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Research paper

The Effect of Palm Oil Fly Ash Reinforcement on Recycle Aluminium via Sand Casting

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Abstract

Recycle aluminium has been mixed with palm oil fly ash based on fraction weight of overall weight of palm oil fly ashes to aluminium recycle. The ratios discussed on this paper are 0%, 3% 6%, 9%, 12% and 15%. The samples have been developed via sand casting method. The result shows that the best composition has been achieved when we added 3% of palm oil fly ashes, with the new composite aluminum have a highest hardness with the value of 119.7HV, with the Modulus of raptured of 7.71Mkg/m^2

;Keywords: *Composite Aluminum; Palm Oil Fly Ashes; Recycle Aluminium; Hardness; Modulus of Rapture*

1. Introduction

Palm oil fly ashes is a waste from palm oil in powder form, has amorphous characteristic and normally in black-grey in color, which darker means higher carbon contain [1]. The composition of palm oil fly ashes are as follows in Figure 1.

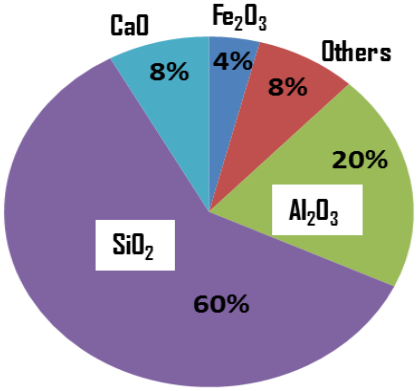

Fig. 1: Fly Ashes compositions

The fly ash has been chosen due to inexpensive, low density reinforcement available in large quantities as solid waste by-product during combustion of palm oil in power plant. The special characteristics palm oil fly ash is on their free lime. This free lime is capable to reduce diffusion and sulfate effect, as well as have higher strength. Fly ash particles are mostly in spherical shape and the shape is insignificant changes even it being mixed with other material [2]. As for coal fly ash, it widely being used in cement as an additive, in lightweight alloy as a concrete aggregate, in structural fill materials as roofing granules and also in in most of Metal Matrix Composite (MMC) [3].
Casting method is very famous methods that frequently used in Aluminum and fly ash mixed, including squeeze casting technology and gravity casting [4]. Besides that, impeller mixing also another method that been used in Al-Fly Ash composite reinforcement process [3]. Furthermore, [5] and [6] has developed the aluminium fly ash composite via stir casting. The objective of this research is to study the effect of the reinforcement of palm oil fly ash into the recycle aluminum by using sand casting method, since this method is less being used in similar composite development.

2. Literature / Previous Research

Upon synthesized the A356 Aluminium Fly Ash composite, it found that fly ash with small range of particle size has shown better mechanical properties in term of ductile and brittle behaviour as compare with wider range of particle size [7]. This also supported [8] and [5] which concluded that by increase the weight fraction of fly ash may increase hardness of the respective composite.
At certain level of increasing the weight fraction percentage of palm oil fly ash may make the hardness become more harmful and this has been proved by [9]. He has studied the dry sliding friction and wear condition of fly ash reinforced AA-6351 Metal Matrix Composite. By end of his research, he concluded that small amount weight percentage can give benefit to hardness, but after 9% of reinforcement, the hardness getting worst.
Different technique in composite preparation (Aluminium adding with fly ash) also may give different result. This has been proved by [9]. The weight fraction of fly ash is varied between 3% up to 12%. The result shows the based alloy prepared by squeeze casting has lower porosity as compared with gravity casting method at the same amount of weight fraction percentage.

3. Methodology

Main materials used in this research are aluminum recycle and palm oil fly ashes. Palm oil fly ashes that has been used in this research is 2nd stage fly ashes, which the size is 250µm< fly ashes size <500µm. This size is very suitable to use for casting process.

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Figure 2 shows the picture of palm oil fly ashes that form into capsule. In order to produce the samples for this experiment, five steps for casting process need to be full fill. This include patent making, core and mold, molten recycle aluminum and pouring, cleaning and lastly testing. Patent has been produced by using wood according to the initial size of sample. This selection of patent material is based on the quantity of the sample, frequency of process repeatable and also depends on the surface on end product to be produced. The core has been made by three elements consist of silica sand, clay and water (85:8:7).



Fig 2: Palm oil fly Ashes in capsule form

The process of pouring and molten of aluminum recycle has been done in cubicle furnace. On top of that, the fly ashes have been prepared according to their weight and the composition between recycle aluminum and palm oil fly ashes presented in Table 1, where the percentages of each material are based on total weight.

Table 1: Reinforcement of Palm Oil Fly Ashes Percentage

Sample	% *Al*	Weight *Al (kg)*	% Fly Ashes	Weight fly ashes (kg)	Total weight
A	100	3.5	0	0	3.5
B	97	3.395	3	0.105	3.5
C	94	3.290	6	0.210	3.5
D	91	3.185	9	0.315	3.5
E	88	3.080	12	0.42	3.5
F	85	2.975	15	0.525	3.5

Eight samples have been prepared for each compositions. Several precautions need to take into account during sand casting process. The moisture contains in the casting's sand must be stable. If the moisture is insufficient and then pouring process is not properly being done, then the sample produce is tending to have higher porosity. When the molted aluminum fly ashes mixes have been solidified (nearly more than 5hours), the sample has taken out from the pattern and ready for machining. Figure 3 shows the sample before and after machining.

Two mechanical testing has been done which are hardness test and MOR test. Hardness Vickers of ASTM E 92 by using machine BUEHLER 1900-2005-250 which has been (~ 6000 H_B) and four square tools which angle of 136^0C and the weight is 30kg. Hardness Vickers number can be calculated as in (1).

$$HVN = \frac{18544P}{D^2} \quad (1)$$

Where P is load (kg) and D is diagonal length. Initially, the samples have to be clean via sand paper to get clean surface for ease of reading. After placing the sample at the platform and the load has been adjusted, the grid has been tuned (horizontal and vertical) until a line has been obtain, then the reset button being pressed. The diamond traced being occurred at the specimen surface and the effect of the load has been monitored under scale microscope. Horizontal grid adjusted to the initial above and below of the diamond effect, as well as vertical grid for left and right. The value of HVN has been recorded.

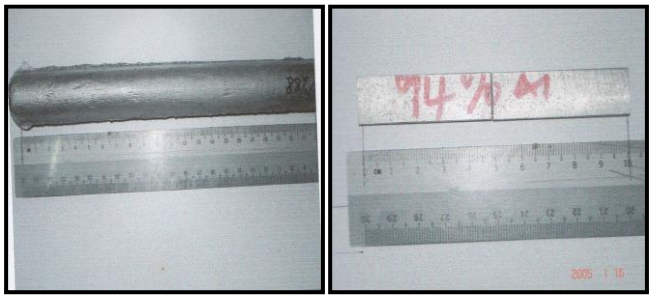

Fig. 3a: Before machining process **Fig. 3b:** After machining process

Another test been done is bending test. This test has been done in order to find modulus of rapture, MOR and it was done under N535 machine. The formula to calculate MOR value is depending on the shape of the specimen, where four square shape specimens can be calculated as in (2).

$$MOR = \frac{3FL}{2bd^2} \quad (2)$$

Where F in load times by gravity force (kgm), L is the length of two points (m), b is the thickness of the specimen (m), and d is width of specimen (m). Initially, all the specimen measurement has been recorded, and need to ensure that the distance between two loads is 0.22m. The surface of the specimen has been cleaned by silicon carbide paper. Some precautions that need to pay attention during then MOR test is that, the value of sensor need to consistent during the test. This sensor value is very important in order to detect any crack occurred on the specimen. The value of the sensor has been set based on the break point that wants to achieve.

4. Results and Discussion

Each composition has eight samples. So the result presented is the average result of eight reading for each composition. Figure 4 shows the Hardness Vickers value of each composition of fly ashes. The hardness value for based composition for 0% reinforcement of fly ashes has been recorded. From the result obtained, we can see that when we added 3% of fly ashes, the hardness has been increase about 13%, where it consistent with [5], [6] and [8]. Keep increasing the percentage of fly ashes has made the hardness of the composite aluminum to be reduced dramatically. For 6% of fly ash reinforcement, we can see the hardness has been reduced 12% as compare with based recycle aluminum. The trend of hardness is continued to reduce as we increased the percentage of fly ashes. The highest reduction of fly ashes is recorded as 38% from based aluminum recycle with 15% reinforcement of fly ashes. The result also supported by [10].

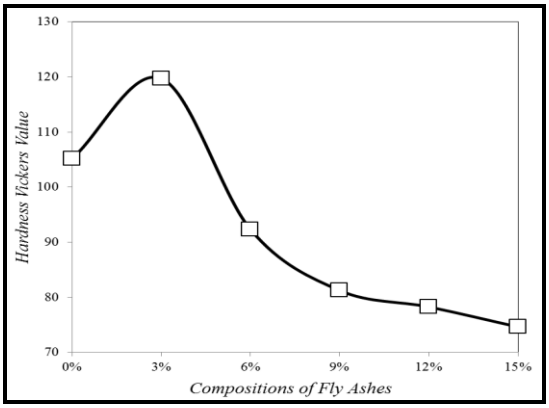

Fig. 4: Hardness Vickers Value (HVN) of each composition

Figure 5 shows the Modulus of Rupture (MOR) for each composition. The trend is almost similar with hardness, as we added small

percentage weight of fly ashes, the MOR getting increased. Maximum reinforcement of fly ashes has reduced 29% of MOR value from 0% reinforcement.

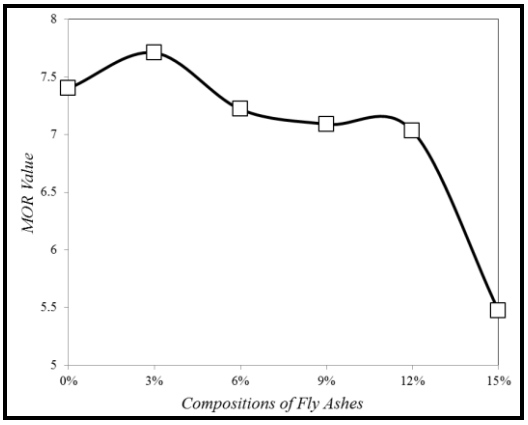

Fig. 5: MOR value for each composition

Rohatgi et al has done a research on synthesizing on palm oil fly ashes has concluded that the contaminant of fly ashes includes silicon oxide, complex iron in glass structure and ceramics. So it's expected that all this element may contributed for hardness and rupture properties [11]. This finding also supported by John and Lindbeck [12], which has concluded that material which has higher hardness may have brittle properties, which lead small amount of energy to be fail. Mills et al. [13] has said that under microstructure analysis large amount of aluminum can reduced the porosity and addition of certain percentage of fly ashes can increase the hardness level.

5. Conclusion

The effect of reinforcement of palm oil fly ashes into the aluminum recycle has been investigated. It was found that addition of small percentage of palm oil fly ashes can affect the mechanical properties of the composite aluminum in term of hardness and MOR value.

Acknowledgment

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