Journal of Manufacturing Engineering, September, 2013, Vol. 8, Issue. 3, pp 192-195

ADHESIVE WEAR BEHAVIOUR OF ALUMINIUM 7075 CENOSPHERE COMPOSITES

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ABSTRACT

Metal matrix composites (MMCs) are gaining wide spread popularity in several technological fields owing to its improved mechanical properties when compared with conventional metals/alloys. Aluminium 7075 is widely used in several applications like aerospace, aircraft, automobile & construction where superior material properties are required. This paper discusses the development of Aluminium 7075 cenosphere composites by stir casting technique and analyzes the experimental results of adhesive wear behavior of this composite. Based on the different percentages of cenospheres used in the preparation of the composite, Aluminium 7075 cenosphere composites with better features in terms of adhesive wear resistance, hardness have been developed.

Keywords: *Al 7075, Hardness, Wear resistance, Flyash and Cenosphere*

1. Introduction

Aluminium alloys because of its low density is an important material for tribological applications. These alloys also possess low density which makes them suitable for wear applications. However aluminium by itself exhibits poor tribological properties. Therefore, the study of tribological behavior of aluminium based materials is becoming increasing important. In the recent past, another class of material namely metal matrix composites is becoming more important. Therefore, this class of material also has been widely studied by numerous investigators with respect to friction and wear behavior [1].

Particle reinforced aluminium matrix composites have emerged from the need of light weight, high stiffness materials which are desirable in many applications such as high speed reciprocating machinery. Reinforcement usually comprises particle or whiskers of a ceramic such as silicon carbide, alumina or graphite. Significant increase in stiffness and strength can be conferred with even small reinforcement volume fractions. Many of the applications for which MMC's are desirable also require enhanced tribological performance. There exists a large amount of literature concerning the wear performance of such materials. Much of it showing the composites in a good light compared to alloys of the unreinforced state [2]. Flyash particles are potential discontinuous dispersoids used in metal matrix composites, since they are of low cost and low density reinforcement available in large quantities as a waste by product in thermal power plants [3]. The fly ash reinforced aluminum matrix composites are also termed as 'Ash Alloys' [4]. Liquid metal stir casting is generally adopted for the synthesis of fly ash reinforced aluminium metal matrix composites [5, 6, 7]. Ramachandra et al in a study on the mechanical properties of hypoeutectic aluminium composites showed that an increase in the percentage content of fly ash particulates results in an increase in the hardness and tensile strength but the density decreases as the fly ash content increases [8]. It is also reported that the matrix hardness has a strong influence on the dry sliding wear behavior of Aluminium composites [9]. It is also reported that improved tensile strength and lower ductility of the Al 7075 reinforced with SiC particles than that of unreinforced material [10]. Few researchers have studied the properties of Al based Alumina and SiC particle reinforced composite materials and found that mechanical properties like hardness of the composite significantly improved the reinforcements [11]. It is also observed that the size of the SiC reinforced particles appeared to be an important factor in the high speed tribological behavior of the composites [12].

The published literature on Aluminium cenosphere composites is rather limited and is primarily concerned with applications of fly ash particles for synthesis of these materials. There is also a lack of information on the influence of light weight microsphere particles on the wear behavior of the composites. Therefore, it was thought worthwhile to study: (1) the microstructural characteristics of aluminium composites reinforced with cenosphere

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The content of this manuscript has been presented in 3rd International Conference on Recent Advances in Material Processing Technology (RAMPT'13)

particles, and (2) the relationships between the reinforcement and wear behavior. The present work is dedicated to such an investigation.

2. Experimental Procedure

The matrix material used in the current investigation is Al 7075 alloy. The chemical composition of the chosen alloy is as shown in table1. Al 7075 is often used in transport applications, including marine, automotive and aviation, due to their high strength-to-density ratio. The reinforcement used in the current investigation is cenospheres.

Table 1: Chemical Composition of Al 7075

Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Al
0.40	0.50	1.2 - 2.0	0.3	2.1 - 2.9	0.18 - 0.28	-	5.1 - 6.1	0.20	Remainder

2.1 Melting procedure

The cleaned metal ingots are heated to a temperature of 800-850^{0}C by placing in a graphite crucible. A filament winding type of induction furnace is used. A degassing agent in the form of Hexamethyelene di amine is added during the melting period. Magnesium is added in small quantities to improve the wet ability of the reinforcement particles with the base matrix. Cenosphere particles are then preheated and added to the molten metal and then continuously stirred by using a mechanical stirrer for a predetermined time. The cleaned metal moulds are then prepared by bolting together each part tightly so that no leakage of aluminium takes place. The melt with the reinforcement was then poured into the preheated metal moulds. The pouring temperature was maintained at 600^{0}C. The melt was then allowed to solidify in the moulds. To compare the properties the base alloy was then cast in the same procedure.

2.2 Specimen preparation and testing

The test specimens are prepared by machining from the cylindrical bar castings. The specimens for microstructure studies are polished with a one micron diamond paste. The samples for the microscopic examination are etched with keller’s reagent as an etchant. The specimens are washed with distilled water followed by acetone and then dried thoroughly.

2.3 Hardness test

Hardness tests are performed on the cast composites to know the effect of the reinforcement in the matrix material. The polished samples are tested using Brinell hardness testing system. A load of 500 Kg for a period of 30 seconds is applied on the specimens. The hardness is determined by recording the diagonal lengths of the indentation produced. The test is carried out at five different locations and then the average value is taken as the hardness for the cast composites [13].

2.4 Wear test

Two body sliding wear tests is done by using a pin on disc wear testing machine. A cylindrical pin of standard size of diameter 5mm is prepared from the cast and machined samples. Ducom make computerized pin on disc wear testing machine with test material as pin and high carbon EN31 steel (HRC60) as counter-surface. The pin on disc wear testing is conducted as per ASTM G-99 standards.

3. Results and Discussions

The samples were designated as shown in table 2 after careful casting and machining process

Table 2: Sample Designation

Sl. No.	Sample Designation	Sample Chemical Composition	Density (gm/cc)
1.	Al7075-0	100 % Aluminium, 0% Cenosphere	2.8
2.	Al7075-2	98% Aluminium, 2% Cenosphere	2.65
3	Al7075-4	96% Aluminium, 4% Cenosphere	2.4
4	Al7075-6	94% Aluminium, 6% Cenosphere	2.25
5	Al7075-8	92% Aluminium, 8% Cenosphere	2.12

3.1 Hardness test results

The figure shows the hardness test results of the sample designations as discussed in table 2. It is seen from the graph (Fig 1) that there is a gradual increase in the hardness of the samples with an increasing content of cenospheres. This is largely due to the fact that the cenosphere forms a hard reinforcement in the aluminium matrix. This is due to the physical and chemical nature of the cenospheres. This is the primary reason for the gradual increase in hardness when compared to the pure aluminium samples [14]. This fact is also attributed to the homogeneous distribution of the cenospheres in the matrix as seen in the microstructure Fig. 2 [13]. The increase in hardness is also expected because of the presence of ceramic reinforcements which are very hard, and act as barriers to the movement of dislocations within the matrix and exhibit greater resistance to indentation [15].

Table 3: Hardness Test Result

Sample Designation	Hardness (BHN)
Al7075-0	35
Al7075-2	41
Al7075-4	49
Al7075-6	52
Al7075-8	55

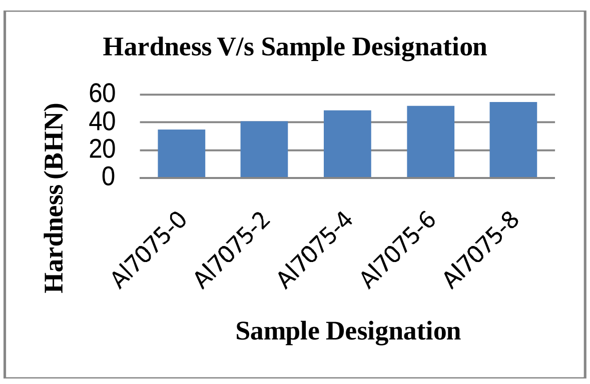

Fig. 1 Graph of Hardness V/s Sample Designation

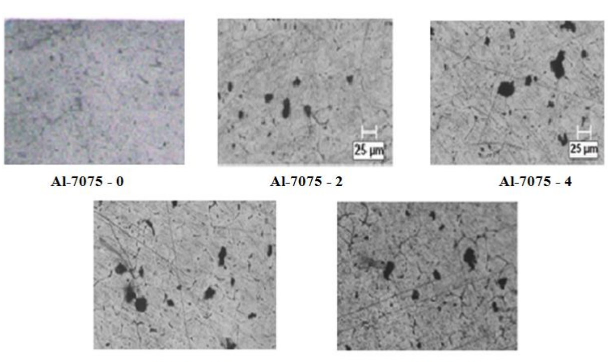

Fig. 2 Microstructure of Al-7075 with different % of cenospheres [13]

3.2 Wear test results

The following graphs (Fig 3) shows the wear behavior of five samples when subjected to pin on disc adhesive wear test for three different varying load of 10, 20 and 30N.

It is seen from the graph that with an increase in loads, there is a higher volumetric wear loss for both the matrix alloy and the composites. It is also seen that for all the loads studied wear resistance of the composites were better when compared to the matrix alloy. It may be attributed to the hardness of the material a dominating factor affecting the wear resistance [16-18]. The increase in the wear resistance is also due to the fact that cenospheres are hard, abrasive particles and resist wear better than the matrix [8].

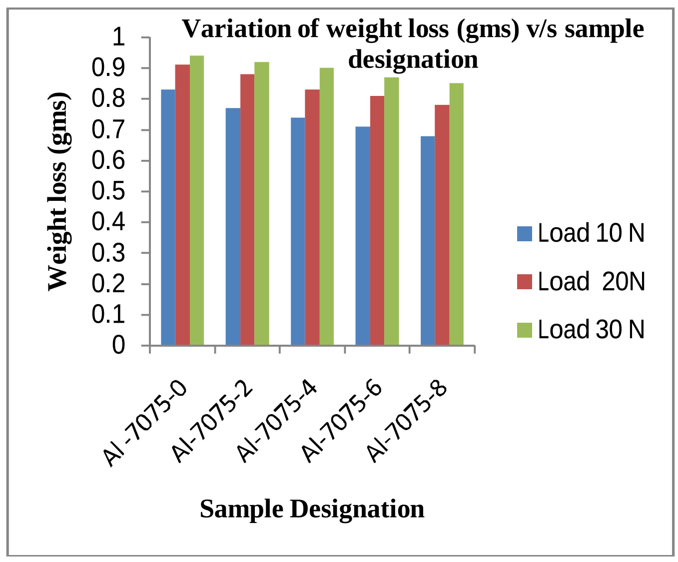

Fig. 3 Variation of weight loss with increasing % of reinforcement at 10, 20 and 30N load

4. Conclusions

1. Cast composites are prepared with varying percentages of reinforcement using forced vortex stir casting technique.
2. Pin on disc wear studies have shown that there is an increase in the wear resistance of the samples with an increasing content of cenospheres
3. The hardness studies also confirms the same, that with an increasing content of cenospheres there is a uniform increase in hardness
4. The developed material therefore suggests that this could be used as a replacement for conventional materials used in the automobile sector.

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