Evaluation of Mechanical Properties of Aluminium 7075 based Metal Matrix Composite reinforced with Tungsten carbide and zircon sand particulates

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Abstract - Metal Matrix Composites (MMCs) constitute an important class of design and weight-efficient structural materials that are encouraging every sphere of engineering applications and mainly in aerospace applications. The present study deals with Aluminium Alloy 7075 reinforced with zircon sand and tungsten carbide. Aluminium alloy 7075 is strong, with a strength comparable to many steels, and has good fatigue strength, but has less resistance to corrosion than many other Al alloys.
The composites are prepared for the different compositions of Zircon Sand and tungsten carbide particulates using stir casting technique. The test specimens are prepared as per the ASTM standards to conduct tensile test and hardness test. Results shows and conclude that the Metal matrix Composite obtained has got better tensile strength and hardness compared to unreinforced Aluminium alloy (7075).

Key words: Tungsten carbide particulates, Zircon Sand, Al7075 alloy composite, tensile strength and hardness.

I. INTRODUCTION

The intensive materials research have provided a wealth of new scientific innovation to synthesize special materials with enhanced efficiency with low manufacturing cost to fulfill the long pending demands of the engineering sector. A new system of materials containing hard particulates embedded in a metal matrix have exhibited superior operating performance and improved tribological behaviours.
Among MMCs, aluminium alloy based composites had shown the significant improvement in the mechanical, thermal, electrical and wear properties to cater the demand of the industries. Al alloys are termed as versatile materials to be used for numerous engineering applications because of its better machining, joining and processability. In addition to this, low cost, increased strength to weight ratio and other environmental friendly characteristics of Al alloys make them a preferable material in engineering applications [1].
Among the aluminium alloys, Al-Si alloy is well known casting alloy having high wear resistance, low thermal expansion coefficient, good corrosion resistance with improved mechanical properties over a wide range of temperatures. The grain refiner elements modify the Si morphology from coarse to lamellar (fine), thus enhancing the mechanical properties [2]. Different researcher developed numerous composite materials by using different type of matrix, reinforcement size, shape and volume as well as suitable processing technique depending upon the requirement and application. In order to achieve the optimum properties of the metal matrix composite, the distribution of the second phase in the matrix alloy must be uniform, and the wettability or bonding between these substances should be optimized. [3].

II. PROPOSED METHODOLOGY

2.1 Die Casting

Is a metal casting process that is characterized by forcing molten metal under high pressure into a mold cavity. Mostdie castings are made from non-ferrous metals, specially zinc, copper, aluminium, magnesium, lead, pewter and tin based alloys. The dies are prepared by spraying the mold cavity with lubricant. The lubricant both helps control the temperature of the die and it also assists in the removal of the casting. The dies are then closed and molten metal is injected into the dies under high pressure; between 10 and 175 Mpa (1,500 and 25,400 psi). Once the mold cavity is filled, the pressure is maintained until the casting solidifies.

2.2 Machining

The specimens that are casted are further machined into desired shape with the help of Lathe in Machine shop because the casted specimen will not have required dimension. For the testing of the specimen on the machine the centre portion diameter should be according to the standard.

2.3 Testing

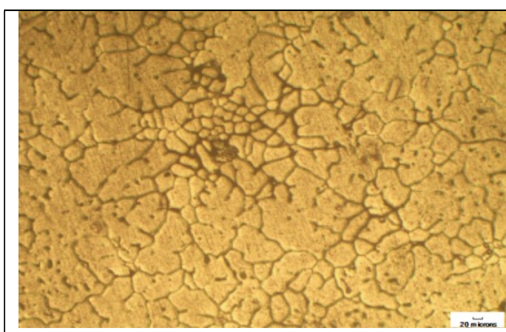
The following tests are conducted.

- Ultimate tensile strength
- yield strength
- % Elongation
- Hardness
- Micro structure

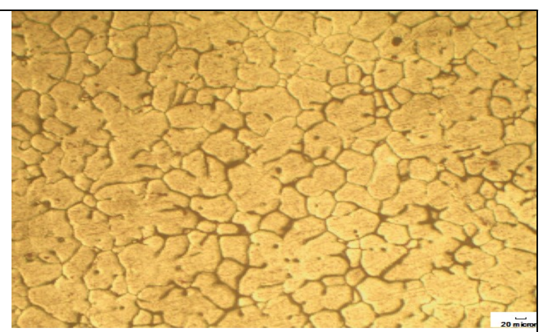
III. EXPERIMENT AND RESULT

3.1 Microstructure Studies

The micrograph clearly reveals the absence of dendritic morphology in all the composites under investigation. It was also found that the perturbation in the solute field due to the presence of particles can change the dendrite tip radius. Also the length of the dendrite is reduced in the presence of the particles. Ceramic particle also act as a barrier for dendritic growth and this phenomena is more pronounced if the cooling rate is high. In this work reported that the particle can be assumed to act as a barrier to the dendritic growth. Microstructure indicates that structure is refined whereas tungsten carbide is having blunted and globular morphological features. This refinement may lead to better tribological and mechanical properties in the composite. Shows that a uniform distribution of the ceramic particulates is achieved in the composites that are reinforced by a lower amount of reinforcement; however, the distribution of the greater amount of ceramic particles is not uniform and Tungsten Carbide and Zircon Sand are agglomerated. Introducing ceramic particles decreases the grain size of the metal matrix and results in the growth in the grain boundary region, which eventually improves the mechanical property of composite compared with those of the non-reinforced alloy [62]. At a higher concentration of ceramic reinforcement, the amount of absorbed ceramic particles did not increase as much as the increase in the volume fraction of the reinforcements



a)



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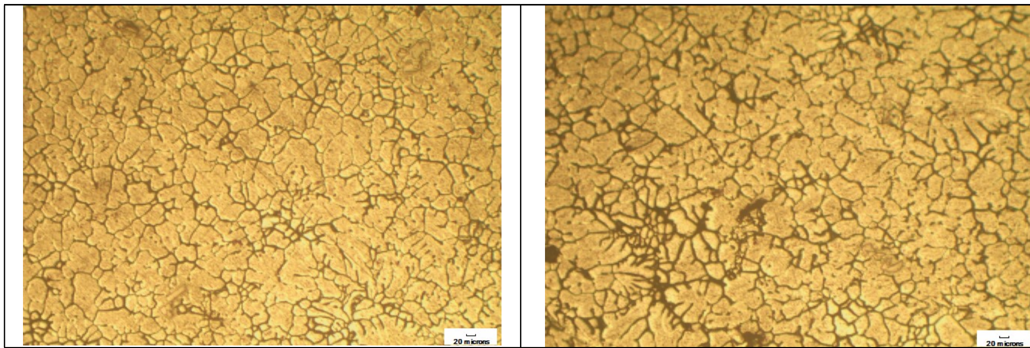
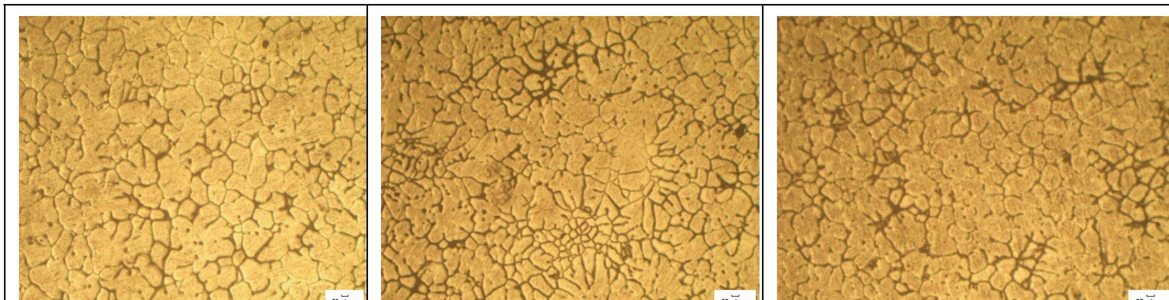


c) d)

Figure 1. Microstructural photos of Al7075 alloy based composites
a) Al 7075 + 2% Zircon Sand + 1% Tungsten Carbide b) Al 7075 + 2% Zircon Sand + 3% Tungsten Carbide
c) Al 7075 + 2% Zircon Sand + 5% Tungsten Carbide d) Al 7075 + 2% Zircon Sand + 7% Tungsten Carbide



a) b) c)

Figure 2. Microstructural photos of Al7075 alloy based composites a) Al 7075 + 2% Zircon Sand + 3% Tungsten Carbide
b) Al 7075 + 4% Zircon Sand + 3% Tungsten Carbide c) Al 7075 + 6% Zircon Sand + 3% Tungsten Carbide

3.2 Effect of Reinforcement on Hardness

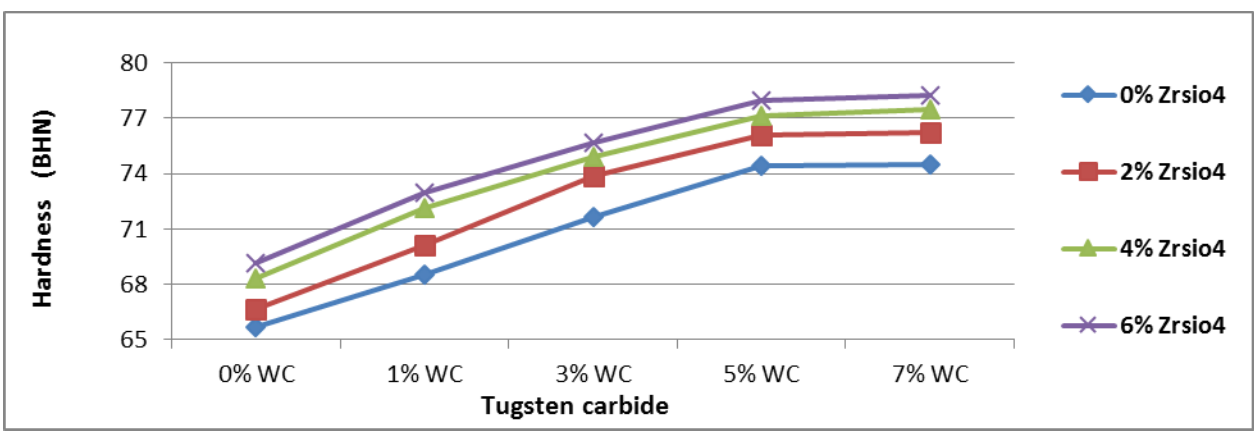


Figure 3. Variation of Tungsten Carbide and Zircon Sand with respect to hardness under as cast condition

Hardness of aluminum based metal matrix composites are mainly influenced by type of reinforcement is largely influenced by type of reinforcement dispersion, size shape. The influence of zircon sand and tungsten carbide particles content on hardness of Al7075 matrix alloy is shown in figure and it shows variation of hardness of Al7075+zircon+WC composite with increase in tungsten carbide particles at constant percentage of zircon sand. It is observed that, for a given percentage of zircon sand, there is a continuous increase in the hardness of the metal matrix composites with increase in tungsten carbide particle. For 4wt% of zircon with 5wt% WC particles a maximum BHN is noticed (Al7075+5%WC+4% zircon). In the presence of zircon , the maximum hardness recorded with increase in the percentage of tungsten carbide alone from 0 to 6wt%, a maximum improvement of 15% is observed, whereas with addition of zircon from 0% to 6% with corresponding tungsten carbide content a maximum hardness was recorded Al7075+5%WC+4%zircon composite. With further increase in tungsten carbide there is decrease or almost remains same in hardness. This marginal decrease is observed at higher percentage of reinforcement may be attributed to uneven dispersion and poor wettability of reinforced phase. This combination has exhibited a maximum improvement of 78 BHN, which is 20% higher than the unreinforced alloy.

3.3 Effect of reinforcement on Ultimate tensile strength

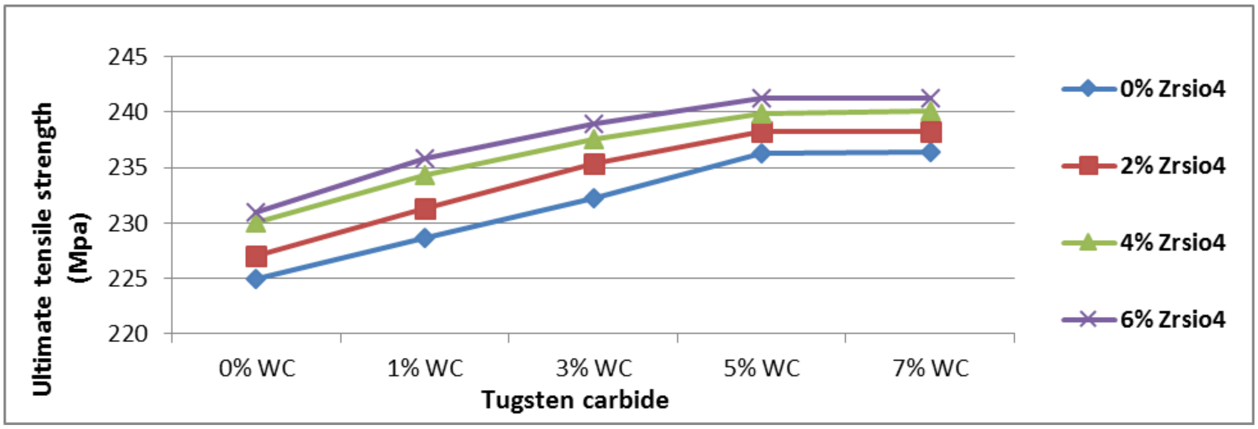


Figure 4. Variation of Tungsten Carbide and Zircon Sand with respect to UTS under as cast condition

The ultimate tensile strength values for Al7075 alloy and its composites with varying Tungsten carbide and zircon sand content are shown in figure. It can be observed that with the increase in Tungsten carbide and Zircon Sand content the ultimate tensile strength is increased Compared to Al7075 alloy, the composite with highest Tungsten carbide and Zircon Sand content has highest tensile strength which is almost 20% increment. The reinforcements, Tungsten carbide and zircon sand are contributing to ultimate tensile strength of Al7075 matrix. The strengthening of Al7075 is mainly due to the even dispersion and good bonding of reinforcements with the matrix material. The uniform dispersion of reinforcements as seen in Fig. is reflected in the increment in ultimate strength values. It is important to be mentioned here that with increase in the percentage of WC particles there is a tremendous enhancement in the tensile strength continuously for a given percentage of Zircon Sand.

3.4 Effect of reinforcement on yield strength

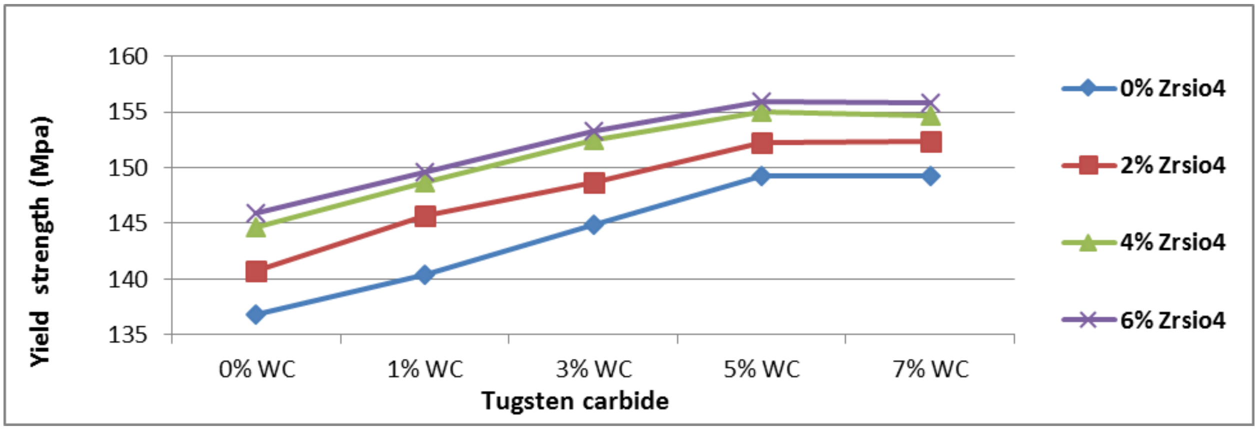


Figure 5. Variation of Tungsten Carbide and Zircon Sand with respect to yield Strength under as cast condition

In the present work, it can be seen from figure that, with the increase in Tungsten carbide and Zircon Sand content, the yield strength is increasing. The Al7075 alloy had yield strength of 137 MPa while that of composite with Al7075+5%WC+6% Zircon Sand had about 157 MPa.

The maximum increment in yield strength of about 25% was displayed by Al7075+5%WC+6% Zircon Sand composite when compared with that of Al7075 alloy. As mentioned, the yield strength of composites mainly depends on the reinforcements and work hardening.

3.5 Effect of reinforcement on ductility

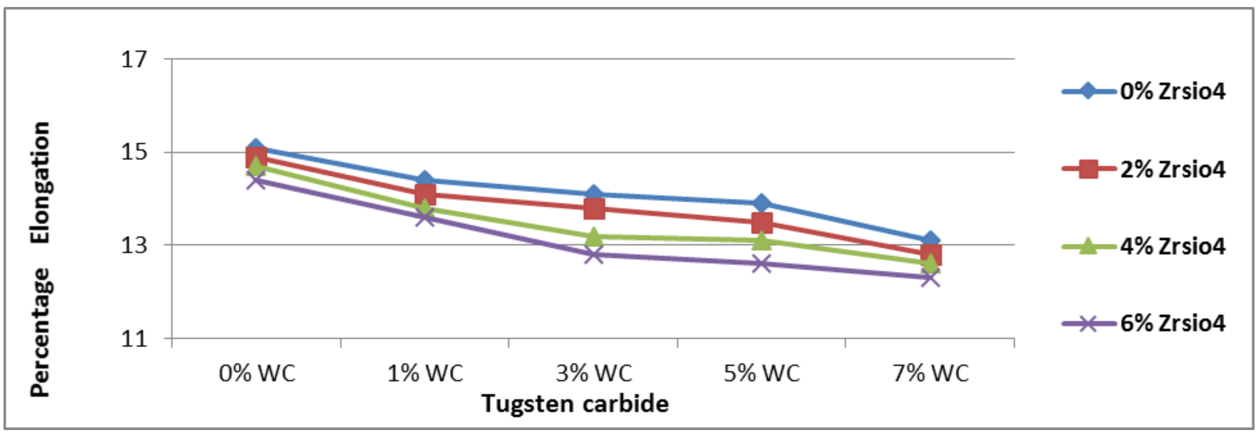


Figure 6. Variation of Tungsten Carbide and Zircon Sand w.r.t percentage Elongation under as cast condition

The figure shows the ductility of Al7075 alloy and its composites with varying Zircon Sand and Tungsten carbide content. It can be observed that the ductility is decreasing with the increase in the Tungsten carbide and Zircon Sand content.

The highest ductility was observed in case of Al7075 alloy while least was observed in case of Al7075+5%WC+6% Zircon Sand composite. The maximum drop in ductility of about 25% was observed in case of Al7075+5%WC+6% Zircon Sand composite when compared to other composites with varied tungsten carbide and Zircon Sand content.

IV. CONCLUSION

The conclusions drawn from the present investigation are as follows:

1. Aluminum matrix composites have been successfully fabricated by stir casting technique with fairly uniform distribution of Zircon Sand and Tungsten carbide particles.

2. Microstructure studies

   Introducing ceramic particles decreases the grain size of the metal matrix and results in the growth in the grain boundary region, which eventually improves the mechanical property of composite compared with those of the non reinforced alloy

3. Tensile test

   From tensile test it is found that

   - The composite with highest Tungsten carbide and Zircon Sand content has highest tensile strength which is almost 20% increment.
   - It is found that elongation tends to decrease with increasing particles weight Percentage, The maximum drop in ductility of about 25% was observed in case of Al7075+5%WC+6% Zircon Sand composite when compared to other composites with varied tungsten carbide and Zircon Sand content.

4. Hardness

   Dispersion of Zircon Sand and Tungsten carbide particles in aluminum matrix improves the hardness of the matrix material. The marginal decrease is observed at higher percentage of reinforcement may be attributed to uneven dispersion and poor wettability of reinforced phase. This combination has exhibited a maximum improvement of 78 BHN, which is 20% higher than the unreinforced alloy.

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