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Tensile Test and Wear Behavior of Titanium Carbide Reinforced With Aluminium Alloy 6063 Metal Matrix Composite

P.Dhanasekaran¹, M.Ravisankar², S.Sathishkumar³, N.Velavan⁴ C.Thiruvassagam⁵,

^{1,2,3,4} U.G students, Department of Mechanical Engineering, Muthayammal College of Engineering, Rasipuram, India

⁵ Assistant Professor, Department of Mechanical Engineering, Muthayammal College of Engineering, Rasipuram, India

ABSTRACT: Metal matrix composite of aluminium alloy (Al 6063) matrix reinforced with titanium carbide (TiC) particulates was fabricated by stir casting technique. Aluminium alloy is selected as the matrix materials and titanium carbide particulates were in co-operated with varying proportions of 2wt% 4wt% and 6wt%. Stirring was done to achieve uniform distribution of reinforcement particulates and rectangular and round shaped castings were made by pouring the composite mixture in sand mould. The composite was then studied with respect to its micro structure and mechanical properties. Tensile specimens as per ASTM standards were machined to find out the mechanical properties of composite. Comparative study for all the said composites is done with respect to tensile strength, wear and micro hardness. Scanning electron microscope (SEM) is used to observe the distribution of particulates to understand the nature of fractured surface.

KEYWORDS: Metal matrix composites, Titanium carbide, Stir casting

1.INTRODUCTION

After iron, aluminium is now the second most widely used metal in the world. This is because aluminium has a unique combination of attractive properties. Low weight, high strength, superior malleability, easy machining, excellent corrosion resistance and good thermal and electrical conductivity are amongst aluminium's most important properties. Aluminium is also very easy to recycle. A combination of two or more materials (reinforcing elements, fillers, and composite matrix binder), differing in form or composition on a macro scale. The constituents retain their identities, that is, they do not dissolve or merge completely into one another although they act in concert. Normally, the components can be physically identified and exhibit an interface between one another. Examples are cermet and metal-matrix composites. Materials are the basic element of all natural and manmade structures. Generally speaking any material consisting of two or more components with different properties and distinct boundaries between the components can be referred to as a composite material. Moreover, the idea of combining several components to produce a material with properties that are not attainable with the individual components has been used by man for thousands of years. Corresponding, the majority of natural material that have emerged as a result of a prolonged evolution process can be treated as composite materials. Almost all the materials which we see around us are composites. Some of them like woods, bones, stones, etc. are natural composites, as they are either grown in nature or developed by natural processes.

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II. MATERIALS PREPARATION AND EXPERIMENTATION

2.1 Matrix and Reinforcement

S. No.	Parameters	Observed Values (%)
1	Si	0.44
2	Mn	0.054
3	Cr	0.021
4	Cu	0.098
5	Ti	0.050
6	Mg	0.46
7	Fe	0.46
8	Zn	0.66
9	Al	97.69

Table: 1 chemical composition of pure aluminium6063 alloy

PHYSICAL PROPERTIES OF TITANIUM CARBIDE (TiC)

Carbide is similar in many ways to tungsten carbide, and is used either on its own or as part of a composition in the preparation of cermets, to enhance the strength of machining tools. Because of its refractory properties and ability to act as a lubricant, titanium carbide is used in machining and other applications that produce high heat and friction.

PROPERTIES OF Ti C

S. No.	Property	Value
1	Density	4900 kg/m
2	Electrical resistivity	0.003- 0.008 $\Omega \cdot m$
3	Hardness, Knoop (KH)	2470 kg/mm

Table: 2 Properties of Reinforcement Material –TiC

2.4 FABRICATION PROCEDURE

The matrix is taken in molten form to which the reinforcement such as particulates, whiskers or discontinuous fibres are added, thoroughly mixed solidified and then cut into required shapes. This technique involves high temperatures and there is a possibility of damage to reinforcements. Sometimes, molten matrix metal will not wet the reinforcement. Al_2O_3 , for instance is not wetted by molten aluminum. Lithium is to be added to increase wet ability.

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The amounts of the matrix material and the reinforcements were determined using the relation $\rho_c = \rho_m V_m + \rho_r^2 V_r^2$, where ρ_m , and ρ are the densities of the materials of the matrix and the two reinforcements respectively and V_m , and V are volume fractions of the matrix and the reinforcements respectively

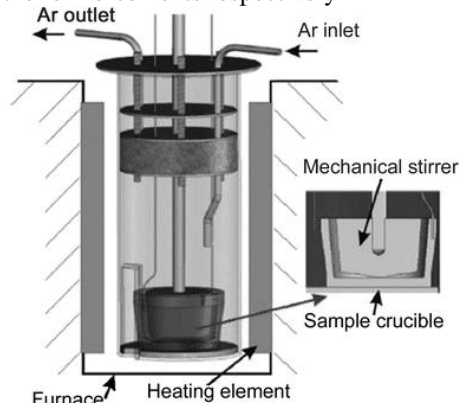


Fig: 1 Preparation of the composites by stir casting

ρ_c is the density of the composite. The melting was carried out in a resistance furnace. Scraps of aluminum were preheated at 450°C for 3 to 4 h before melting. The B_4C particles were also preheated at around 1,000 to 1,200°C to make their surfaces oxidized. The preheated aluminum scraps were first heated to above the liquid to the temperature to melt them completely. They were then slightly cooled to below the liquidus, to maintain the slurry in the semi-solid state. This procedure has been adopted while stir casting aluminum composites with single reinforcement. The preheated reinforcements were added and mixed manually. The composite slurry was then reheated to a fully liquid state and mechanical mixing was carried out for about 10–15 min at an average mixing speed of 150–300 rpm. The final temperature was controlled to be within 750°C±10°C and pouring temperature was controlled to be around 720°C. After thorough stirring the melt was poured into steel moulds of 20 mm diameter and 30 cm in length and allowed to cool to obtain cast rods.



Fig: 2 Pouring the molten metal in die cavity

2.5 WEAR TEST

Wear testing specimen is casted according to ASTM G99. A pin on disc wear testing configuration is used to check wear properties of composite specimen. The specimen is rubbed against rotating hard steel disc without any lubricant. Dry sliding method is followed. Variable parameters such as speed, which is varied between 1.2 m/s to 5.1 m/s and load is varied between 10 N to 40 N. Common track diameter of 120mm is used to test the specimen. After testing, the specimen is removed from the machine and weighed. Difference in initial and final weight gives the loss of material in turn wear rate of the material. The specimen is weighed using electronic balance. Tests are conducted at normal room temperature. The principal objective of investigation was to study the effect of variation of normal load, sliding velocity and percentage TiC on wear rate.

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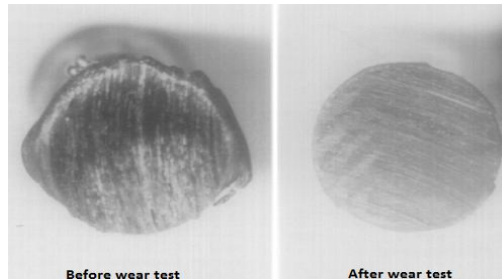


Fig: 3 Microstructural Effect of Pin on discwear test Al-TiC Material

2.6 TENSILE TEST

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure. The commonly used specimen for tensile test is the flat bar type. During the test a uniaxial load is applied through both the ends of the specimen. The dimension of specimen is as per ASTM B557 M-94, (30x30x10) mm. typical points of interest when testing a material include: ultimate tensile strength or peak stress; offset yield strength which represents a point just beyond the onset of permanent deformation; and the rupture or fracture point where the specimen separates into pieces. The tensile test is performed in the universal testing machine (UTM) and results are analyzed to calculate the tensile strength of composite samples.



Fig: 4 Tensile Test

2.7 SEM TEST

The intense plastic deformation and exposure to elevated temperature cause dynamic recrystallization which refines the grains of aluminium alloy Al6063. Dynamic recrystallization is a well-known established phenomenon in FSW and FSP. The average grain size of friction stir processed Al6063 is about 10 μm . Dynamic recrystallization resulted in an extensive grain refinement.

The SEM micrographs of the prepared AMCs are shown in Fig. The distribution of TiC particles is fairly homogeneous in the AMC.

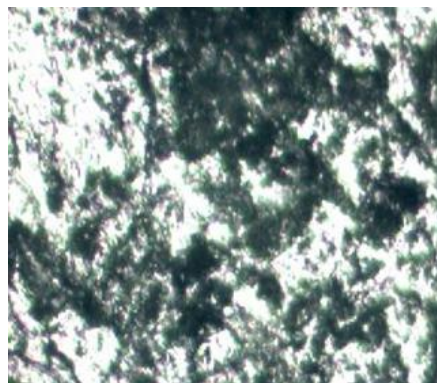


Fig:5 SEM Image on Al6063

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During the initial stages of the formation of the AMC, the plasticized aluminium alloy flows into the groove and forged at the back of the tool. The rotating action of the tool provides a vigorous stirring which causes the packed TiC particles in the groove to be uniformly distributed in the aluminium matrix. Segregation reduces mechanical and tribological properties of the AMC. Since the AMC is formed in the solid state, the free movement of particles due to density gradient is absent. However, an agglomeration of TiC particles was observed at few places. The dark regions in the macrostructure exhibit bands of TiC particles. Those regions were present close to the centre of the AMC. The threaded tool causes a vertical flow might have formed the agglomeration of the plasticized composite. The trapped TiC particles during the vertical flow might have formed the agglomeration while the particles in groove were mixed with plasticized aluminium. The grains are not clearly visible because they are ultrafine in nature.

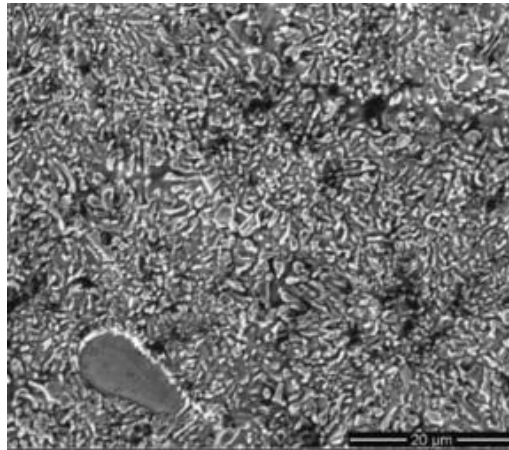


Fig:6 SEM Image on Al-TiC

The grain modification can be attributed to the presence of TiC particles in the AMC because TiC particle acted as an effective grain refiner. The TiC particles pin the movement of the grain boundary and retard the grain growth subsequent to dynamic recrystallization. This is known as pinning effect which produces finer grains in AMCs.

III.RESULT AND DISCUSSION

Abrasive wear has been defined as the displacement of material caused by hard particles or hard protuberances where these hard particles are forced against and moving along a solid surface. By incorporating the TiC particles in to the matrix, the sliding wear properties are enhanced. The hardness of the specimen increases and fluidity decreases. The effect of variable load and speed on specimen wear is checked against variable reinforcement percentage. The effect of applied normal load on the MMC with different TiC reinforcement percentage. In this test, for constant speed of 3.7 m/s, load is increased in steps of 10N. The test is conducted for normal loads of 10, 20, 30 and 40N. It is observed that wear of the composite specimen decreases with increase in TiC percentage. This happens because of TiC, which is hard material which improves the hardness. For specimen with 1% reinforcement with 10N load, almost wear is negligible. As load is increased, increase in wear is observed. Decreasing trend is observed with increase in reinforcement. For 5% reinforcement load is increase, less weight loss is observed.

The as-cast and heat treated samples were machined to get specimens for tensile test. The shape and dimensions of the tensile specimen are shown in figure 3. The universal testing machine (UTKE: PC based) was used for the tensile test. The specimens were loaded hydraulically. The loads at which the specimen has reached the yield point and broken were noted down. The extensometer was used to measure the elongation.

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SPECIMEN	TiC (wt %)	SIZE (mm ³)	PEAK LOAD (KN)
1	2	30 x 10 x 10	410
2	4	30 x 10 x 10	395
3	6	30 x 10 x 10	380

Table: 3 Tensile Strength Result

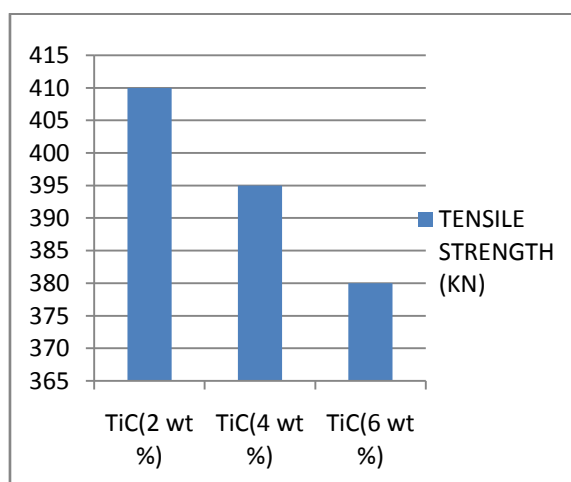


Fig: 7 Comparison of peak load

IV.CONCLUSION

TiC particles have been spontaneously incorporated in to commercial available Al6063 alloy a melt using fluxing agents which remove the melt surface oxide and promote contact between clean, wetting surface. TiC particle addition significantly refines the grain structure which increase of the strength of the composite. But at higher percentage of TiC, there is a decrease in the mechanical properties. At lower composition better properties are exhibited which can be explained by stronger interfacial bonding in the TiC system due to wetting of the reinforcement by the liquid and particle engulfment into the solid phase caused principally by the increased tendency for nucleation of solid on the particle surface. Also the ductility decrease with increasing particle reinforcement as seen in the tensile fractured surface. Hardness value increase up to 4wt% Tic addition but show a decreasing trend when reinforcement composition is increased to 6wt%.

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