MECHANICAL AND TRIBOLOGICAL BEHAVIOR OF AL6061 HYBRID METAL MATRIX COMPOSITES

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Abstract: Aluminium is used, matrix material for its outstanding mechanical properties conjugate with great formability. Various technological problem arises in casting process for a uniform distribution of reinforcement materials. In this present, work Al 6061 alloy act as a matrix and chopped E glass fibre with micro titanium as a reinforcement materials. Stir casting is the best technique for preparation of Al hybrid mmc because it reduces the casting defects and improve the uniform mixing of reinforcement material and matrix. Al 6061 alloy heated up to its melting temperature at around 690° C. Initially heated reinforcement material, is included to molten aluminum with constant stirring speed at 250 rpm. Composite are prepared as per ASTM standards for Wear analysis, Tensile, bending test were performed. The wear tests performed in Pin on Disc apparatus at various loads. From the experimental results the minimum wear, high bending and high tensile strength found in Al 6061 mmc. Distribution of reinforcement were observed by SEM.

Index Terms - **Al 6061 alloy, micro titanium, E glass fibre, Tensile strength, mmc, stir casting.**

I. INTRODUCTION

Aluminium mmc, are almost used in all engineering industry since they possess less density and good specific strength and coupled with good machinability. Aluminium 6061 has higher resistance towards corrosion and therefore used in industries like marine, automobile etc. [1]. In MMCs wear, resistance properties are most significant [2-3]. In order to explore this behavior aluminium is reinforced with ceramic particles. Particle composites also have higher heat and wear resistance properties as per findings [4, 5]. Wear of materials is the most vital yet least focused parts of tribology. Wear of a material is the surface harm caused due to relative movement between the two surfaces. It might be in form of loss of material, micro-cracks or localized plastic deformation. Literature also shows that the adding of harder particles revamp the wear withstanding property of aluminium matrix composite [6]. The mechanical properties such as elongation, flexural and hardness has increased for reinforcing material of Silicon carbide at 1.5 % and copper at 5 % added with aluminium. Hardness and flexural properties has increased with varying composition of reinforcement material and observed that the properties improved with Al mmc [7]. Less wear rate, high tensile strength and high yield strength was in case of composites was observed in 6061Al–Al2O3 composites. Al2O3 reinforcement material uniformly distributed with Al6061 these has observed by optical microphotographs [8]. In the current job, an effort has made to cast 6061 Al MMCs. Composites obtained for different composition of reinforcement micro titanium and e glass fibre at different weight percentage. Mechanical and tribological properties are noted.

II. EXPERIMENTAL PROCEDURE

2.1 Stir Casting

Fig 1: Stir Casting Setup

Appropriate quantity of Aluminum ingots added in graphite container and it kept for two and half hours inside the furnace until it reaches 690° C. Reinforcement material are preheated before mixing with molten aluminium. To remove the adulteration and all the gases, degasses were added to the molten aluminium before adding the reinforcements. When the stirring of molten metal is going on the preheated Micro titanium and E glass fibre, poured in small increment in the molten metal. Molten metal with added composites will have a stirring speed around 250 rpm for few minutes and the stirring temperatures maintained around 6500C -7000C. Die will be preheated externally at around 5500C this will avoid casting defects. Now the molten metal poured in to the die (10x100x100mm)

and allowed to solidify. The obtained casting samples, machined to 6mm thickness and test conducted as per ASTM standard, specimens prepared by wire EDM. Table 1 indicates the different composition of MMC involved.

Table 1: Different Casting composition

Sl.no	Composition	Glass fibre %	Micro titanium%
1	AA01	0	1
2	AA03	0	3
3	AA05	0	5
4	AA11	1	1
5	AA13	1	3
6	AA15	1	5
7	AA31	3	1
8	AA33	3	3
9	AA35	3	5
10	AA51	5	1
11	AA53	5	3
12	AA55	5	5
13	AA10	1	0
14	AA30	3	0
15	AA50	5	0
16	AA00	0	0

Fig. 2. Specimens used for tensile test.

III. RESULTS AND DISCUSSION

3.1 Tensile behavior of composites

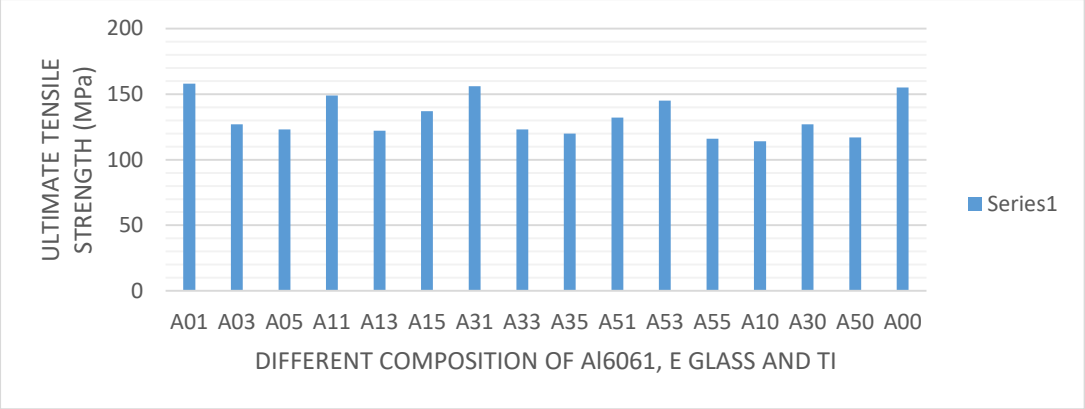

Fig 6: Variation of UTS

The tensile strength of a material is the maximum amount of tensile stresses that it can take before failure. The cast specimen machined to 6mm thickness and these 6mm thickness flat plates and used for tensile tests. For the tensile test load applied at both the ends of the specimen and the loads were uniaxial loads. The dimension of the specimen is as per ASTM standards. The tensile test, performed in the universal testing machine (UTM). Results are scrutinize to evaluate the tensile strength of samples. Fig 2 shows the tensile specimens. The 6mm thick flat plate machined in Wire EDM for tensile test. ASTM E8M standard followed to perform the tensile test. Fig. 3 shows the readings of ultimate tensile strength of base material and Al6061 hybrid mmc with reinforcing material. From the test, we noticed that few Al mmc has resulted in a better strength then the base materials. Al hybrid mmc with one percent of Ti and three percent has increased the tensile property

3.2 Metallographic Study

Preparation of hybrid metal matrix composites with micro titanium and chopped E glass fibre of 2-3mm length strands by stir casting processes is usually onerous by the reason of its very low wettability. The samples machined by wire EDM of 6mm thick and 10 mm diameter. The samples etched with Keller's reagent after polishing. Fig. 4 signifies the presence of reinforcement materials. This signifies the evenly distribution of Ti and E glass fibre particles all over the hybrid mmc and has be observed from the micrographs.

Fig. 4

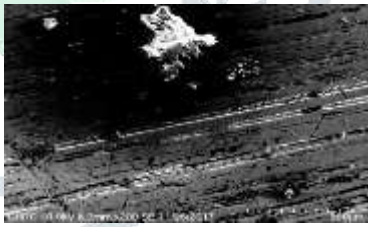

Fig.5

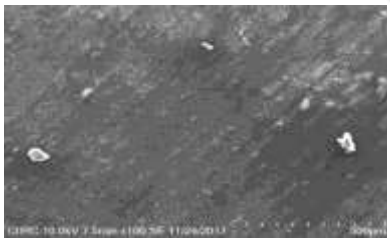

Fig.6

Fig.7

Fig. 4. To Fig. 7. Optical Microstructure of Al 6061 mmc.

3.3 Bending Test of Composites

The bending test of micro titanium and chopped E glass fibre-reinforced Al 6061 hybrid mmc by three-point bend test were analyzed. Bending strength increased with the added reinforcement material

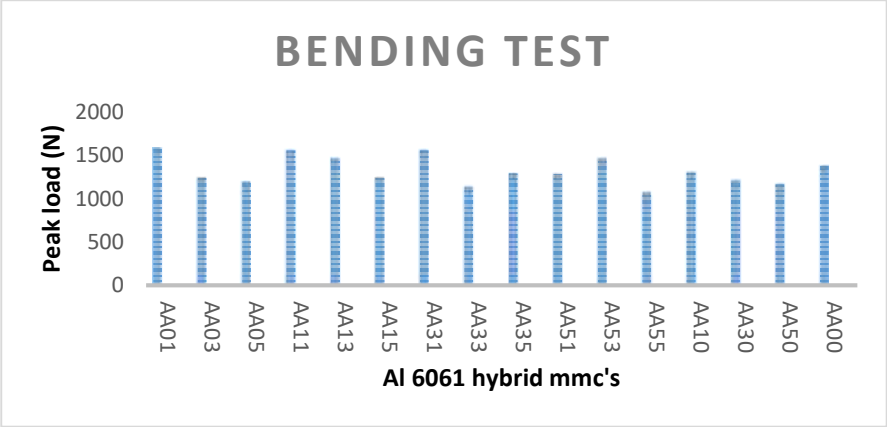

Fig. 8. Bending Test

Fig. 8 shows the change in the Peak load for three point bending test of base material and Al6061 hybrid mmc. Noted that only up to one percent of Ti particles reinforcement has obtained good results in increasing the resistance to bending load of the composite. One percent of Ti and three percent of chopped E glass fibre particles also resulted in an increase in resistance to bending load of the hybrid mmc. Further, it has observed that addition reinforcement material with Al6061 will increase the bending strength when compared to base material.

3.4 Friction and Wear Test

The wear test of Al 6061 added with micro titanium and e glass fibers performed at ambient temperature. Hybrid composites used as a pin on disc wear testing machine with pin on disc contact geometry. Comparisons made for 0.5 kg load with 300 rpm, Track dia-70mm and for 20 minutes duration.

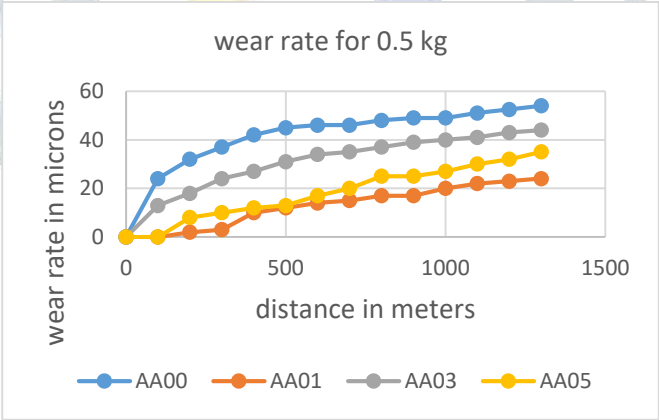

Fig. 9. Wear rate of 6061 Al mmc with 0% E glass fibre and varying micro titanium

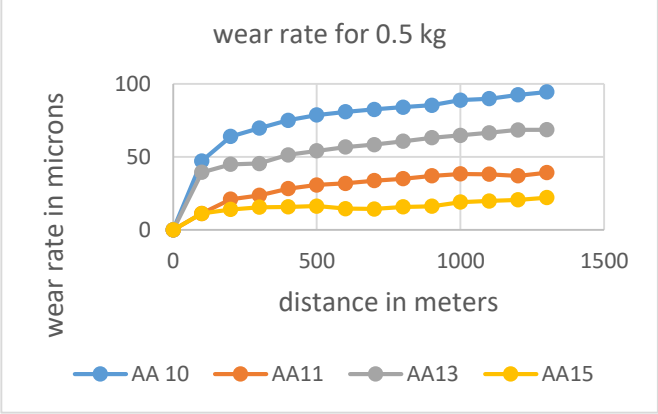

Fig. 10. Wear rate of 6061 Al mmc with 1% E glass fibre and varying micro titanium

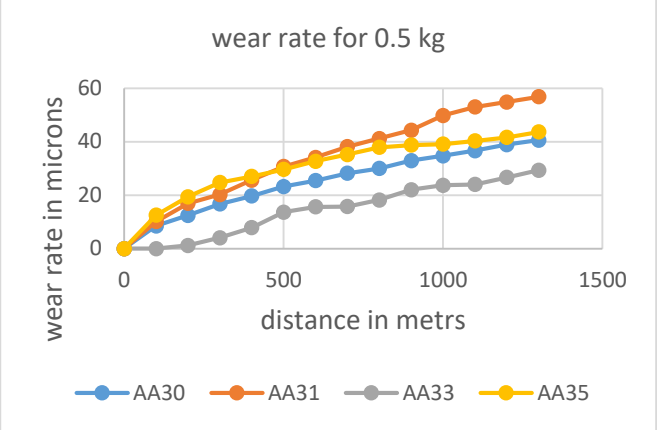

Fig. 11. Wear rate of 6061 Al mmc with 3% E glass fibre and varying micro titanium

Fig. 9-11 indicate the wear rate against the distance travelled. Fig. 9-11 shows the wear rate against the distance travelled with 0.5 kg load. For different composition of reinforcement. Wear analysis were done for 0.5 kg load disc was rotating at 300rpm and 70mm diameter for 20 min duration. Al 6061-hybrid mmc wear rate were reduced when compared with Aluminium 6061 alloy.

IV. CONCLUSIONS

- The hybrid metal matrix composite of Al6061 reinforced with micro Ti and E glass fibre were prepared successfully by Stir casting.
- Uniform mixing of the reinforcement, noticed in Sem.
- The properties improved with adding reinforcement.
- Tensile and bending strength were improved.
- Wear rate were less for Al6061 hybrid mmc when compared to base material.
- Finally adding the reinforcement material has increased the mechanical and tribological property of the Al 6061 mmc.

REFERENCES

[1] C. Saravanan, K. Subramanian, V.A. Krishna and R.S. Narayanan, "Effect of particulate reinforced aluminium metal matrix composite –a review", Machanics and Mechanical Engineering, vol. 19, pp. 23–30, 2015.
[2] G. Straffelini, "Influence of matrix hardness on the dry sliding wear behavior of 20 vol. % alumin", Wear, vol. 211 , pp. 192–197, 1997.
[3] R.R. Bowles, D.L. Macini and M.W. Toaz, P. Beardmore and C.F. Johnson, "Advanced composites: the latest developments", Michigan ASTM International, pp. 21-27, 1990
[4] G.B.V. Kumar, C.S.P. Rao, N. Selvaraj and M.S. Bhagyashekar, "Studies on Al6061-SiC and Al7075-Al2O3 Metal Matrix Composites", Journal of Minerals & Materials Characterization and Engineering, vol. 9, pp. 43-55, 2010.
[5] S.K. Ghosh and P. Saha, "Crack and wear behavior of SiC particulate reinforced aluminium based metal matrix composite fabricated by direct metal laser sintering process", Materials & Design, vol. 32, pp. 139-145, 2011.
[6] S. Suresh, N.S.V. Moorthi and C.E. Prema, "Tribological and Mechanical Behavior Study of Al6061-TiB2 Metal Matrix Composites Using Stir Casting", Advanced Material Research, vol. 984-985, pp. 200-206, 2014.
[7] Shreyas P S, Shriramkumar S, Sruthisagar R, Vijaya Ramnath B and Elanchezhian C "Studies on Mechanical Behaviour of Aluminium-Silicon Carbide-Copper Metal Matrix Composite" MATEC Web of Conferences 166, 01001(2018).https://doi.org/10.1051/matecconf/201816601001 ICMAA 2018.
[8] Madeva Nagaral, Bharath V and V Auradi "Effect of Al2O3 Particles on Mechanical and Wear Properties of 6061al Alloy Metal Matrix Composites"Journal of Material Sciences & Engineering Nagaral et al., J Material Sci Eng 2013, 2:1 DOI: 10.4172/2169-0022.1000120
[9] P.V. Krupakara, "Corrosion Characterization of Al6061 / Red Mud Metal Matrix Composites in sea water", Portugaliae electrochimica Acta, vol. 31, pp. 31:157–64, 2013.
[10] S. Rajesh, D. Devaraj, P.R. Sudhakara and S. Rajakarunakaran, "Multi-response optimization of machining parameters on red mud-based aluminum metal matrix composites in turning process", International Journal of Advanced Manufacturing Technology, vol. 67, pp. 811–821, 2012.