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Assessment of Mechanical Properties of Aluminium 7075 based Metal Matrix Composite

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***Abstract*— - In this present investigation efforts are made to study the mechanical properties of as cast Tungsten carbide particulates and Short E-glass fibers reinforced AA7075 Hybrid composites. The vortex method of stir casting was employed, in which the reinforcements were introduced into the vortex created by the molten metal by means of mechanical stirrer. Castings were machined to the ASTM standards on a highly sophisticated lathe. The degree of improvement of mechanical properties of MMCs is strongly dependent on the kind of reinforcement. An improved mechanical properties occurs on reinforced compared to Unreinforced MMCs alloys.**

1 INTRODUCTION

At present MMCs offer attractive performance as weight saving alternatives for a wide range of applications, starting from toys to high performance required areas like automobile industry and aerospace industry, as they can provide highly beneficial characteristics over existing materials [1]. In the present context, industries need better performance materials, which are less in weight, more strength (high specific strength), cost- effective and resistance to corrosion / environmental degradation. This resulted in the emergence of composites.

Metal is a chemical element that is a good conductor of both electricity and heat forms cat-ions and ionic bonds with non-metals. In chemistry, a metal is an element, compound, or alloy characterized by high electrical conductivity. An alloy is a mixture of two or more element in solid solution in which the major component is a metal. Most of pure metals are either too soft, brittle or chemically reactive for practical use. Combining different ratios of metal as alloys modifies the pure metals to produce desirable characteristics. Metals are used because of desirable properties such as low weight, higher conductivity, and resistance to corrosion. Example: Aluminium, Copper, Brass, Silver, Lead.

2. OBJECTIVES OF PRESENT WORK

Mechanical properties like Tensile test, Hardness test are conducted on Al 7075 reinforced with Tungsten carbide and E-glass. These reinforcements provide comparatively high Strength and Hardness.

The main objective of this project is to develop Al (7075)/ E-Glass & Tungsten carbide particulate metal matrix composites where the E-glass & Tungsten carbide are used as reinforcement material & Al 7075 is used as matrix material. Different weight percentages of Specimens are prepared by using liquid route metallurgy technique. Test specimens are prepared to evaluate tensile and hardness properties.

3. EXPERIMENTAL DETAILS

Following steps are carried out in our experimental work:
1. Material selection
2. Composite preparation
3. Testing

3.1 Material selection

The Al 7075 alloy (matrix material), WC 30-40 μm size particles (reinforcement) and E-glass short fibers (reinforcement) were used for fabrication of MMCs. The chemical composition of Al7075 is given in the Table 1.

Table 1: Chemical Composition of Al 7075

Composition	Zn	Fe	Mg	Mn	Cu	Si	Cr	Ti
% Composition	5.6	0.5	2.5	0.3	1.6	0.4	0.23	0.2

3.2 Composite preparation

The WC of 30-40 μm size and short E-Glass fibers were used as the reinforcement and the WC content in the composites was varied from 2 to 6% in steps of 2% by weight and E-glass short fibers are varied from 1 to 5% in steps of 2% by weight. Liquid metallurgy technique was used to prepare the composite materials in which the WC particles were introduced into the molten metal pool through a vortex created in the melt by the use of an alumina-coated stainless steel stirrer. The coating of alumina on the stirrer is essential to prevent the migration of ferrous ions from the stirrer material into the molten metal. The stirrer was rotated at 550 rpm and the depth of immersion of the stirrer was about two-thirds the depth of the molten metal. The pre-heated (773 K) WC particles and short E- Glass fibers were added into the vortex of the

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liquid melt which was degassed using pure nitrogen for about 3 to 4 min. The resulting mixture was tilt poured into preheated permanent moulds.

3.3 Tensile test

Tensile tests were conducted at room temperature using universal testing machine (UTM) in accordance with ASTM E8-82. The tensile specimens of diameter 8.9 mm and gauge length 76 mm were machined from the cast composites with the gauge length of the specimen parallel to the longitudinal axis of the castings.

3.4 Hardness test

Brinell hardness is determined by forcing a hard steel or carbide sphere of a specified diameter under a specified load into the surface of a material and measuring the diameter of the indentation left after the test. The Brinell hardness number, or simply the Brinell number, is obtained by dividing the load used, in kilograms, by the actual surface area of the indentation, in square millimeters. The result is a pressure measurement, but the units are rarely stated.

The BHN is calculated according to the following formula:

$$BHN = \frac{F}{\frac{\pi}{2} D * (D - \sqrt{D^2 - Di^2})}$$

Where

BHN = the Brinell hardness number

F = the imposed load in kg

D = the diameter of the spherical indenter in mm

Di = diameter of the resulting indenter impression in mm

4. RESULTS AND DISCUSSION

4.1 Mechanical properties

The results of the mechanical tests such as ultimate tensile strength, yield strength, ductility and hardness of as cast Al7075 MMCs are given in the Figure 4.1, Figure 4.2, Figure 4.3 and Figure 4.4 respectively.

4.1.1 Effect of Wc and E-glass on UTS of Al 7075 alloy

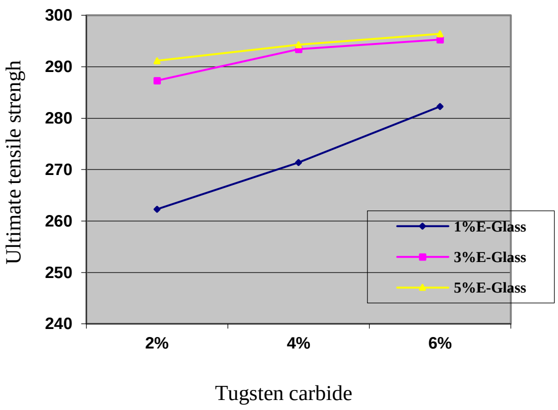

Fig 4.1 Variation of UTS with respect to Tungsten carbide and E- Glass variation

From the Fig. 4.1 it is obvious that the Al7075 MMCs exhibits higher ultimate tensile strength (UTS) than the Al7075 matrix materials. Consequently the UTS are not only dominated by the particles, but also influenced by the properties of matrix and particle interface. The maximum percentage increase in UTS of the composites is 16%.

4.1.2 Effect of WC and E-glass on YS of Al 7075 alloy

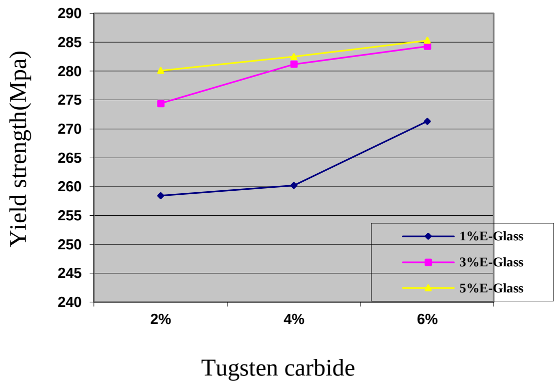

Fig 4.2 Variation of YS with respect to Tungsten carbide variation

The Fig. 7.2 shows the yield strength of Al 7075 with varying compositions of WC and E-Glass. It may be inferred from the graph that as the percentage of WC particulate increases from 2 to 4% weight there is increasing of yield strength 7% in an average for as cast condition. E-Glass is very stiff material which makes base matrix more strengthen .Kennedy & Wyatt [2], obtained similar results in particulate reinforced Al alloy composites and observed an increase in yield strength with addition of particulate regardless of the type of reinforcement used.

4.1.3 Effect of WC and E-glass on percentage Elongation of Al 7075 alloy

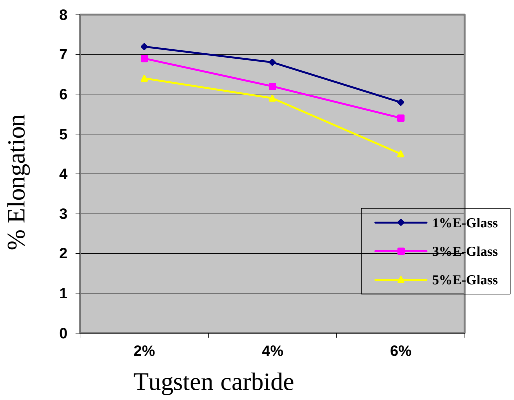

Fig 4.3 Variation of % Elongation with respect to Tungsten carbide variation

The ductility decreases with the increase in WC content by a significant amount. The reduction in ductility was about 30% as the WC content was increased from 0 to 6 wt%.

Olivier et al.[3] are of the opinion that this behavior is probably due to void nucleation during plastic straining of the reinforcement, either by reinforcement interface or by the de-cohesion of the matrix-reinforcement interface. Similarly, as Eglass increases from 0% to 5%, there is decrease in % Elongation about 20%. Some authors believe that the compressive-to-tensile stress transition for a critical volume fraction could be described as one of the contributing factors for the steep decrease of ductility and fracture toughness of the composites with increasing volume fraction. The ductile failure in the matrix caused either by the nucleation, growth and coalescence of voids from the cracking of the intermetallic inclusions and dispersoids in the matrix, by ductile tearing of the matrix between the reinforcement [4].

4.1.4 Effect of WC and E-glass on Hardness of Al 7075 alloy

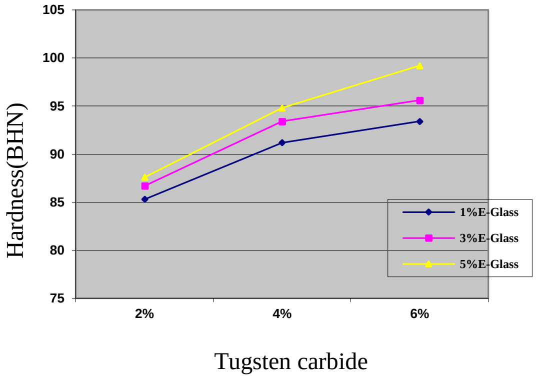

Fig 4.4 Variation of Hardness with respect to Tungsten carbide variation

Fig.4.4 shows the effect of increase in particulate and fiber content on the hardness of the Al 7075 MMCs. The increase in hardness was about 46% as WC particulate was increased from 0 to 6 wt%. The increased hardness is attributed to the presence of hard ceramic particles, which act as barrier to the movement of the dislocations in the matrix. It is very clearly observed that overall combination of 5% Eglass and 6% Wc, will increase the hardness about 33%.

5 CONCLUSIONS

1. The hardness increases with increasing wt. % of reinforcement for the MMCs.
2. Important micro-structural changes occur during initial addition of reinforcement.
3. The mechanical properties such as UTS, yield strength and hardness increase with increasing wt. % of reinforcement for the MMCs.

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