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EFFECT OF VARYING PERCENTAGE INCREASE IN REINFORCEMENT ON SOME MECHANICAL PROPERTIES OF DIE CAST ALUMINUM ALLOY COMPOSITES

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Abstract: The die-casting process is a metal casting processes that utilize metal molds or permanent dies. In this work, the effect of varying percentage increase in reinforcement on some mechanical properties of aluminum alloy composites was obtained by the die cast process. The process was applied to produce various casts using aluminum alloy as the metal matrix and sawdust as the reinforcement at 5%, 10% and 15% by weight. Aluminum Scrap was sourced and sent for elemental characterization at Engineering Materials Development Institute (EMDI), Akure Nigeria. Tensile and hardness test were the mechanical tests carried out on the different samples of the cast. The elemental characterization test result showed that, the composition of the aluminum alloy used is Al-8.1%Mg-0.4%Fe-0.2%Zn. Results showed that at 10% by weight of reinforcement, the average tensile strength of the composite had the highest value while the lowest tensile strength was recorded at 15% by weight of reinforcement. At 15% by weight of reinforcement, the average hardness of the composite had the highest value while the lowest hardness was recorded at 5% by weight of reinforcement. Results were compared with the works of Ranjit et al. (2020) and Belete et al. (2013) and it was concluded that the results obtained from this work are adequate and significant for use.

Keywords: Percentage increase, Mechanical properties, Die casting, Aluminum alloy, Composites

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1. Introduction

Recently, great attention has been focused on aluminum and its alloy due to their high technological value, wide range of industrial applications, and various advantages such as lower density, good formability, high conductivity, high specific rigidity, excellent corrosion resistance, high castability and attractive tensile strength (Cole and Sherman, 1995; Miller et al., 2000). Aluminum alloys has widespread use especially as the most important industrial material of foundry. They offer important opportunities for applications in a diversity of areas particularly in the mechanical, automotive and aerospace industry (Guo and Yang, 2007).

Die-casting is an economical way of producing large quantities of complicated shaped products of light metals with high precision. The die casting process, in which molten metal is injected into a preheated die cavity on the die and left to solidify completely (Hassan et al., 2019).

Composites which are materials made by combining numerous components or constituent materials with varying advantageous features, either chemical or mechanical, or both, to create a material with varying characteristics – are becoming more popular because of the large number of combinations that can be done to generate adequate material (Kumar et al., 2011). Composites have a wide range of properties due to their different structures, which are made up of different reinforcements and metal matrices. These composite materials can be used in a variety of applications (Panemangalore and Shabad, 2021).

Die casting is an important technology for metal manufacturing in many modern industrial fields (Mahendra, 2018). The majority of metal complexes have restrictions that make them inappropriate for usage in today's technological era. As a result, composites are becoming more popular because of the large number of combinations of different matrix and reinforcement that are possible to produce varieties of choice materials (Sujan et al., 2012).

Composites have a wide range of properties due to their different structures, which are made up of different reinforcements and matrices. These composite materials can be used in a variety of applications in many industries (Evans, et al., 1993).

The need for improved engineering material with flexible design, fabrications and improved mechanical properties brought about the need for this research. Over the years, there have been different parameters used in the development of metal matrix composites. This study

focused on the effect of varying percentage increase in reinforcement on some mechanical properties of die cast aluminum alloy composite.

2. Material and Methods

2.1. Composite Preparations

Aluminum scraps used for window frames were sourced from a local workshop in Edo state. The Aluminum scrap was characterized using the energy dispersive X-ray fluorescence spectrometer.

2.2. Experimental Procedure

The fabrication of the metal matrix composite was done using the die casting method. In this method, molten metal is injected into a preheated die cavity on the die and left to solidify completely. The procedure involved in this process is highlighted:

1. The mold which has the cavity of the desired shape was produced.
2. The furnace (open hearth furnace) was powered with the aid of 30 liters of diesel.
3. 2kg of aluminum scrap was measured and placed in a crucible that fit the inner diameter of the furnace to melt.
4. The aluminum scrap was heated to a temperature above 600˚C.
5. All dirt and unwanted materials were removed from the molten metal.
6. Sawdust Ash was added in 5%, 10% and 15% by wt. respectively into the molten Al alloy in steps and was mixed thoroughly to get the uniform distribution of the residue in the metal matrix.
7. The reinforced molten aluminum was placed back into the furnace and was left for about 60 minutes.
8. The slurry was poured into the pre-heated mold, to get a near net shape according to the ASTM standards for testing tensile and hardness and allowed to cool to room temperature.
9. After solidification, the reinforced matrix was allowed to cool.
10. The specimens produced (Figures 1) were machined and tested for tensile (Figures 2) and hardness (Figures 3).
11. The hardness of each specimen was measured using hardness apparatus while the tensile tests were done using the tensor meter.

3. Results and Discussion

From the elemental characterization results, the aluminum alloy comprises of Al-Mg-Fe-Zn. The percentage composition of each constitutes of the alloy is 91% Al, 8.1% Mg, 0.4% Fe, 0.2% Zn etc.

In Table 1, results showed that tensile strength of the composite varied for all samples, at the different percentage by weight of reinforcement. At 10% by weight of reinforcement, the average tensile strength of the composite had the highest value while the lowest tensile strength was recorded at 15% by weight of reinforcement. Comparing our results with the work of Ranjith et al. (2019) in which they obtained optimum tensile strength at 10% by weight of reinforcement, it can be concluded that, the results obtained from this work are adequate and significant for use.

In Table 2, results showed that hardness of the composite varied for all samples, at the different percentage by weight of reinforcement. At 15% by weight of reinforcement, the average hardness of the composite had the highest value while the lowest hardness was recorded at 5% by weight of reinforcement.

Figure 1. Sample of composite after die-casting.

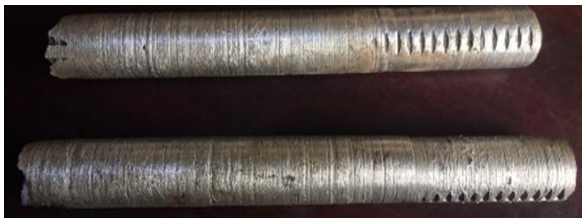

Figure 2. Sample of composite after tensile test.

Figure 3. Samples of composite after hardness test.

Table 1. Tensile test result of aluminum alloy composite reinforced with sawdust

Percentage (%) by wt. Composition of Reinforcement	Tensile load on aluminum alloy composite reinforced with sawdust (KN)			
	Sample 1	Sample 2	Sample 3	Average
5	17	16	18	17
10	24	20	21	21.67
15	16	16	16	16

Table 2. Hardness test result of aluminum alloy composite reinforced with sawdust

Percentage (%) by wt. Composition of Reinforcement	Hardness test on aluminum alloy composite reinforced with sawdust (KN)			
	Sample 1	Sample 2	Sample 3	Average
5	4.824	4.878	4.875	4.859
10	4.887	4.891	4.899	4.892
15	4.996	4.993	4.997	4.995

Table 3. Diameter of indentation of the aluminum alloy composite reinforced with sawdust

Percentage (%) by wt. Composition of Reinforcement	Sample 1 (mm)	Sample 2 (mm)	Sample 3 (mm)	Average
5	2.09	2.06	2.03	2.06
10	2.14	2.37	2.66	2.39
15	2.18	2.23	2.97	2.46

Comparing our results with the work of Belete et al. (2013) in which they obtained optimum hardness at 15% by weight of reinforcement, it can be concluded that, the results obtained from this work are adequate and significant for use.

In Table 3, results showed that diameter of indentation of the composite varied for all samples, at the different percentage by weight of reinforcement. At 15% by weight of reinforcement, the average diameter of indentation of the composite had the highest value while the lowest diameter of indentation was recorded at 5% by weight of reinforcement.

4. Conclusion

In this work, the effect of varying percentage increase in reinforce on some mechanical properties of aluminum alloy composites were obtained by the die cast process. The die casting process was applied to produce various casts using aluminum alloy as the metal matrix and sawdust as the reinforcement at 5%, 10% and 15% by weight. Tensile and hardness test were carried out on the die casts samples. Results showed that at 10% by weight of reinforcement, the average tensile strength of the composite had the highest value while the lowest tensile strength was recorded at 15% by weight of reinforcement. At 15% by weight of reinforcement, the average hardness of the composite had the highest value while the lowest hardness was recorded at 5% by weight of reinforcement. Results were compared with the works of Ranjit et al. (2020) and Belete et al. (2013) and it was concluded that the results obtained from this work are adequate and significant for use.

Author Contributions

All tasks were done by all authors. The authors reviewed and approved the manuscript.

Conflict of Interest

The author declared that there is no conflict of interest.

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