Investigation of wear behaviour on AA 6082-Hybrid Metal Matrix Composite

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Abstract - *Due to the improvement in the field of engineering, there is an enormous necessity of metal matrix composites (MMCs) for the manufacturing of innumerable structures that desires high strength to weight ratio. Aluminium metal matrix composites (AMCs) reinforced with hard ceramics are required composites which have the potential of satisfying the current demands of advanced industrial applications due to its fewer weight and high strength properties. In present study deals with investigation of wear behavior of aluminium metal matrix composites (AA 6082+B_4C+ZrO_2+Gr). The dry sliding wear operation was carried out on Aluminium composite by using pin on disc machine. The wear rate and coefficient of friction were taken as output response from data acquisition system. The experimental result shows that the wear rate and coefficient of friction were gradually increasing with increase in time. At the same time, the wear rate and coefficient of friction were decreasing with increase in reinforcement percentage.*

Key Words**: AA 6082, B_4C, ZrO_2, stir casting, dry sliding wear, Pin on disc*.

1. INTRODUCTION

Aluminum metal matrix composites (AMMC) have emerged as a material for advanced automobile, aerospace and marine applications. It holds properties like high specific strength, high stiffness and augmented fatigue resistance, decent wear resistance at higher temperatures, excellent corrosion resistance, and high temperature durability [1]. The 6000 series aluminum alloys are harden able with super high strength aluminum alloys belonging to the Al - Si - Mg group, broadly used as aircraft structural materials, especially 6082 aluminum alloy widely used in aircraft structures and other highly stressed structural applications because of its high strength to-density ratio, good ductility, high toughness, resistance to fatigue and very good machinability [3].

Zirconium dioxide was a silvery crystalline ceramic material which has good mechanical properties. It has high strength and toughness which advances the mechanical properties of the composites. Due to biocompatibility and strength properties, ZrO_2 was used in engineering applications such as engine machineries, high resistant linings in furnaces and high-speed cutting tools [4].

The Aluminium matrix composites are fabricated by diverse approaches such as squeeze casting, compo casting, stir casting, powder metallurgy and liquid infiltration. Among the fabricating methods, the stir casting is an attractive processing technique for manufacturing aluminium matrix composites [5].

Stir casting generally includes lengthy liquid reinforcement interaction, which can cause substantial interface response. By increasing the oxide percentage up to 4%, the hardness is improved [6].

Wear is the progressive loss of material or surface impairment, due to relative motion such as sliding, rolling or impact motion among a two solid surface and contacting material. The unremitting unidirectional or reciprocating relative motion between two moving bodies in contact under load is known as sliding wear. The loss of material from a surface, transfer of material from one surface to another or movement of material within a single surface leads to wear. It is a serious problem in many engineering applications such as bearings, moving parts, engine parts, etc. [7].

The wear properties were examined in the aluminium alloy reinforced with silicon carbide and boron carbide. Zirconium oxide in the alumina matrix decreases the brittleness and advances the wear characteristics of the matrix [7].

In this work, an attempt has been made to prepare Hybrid Metal Matrix Composites by adding B_4C, ZrO_2 and Gr reinforcement particles into AA6082 matrix alloy using a stir casting method. The objective of the present investigation is to determine the wear properties of the HMMC by varying reinforcement percentage into the aluminium alloy.

2. Materials and Methods

2.1 Materials

AA 6082 was selected as matrix material due to its good machinability and excellent wear resistant. The chemical composition of AA 6082 is shown in Table 1. B_4C, ZrO_2 and Graphite were used as reinforcement material in AA 6082 matrix.

Table -1: AA 6082 COMPOSITION

Alloying Element	Al	Cr	Cu	Fe	Mg	Mn	Si	Ti	Zn
Wt (%)	95.2 – 98.3	0.0 - 0.25	0.0 - 0.1	0.0 – 0.5	0.6 - 1.2	0.4 - 1.0	0.7 - 1.3	0.0 – 0.1	0.0 - 0.2

2.2 Experimental Procedure

The composites were fabricated by using Stir casting method. The AA 6082 alloy of appropriate weight was placed in a graphite crucible and was heated in a furnace. The reinforcements were heated in a preheater to remove moisture content. Subsequently the aluminium is melted the preheated reinforcements were added and mixed by means stirrer for even distribution of reinforcement. The crucible was maintained at 850^0C temperature by the furnace for 10 minutes. Then the molten metal is poured into the sand mould and allowed it to cool down. The ingot was taken away from the mould after it cooled.

2.3 Wear Test

The test samples were prepared according to ASTM: G99 standard to evaluate the wear and frictional behavior of Al 6082 composite. The Dry sliding wear test was carried out on Pin on Disc apparatus.

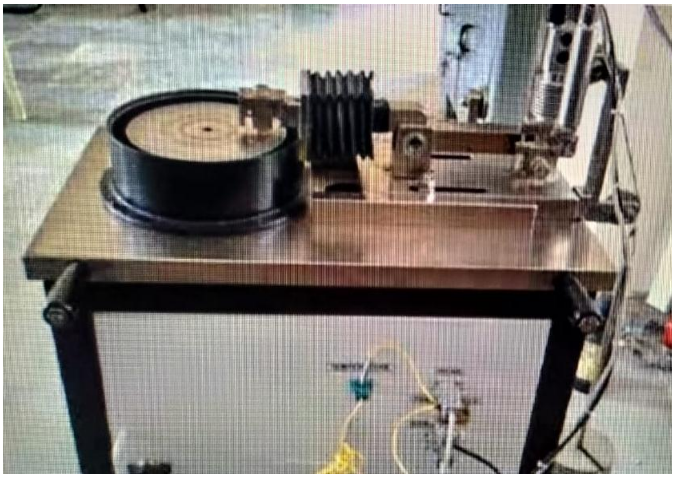

Fig -1: Pin on disc apparatus

The samples were machined to dimension of 10mm Diameter and 35mm Length. Before testing the samples, the weight was measured and compared with the result samples to examine the wear rate of the composite.

Table -2: TECHNICAL SPECIFICATION OF WEAR MACHINE –PIN ON DISC

Load	Duration	Dia	RPM
2KG	15min	60mm	400

Fig -2: Wear test pin samples

3. RESULT and DISCUSSION

The wear test was carried out by using Pin on Disc equipment. In this wear behavior analysis, the load of 2Kg and duration of 15minutes were applied constantly for various samples. The wear rate of testing samples was noted directly from data acquisition system. The coefficient of friction was also noted from data acquisition system coupled with wear testing machine for each and every experimental run. The wear rate was calculated by weight reduction of material.

Table -3: WEAR RATE OF VARIOUS SAMPLES

Sample No	Sample	Before weight	After weight	Difference
A	AA6082-100%	6.5979	6.5821	0.016
B	2%-ZrO_2 + 1% B_4C +1%Gr Remaining AA-6082	6.2458	6.2314	0.014
C	4%-ZrO_2 + 2% B_4C +1%Gr Remaining AA-6082	6.0712	6.0575	0.014
D	6%-ZrO_2 + 3% B_4C +1%Gr Remaining AA-6082	6.0077	5.9944	0.013

The wear rate and coefficient of friction of various samples were plotted as a graph by using Ducom software.

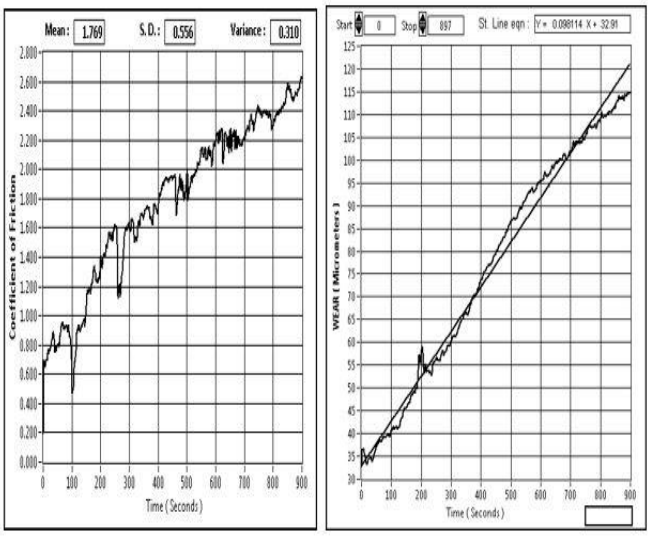

Fig -3: Sample A – Coefficient of friction vs Time, Wear rate vs Time

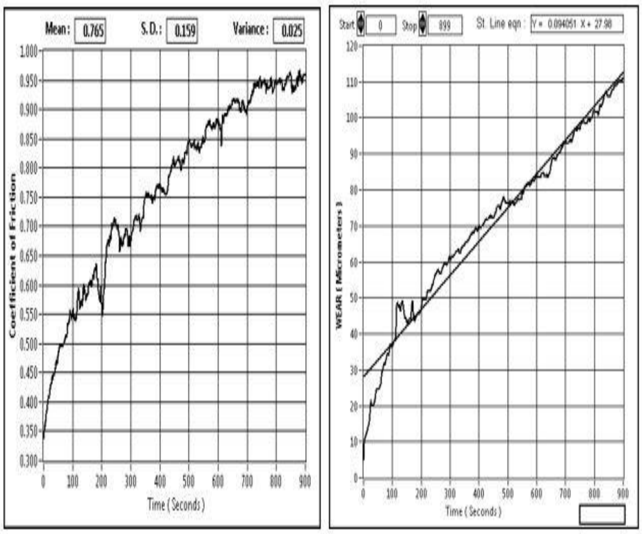

Fig -4: Sample B – Coefficient of friction vs Time, Wear rate vs Time

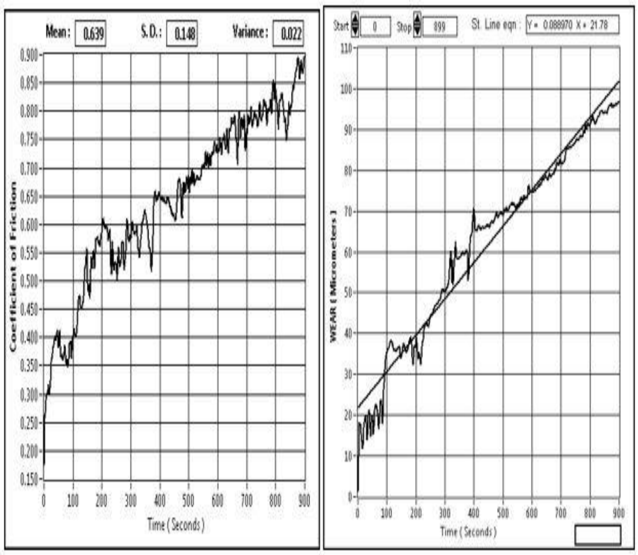

Fig -5: Sample C – Coefficient of friction vs Time, Wear rate vs Time

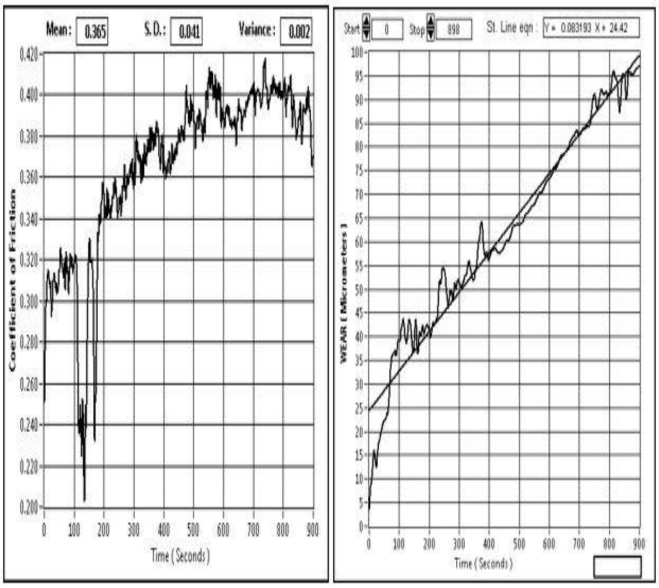

Fig -6: Sample D – Coefficient of friction vs Time, Wear rate vs Time

The overhead graphs illustration that the coefficient of friction and wear rate of cast AA6082 with varying weight percentage of reinforcement particles. Both wear rate and coefficient of friction of composites were decreases with rise in volume fraction of reinforcement particles. The value of wear rate and coefficient of friction at Sample D is lower than that of the cast AA6082. This decrease in wear rate and coefficient of friction may be due to existence of graphite particles in the hybrid composite. It seems that the entrenched graphite reinforcement particles in the AMCs perform as a lubricant through the abrasion process thereby reducing the wear rate. The reduction in the coefficient of friction exhibited by the hybrid composite relative to AA

6082 is due to the release of reinforcement during their wear process which acted as the solid lubricant.

4. CONCLUSION

In the Current investigation, hybrid metal matrix composites (AA 6082/B_4C/ZrO_2/Graphite) has been effectively fabricated using stir cast method. Dispersion of reinforcement particles (B_4C, ZrO_2 and Graphite) in aluminium matrix lessens the wear of the matrix material. Wear tends to decrease with increasing particle volume content. It also shows that addition of reinforcement particles is useful in reducing wear of the aluminium composite. Wear rate in reinforced alloy is less compare to monolithic aluminium alloy. Coefficient of friction decreases with respect to increase in particle volume content. The wear rate and coefficient of friction were reducing with increase in reinforcement content and it was found least at Sample D (6% ZrO_2 + 3% B_4C +1% Gr Remaining AA-6082), which shows the superior wear properties than that of conventional cast AA6082 material.

REFERENCES

[1] T. M. Hosking, F. F. Portillo, R. Wunderlin and Mehrabian Material Science. 17, 477 (1982).

[2] A. Ibrahim, F.A. Mohammed, and E.J. Lavernia, Metal Matrix Composites— A review Material Science, 1991, 26, 1137-1157.

[3] Davis, J.R., "Aluminum Matrix Composites, ASM specialty hand book: Aluminum & Aluminum Alloy" ASM International, P. 160-179, (1993).

[4] Abdul-Lattif, N.I., Kheder, A.R.I. & Goel, S.K., J. Materials Science, 22 (1985), P. 466-472.

[5] Lioyd, D.J., Composite Science Technology, vol. 35 (1989) pp. 159-179.

[6] R.L. Deuis, C. Subramanian, and J.M. Yellup, Abrasive Wear of Aluminum Composites—A Review, Wear, 1996, 201, p 132-144.

[7] G.J. Howell and A. Ball, Dry Sliding Wear of Particulate Reinforced Al Alloys against Automobile Friction Materials, Wear, 1995, 181-183, p 379-390

[8] Hao H, Liu L, Hu W, Shen B. Friction and wear behavior of Ni–graphite composites prepared by electroforming. Mater Des 2007; 28:1374–8.

[9] Yuvaraj N. (2018) Improving the Wear Properties of Aluminum 6082 Alloy by Surface Compositing with ZrO2 Ceramic Particles Via Friction Stir Processing. Material Science Research India, 15(1), 68-74.

[10] Sandhya Rani Rana, A.B. Pattnaik andS.C. Patnaik, (2018) "Comparison of wear behaviour and mechanical properties of as-cast Al6082 and Al6082-T6 using statistical analysis", 338, pp. 1-6.

[11] Torabian H, Pathak JP and Tiwari SN, "Wear characteristics of Al-Si alloys", Wear, volume172 (1994), pages 49-58

[12] A. Venkataraman and G. Sundararajan "the sliding wear behaviourof al-sic particulate composites. Macrobehaviour" Acta mater. Vol.44, No. 2, pp. 451460, 1996

[13] L.S. Eyre, "Wear Characteristics of Metals", Tribology International, 203-212, 1976.

[14] A.P. Sannino and H.J. Rack, Dry Sliding Wear of Discontinuously Reinforced Aluminum Composites—Results and Discussions, Wear, 1995, 189, p 1-19

[15] S.K.Thakur, B.K .Dhindaw.The influence of interfacial characteristics between Sip and Mg/Al metal matrix on wear rate, coefficient of friction and microhardness, Wear 247(2001) 191-201.

[16] G.J. Howell and A. Ball, Dry Sliding Wear of Particulate Reinforced Al Alloys against Automobile Friction Materials, Wear, 1995, 181-183, p 379-390.