Investigation Of Tribological Behavior Of Bearing Material Using Taguchi's Techniques

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Abstract- *Aluminum alloy meets the requirements of various high performing components, bearing and they are being used for varieties of engineering applications owing to their unmatched low weight and excellent thermal conducting properties. The Aluminum fly-ash composite was fabricated using stir casting technique with 13% in in total weight percent (100%) of aluminum 6061 fly ash composites as reinforcing phase. The wear and friction characteristics of the composite in the as-cast conditions were studied by conducting sliding wear test. The sliding wear behavior of the MMCs was investigated by varying parameters like normal load, and track velocity, and track distance. Pin-on-disc wear testing machine was used for investigating sliding wear behavior. An attempt has been made to study the wear properties of the metal matrix composite and to improve the performance of the component and the service conditions. The results indicate that the wear resistance of the fly-ash reinforced material increased with increase in fly-ash content, but decreases with increase in normal load, and trackvelocity.*

Keywords- Aluminum – 6061, Friction & Wear rate, Design factors, Taguchi's technique

I. INTRODUCTION

Aluminum is the most abundant metal and the third most abundant element in the earth's crust, after oxygen and silicon. It is the most widely used non-ferrous metal. Aluminum and its alloys are light, has high strength to weight ratio, corrosion resistant, durable, and withstands high stresses and many other desirable properties, which makes it suitable for use a bearing material. Selecting the right alloy for bearing application entails considerations of its mechanical properties, tensile strength, density, ductility, formability, workability, weldability, and corrosion resistance. Aluminum alloys are alloys in which aluminum (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, and zinc.

In our present study, we have selected aluminum 6061 alloy for their vast use in our day-to- day life. Generally, Al 6061 has found widespread applications in bearing, automobile and aerospace industries, because of their excellent properties such as high strength to weight ratios, high thermal conductivity and good corrosion resistance. However, the conventional aluminum 6061 alloys have limitations in achieving good combinations of strength, stiffness, toughness, density and wear resistance. To overcome these shortcomings and to meet the ever-increasing demand of modern day technology, composites are best-suited and most promising materials of recent interest

A composite material is a material system composed of a suitably arranged mixture or combination of two or more nano, micro, or macro constituents with an interface separating them that differ in form and chemical composition and are essentially insoluble in each other. Generally, a composite material consists of two phases namely matrix and reinforcement. The intended bearing application of the composite materials mainly determines the selection of suitable matrix alloys. The matrix is the monolithic material into which the reinforcement is embedded, and is completely continuous. The strength of the composite depends primarily on the amount, arrangement and type of fiber (or particle) reinforcement in the resin. Typically the higher the reinforcement content, the greater the strength.

Reinforcing materials are strong with low densities while the matrix is usually a ductile, or tough,material. Among the various types of composites, metal matrix composites are most commonly composite due to their high strength, fracture toughness and stiffness. They are usually reinforced by low density and low cost reinforcements. Among various discontinuous dispersions used, fly ash is one of the most inexpensive and low-density reinforcement available in large quantities as solid waste by-product during the combustion of coal in thermal power plant. Hence composites with fly ash as reinforcement are likely to overcome the cost barrier for wide spread applications in automobile fields and small engine applications. In the present work, fly ash, which mainly consists of refractory oxides like silica, alumina and iron oxide, is used as a reinforcement phase. Composite was produced with 13% in total weight percent (100%) of aluminum 6061 fly ash composites as reinforcing phase.

II. LITERATURE SURVEY

Rajeshkumar, et al. 2013 paper presented that the "composite material" is composed of a discrete reinforcement & distributed in a continuous phase of matrix. Manufacturing of aluminium alloy based casting composite by stir casting is one of the most economical method of processing MMC. Properties of these materials depend upon many processing parameters and selection of matrix and reinforcements and their paper presents an overview of stir casting process, process parameter, & preparation of AMC material.

Anand Raju, et al. 2014 inferred that the addition of fly ash with aluminium reinforcement by using stir casting process can reduces the cost and density of aluminium material. Metal composite processes are improved mechanical properties like strength, hardness, low density and good wear resistance compared to other metals and in their journal they also studied both the aluminium alloy and fly ash reinforcement particulate metal matrix composite by comparing their mechanical properties and the wearproperties.

Bharat Admile, et al. 2014 reviewed extensive literature on the overall performance of these fly ash reinforced composites fabricated by stir casting and attempts were also made to provide aclear overview of the usage of fly ash as a reinforcing agent in different Al alloy matrices along with its distinctive performance.

Fig 1. Stir Casting Utility

Uthayakumar, et al. 2012 study describes multifactor-based experiments that were applied to research and investigation on dry sliding wear system of stir-cast aluminium alloy 6061 with 5, 10, and 15 wt% fly ash reinforced metal matrix composites (MMCs). Effects of parameters such as load, sliding speed, and percentage of fly ash on the sliding wear, specific wear rate, and friction coefficient were analyzed using Grey relational analysis on a pin-on-disc machine. Analysis of variance (ANOVA) was also employed to investigate which design parameters significantly affect the wear behaviour of thecomposite.

Ramachandra, et al. 2007 fabricated a composite with Al (12 wt% Si) as matrix material and up to 15 wt% of fly-ash particulate using the liquid metallurgy route. The wear and friction characteristics of the composite in the as-cast conditions were studied by conducting sliding wear test. The results indicate that the wear resistance of the fly-ash reinforced material increased with increase in fly-ash content, but decreases with increase in normal load, and trackvelocity.
Based on the literature survey lot of information was obtained based on the uses and need of the aluminium and its metal matrix composites in the field of bearing, automobile industry and aerospace applications. It was also found that the fabrication of the aluminium with fly ash reinforced composites could be done using stir casting method because it was found to be most simple and most economical method because of its easy operating principle and their limitations, which cannot be obtained in any other methods. It was also found that after fabrication the best method of conducting experiments in pin on disc apparatus for the analysis of the wear properties are by following Taguchi design ofexperiments.

III. STIRCASTING UTILITY

Stir casting is considered most effective process for the manufacturing of the discontinuous metal matrix composites based on literature survey and analysis. It is the most promising route currently practiced commercially. Stir casting is also most attractive because it minimize the cost if manufacturing and it is the most economical of all the available manufacturing process and the most important thing is that it allows the fabrication of very large sizedcomponents.

In this process, the reinforcing phases are distributed into molten matrix by mechanical stirring. Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement. Two step mixing process is followed to ensure the distribution of the particles into the matrix phase. In this process, the matrix material is heated to above its liquids temperature so that the metal is totally melted. The melt is then cooled down to a temperature between the liquids and solidus points and kept in a semi-solid state. At this stage, the preheated particles are added and mixed. The slurry is again heated to a liquid state and mixed thoroughly. This two-step mixing process has been used in the fabrication of aluminium composite.

The aluminium 6061 alloy is kept in the crucible and held inside the electric furnace now it is heated to a temperature of 850ºC. Then is held at 750ºC. Now the stirrer is inserted inside the crucible and rotated at 500 rpm. The reinforcement material is preheated at a temperature of 450ºC in order to remove the moisture content in the fly ash. The fly ash is added into the crucible slowly and steadily. The reinforcement particulate is mixed with the molten matrix by the vortex method. When the fly ash is completely added into the molten alloy, the stirrer is rotated at 1000 rpm, so that the reinforcement particulate is uniformly distributed throughout the matrix phase. Once when the stirring is complete the molten composite inside the crucible is poured into the mould. The bottom pour has uniformly distributed reinforcement material when compared to the top pour. Now the mould is allowed to cool in open atmospheric condition. The specimen prepared by stir casting technique is 25mm in length and 8mm in diameter.

IV. SPECIMEN PREPARATION AND TESTING

The different grades of emery sheets such as 100,220,400 and 800 are used in preparing the specimen. The pin is first polished with emery sheets and also the flatness is also maintained on the face of the pin. Then the polished face is cleaned with the help of cotton and acetone to remove the dust particles. Then the specimen is weighed. The process parameters are selected and with this process parameters the sliding time and rpm is calculated. Then the sliding time is divided into 20 parts and the rpm and the time is in the interface. Now the pin is practically mounted on the clamp in the projection provided in the apparatus. The fine adjustments are made with the help of Allen key. Then by using the calibration block the height of the pin is adjusted and then tightened. Then for the calculated intervals of time the frictional force and the wear rate is determined. Now the pin is un- mounted from the apparatus and then weighed. The change in weight gives the wear of the component.

L9 orthogonal array was used to carry out the experiments. The main factors are load(A), sliding velocity (B), sliding distance (C). Details of the design factors and their levels are shown in Table 1. Standard L9 orthogonal array used in this study is shown in Table 2. Wear loss was calculated using mass loss technique. The wear rate was calculated by using theformula:

Wear rate (g/m) = Mass loss (g) / Sliding distance (m)

Table 1. Design factors and its levels

Load (A)	10 N	20 N	30 N
Sliding Velocity (B)	1 m/s	2 m/s	3 m/s
Sliding Distance (C)	1000 m	2000 m	3000 m

When the specimen is subjected to wear testing in the pin on disc apparatus, the surface of the specimen that is in contact with the sliding disc starts to wear. After the completion of the test then worn surface of the specimen is shown, but not only the specimen surface wears, the relative motion between two has such a circumferential wear path on the sliding disc surface and there will be a small micro weld seen on the track that represents portion from where the wear is started

Fig 2. Pin subjected to wear

Fig 3. Track of the Specimen after wear test

V. RESULTS AND DISCUSSIONS

The table below shows variation in wear rate of alloy and wear rate of composite as a function of load, sliding velocity and sliding distance. From this table we also conclude that wear rate of composite is slightly lesser than that of alloy and this is due to the addition of fly-ash reinforced particles.

The Fig. shows the wear rate of aluminum 6061 alloy and it's composite as a function of no of trails respectively. It is observed that wear rate of aluminum 6061alloy decreases after addition of fly-ash particles. It can be attributed to the increase in hardness of material due to presence of hard ceramic particles. Material removal in a ductile material such as aluminum alloy matrix is due to the indentation and ploughing action of sliding indenters (Siabrasive particles). The hardness of the material determines the depth of indentation of abrasive particle. Incorporation of hard fly-ash particles in the aluminum 6061 alloy restricts such as ploughing action of sliding indenters (Siabrasive) and improves the sliding wearresistance.

TEST NO.	Load (N)	Sliding Velocity (m/s)	Sliding Distance (m)
1.	10	1	1000
2.	10	2	1500
3.	10	3	2000
4.	20	1	1500
5.	20	2	2000
6.	20	3	1000
7.	30	1	2000
8.	30	2	1500
9.	30	3	1000

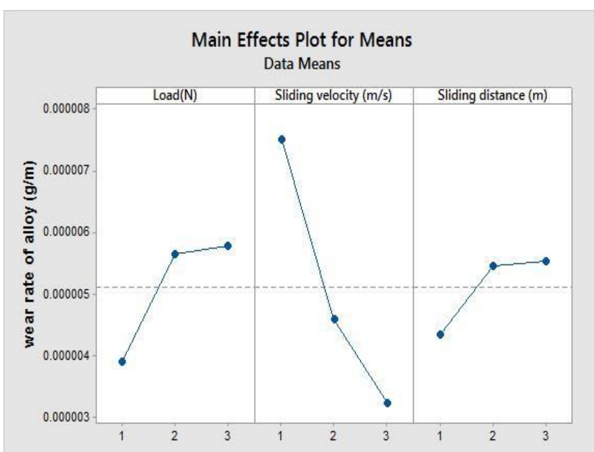


Fig 4. Effect of design factors on wear rate of Al-6061 alloy

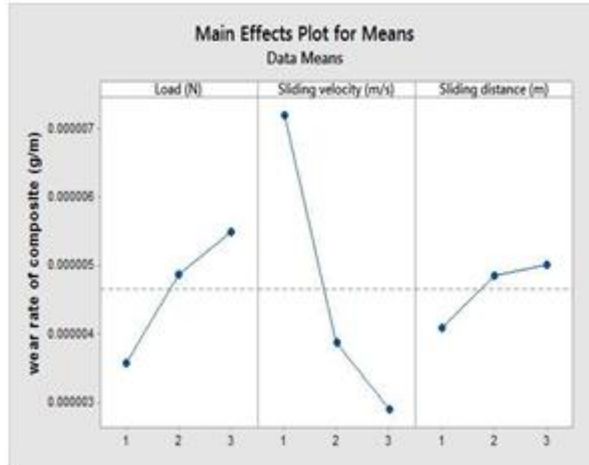
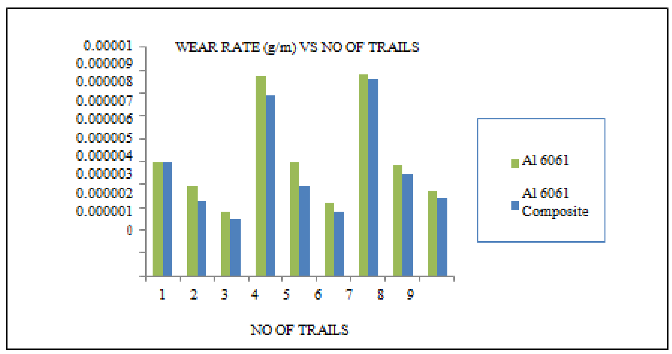


Fig 5. Effect of design factors on wear rate of Al Composite

Table 3. Interpretation of results

S.No	LOAD (N)	SLIDING VELOCITY (m/s)	SLIDING DISTANCE (m)	MASS LOSS OF ALLOY (g)	MASS LOSS OF COMPOSITE (g)	WEAR RATE OF ALLOY (g/m)	WEAR RATE OF COMPOSITE (g/m)
1.	10	1	1000	0.005	0.005	5E-06	5E-06
2.	10	2	1500	0.0059	0.0049	3.933E-06	3.267E-06
3.	10	3	2000	0.0056	0.005	2.8E-06	2.5E-06
4.	20	1	1500	0.0131	0.0119	8.733E-06	2.933E-06
5.	20	2	2000	0.01	0.0078	5E-06	3.9E-06
6.	20	3	1000	0.0032	0.0280	3.2E-06	2.8E-06
7.	30	1	2000	0.0176	0.0173	8.8E-06	8.65E-06
8.	30	2	1500	0.0073	0.0067	4.867E-06	4.467E-06
9.	30	3	1000	0.0037	0.0034	3.7E-06	3.4E-06



From the Fig and Fig, we conclude that the variation of wear rate of Al- 6061 and it's composite as a function of load, sliding velocity and sliding distance. As load decreases wear rate decreases and is due to the fact that pressure will be minimum in low loading condition so that it results in lower wear rate.

VI. CONCLUSION

Al-6061 and its composite, identified as suitable bearing material, were fabricated by stir casting technique. Wear resistance of Al-6061 improved significantly after addition of 13 wt% of flyash. The variation of wear rate was found out using the Minitab software as the function of load, sliding velocity and sliding distance at differentlevels.

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