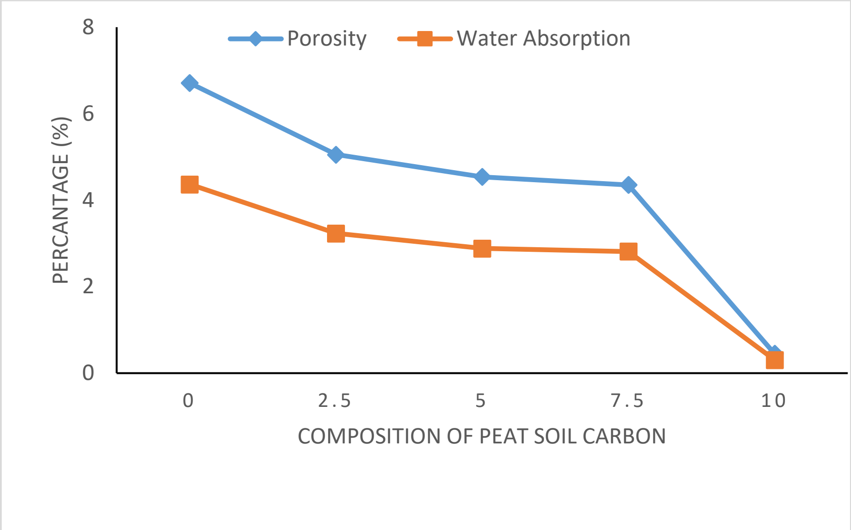

Figure 5 : The changes in porosity and water absorption-based percentage and the composition of peat soil carbon.

This also reported by Yusuf et al [14] which density increased the direct recycling of aluminium AA6061 reinforced with 2.0 wt.% of aluminium oxide (Al_2O_3) involving holding time with various temperature affecting density of the sample. Figure 6 from the same study shows density increased according to holding time where higher temperature provides higher density that near to theoretical density of AL6061.

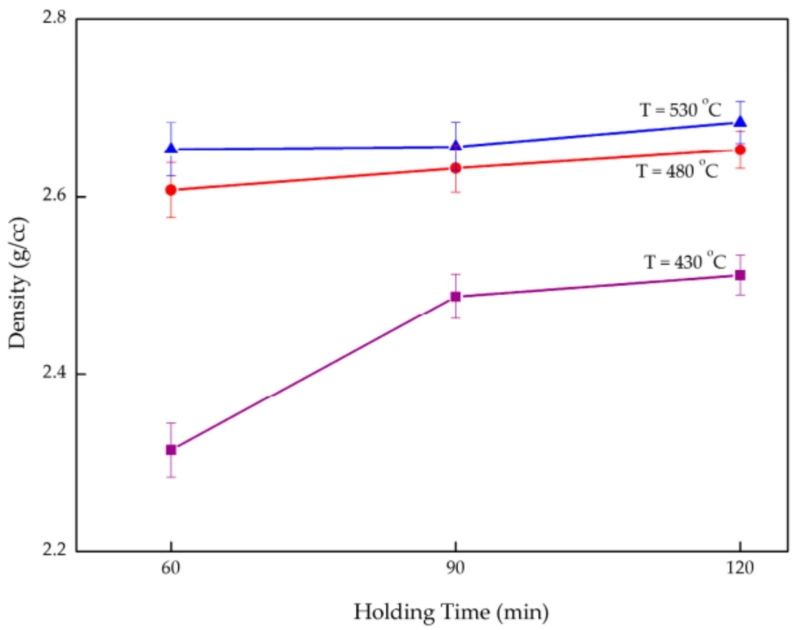

Figure 6 : Change in density with different temperatures and holding times [14]

4. Conclusion

A new solid state recycling method has been studied, which includes machined chips block consolidation preceded by sample manufacturing using cold compaction and sintering. The machined aluminium chips are compacted straight to a composite body that uses remarkably less energy in comparison with typical recycling with that approach as a substitute for remelting. The following conclusions can be drawn based on sample creation and characterization of recycled AA6061 chips and peat soil carbon. Increasing peat soil carbon content caused an improvement in microstructure with reduced surface porosity creation. In this study, density and drop after peak are shown to be higher. The densities of 2.47 g/cm3 and the peaks were 2.53 g/cm3 correspondingly, without reinforcing the peat soil carbon, which is significantly closest to aluminium alloy 6061 theoretical density. In addition, density changes can be analyzed because the increased sintered density leads to decreased porosity.

The research objective has been achieved. Based on the examination of metal matrix composites samples, peat soil can potentially be agents to improve structural properties with appropriate peat soil to metal matrix composite composition. The usage of agricultural materials derived from peat soil has the potential to convert industrial waste into industrial wealth.

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