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Study of Sliding Wear Behaviour of Hybrid Al 6061/Al2O3 Composites

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***Abstract*: In this study the solidification synthesis of metal matrix composite carried out involves a melting of the selected matrix material followed by the introduction of a reinforcement material into the melt obtaining a suitable dispersion. Solidification of the melt containing suspended dispersions under selected condition has been tried 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 needed considerable attention which include the difficulty in achieving a uniform distribution of the reinforcement material, wet ability between the two main substances, porosity in the cast metal matrix composites and chemical reaction between the reinforcement material and the matrix alloy. Scanning Electron Microscopy (SEM) has been used to find the bonding between the matrix and the reinforcements interface. This bonding increases the wear resistance of the test samples as seen from the results discussed.**

Key words: Stir casting, Dispersion, Wetability, Porosity

1.0 Introduction

The most primitive man made composite materials from mud, clay and ash mixed to prepare bricks followed by sand, stones, and cement mixtures to make concrete for builder's constructions. Composite materials have achieved success with in a short span despite facing several challenges during the course of its journey. The challenges have only reinforced our abilities to excel in challenging situations. Today worldwide the engineers face several problems like right selection of materials. Among all the materials, composite materials have the potential to replace widely used steel and aluminum parts. In the present market scenario out of 1600 engineering materials available today more than 200 are made up of composite materials. Due to the limitations of the conventional materials with respect to achievable combination of strength, stiffness and density composite materials substitute to meet the ever-increasing engineering demands of modern technology. Metal matrix composites are gaining importance and have become common engineering materials which are designed and manufactured for various application including automotive components, sporting goods, aerospace parts, consumer goods and in many other industrial applications that require high performance and light weight. In the present work considerable attention is being drawn to the study of the micro structural evolution and the structure-property correlation of the Al-alloys, particularly for the automotive applications. There exists knowledge about influence of alloying elements on the microstructure, mechanical and wear properties of as cast materials. Although there are large number of investigations on Al alloys, systematic and detailed research reports on micro structural control and the effect of processing route on the properties of Al-alloys at elevated temperature for automotive applications remain to be understood clearly. This study will help in using the enhanced properties for manufacturing the automotive as well as some aerospace components that need elevated temperature resistance**.** Stir casting method is used in this work. Stir casting set up mainly consists of a furnace and a stirring assembly as shown in figure.1.6. Presently very few work has been reported in the field of elevated temperature studies on Al_2O_3 alloys.

2.0 Experimental details

2.1 Work plan for experiment

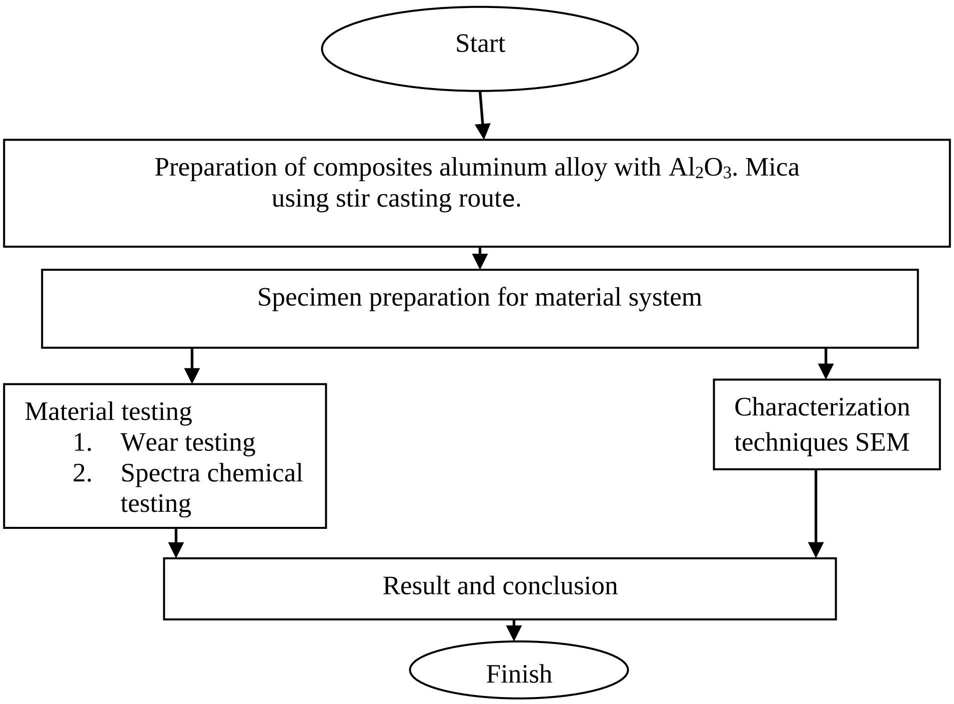


Figure 1. Flow chart of work plan for experiment

2.1 Preparation of composites Al6061 with Al_2O_3

A brief description of the raw material as well as reinforcement materials used to prepare the composite is as follows.

2.1.1 Matrix alloy

In this work Al6061 is used as the base metal and it should be taken from the xxx series in the form of ingots and that should be cut into small pieces to properly fit into the crucible. The Spectroscopic analysis of the Al6061 is in the given table

Table: 1 chemical analysis of the al6061 alloy

Element	Al%	Si%	Mg%	Pb%	Zn%	Cu%	Fe%	Ti%
Al Cube-1	97.28	1.600	0.045	0.076	0.104	0.176	0.413	0.018

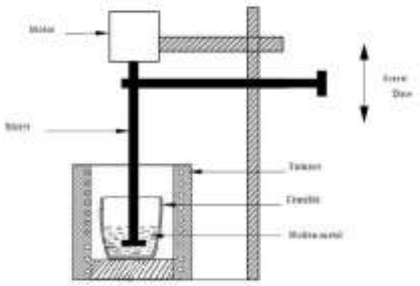
2.1.2 Reinforcement material

Al_2O_3. & mica used as reinforcement materials are for high strength, low density and corrosion resistance. Mica is used as a solid lubricant. The reinforced particles of deferent size is as shown in the Table 2

Table: 2 Particles size range of sic graphite Al_2O_3 Mica.

Reinforcement	Practical size range (mm)
Al_2O_3.	30-50

2.1.3 Al MMC preparation by the stir casting route



(a)

(b)

Figure: 2 (a) Stir casting setup (b) Sample for spectroscopic analysis of the Al6061alloy

As shown in figure 1(a) the stir casting setup consists of the induction furnace and the stirrer assembly. The stirrer assembly consist of the mild steel stirrer which is connected to the radial drilling machine with varying speed 80-800 rpm by means of steel shaft. Mild steel crucible coated with graphite having 5kg capacity is placed inside the furnace. A known quantity of (3kg) of Al alloy solid ingot is melted in the induction furnace. Slag is removed by adding the flux powder and degassing is achieved by adding the tablets. After the Al6061 alloy is completely in the molten state, the reinforcement is pre heated on the surface of the furnace to remove moisture to achieve good wet ability of the reinforcements. Stir setup is Reedley available for next process. The stirrer will be depend 1¼ of its body stirrer will be stated up to 500 rpm and the vortex will create in sides the crucible. The mixture of reinforcement like Al_2O_3 and mica by 2% & 4% were added with spoon at the rate of 10-20gm/min in to the metal. The speed is controlled with the speedometer and temperature is closely monitor at the stage of reinforcement adding in the composite After complete addition of the reinforcement remove the stir and the glass well be remove by molten metal and melt poured in to the preheated mold allows it in to solidified in the atmospheric air This will be rappelled for 4%, 6% & 8% Al_2O_3. Important parameter used in stir casting are Pouring temperature, Stirring speed, Stirrer design, Preheated mould.

2.2 Wear test

2.2.1 Experimental procedure of wear test

The number of specimen that undergo dry sliding wear test is conducted by using pin on disc machine (modal; wear and friction monitor.TR-20). As shown in the figure 4.8 the pin on disc machine the disc is made up of EN32 steel disc the pin was held against the counter face of a rotating disc track diameter 60mm. The pin was initially weighted w_1 and then fixed to the jaw and test concerned for different loads. Normally the load was weary like 1kg, 2kg, 3kg, 4kg and the speed (velocity) like 1m/sec,2m/sec,3m/sec the sliding distance was taken by,1000m, (Al6061/ Al_2O_3.) The pin sample were 30mm length 10mm diameter the surface of the pin was polished using 600grnt emery paper for flat surface with the steel disc. After the wear the sample is weight w_2 the volume loss is found out. In this experiment the test is conducted with the following parameters : Load , Sliding speed, Sliding distance. In the present experiment the parameter such as sliding speed, load and sliding distance vary as per the work plan

Table: 3 The parameter are given in table

Load (kg)	Speed V (m/sec)	Distance (M)

1	1,2,3	1001
2	1,2,3	1000
3	1,2,3	1000

2.2.2. Pin on disc test

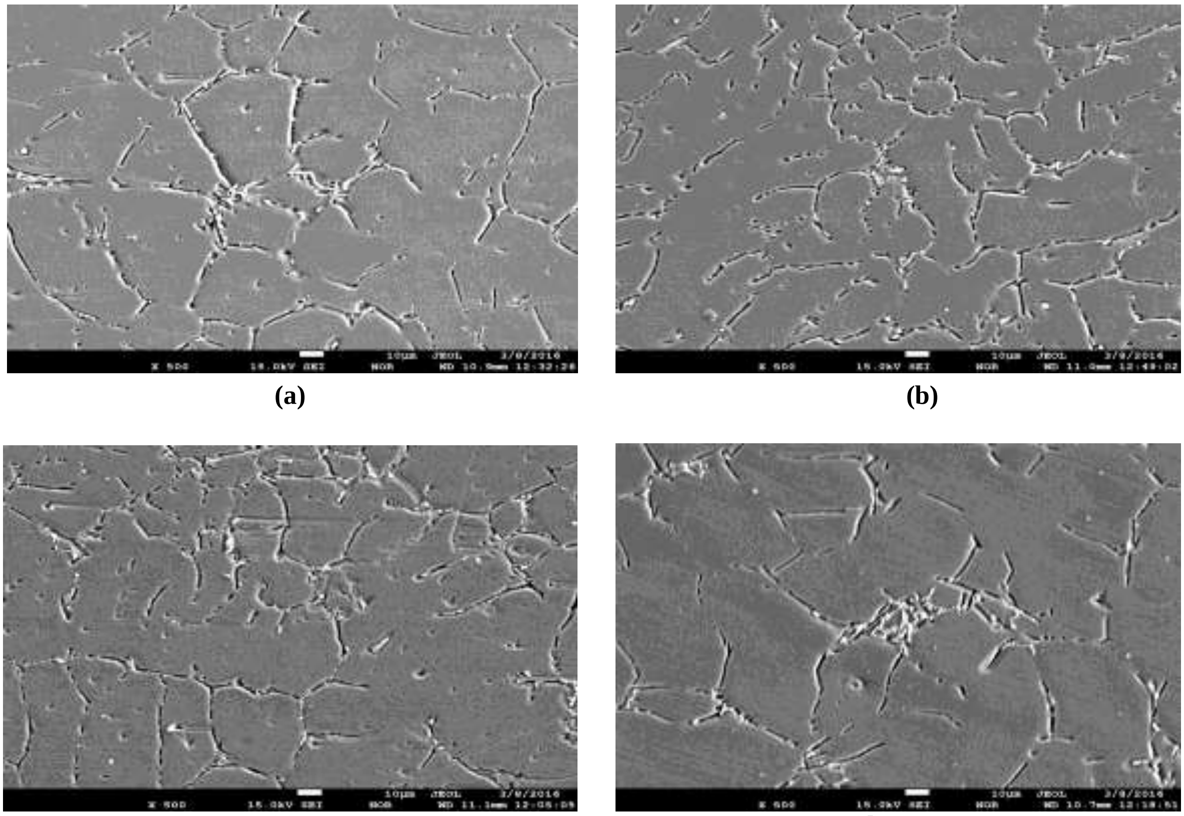
In this study pin on disc wear testing machine is used for tribological characterization of the test pieces. Initially the specimen is polished with the 600grit emery paper to obtain the flat surface. Initial weight w_1 is taken using the electronic balance machine with an accuracy of 0.0001gm. Sample is fixed in the pin holder with 90mm track diameter. Sample is loaded with 1,2 and 3kg. Speed and time is set as calculated. Frictional force readings are taken every minute after completing of the 1000 distance. Final Wight w_2 is taken and volume loss is calculated. The test is repeated for remaining specimens.

2.3 Hardness measurement

A hardness tester model no FV 700 is used for the hardness measurement. The load used on Vickers hardness tester is 1,3 and 5kg at 10x optical zoom with the dwell time of 10 secs for each sample.

3.0 Results and discussion

3.1 Microstructure Analysis



(a) (b) (c) (d)

Figure 3: SEM micrographs of Al6061 alloy and its Al_2O_3 composites at 500x a) Al6061-2%Al_2O_3, b) Al6061-4%Al_2O_3, c) Al6061-6%Al_2O_3, d) Al6061-8%Al_2O_3.

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Figure 3 (a-d) shows SEM micrographs of MMC composites. It is observed from the micrographs that the distribution of Al_2O_3 particles in the base matrix alloyed is fairly uniformly distributed in the matrix and excellent bond has developed between matrix and reinforcement particles. Also the grain size is observed to increase with increase in the addition of the reinforcement.

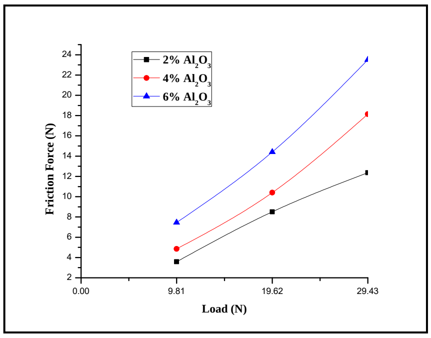
3.2 Wear test analysis

3.2.1 Effect of normal load on volumetric wear rate of Al6061/Al_2O_3

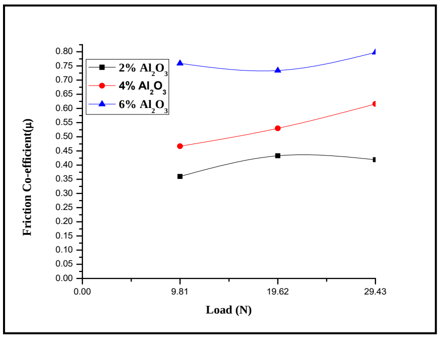
Figure 4(a) shows that the wear rate has increased with increase in load. Wear rate is maximum at 8% reinforcement of Al_2O_3 and minimum wear rate is at 6% reinforcement of Al_2O_3 irrespective of load applied. This is due to increasing contact between disc and pin which increases the friction force increasing the volumetric wear rate. From the figure 4(b) it is observed that with an increasing load volumetric wear rate increases with increase in load steadily and increased gradually until they material experienced transient from mild to severe load the severe load manifested itself by massive surface damage and large scale aluminum transfer to the counter face accompanied by the generation of Corus debris's partially the futures readily identified during the test showing naked eye.

From the figure 4(c) it is evident from the experiment that at low applied load and 2m/s speed the warm pin surface predominantly raises fine and shallow grooves at the interface. As seen from figure 4(d) characteristics of abrasive wear is observed in which hard appearance of counter face ploughing through the hybrid composite causing wear due to the removal of small fragments of metal. Al_2O_3 particulates efficiently act as load carrying member and coupled with the formation of lubricants mica keep the wear rate low. The fractured Al_2O_3 particulates and sharp asperities on the counter face easily penetrate the mica film covers and into the deeper groves, thus the wear rate is increases.

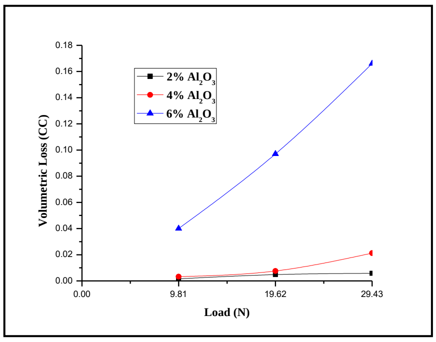
3.2.2 Results and discussions of wear test



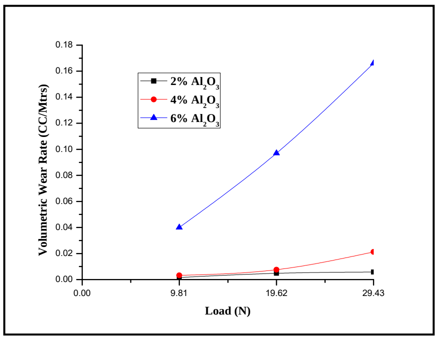
(a)



(b)



(c)



(d)

Figure 4 (a) Load v/s Friction force, (b) Load v/s Friction coefficient (c) Load v/s Volumetric loss (d) Load v/s Volumetric Wear Rate

The result of Vickers hardness tester for alloy Al6060 without reinforcement sample no 1 and variation of different reinforcement such as Al_2O_3 and mica as shown in table below

3.3 Hardness test results and analysis

Table 4 Hardness test results

Sample no	Sample name	Mean hardness no
1	Pure	62.40
2	Pure Al6061+2% Al_2O_3	56.30
3	Pure Al6061+4% Al_2O_3	65.26
4	Pure Al6061+6% Al_2O_3	67.33
5.	Pure Al6061+8% Al_2O_3	55.96

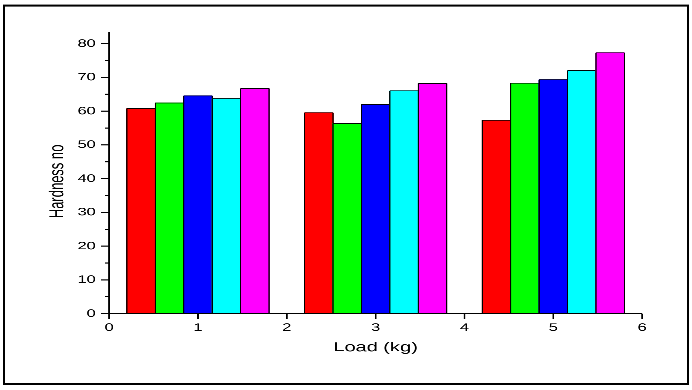


Figure 5 Comparison of hardness no Al6061 and with different % of reinforcement

Conclusion

1.From the graph we can conclude that load and the friction force are directly proportional to each other.
2. From the graph we can say that load and friction co-efficient are directly proportional to each other.
3. By referring the graph (4% and 6% Al_2O_3) load and volumetric loss are directly proportional to each other.
4. By referring the graph (4% and 6% Al_2O_3) load and volumetric wear rate are directly proportional to each other.

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