A Study of Microstructure and Mechanical Property of Aluminium – Alumina Metal Matrix

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ABSTRACT

Aluminium alloys are widely used in aerospace and automobile industries due to their low density and good mechanical properties, better corrosion resistance and wear, low thermal coefficient of expansion as compared to conventional metals and alloys. The excellent mechanical properties of these materials and relatively low production cost make them a very attractive candidate for a variety of applications both from scientific and technological viewpoints. The aim involved in designing metal matrix composite materials is to combine the desirable attributes of metals and Ceramics. Present work is focused on the study of behaviour of Aluminium Cast Alloy (LM6) with and Al_2O_3 *composite produced by the stir casting technique. Different % age of reinforcement is used. Tensile test, Impact test and wear test performed on the samples obtained by the stir casting process. optical microscope was performed to know the presence of the phases of reinforced material.*

Keywords: *Stir casting, Alloy LM6,* Al_2O_3*, MMc's, Composites, Mechanical Property.*

1. Introduction

Major concentration on this thesis project is to study the mechanical property of aluminium (Al) based metal matrix composites AMCs. Metal matrix composites (MMCs), like all composites; consist of at least two chemically and physically distinct phases, suitably distributed to provide properties not obtainable with either of the individual phases. Generally, there are two phases either a fibrous or particulate phase in a metallic matrix. and ceramic particle reinforced with in the Al matrix composites used in aero space, automotive and thermal management applications. For many researchers the term metal matrix composites is often equated with the term light metal matrix composites (MMCs). Substantial progress in the development of light metal matrix composites has been achieved in recent decades, so that they could be introduced into the most important applications. In traffic engineering, especially in the automotive industry, MMCs have been used commercially in fiber reinforced pistons and aluminium crank cases with strengthened cylinder surfaces as well as particle strengthened brake disks. These innovative materials open up unlimited possibilities for modern material science and development; the characteristics of MMCs can be designed into the material, custom-made, dependent on the application.some of the authors has carried out the work on different composits of materials.

N. Parvina and M. Rahimianb [1] Al_2O_3 is widely used as the reinforcing additive in the metal matrix composites. The influence of Al_2O_3 particle size on the density, hardness, microstructure, yield stress, compression strength, and elongation of the sintered Al– Al_2O_3 composites were investigated. In the present study, 10 wt% of Al_2O_3 powder with three different particle sizes (3, 12 and 48 μm) were used in the production of the samples.

Dr. Ali Hubi Haleem, Newfal Zuheir, Newal Muhammad Dawood [2] The aim of this work is preparing and studying some of mechanical properties [Brinell hardness (BHN) and compression strength] of aluminum matrix composite material that reinforced by (3, 6 , 9 , and 12 wt.%) Al_2O_3 particles. Powder technology technique is used in samples preparing. Samples were compacted by using single action pressing then followed directly by sintering process at 500°C under the effect of inert gas conditions

A. Vencl, A. Rac, I. Bobić, [3] The use of different kind of composite materials is in constant growing over the years, because they have better physical, mechanical and tribological properties comparing to matrix materials. Composite materials based on light metals like Aluminium, Magnesium and Zinc, due to their low density, find application in many industries. In automotive industry they are used for pistons, cylinders, engine blocks, brakes and powertransfer system elements. This paper considers the tribological properties of Al-based MMCs as a function of the manufacturing technologies and variation of shape, dimension and percentage of reinforcement material.

K.S.Raghuram (Corresponding Author), Dr. N.V.S.Raju, [4] IN-SITU Al_2O_3 SiC C having 20 wt%, 25 wt%, 30 wt% and 35wt% of powdered particulate were fabricated by liquid metallurgy (stir cast) method. The composite specimens were machined as per test standards. The specimens were tested to know the common casting defects using image analyzer. Some of the mechanical properties have been evaluated and compared with Al6061 alloy. Significant improvement in uniform distribution of particulates is noticeable as the wt % of the flake particles increases. The microstructures of the composites were studied to know the dispersion of the powdered particles in the matrix. It has been observed that addition of flake particles significantly improves particulate distribution. Addition of Al_2O_3 SiC C particles significantly improves ultimate tensile strength of Al6061, when compared with that of unreinforced matrix, the ultimate tensile strength of Al_2O_3 SiC C composite is increased by 36.71%.

J.W. Kaczmar, K. Naplocha, [5] Wear improvement of aluminum matrix composite materials reinforced with alumina fibres, was investigated. The effects of the applied pressure and heat treatment on wear resistance were determined. Wear tests were carried out on pin-on disc device at constant sliding velocity and under three pressures, which in relation to diameter of specimens corresponds to pressures of 0.8 MPa, 1.2 MPa and 1.5 MPa. To produce composite materials porous performs were prepared. They are characterized by the suitable permeability and good strength required to resist stresses arising during squeeze casting process. Performs exhibited semi-oriented arrangement of fibres and open porosity enabled producing of composite materials 10% (in vol.%) of Al_2O_3 fibres (Saffil). Aluminum casting alloys can be locally reinforced to improve hardness and wear resistance under small pressures.

2.1 Methodology

Stir casting set-up mainly consists a furnace and a stirring assembly as shown in Figure 1.1. In general, the solidification synthesis of metal matrix composites involves a melt of the selected matrix material followed by the introduction of a reinforcement material into the melt, obtaining a suitable dispersion. The next step is the solidification of the melt containing suspended dispersoids under selected conditions to obtain the desired distribution of the dispersed phase in the cast matrix. In preparing metal matrix composites by the stir casting method, there are several factors that need considerable attention, including

- The difficulty in achieving a uniform distribution of the reinforcement material.
- Wettability between the two main substances.
- Porosity in the cast metal matrix composites.

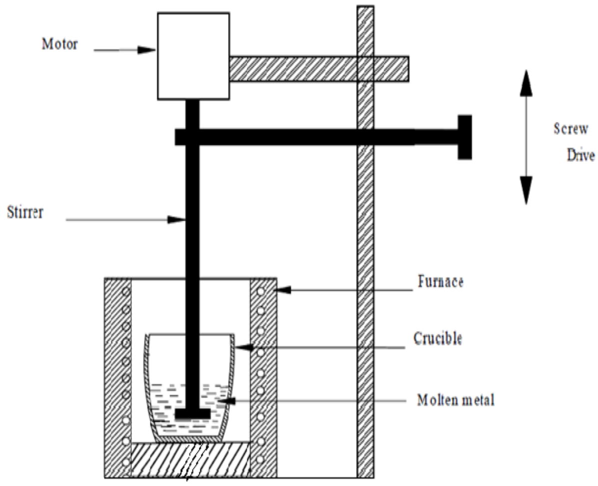


Figure 1.1 Stir Casting

Chemical reactions between the reinforcement material and the matrix alloy In order to achieve the optimum properties of the metal matrix composite, the distribution of the reinforcement material in the matrix alloy must be uniform, and the wettability or bonding between these substances should be optimized. The porosity levels need to be minimized

. 2.2 Characterization of Stir Casting

- Contents of dispersed phase are limited (usually not more than 30% by volume).
- Distribution of dispersed phase throughout the matrix is not perfectly homogeneous:
- There are local clouds (clusters) of the dispersed particles (fibers).
- There may be gravity segregation of the dispersed phase due to a difference in the densities of the dispersed and matrix phase. The technology is relatively simple and low cost.

2.4 Flow Chart Showing Steps Involved In Stir Casting

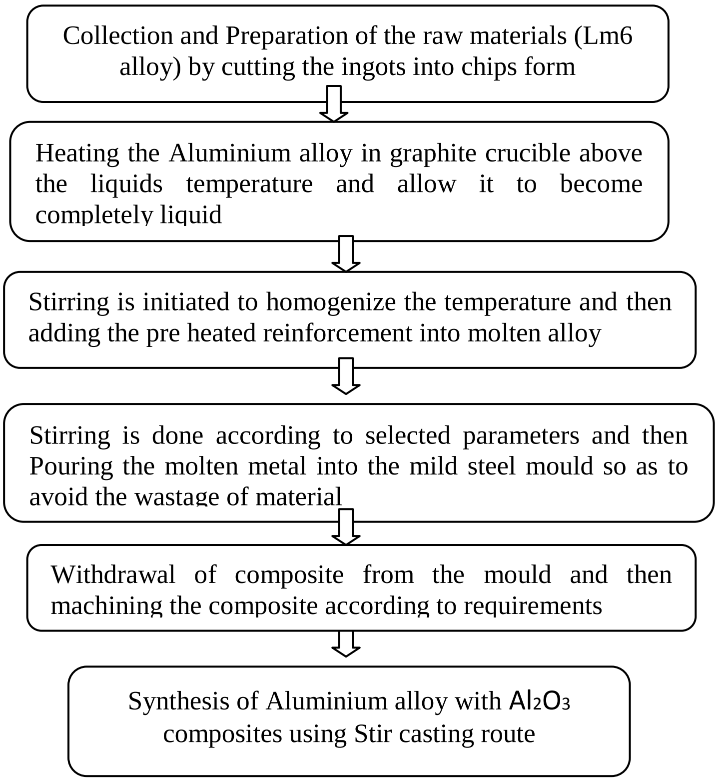


Figure 4.2- Flow Chart Showing Steps Involved in Stir Casting

3.0 Results And Discussion

By considering different parameters under the constants. standard specimen shape and size has been prepaid to conduct the mechanical test. Table and graph shows the imprument of mechanical Property by Adding the reinforcement of composite material Al_2O_3, In Microstructure structure shows the fine distribution of grains.

3.1 Microstructural Of Different Specimens

Microstructure was visualized with the help of optical microscope.

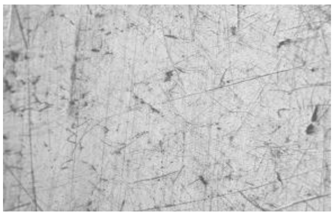


Figure 3.1 Optical micrographs of alloy Lm6 at 100X

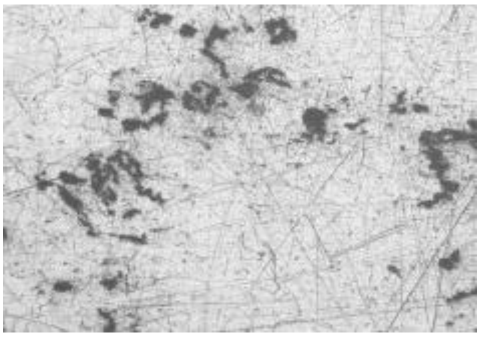


Figure 3.2 Optical micrographs of alloy Lm6 + 5% of Al_2O_3 at 100X

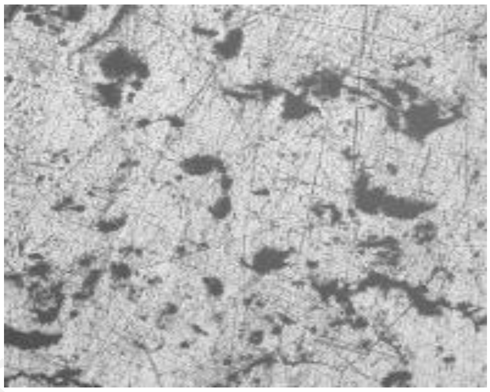


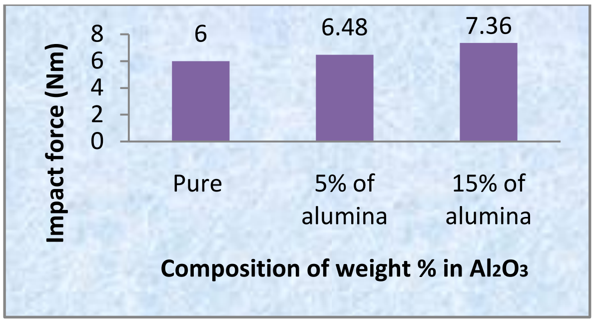
Figure 3.3 Optical micrographs of alloy Lm6 + 5% of Al_2O_3 at 100X

3.2 Impact Test Results

The Charpy impact test, also known as the Charpy v-notch test,

Table 3.1: Results of Impact Test

Serial no.	Composites of alloy Lm6+	Load	Trails				Average force
			1	2	3	Total force	
1	Pure	30	6.5	5.8	5.7	18	6
2	5% of Al_2O_3	30	5.9	6.7	6.8	19.4	6.48
3	15% of Al_2O_3	30	7.2	7.5	7.4	22.1	7.36



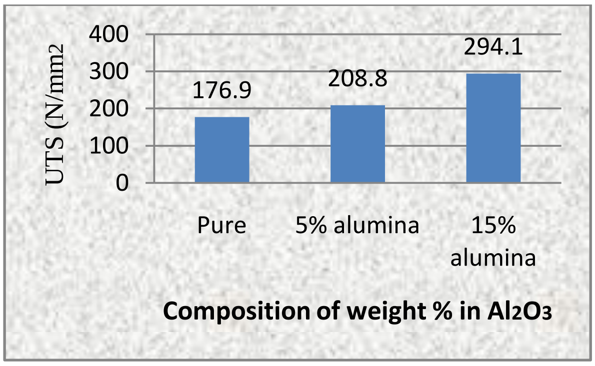
Graph 3.1 Impact strength of alloy Lm6 with different compositions

3.3 Tensile Strength Test

Tensile test has been carried out and the results are listed below for different material composition

Table 3.2: Tensile Strength Results

S n	Composition of alloy Lm6+	Trail 1	2	3	Total load (Nm)	Average force (Nm)	UTS N/mm2
1	Pure	13.1	14.3	14.3	41.7	13.9	176.9
2	5% of Al2O3	16.3	16.8	16.1	49.2	16.4	208.8
3	15% of Al2O3	23.1	23	23.2	69.3	23.1	294.1



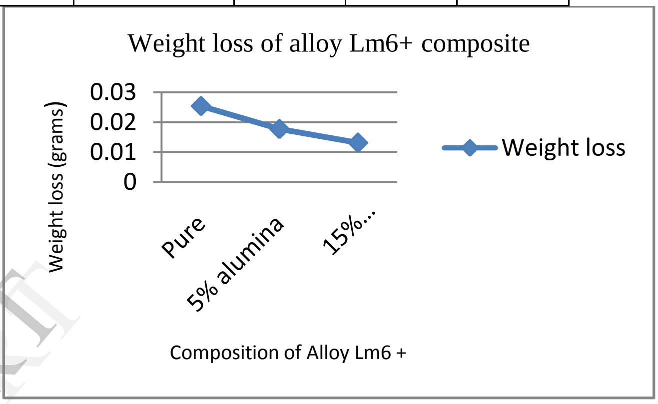
Graph 3.2 Tensile strength of Alloy Lm6 + different composites

3.4 Wear Test

A pin-on-disc tribometer is used to perform the wear experiment. The wear track, alloy and composite specimens are cleaned thoroughly with acetone prior to test.

Table 3.3 Weight loss of Samples at constant speed 300rpm wt 2 Kg and time 240 seconds under

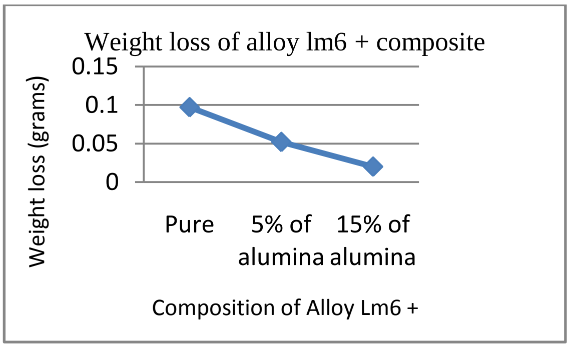
Serial no	Composition of alloy Lm6+	Initial weight (gm)	Final weight (gm)	Weight loss (gm)
1	Pure	96.0158	95.9904	0.02542
2	5% of Al_2O_3	96.2100	96.0324	0.01776
3	15% of Al_2O_3	96.6087	96.4769	0.01318



Graph 3.3 Weight loss of alloy Lm6+ composites

Table 3.4 Weight loss of Samples at constant speed 500 rpm wt 4 Kg and time 480 seconds under dry sliding condition

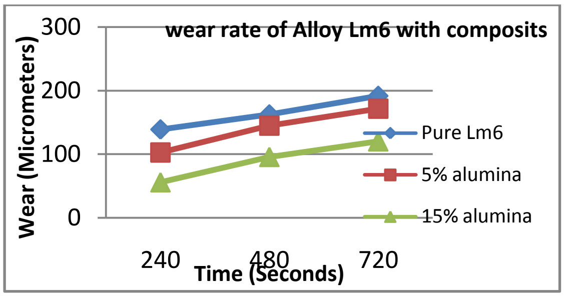
Serial no	Composition of alloy Lm6+	Initial weight (gm)	Final weight (gm)	Weight loss(gm)
1	Pure	95.8120	94.840	0.0972
2	5% of Al_2O_3	96.2011	96.149	0.0521
3	15% of Al_2O_3	96.6000	96.580	0.0201



Graph 3.4 Weight loss of alloy Lm6+ composites

Table 3.4 Wear rate of Alloy Lm6+ with composite at constant wt 2 Kg and speed 300 rpm.

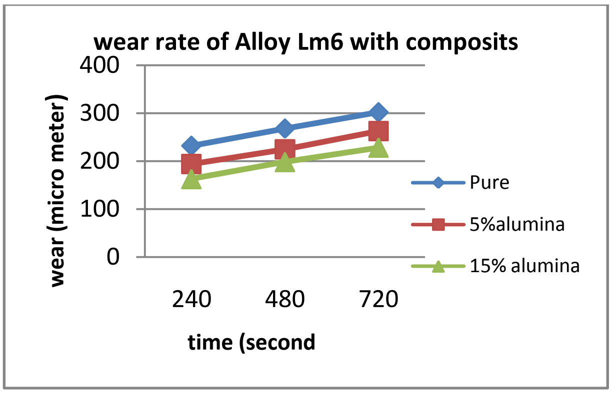
Serial no.	Composite Alloy Lm6 +	Time in second	Wear rate in micro meter
t	Pure	420	138.98
		480	162.66
		720	192.01
2	5% Al_2O_3	420	102.75
		480	144.87
		720	171.64
3	5% Al_2O_3	420	55.91
		480	95.93
		720	120.48



Graph 3.5 Wear in Micrometers Vs Time in Seconds of Alloy Lm6 + composites

Table 3.5 Wear rate of Alloy Lm6 + composite of Al_2O_3 at constant wt 4 Kg and speed 500 rpm.

Serial no.	Composite	Time in second	Wear rate in micro meter
t	pure	420	232.02
		480	268.04
		720	302.2
2	5% Al_2O_3	420	193.91
		480	224.99
		720	262.86
3	5% Al_2O_3	420	163.01
		480	198.39
		720	228.2



Graph 3.6 Wear in Micrometers Vs Time in Seconds of Alloy Lm6 + Composites

4.0 Conclusions

The conclusions drawn from the present investigation are as follows:

- The results confirmed that stir formed al alloy Lm6 with Al_2O_3 reinforced composites is clearly superior to base al alloy Lm6 in the comparison of tensile strength, impact strength as well as wear resistance.
- It is found that elongation tends to decrease with increasing particles wt. Percentage, which confirms that alumina addition increases brittleness.
- Aluminium matrix composites have been successfully fabricated by stir casting technique with fairly uniform distribution of Al_2O_3 particles.
- It appears from this study that uts and trend starts increases with increase in weight percentage of Al_2O_3 in the matrix.
- Impact strength is increase by adding Al_2O_3.
- Stir casting process, stirrer position, stirring speed and time, particle preheating temperature, are the important process parameters. It appears from this study, the wear rate trend starts decreasing with increase in weight percentage of Al_2O_3 in the matrix.
- The optical micrography that alumina particulates are fairly distributed in aluminium alloy matrix

References

1. The Characteristics of Alumina Particle Reinforced Pure Al Matrix Composite by N. Parvina and M. Rahimianb aFaculty of Mining and Materials Engineering, Amirkabir University of Technology (AUT) Hafez Ave., Tehran, Iran published on vol 121(2012)

2. Preparing and Studying Some Mechanical Properties of Aluminum Matrix Composite Materials Reinforced by Al_2O_3 particles by * Dr. Ali Hubi Haleem **Newfal Zuheir *** Newal Muhammad Dawood Babylon university –Materials Engineering Collage)

3. Tribological Behaviour Of Al-Based Mmcs And Their Application In Automotive Industry (By A. Vencl, A. Rac, I. Bobić, Tribology in industry, Volume 26, No. 3&4, 2004.)

4. Characterization study on the variation of weight percentage of Alumina Aluminum in-situ Particulate reinforced composite material (By K.S.Raghuram (Corresponding Author), Dr. N.V.S.Raju, Innovative Systems Design And Engineering ISSN 2222-1727 (Paper) ISSN 2222-2871 (Online) Www.Iiste.Org)

5. Wear Behaviour Of Composite Materials Based On 2024 Al-Alloy Reinforced With Δ Alumina Fibres (by J.W. Kaczmar*, K. Naplocha, volume 43, issue 1, international OCSCO world press, November 2010)