

Characterization of ZA27-Fly Ash Graphite Particulate Reinforced Hybrid Composites

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Abstract

In the present paper an attempt has been made to develop zinc aluminum based fly ash and graphite particulates MMCs with an objective to develop a conventional low cost method of making MMCs and to acquire homogenous dispersion of ceramic material. To achieve these objectives, stir casting technique has been used and following property analysis has been made. Zinc, aluminium and fly ash, graphite have been chosen as matrix and reinforcement materials respectively. Experiments were conducted by keeping weight fraction of fly ash at a constant percentage value (5%) and by varying weight fraction of graphite (2%, 4 %,) while keeping all other parameters constant. An increasing trend of tensile strength, impact strength and wear resistance has been observed. However hardness decreased with dispersion of graphite.

Keywords: Fly ash, Graphite, MMC'S; Stir casting, ZA-27.

INTRODUCTION

Over the past few decades zinc-aluminum alloys (ZA alloys) have been widely investigated as promising material for tribological applications. At this moment the ZA alloys have become the alternative

material primarily for aluminum cast alloys and bronzes due to good cast ability and unique combination of properties. This can also be considered as competing materials for cast iron, plastics, and even steel when being applied for operation

under conditions of high mechanical loads, moderate sliding speeds and moderate operation temperatures. Interest for extending the practical application of these alloys is based on tribological, economic and ecological reasons.

Metal matrix composites (MMCs) reinforced with ceramic particulates offer significant performance advantages over pure metals and alloys. MMCs have the best properties of the two components, such as ductility and toughness of the matrix; wear resistance, high young's modulus and strength of the reinforcements. These prominent properties of these materials enable them to be potential for numerous applications such as automotive, aerospace and military industries.

J Babu Rao et al [1] reported the deformation behaviour of Al-4Cu-2Mg alloy during cold upset forging, and found the relationship between the circumferential strain and axial strain increments is continuously changing with increasing deformation.

Sandeep Kumar et al [2] the author investigated mechanical and tribological properties of stir cast aluminium matrix composites containing single and multiple

reinforcement. Addition of alumina to aluminium has shown increase in its mechanical and tribological properties.

P.B. Pawar et al [3] in this work metallic gears of steel alloy and Aluminium Silicon Carbide composite have been manufactured Composites provide much improved mechanical properties such as better strength to Weight ratio, more hardness, and hence less chances of failure. So this work is concerned with replacing metallic gear with composite material so as to improve performance of machine and to have longer working life.

Seah et al [4] investigated the mechanical properties of ZA-27 zinc-aluminium alloy/graphite particulate composites containing graphite particles of size 100-150 μm ranging from 0 to 5 wt.%. The results revealed that as graphite composition was increased, there were significant monotonic increase in ductility, tensile strength, compressive strength and Young's modulus while there was a significant monotonic decrease in hardness of the material.

Xiao-dong et al [5] made a study on mechanical properties by varying the particle size of SiC reinforcement in Al matrix composite fabricated by squeeze

casting technique. They investigated the bending strength and fracture toughness of the composites and found that as the particle size decreased, bending strength increased and fracture toughness decreased.

EXPERIMENTAL METHODOLOGY

Materials Used

Hard and thermally stable ceramic reinforcement in ZA alloys contributes to a higher hardness, superior elastic modulus and lower coefficient of thermal expansion of the matrix alloy at ambient temperature. The main reason for selecting the ZA-27 is a good strength alloy with excellent wear resistance & corrosion resistance. Fly ash and graphite have taken as reinforcement materials.

Composites Preparation

Stir casting is the most demanded process for the production of MMCs. Stir casting process is used to fabricate ZA-27 composites. In this process, the base metal was heated about 600°C, above its melting temperature using furnace. After melting, the required quantity of filler particulates (Fly ash) was preheated at 500°C. Because of vortex formation is more responsible for mixing of powder, the molten metal are stirred continuously by using a mechanical stirrer at 800 rpm as shown in

fig.1. The molten metal was then poured into permanent casting die and a pressure is applied for 2-3 minute, the temperature is lowered gradually. After solidification, the pressure is released and castings are taken out from the permanent die, and are cut to the required shape and sizes. Die and stirrer were preheated before reinforcement to remove sudden temperature effect.



Fig-1 Stir casting set up

Preparation of Specimens for Testing

The product obtained after casting is taken and machined by using lathe machine by performing turning operation and the wear samples are prepared.

Wear Testing

Wear test is conducted on Pin on Disc apparatus the specimen sizes are length

of 20 mm and in it quarter circle of radius of 3.5 mm is prepared as shown in fig.2. Wear depth of the samples was evaluated. Tests were carried out with an applied load of 5.0 kgf, 100 rpm rotational speed for a period of 10 minutes.



Fig-2 Wear test specimens

Toughness Testing

Toughness test is conducted on Charpy test apparatus the specimen sizes are of 10 × 10 mm² and 55 mm length. In this test swinging head strikes other side of specimen notch.

Pendulum falls from 1.457 height at an angle of 1400 and the weight of hammer was 250 N The pendulum impact testing machine as certain the notch impact strength of the material by shattering the V notched specimen with a pendulum hammer, measuring the spent energy and relating it to the cross section of the

specimen. The specimens were clamped in a square support.

Tensile Testing

For performing of tensile test we had prepared the specimens of length 90 mm long and 12 dia. To perform this test we changed the dimensions of above obtained specimen to standard ASTM E 8 dimensions for performing tensile test for different compositions as shown in fig 3. Tensile properties of the alloys were analysed by carrying out the test on the universal testing machine.



Fig-3 Broken composite specimens

Hardness Measurement

For performing Vickers hardness test the specimens of diameter 18 mm were prepared and they were polished by disk polishing machine and using emery papers. The hardness of the composites specimens was measured by Vickers hardness tester Microhardness of all the

samples was measured under a load of 30 kgf for an indentation time of 5 seconds.

RESULTS AND DISCUSSION

Wear Study

Table 1 shows the variation of wear depth with time for pure ZA27, ZA27-6% fly ash, ZA27- 6% fly ash and 2% graphite, and ZA27-5% fly ash and 4% graphite samples. It observed that a decreasing trend in wear depth with increase in weight percentage of graphite for the samples. When the graphite content is low, the interface of the mating parts is largely not covered by a film of graphite, and the tribological properties are almost similar to or only slightly better than those of the matrix materials.

As the graphite content is increased, the wear rate decreases due to the presence of graphite on the mating surfaces during

sliding. The graphite acts as a solid lubricant, which is smeared onto the sliding surfaces, thereby preventing a metal-to-metal contact. **See Table: 1**

Toughness Study

The impact strength of a material is its capacity to absorb and dissipate energies under impact or shock loading. The suitability of a composite for certain applications is determined not only by usual design parameters, but also by its impact or energy absorbing properties present.

The measured impact energy values of the ZA-27 metal matrix composites filled with fly ash and graphite particulate fillers respectively. It is see that the impact energies of the composites increase gradually with filler contents. **See Table: 2**

Table: 1 Wear rate in micrometers.

S.No	Material	Wear rate in micrometers
1	ZA27	485
2	ZA27+Fly ash (5%)	660
3	ZA27+Fly ash (5%) + Gr (2%)	595
4	ZA27+Fly ash (5%) + Gr (4%)	475

Table : 2 Toughness in j/mm²

S.No	Material	Toughness (joule/mm ²)
1	ZA27	3.3
2	ZA27+Fly ash (5%)	3.6
3	ZA27+Fly ash (5%)+Gr (2%)	3.7
4	ZA27+Fly ash (5%)+Gr (4%)	3.75

Tensile Strength

Table: 3 Tensile strength (Mpa)

S.No	Material	Tensile strength (Mpa)
1	ZA27	285
2	ZA27+Fly ash (5%)	330.5
3	ZA27+Fly ash (5%)+Gr (2%)	354.6
4	ZA27+Fly ash (5%)+Gr (4%)	404.1

The test results for tensile strengths of the composites with ZA27-fly ash-graphite are shown in table 3. It is seen that in all the samples, irrespective of the filler material the tensile strength of the composite increases with increase in filler content.

The enhancement of tensile strength with incorporation of particulate fillers can be explained as follows. With the presence of hard particulates, the load on the matrix gets transferred to the reinforcing elements there

by increasing the load bearing capability of the composites. With increase in weight percentage of the filler material, more load gets transferred to reinforcement which leads to increase in tensile strength. Moreover, with the presence of hard ceramics like fly ash there is a restriction to the plastic flow as a result of dispersion of these hard particles in the matrix, thereby providing enhanced tensile strength in the composite.

Vickers Hardness Study

Table: 4 Vickers hardness values

S.No	Material	VHN
1	ZA27	135
2	ZA27+Fly ash (5%)	215
3	ZA27+Fly ash (5%)+Gr (2%)	165
4	ZA27+Fly ash (5%)+Gr (4%)	181

CONCLUSION

Vickers hardness of the samples was determined using Banbros (Model: LV 700) Hardness tester. A diamond indenter was impressed on material at a load of 5 kg for 10 seconds. To avoid the segregation effect of the reinforcements in the matrix, four readings were taken for each sample. The hardness of the composite is increased with the reinforcement because effect of graphite content on the hardness of cast ZA27 -fly ash -graphite particulates composites. It can be seen that when only fly ash is added in ZA27 then its hardness increases but as the graphite content increases, the hardness of the composite material decreases by significant amounts. In fact, as the graphite content is increased from 0% to 4% the hardness decreases.

- 1) Zinc aluminum based hybrid metal matrix composites are successfully fabricated by stir casting method.
- 2) Tensile strength of prepared composites is higher in the case of composites, when compared to cast ZA27.
- 3) Addition of 5 wt% Fly ash increases the tensile strength increased whereas the addition of graphite particulates doesn't vary the tensile strength much with respect to fly ash added composition.
- 4) Hardness of the prepared composites is higher than the base ZA27 alloy.
- 5) In Addition of 5 wt% fly ash hardness is increased considerably. And the addition of graphite

particulates decreases the hardness, but is higher than the ZA27 alloy.

6) Wear rate of the composites has been decreased by adding more amount of graphite

7) The composite Toughness increased by the addition of fly ash and graphite.

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