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Characterization of Za-27 Alloy Reinforced with MgO Particles by Stir Casting Technique

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Abstract—*Composites are the essential materials of today's manufacturing world which consists of a matrix material with continuous phase and one or more reinforcements with discontinuous phase mixed uniformly at macroscopic level. In the present study ZA-27 alloy reinforced with MgO particles of size 30 µ m were fabricated by stir casting technique by varying weight percentage (wt. %) of reinforcement from 0 wt. % to 3 wt. % in steps of 1 wt. %. MgO was preheated and poured into the molten slurry. The melt was poured into permanent moulds of casting. Density, hardness, and tensile tests were carried out as per ASTM standards. Microstructure showed fine distribution of the MgO particles in the specimen. The results showed that, as the percentage of MgO increased, UTS and hardness increased along with decrease in density.*

Keywords*: ZA-27, MgO, Stircasting, Mechanicalproperties.*

1. INTRODUCTION

Metal matrix composites are used in various applications due to their better mechanical properties compared to monolithic alloys. To improve the mechanical and tribological properties, hard ceramic particles or fibers or whiskers are used as reinforcements [1]. When a ceramic reinforcement is added to the metal matrix, the properties are further enhanced making way for much light weight engineering applications [2].Cast alloys of zinc with aluminium have better mechanical properties which are usually used for bearing applications [3]. ZA (zinc aluminium) cast alloys exhibit excellent castability, wear resistance and good mechanical properties which are used in many applications in recent years[4] .These alloys are grouped into ZA-8,ZA-12 and ZA-27 with respect to aluminum content .ZA-27 is the light weight alloy among them which offers excellent bearing and wear resistance properties. MgO (magnesium oxide) is light weight with good castability, weldability, recyclability and abundantly available in nature. It has various characteristics like fire resistance, moisture resistance and mold resistance [5].

2. MATERIALS

In the present work ZA-27 alloy is used as matrix material with MgO (magnesium oxide) as reinforcement. The chemical composition of ZA-27 alloy as per ASTM B669-82 and MgO is shown in Table 2.1 and 2.2 respectively. The reinforcement was varied by weight percentage (wt. %) from 0 wt. % to 3 wt. % in steps of 1 wt. %.

Table 2.1: Chemical composition of ZA-27 alloy

Component	% Composition
Aluminum	25-30
Copper	2.06
Iron	0.065
Magnesium	0.012
Silicon	0.02
Zinc	Balance

Table 2.2: Chemical composition of MgO

Component	% Composition
Magnesium	60.39
Oxygen	39.67

3. PREPARATION OF COMPOSITE

For preparation of metal matrix particle reinforced composites stir casting method is the most promising method among other processing methods [6].It is the low cost liquid processing technique with simplicity, flexibility and suitable for mass production[7]. A stir casting setup was used with induction furnace and a mechanical stirrer unit.1500 grams of ZA-27 alloy ingots were cut into pieces and fed into the crucible. The temperature of the furnace was raised slowly above liquideous temperature above 484ºC .The stirrer was coated with aluminate so that it prevents migration of ferrous ions to the molten metal from the stirrer[8]. Stirrer was positioned into the crucible and rotated at a speed of 500 rpm for about 10 minutes. The MgO contents were varied from of 0-3% by weight in step of 1% .The preheated MgO particles in weighed quantities were added slowly into the melt. Later the molten metal was poured into preheated permanent moulds of casting.

4. TESTING

Microstructures of the cast specimen were taken to observe the distilution of reinforcement. The density, hardness and tensile tests were conducted as per ASTM standards. The density measurement was carried out using Archimedes principle. The specimens with 10 mm diameter and 10 mm height were used [9]. Theoretical density was calculated using Halpin-Tsai equation as shown in the equation (1).

$$\rho_c = (\rho_r V_r + \rho_m V_m) \quad (1)$$

Where,

ρ_C density of the composite in g/cc

ρ_r density of the reinforcement in g/cc

V_r Volume fraction of reinforcement in cc

ρ_m density of the composite in g/cc

V_m Volume fraction of matrix in cc

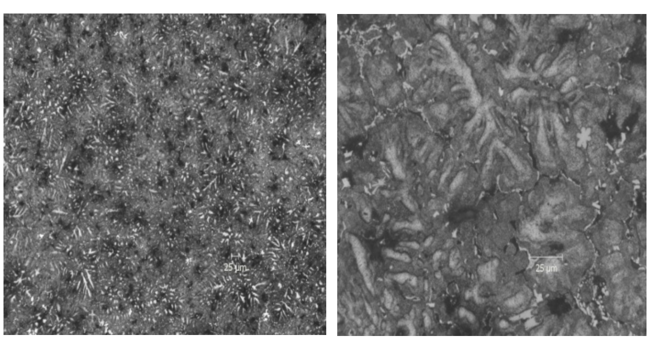
m is the matrix material and r is the reinforcement material

The Brinell hardness test was carried out as per ASTM-E10-93 standards. The tests were conducted on 3 locations and average of those was taken as BHN. Tensile test was carried out on ZA-27 alloy and composite with 3% of reinforcement as per ASTM-E8-04 standards.

5. RESULTS AND DISCUSSIONS

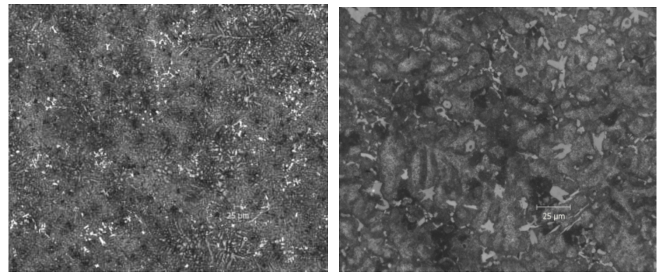
5.1 Microstructure

Microstructure of ZA-27 alloy and composite with 3wt% MgO is shown in the Fig. 1 and 2 respectively. The samples were etched with keller's reagent and observed under optical microscope NIKON LV150 with Clemex Image Analyser. The Microstructure showed nearly uniform distribution of the reinforcement particles in the composite.



a)100X b)500X

Fig. 1 Microstructure of ZA-27 alloy



a)100X b)500X

Fig. 2: Microstructure of ZA-27/3%MgO composite

Density

Theoretical density was calculated using rule of mixture and experimental density was found out by Archimedes principle. From the Fig. 3 it is observed that as the weight percentage of reinforcement increases density of the composite decreases and also theoretical density is almost parallel to experimental density [9].

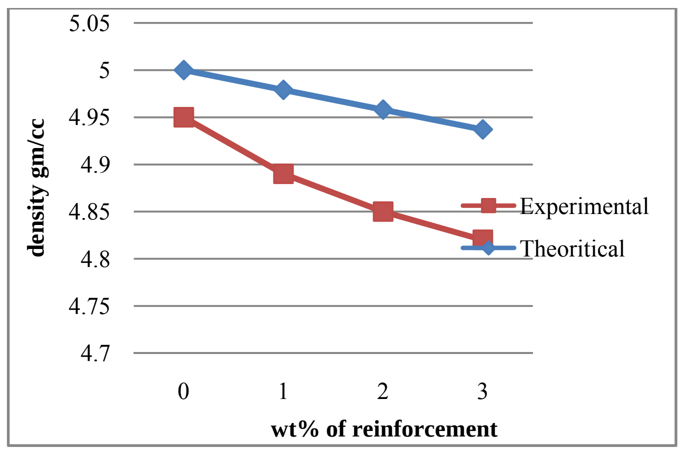


Fig. 3: Effect of reinforcement on theoretical and experimental density

Hardness

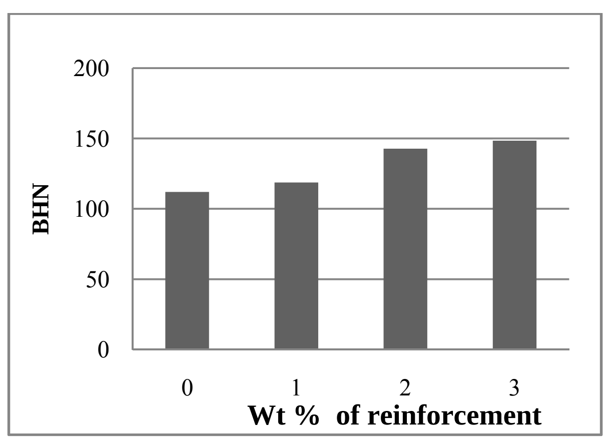


Fig. 4: Effect of Reinforcement Content on Hardness of ZA-27Alloy and its Composite

The results of Brinell hardness test of ZA-27 alloy and its composites are shown in the Fig. 4. The hardness of composite is increased compared to the matrix alloy which is similar to the other researchers. This increase in hardness is due to MgO particles being hard ceramic material which increases the hardness of the composite [10, 11]

Tensile strength

Fig. 5 shows the tensile strength of base alloy material and 3 wt% of MgO composite. It is noted that as MgO percentage increases, the tensile strength of the composite material also increases which is similar to the results of other researchers [12].

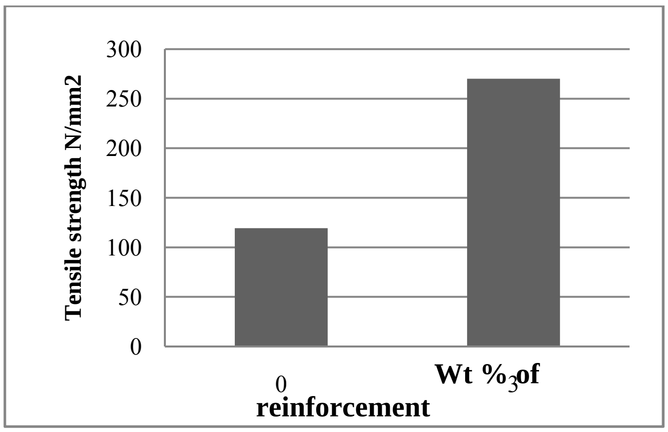


Fig. 5: Effect of Reinforcement Content on Tensile strength of ZA-27 Alloy and its Composite

6. CONCLUSIONS

Based on the results, the following conclusions were drawn

- The Za-27/MgO reinforced composites were successfully developed using stir casting technique.
- The micro structure showed nearly uniform distribution of reinforcement particles in the matrix.
- The density of the composite material decreased with increase in the reinforcement content.
- The Brinell hardness of composites increased with increase in weight percentage of MgO particles.
- The tensile strength of the composite increased as compared to the tensile strength of the alloy material.

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