Development and Characterization of Aluminium 6061 Matrix Reinforced with Titanium Carbide

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Abstract - Interest in reinforcing Al alloy matrices with ceramic particles are mainly due to the low density, low coefficient of thermal expansion and high strength of the reinforcements. Metal-matrix composites are widely used in shipping, aerospace, automotive, and nuclear applications. Among the various useful alloys, Aluminium 6061 is typically characterized by properties such as fluidity, cast ability, corrosion resistance and high strength-weight ratio. Aluminium based MMCs have received increased attention in recent decades as engineering materials. Research attempts have been made in the past to reduce the cost processing of composites, decrease the weight of the composites, and increase the desired performance characteristics. In the present research, the effect of titanium carbide particles on their mechanical properties with Aluminium 6061 matrix has been reviewed. The hardness and tensile strength have been reported to increase with increasing weight percentage of Titanium carbide. The wear rate of the composites has been reported to decrease linearly with increasing weight percentage of Titanium carbide.

***Key words* – Metal Matrix Composite (MMC), Titanium Carbide (TiC), Aluminium (Al)**

1.INTRODUCTION

Aluminium-based Metal Matrix Composites (MMCs) have been in high demand in recent decades as engineering materials. The addition of a ceramic material into a metal matrix produces a composite material that results in an extremely useful combination of physical and mechanical properties which cannot be obtained with other alloys. Aluminium is worked and formed using a large variety of forming processes such as deep- drawing and roll forming. Aluminium can also be recycled. Aluminium is not toxic and is used in contact with food stuff. Aluminium alloy-based particulate-reinforced composites have a huge potential for a number of engineering applications. The particulate reinforced MMCs is used due to accessibility of particles and economic processing techniques adopted for producing the particulate-reinforced MMCs[1].

2 MATERIALS USED AND METHODS

2.1 Matrix and Reinforcement:

Aluminium 6061 matrix has been used as the base alloy and Titanium Carbide has been used as the reinforcment. The chemcial composition of the Al 6061 is shown in Table 1. The Table 2 shows the different composition ofcomposites developed for the pressent study

Table 1: Chemical Composition of Al6061

Mg	Si	Mn	Zn	Al
1.2	0.8	0.8	0.25	Balance

2.2 METHODS

In the present invesitgation stir casting techniques is used to develop the Al MMC. Aluminium 6061 matrix material was heated in an electric furnace at a temperature of 800 degree Celcius to obtain molten metal.Titanium Carbide will be preheated to remove moisture. Titanium Carbide was added in 0%, 4%, 8% and 12% weight percentages to the molten metal as a reinforcment material. The stirring speed maintained was 300 rpm. Stirring is continued for about 10 min after addition of Titanium Carbide for uniform distribution in the melt. Castings are prepared by pouring the melt into preheated moulds of cylindrical shapes. Scanning Electron Microscopy (SEM) test has been conducted on all the composites. Machining was done to a dimension of 10x10mm. The specimens were then polished to remove rough surfaces. Keller’s reagent was added to the specimen as an etchant. The specimens were then scanned using the SEM to study the microstructure. Machining was done as per ASTM E-8 standard. The tensile test was conducted with a UTM TUE C-1000 model. The tensile test is conducted to determine the ultimate tensile strength and the percentage of elongation of the composite material. For the present research, we have used the Micro Vickers Hardness Tester to study the hardness of the developed Aluminum MMC. The load applied for the hardness test was 1kg. For the present research, we have used the Pin-on-Disc Wear Setup. The specimens were machined to a size of 30x10mm.The disc speed was constant at 286 rpm. The loads applied were 10N, 20N and 30N.

Table 2: Composition of matrials

Specimen	Aluminium	Titanium
S1	100 wt. %	0 wt. %
S2	96 wt.%	4 wt. %
S3	92 wt. %	8 wt. %
S4	88 wt. %	12 wt. %

.3. RESULTS AND DISCUSSIONS

3.1 Microstructure

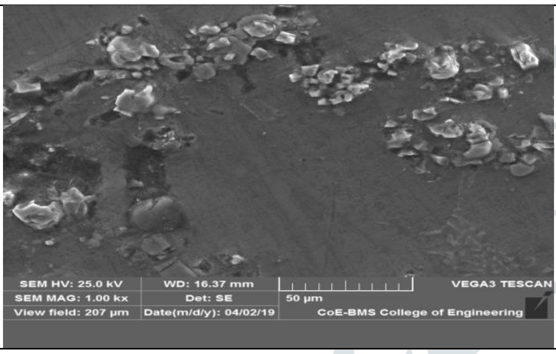


Fig. 1 (a) Al 6061+ 4 wt.% of TiC specimen

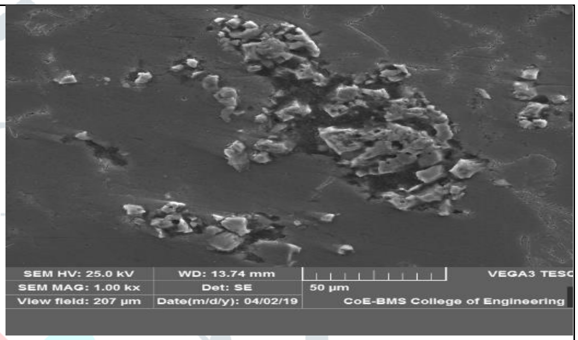


Fig. 1 (b) Al 6061+ 8 wt.% of TiC specimen

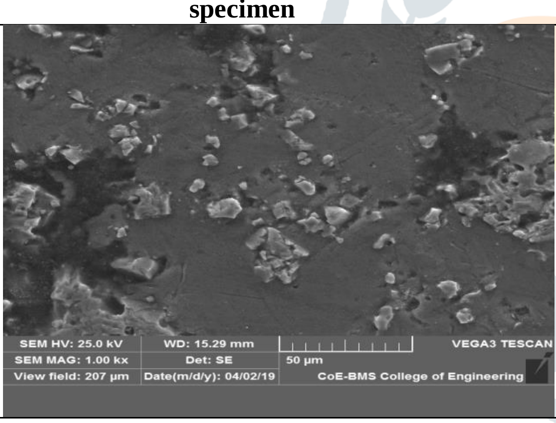


Fig. 1 (c) Al 6061+ 12 wt.% of TiC specimen

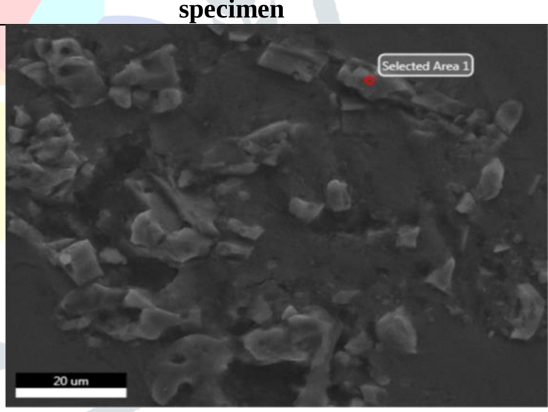


Fig. 1 (d) Spot EDAX

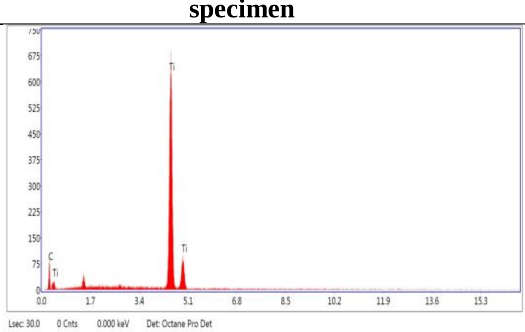
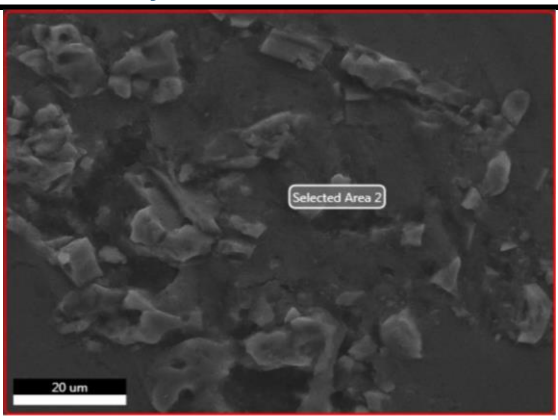


Fig. 1 (e) EDAX spectrum

Element	Weight %	Atomic %
C K	25.29	57.45
TiK	74.71	42.55

Fig. 1 (f) Chemical Composition of Spot EDAX



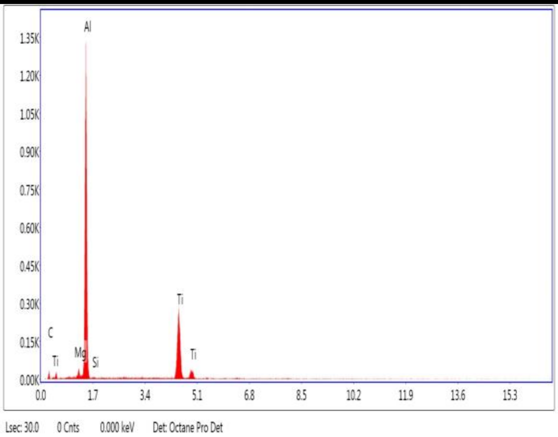


Fig. 1 (g) Selected area for EDAX	Fig. 1 (h) Chemical Composition Selected area for EDAX

Fig.1 SEM images of developed compsites

The above figures show the SEM images of the developed composites. The microstructure study reveals that the uniform distribution of TiC particles into Al 6061 Matrix material with minimal porosity and also the presence of TiC is confirmed through the EDS analysis.

3.2 ULTIMATE TENSILE STRENGTH:

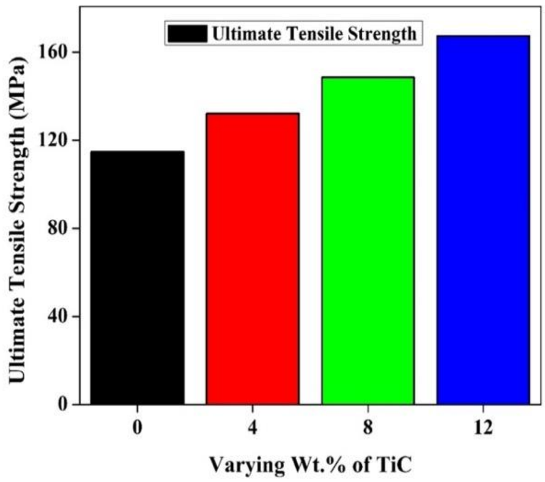


Fig. 2: Bar graph of Ultimate tensile strength v/s varying Wt.% of TiC

From figure 2, it is inferred that the Ultimate tensile strength increases as the reinforcement increases. The tensile strength of the composite is higher than the base matrix material. The increase in the tensile strength is because of incorporation of hard Titanium Carbide particles into the soft Aluminium 6061 matrix material. The maximum ultimate tensile strength achieved for 12wt% of TiC is **167.410 MPa**. The percentage of increase in tensile strength is found to be **46.5%** for 12% compared to base Al alloy.

The following table 3 shows the Tensile Test Results.

Table 3: Tensile Test Results

Specimen	Ultimate Tensile Strength σ_u (MPa)	% Elongation
S1	114.82	8.56
S2	132.208	7.64
S3	148.560	6.46
S4	167.410	5.02

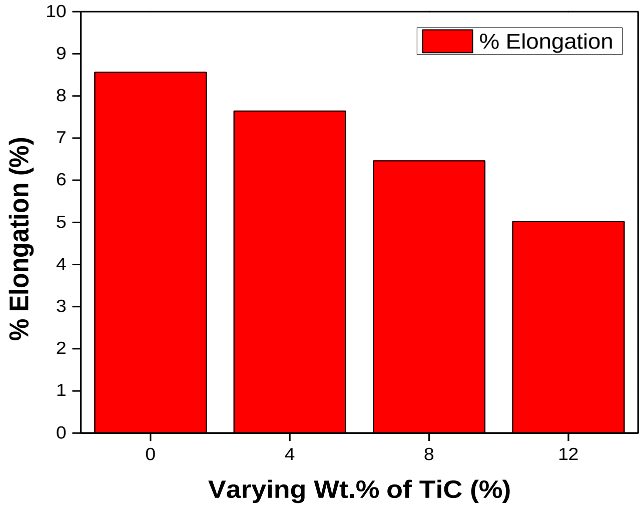


Fig. 3: Elongation of Al 6061 with varying % of TiC

Figure 3 shows the effect of TiC on the elongation of Al 6061. It is inferred from the results that the elongation of MMC decreases with increasing percentage of TiC content. The percentage decrease in elongation is found to be **41.35%.**

3.3 HARDNESS

Figure 4 shows the effect of TiC on the hardness of Al 6061. It is inferred from the test results that, the hardness of MMC increases with increasing percentage of TiC content. This is because of the incorporation of hard, brittle TiC particles into the soft, ductile Al 6061 matrix material. The maximum micro Vickers hardness is found to be **165VH**. The increase in percentage of hardness is found to be **107.28%.**

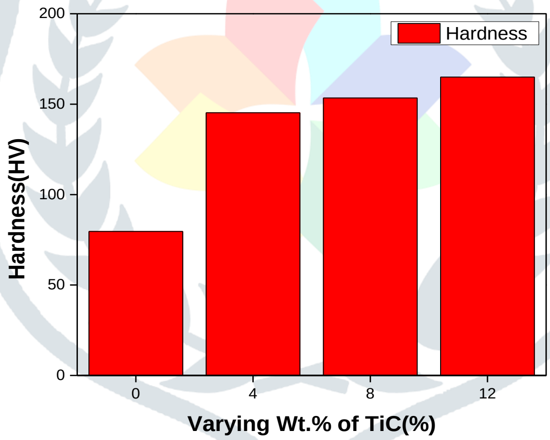


Fig. 4: Hardness vs Vol.Wt% of TiC

3.4 WEAR

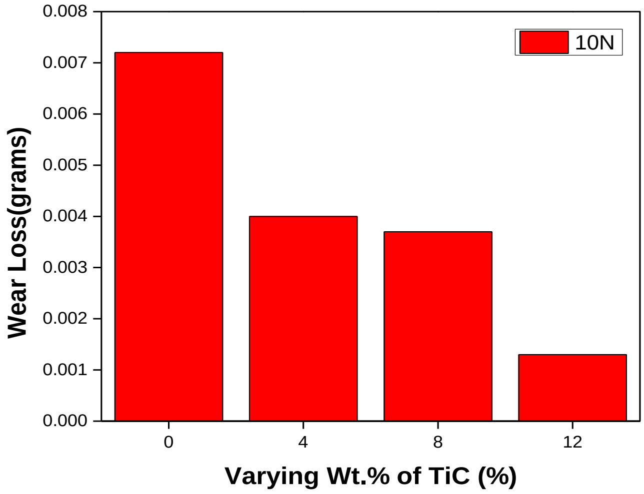


Fig. 5: Graph showing Vol.Wt% of TiC v/s Wear loss for 10N load

Figure 5 show the effect of TiC on the wear loss of Al 6061 for 10N load.

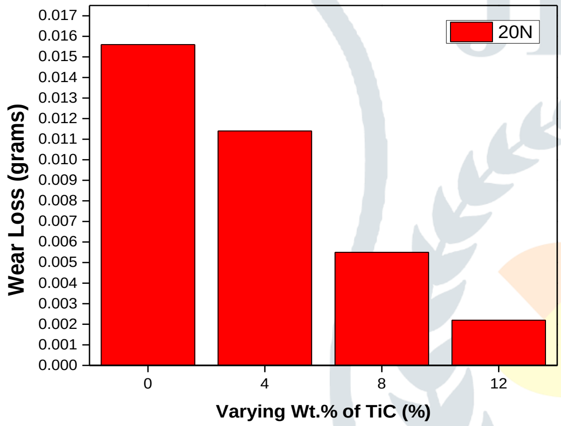


Fig. 6: Graph showing Vol.Wt% of TiC v/s Wear loss for 20N load

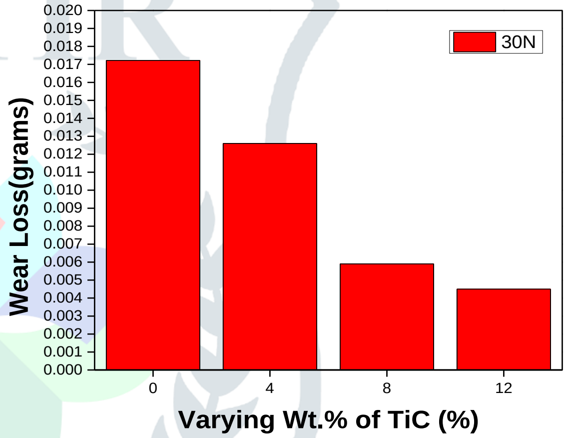


Fig. 7: Graph showing Vol.Wt% of TiC v/s Wear loss for 30N load

Figure6 and figure 7 show the effect of TiC on the wear loss of Al 6061 for 20N load and 30N load respectively.

Table 8: Wear test results

TiC weight %	Wear out 10N (g)	Wear out 20N (g)	Wear out 30N (g)
0	0.0072	0.0156	0.0172
4	0.004	0.0114	0.0126
8	0.0037	0.0055	0.0059
12	0.0013	0.0022	0.0045

From the above test results, it is inferred that as the load increases, wear increases but whereas wear decreases as the percentage of reinforcement increases. This is because incorporation of hard, brittle TiC reinforcement resists wear.

4. CONCLUSIONS

1. The tensile strength increases with varying percentage of TiC (4wt%, 8wt% and 12wt% respectively).
2. The hardness of the material increases with the increase in the percentage of TiC content for specimen of pure aluminium, 4wt%, 8wt% & 12wt% respectively.
3. The wear rate decreased with increase of TiC content whereas when the load increases, wear increases.

From the above results we found the composites having good hardness, tensile strength and also having the low density comparatively alloys with reinforcement. So that these composites could be used in those sectors where light weight and good mechanical properties are required as like in automobile and space industries.

REFERENCES

[1] Zhi Wang, Tao Lin, He Huiping Shao. "Fabrication and properties of the TiC reinforced high-strength steel matrix composite", Int. Journal of Refractory Metals and Hard Materials, 58 (2016) 14-21.

[2] M.O. Hugo, E. Peter, K. Hans, the history of the technology process of hard metals, Int. J. Refract. Met. Hard Mater. 44 (2014) 148–159.

[3] K. Kinukawa, N. Buschmohle, The case for cermets, Tool Prod 53 (1987) 36–39.

[4] S. Park, S. Kang, Toughened ultra-fine (Ti, W) (CN)–Ni cermets, Scripta Mater. 52 (2005) 129–133.

[5] M.K. Meyer, R. Fielding, J. Gan, Fuel development for gas-cooled fast reactor, J. Nucl. Mater. 371 (2007) 281–287.

[6] R. Kieffer, P. Ettmayer, M. Freundhofeier, New sintered nitride and carbonitride hard metals, Metal 25 (1971) 1335–1342.

[7] J. Zhang, Q. Xue, S. Li, Microstructure and corrosion behavior of TiC/Ti (CN)/TiN multilayer CVD coatings on high strength steels, Appl. Surf. Sci. 280 (2013) 626–631.

[8] S.W. Hu, Y.G. Zhao, Z. Wang, et al., Fabrication of in situ TiC locally reinforced manganese steel matrix composite via combustion synthesis during casting, Mater. Des. 44 (2013) 340–345.

[9] F. Akhtar, S.J. Askari, J.A. Shah, et al., Processing, microstructure and mechanical properties of TiC-465 stainless steel/465 stainless steel layer composites, J. Alloys Compd. 493 (2007) 287–293 and TiC reinforced steel matrix composites, J. Alloys Compd. 459 (2008) 491–497.

[10] B.H. Li, Y. Liu, H. Cao, et al., Rapid fabrication of in situ TiC particulates reinforced Fe based composites by spark plasma sintering, Mater. Lett. 63 (2009) 2010–2012.