

Wear Testing of Aluminium Alloy composites reinforced with Alumina Nanoparticles by Taguchi method

Vijaya.B¹, Dhanush U², Kishan Kumar E², Praveen Pawar², Vinay Y S²

Associate Professor, Department of Mechanical Engineering, Sai Vidya Institute of Technology, Bangalore,
Karnataka. India¹

UG Students, Department of Mechanical Engineering, Sai Vidya Institute of Technology, Bangalore, Karnataka. India
Bangalore, Karnataka. India²

ABSTRACT: Metal Matrix Composites (MMCs) are known for higher strength, toughness and superior Mechanical and Tribological Properties. They can withstand elevated temperatures in corrosive environment. Most metals and alloys could be used as matrices and they require reinforcement materials which need to be stable over a range of temperatures and also non-reactive. However, the choices for low temperature applications are not many. Only light metals, with their low density prove to be advantageous. Aluminum, Titanium and Magnesium are the popular matrix metals. Tensile and hardness test were carried out on aluminum metal matrix composites to study the influence of addition of Al₂O₃ Nano particles in Al7075 matrix material with addition of rare earth material Cerium and to understand their mechanical properties. Aluminum alloy together with its composites were prepared by stir casting method with suitable die measuring diameter of 25mm and 225mm length. Wear specimen was prepared as per ASTM standards. Standard ASTM procedure was followed to conduct Wear test by Taguchi method. Further micro structural studies on the composites were obtained and analyzed.

KEYWORDS: Metal matrix composites, Stir- casting, Reinforcement, ASTM standards, Wear test, Taguchi method

I. INTRODUCTION

The toughest job for the designer is to find the right material for structures and machine components. Many researchers are working in this direction to find new materials and to develop methodologies to characterize them to use in new design situations.. Steels are widely used in structures and machine components. Different grades of steels are available from high strength steels to medium strength steels. Now a day's aluminium alloys are replacing steels wherever possible, because it is comparatively lighter in weight and resistant to corrosion. Alloys of Al-Zn-Mg-Cu series are extensively used in aerospace industry [3]. The yield strength of pure aluminium is 7 to 11 MPa, while its alloys range from 200 to 600 MPa [6]. Aluminium, having one third the density and stiffness of steel is ductile, easy to machine, cast, draw and extrude. Corrosion resistance is excellent due to a thin layer of aluminium oxide formed when exposed to air, preventing oxidation

Metal matrix composites (MMCs) have better performance advantages compared to pure metals and alloys since they possess the best properties such as ductility and toughness of the matrix and high modulus and strength of the reinforcements[1-3]. MMCs are the attractive choice of materials for several applications such as aerospace, automotive, sporting and military applications [4-5]. The aluminum alloys were processed in different ways, adding different alloying elements, subjected to different heat treatment processes to improve its mechanical and fracture. 1.4 Rare earth element (Cerium)

1.1 It is the most abundant rare earth metal found in many minerals like allanite, monazite, bastnasite, cerite and samarskite. Monazite and bastnasite are the two important sources of cerium. Fig shows that cerium is an iron grey lustrous metal. It is malleable and oxidizes very readily at room temperature, especially in moist air. It is the most

reactive rare earth metal reacting rapidly by both alkali and acid solutions except europium. The pure metal ignites if scratched with a sharp instrument.



Fig 1.1 Image of cerium metal

2.0 Processing techniques: Among the variety of manufacturing processes available for discontinuous Metal matrix Composites, Stir casting is generally accepted as particularly promising route, currently practiced commercially. Its advantages lie in its simplicity, flexibility and applicability to large quantity production. It is also attractive because, in principle, it allows a conventional Metal processing route to be used and hence minimizes the final cost of product. This liquid metallurgy technique is the most economical of all the available routes for Metal matrix Composites production (3-2) and allows very large size components to be fabricated. According to Skibo et al (3-3) the cost of preparing composites material using casting method is about one third to half that of competitive methods and for high volume production, its projected that cost will fall to one tenth



Fig.2.1 Stir casting



Fig 2.2 Casted Aluminium alloy

2.1 Material System

Al 7075 alloys reinforced with Alumina Nanoparticles were cast using liquid metallurgy route in the form of cylindrical bars of length 225mm and diameter 25mm

Table 1: Chemical composition of Al7075

Element	Si	Cu	Mg	Ni	Fe	Mn	Ti	Cr	Al
Weight %	12.77	0.94	0.96	1.06	0.20	0.01	0.20	0.02	Rem

TABLE-2 : Designation of Composites

Sl.no	Alloy/composite	Designation
1	AS CAST	C
2	AS CAST+Al ₂ O ₃ (2%)	C1
3	AS CAST + Al ₂ O ₃ (4%)	C2
4	AS CAST + Al ₂ O ₃ (6%)	C3

III. TESTING

3.1 Microstructure

Micro structural studies on the hot forged square cross-section bar were conducted using Optical microscope with an object lens range 100x, 300x, 500x and 1000x fitted with camera interfaced with a computer for image capture and analysis. The samples were surface ground with 220 grit at 250 rpm, 320 grit at 350 rpm, 400 grit at 450 rpm and 600 grit at 550 rpm of emery paper at speed respectively. Then polished with 5 m diamond paste. The samples were washed with distilled water and dried with warm flowing air. These samples were then etched with solution of 10g of Sodium hydroxide with 90ml of water. They were then washed with distilled water and dried with warm flowing air before microstructure viewing

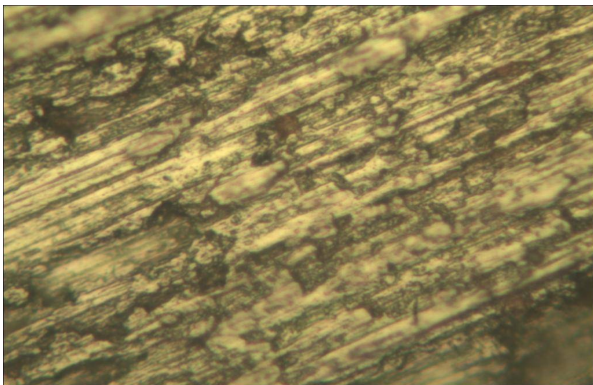


Fig 3.1 C2 Sample before etching

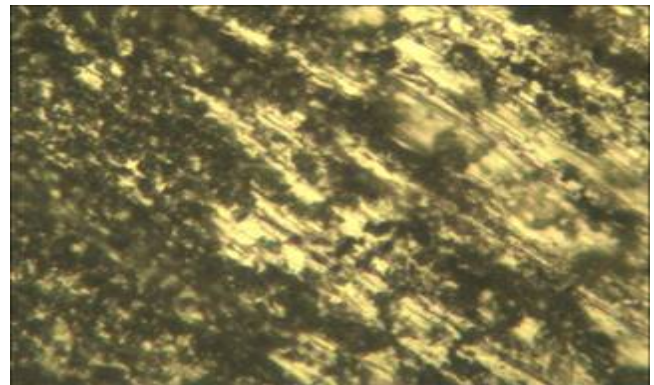


Fig 3.2 C2 Sample After etching

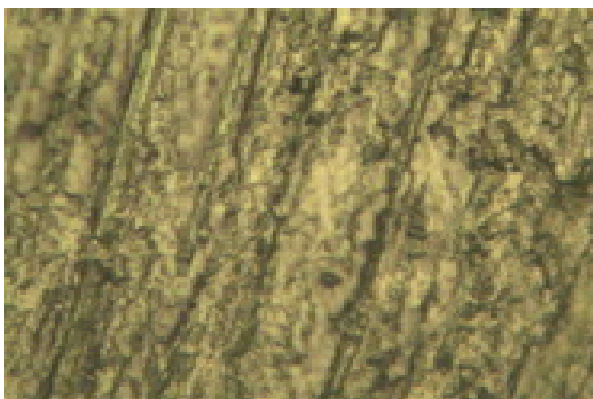


Fig 3.3 C3 Sample before etching

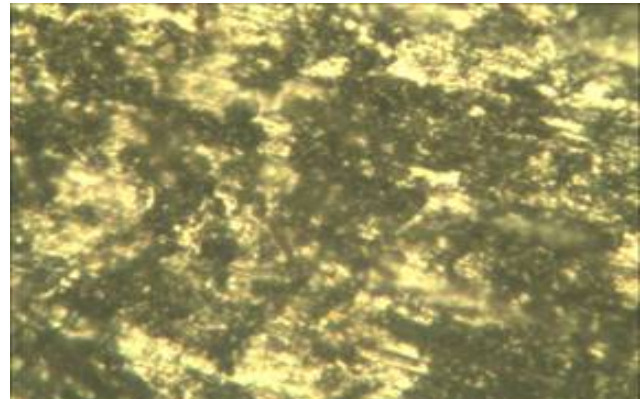


Fig 3.4 C3 Sample After etching

3.2 Wear Test:

A pin on disc wear testing machine is used to evaluate the sliding wear behaviour of the composites. The wear test was carried out under dry sliding conditions as per ASTM E-8 Standard. Pin specimen of diameter 8mm and 50mm height were cut from the machined parts and then polished. A normal load of 0.5, 1 and 1.5 kg were applied using dead weights, at 750 rpm for 5 minutes and the pins were cleaned with acetone and weighed using a sensitive electrical balance. During the test, the pin was pressed against the counter-part rotating against the disc by applying the load. Wear studies were conducted in order to determine the coefficient of friction.

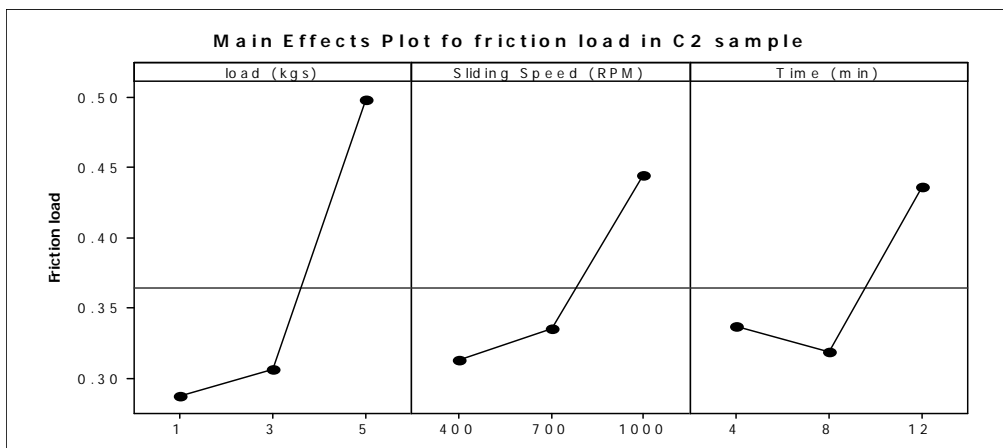
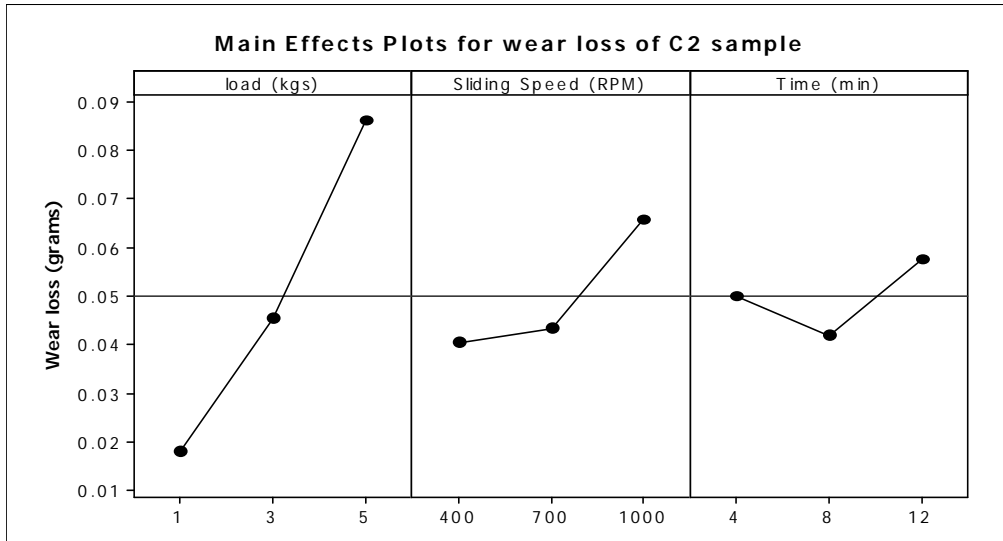
IV. RESULTS AND DISCUSSION

C1 Specimen (2% Al₂O₃)

Sl. No	Load in kg	Speed in rpm	Time in minute	Initial weight	Final weight	Weight losses
1	1	400	4	6.0354	6.7145	0.18
2	3	700	8	6.1214	6.7550	0.58
3	5	1000	12	6.5334	6.9875	1.35
4	1	400	8	6.6869	6.9931	0.28
5	3	700	12	6.9597	7.0711	0.36
6	5	1000	4	6.9559	6.8796	0.47
7	1	400	12	6.8726	6.7569	0.20
8	3	700	4	7.0351	6.9758	0.30
9	5	1000	8	7.5762	7.8756	0.50

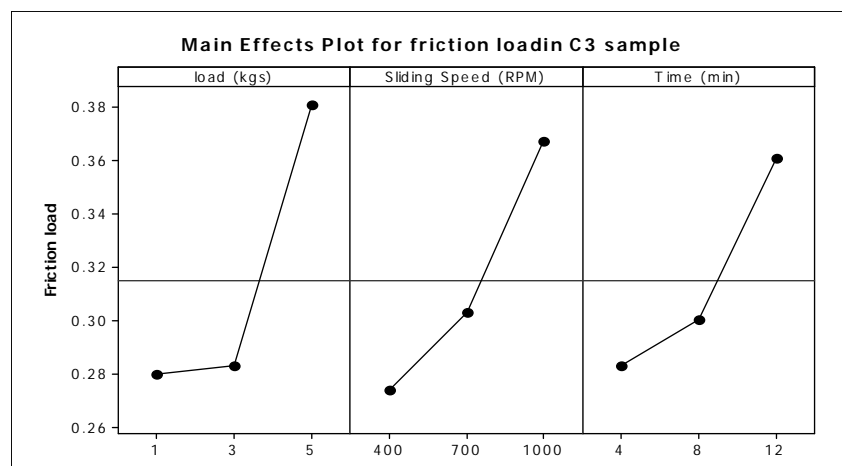
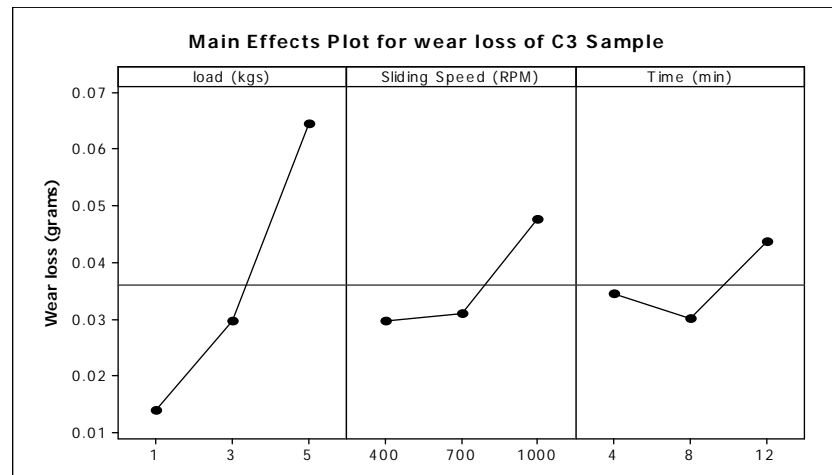
C2 Specimen 4% Al₂O₃

Sl. No	Load in kg	Speed in rpm	Time in minute	Initial weight	Final weight	Weight losses
1	1	400	4	6.8761	6.8758	0.16
2	3	700	8	6.8358	6.8246	0.54
3	5	1000	12	6.6053	6.5068	1.25
4	1	400	8	6.5573	6.5509	0.22
5	3	700	12	6.6535	6.6329	0.30
6	5	1000	4	6.9617	6.9523	0.40
7	1	400	12	6.7173	6.7118	0.10
8	3	700	4	6.7495	6.7389	0.25
9	5	1000	8	6.8675	6.8551	0.42



C3 Specimen 6% Al₂O₃

Sl.no	Load in kg	Speed rpm	Time minute	Initial weight	Final weight	Weight losses
1	1	400	4	6.7457	6.7526	0.18
2	3	700	8	6.9079	6.8950	0.30
3	5	1000	12	7.0264	7.0172	0.36
4	1	400	8	6.9598	6.9564	0.21
5	3	700	12	7.0906	7.0711	0.29
6	5	1000	4	6.9559	6.9494	0.35
7	1	400	12	6.9933	6.9908	0.20
8	3	700	4	6.987	6.9830	0.32
9	5	1000	8	7.0367	7.0256	0.31



V. CONCLUSIONS

The authors experienced a new problem when they made an attempt to mix Alumina into Aluminium melt, Alumina could not get mixed well due to poor wetting properties of Alumina as well difference in their densities. Due to complexity associated with the interfacial reaction between Alumina and metal matrices, much of the progress could not be achieved. Lack of a suitable synthesis technique is one of the major challenges in achieving dispersion of Alumina in MMCs

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