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Review On Abrasive Wear Behaviour Of Al 6061 And Selection Of Material And Technology For Forming Layer Resistant To Abrasive Wear

(Interaction Of Graphene As Layer Resistance To Alimunium Alloys)

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ABSTRACT

This article deals with in-depth analysis of previous work done on the selection of materials for forming wear resistant layers within machine parts wear made of aluminum alloys (AL6061) and methods through which we can achieve required hardness, wear resistance and life extension of a machine parts and tools by the selection of a suitable material and surfacing technology.

Keywords :- Abrasive Wear, Resistant Layers, Aluminium Alloys, AL6061,Graphene.

I. INTRODUCTION

In recent decades, aluminum alloy based metal matrix composites are gaining important role in several engineering applications. Al6061 alloy has been used as the matrix material because of its good formability, excellent mechanical properties and manufacturing properties. wide spectrum of the applications in the industrial sectors. Inclusion of Frit particulates as reinforcement in Al6061 alloy material system has shown improvements its hardness, tensile strength, wear resistance. In this present investigation Al6061-Frit particulate composites were produced by 'VORTEX' method with varying percentages of Frit particulate from 0 wt% to 10 wt% in steps of 2.The as-cast matrix alloy and its composites have been subjected to solutionizing treatment at a temperature of 5300C for 2 hours followed by quenching in ice. The quenched specimens were subjected to both natural and artificial ageing. Microstructure studies were conducted on as cast and composites in order to investigate the distribution of frit particles retained in matrix material system. Densities of Al6061 matrix alloy and Al6061-Frit particulate composites were measured. Mechanical properties such as Hardness and sand abrasive wear test have been conducted on both Al6061 alloy matrix and Al6061-Frit particulate composite before and after treatment. It has been observed that under identical treatment conditions adopted, a Al6061-Frit particulate composites exhibited significant improvement in hardness, wear resistance and reduced density when compared with Al6061 matrix alloy. [3]

In the present study, a mathematical model has been developed to predict the abrasive wear behavior of Al 6061. The experiments have been conducted using central composite design in the design of experiments (DOE) on pin-on-disc type wear testing machine, against abrasive media. A second order polynomial model has been developed for the prediction of wear loss. The model was developed by response surface method (RSM). Analysis of variance technique at the 95% confidence level was applied to check the validity of the model. The effect of volume percentage of reinforcement, applied load and sliding velocity on abrasive wear behavior was analyzed in detail. To judge the efficiency and ability of the model, the comparison of predicted and experimental response values outside the design conditions was carried out. The result shows, good correspondence, implying that, empirical models derived from response surface approach can be used to describe the tribological behavior of the above composite. [1]

Studying wear is characterized by many different aspects and it is mostly influenced by the complexity of materials interaction on a functional surface as well as by operation conditions. In machine elements, there is a gradual wear in the result of friction. This is considered to be an undesirable effect in most cases. Therefore, we have to search for the possibilities to prevent it thus extending the technical life of a component. Surfacing presents one of these possibilities. Searching for the possibility of cutting the costs of changing the worn or damaged machine elements has led to the development of a wide range of surfacing technologies. Increasing the safety and extending the technical life of machines and devices are important requirements of modern technology. We can also add the requirement for simple maintenance, as well as simple and less time-consuming repairs in solving the random failures or operation accidents. [2]

II. ALUMINIUM ALLOYS (AL6061)

Improvement in the mechanical properties of wear resistance of Aluminium matrix composites can be achieved by adopting suitable treatment; (Das et al., 2008) have reported the abrasive wear behavior of as-cast and treated SiC reinforced Al-Si composites. They have reported that un-reinforced matrix material suffers from higher wear rates then that of Al-Si/SiC composites in both as-cast and heat treated conditions. Further, heat treated Al-Si/SiC composites exhibits better performance under all studied conditions. (Modi et al., 2001) have reported the three body abrasive wear behavior of Aluminium-Zinc/ Al2O3 composites exhibited excellent wear resistance under all the test conditions employed.[3]

A comparative study by (S.Das et al. 2007) on wear resistance of Zircon sand and Alumina reinforced AMC`s, revealed improved abrasive wear resistance with the decrease in particle size. Adhesive wear behavior of cast Al6061-TiO2 composites studied by (Ramesh et al., 2005) reported that, the wear resistance of composites is superior when compared to Al6061 matrix alloy. Further, it increases with increase in TiO2 particle content.S.Das (2004) reported the effect of load on abrasive wear rate of LM13-alloy and LM13 – SiC composites, results revealed that wear rates increases as the applied load increases for both as-cast alloy and its composites.[3]

An extensive review work on the dry sliding wear characteristics of composites based on aluminum alloys have been under taken by (Sannio et al., 1995) and abrasive wear behavior by (Deuis et al., 1996).In their studies and discussions, the effect of reinforcement volume fraction, reinforcement size, sliding distance, applied load, sliding speed, hardness of the counter face and properties of the reinforcement phase which influence the wear behavior of this group of composites are examined in detail.[3]

Reinforcement of hard particles in Al matrix protects the matrix alloy surface against destructive action of the abrasive during the abrasive wear behavior and rake angle of the abrasive affects the behavior (ZumGhar K.H., 1979, Hutchings.J.M, 1987, Kulik.T et al., 1989, Jain-main.T 1985, Axen N, 1992). (Wang et al., 1989) Reported that coarse abrasive particles and high volume fraction of reinforcement results in decreased resistance; this is attributed mainly due to fragmentation of reinforcement phase. On the other hand, it was mentioned with decrease in the abrasive particle size. [3]

A. Composite production

Al6061-Frit composites were prepared using liquid metallurgy route (VORTEX).Particulate MMC`s are most commonly manufactured either by melt incorporation and casting technique or by powder blending and consolidation (Clyne T.W., 2001). AMC`s are synthesized via variety of manufacturing routes. These techniques include stir casting (S.Skolians. 1996, Kang C.G. et al., 1997, XUY et al., 1998), liquid metal infiltration (Seo Y.H. et al., 1995), Squeeze casting (Lee J.C., et al.,1998) and spray co-deposition (Bar J. et al.,1993). Stir casting route is generally practiced commercially (Skolianos S., et al., 1993, Banerji A. et al., 1982, Surappa M.K, et al., 1982) .Its advantage lies in its simplicity, flexibility and applicability to large quantity of production. Al6061 matrix alloy material was melted using 6 KW electrical resistance furnace. Pre heated Frit particles were slowly added into the molten matrix alloy material and mixed thoroughly by means of mechanical stirrer. Thoroughly mixed composite melt maintained at a temperature of 710 0C was poured into the preheated metallic molds. The proportion of Frit particles was varied from 2 wt% to 10 wt% in steps of 2 wt%. However Al6061 matrix alloy material was also casted for comparison. Cast Al6061 matrix alloy material and Al6061- Frit particulate composites were machined to test standards.[3]

B. Heat treatment

Al6061 matrix alloy and Al6061-Frit particulate composites were subjected to thermal treatment by solutionizing at a temperature of 5300C followed by ice quenching. Both artificial and natural ageing (0 h) were employed on the quenched specimens. Artificial ageing was performed at a temperature of 1750C for duration of 2 h to 10 h in steps of 2 h.[3]

C. Microstructure

Al6061 matrix alloy and Al6061 -Frit particulate composites were subjected to microstructural studies. The standard metallographic technique was adopted on Al6061 matrix alloy and Al6061-Frit particulate composites for microstructural characterization.[3]

The polished specimens were etched with Keller's reagent.

D. Density test

The theoretical density was calculated using rule-of-mixture and experimentally, the density measurements were carried out on the base alloy and reinforced samples using Archimedes principle. The buoyant force on submerged object is equal to the weight of the fluid displaced. This principle is useful for determining the volume, by measuring its mass in air and its effective mass when submerged in water (density=1 g/cc).This effective mass under water will be its actual mass minus the mass of the fluid displaced. The difference between the real and effective masses therefore gives the mass of the displaced water and allows the volume of the object to be calculated. Mass divided by the volume thus determined gives a measure of the average density of the object (Ramachandra M. et al., 2006). The density of material, which is ratio of weight to volume (Bermudeza M.D. et al., 2001, Ahmad S.N. et al., 2005), [3]

E. Hardness test

Hardness is one important property which effects wear resistance of any metal or alloy, hardness measurements were carried out on Al6061 matrix alloy and Al6061-Frit particulate composite specimens of both as-cast and treated. Brinell hardness measurements were carried out in order to investigate the influence of Frit particulate on the matrix alloy hardness. The applied load was 500 Kgs and an indenter of 10 mm diameter steel ball (HB500). Round specimens of 20 mm in diameter were prepared and polished on different grits of emery paper. The polished specimens were tested using Brinell hardness tester. The test was carried out at five different locations to controvert the possible effect of indenter resting on the harder particles. Hardness was determined by measuring the indentations diameter produced. The average of all the five readings was taken as the hardness of as -cast and composite specimens. FIGURE 1 & 2 shows the hardness test specimen before and after indentation.[3]

III. ABRASIVE WEAR

Abrasive wear belongs to such wear types that can occur most frequently in machine elements of industrial installations and it presents up-to 80% of overall volume [4]. It can also originate from other wear types in the course of which the free particles are being formed. These particles are becoming stiffer than the parent material. This happens under the influence of either intensive plastic deformation, or air oxygen oxidation. Abrasive wear rate can be reduced by:

- load reduction – particles will not be imprinted so deeply into the material surface and the riffles will be shallower
- hardening – with the same effect as it is in previo us possibility [6]

Abrasive wear consists in separation of surface parts by undulation of another surface or particles that are situated between the friction areas. It mainly depends on load, slide-way length and hardness. The influence of number, size and shape of the particles is also very important [5]. Riffles belong to typical surface damages in abrasive wear.

In abrasive wear, it is necessary to distinguish between two critical phases, namely the process of imprinting the abradant into the surface where the imprint hardness and destruction process are the limiting factors. Interatomic bond force and the composition strength between structural components reciprocally at the borders of grains play a decisive role [4].

Studying wear is characterised by many different aspects and it is mostly influenced by the complexity of materials interaction on a functional surface as well as by operation conditions. In machine elements, there is a gradual wear in the result of friction. This is considered to be an undesirable effect in most cases. Therefore, we have to search for the possibilities to prevent it thus extending the technical life of a component. Surfacing presents one of these possibilities. Searching for the possibility of cutting the costs of changing the worn or damaged machine elements has led to the development of a wide range of surfacing technologies. Increasing the safety and extending the technical life of machines and devices are important requirements of modern technology. We can also add the requirement for simple maintenance, as well as simple and less time-consuming repairs in solving the random failures or operation accidents.

Wear is the (permanent) change of shape, size or features of material layers that usually form the surface of solids. It occurs as a result of friction and out of technologically required shaping or required change of material characteristics [4].

Slovak technical standard 01 5050 classifies wear as follows: adhesive, abrasive, erosive, fatigue, cavitation and vibration wear. Wear can have many forms that depend on the surface topography, contact conditions and environment.

IV. GRAPHENE ALUMINIUM INTERACTION

A novel aluminium oxy hydroxide [Al–O(OH)] modified graphene oxide was prepared by a chemical precipitation method wherein Al3+ ions could interact effectively with the different functional groups of graphene oxide (GO). The prepared (GO–Al–O(OH) adsorbent was tested for the effective defluoridation of water. The Al3+ modified graphene oxide adsorbent was characterized using FT-IR, FT-Raman, SEM-EDS, XRD and XPS studies. The thermodynamically feasible adsorption is supported by the pseudo second order kinetics and a high Langmuir maximum adsorption capacity (51.42 mg g−1) for the GO–Al–O(OH) adsorbent. Furthermore, we could treat 2.0 L of 5.0 mg L−1 fluoride ion solution to bring the level within the permissible limits and the regeneration of the adsorbent was done using ammonium hydroxide.[11]

V. CONCLUSION

The present study is an overview of latest research works on Abrasive Wear. It will give you a brief information about the Abrasive Wear, its parameters and about the techniques used to optimize the parameters and wear resistance of aluminum alloys.

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