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Assessment of Wear Resistance of Aluminium Alloy in Manufacturing Industry-A Review

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Abstract

Aluminium alloy composites are attaining vast industrialized recognition in the area of aircraft, automobile, aerospace as a result of its improved mechanical characteristics in relating to stiffness; quality and impact load to weight proportion and better wear protection. They are widely used in automobile industry to manufacture various parts where wear resistance is serious like valve, water coolant, cylinder lining, fan blade, piston and rings etc. Stir casting technique is a liquid state method for the fabrication of composite materials. The part critical to these functional areas is the valves which are often fabricated by stir casting method. The wear parameters considered in the study of wear resistance include sliding speeds and applied loads.

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Keywords: Stir casting technique, wear, reinforcement. mechanical properties

1. Introduction

Aluminium alloys have major application in engineering construction due to the strength to weight proportion and other mechanical differences. Aluminium is the best material used for structural application because it is light in

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weight, low density and improved wear resistance. Other element of normal strength is added to aluminium to produce structural components [1]. Aluminium alloy are utilized in the industry as a result of their improved interaction of mechanical, strength and tribological properties over the parent metal. Selection of two or more metals is anchored on their respective characteristics as they add to the character performance of individual material [2]

There is urgent need to enhance the tribological element of aluminium alloys for better result [3]. To produce a good aluminium metal matrix composites involves the addition of reinforcements to increase its mechanical properties and reduce wear rate. The higher strength to density ratios, higher stiffness to density ratios, better fatigue resistance, lower coefficient of thermal expansion and better wear resistance are the properties of aluminium metal composites have over parent metal. The industrial application of the properties of metal matrix composite is of immense benefit to the automotive, aerospace and marine industries [4]. The examples of reinforcement used for metal matrix composites are aluminium oxides, silicon carbide, boron carbides, titanium carbides, titanium borides etc. Others are natural reinforcement's like fibers, whiskers, particles. These reinforcements will enhance the physical and wear characteristics of the material [5]. Wear is the slow taking away part or displacement between two contacting surfaces. It can be caused by physical actions such as erosion or chemical action such as corrosion. Machine components experience wear which resulted to malfunction of various parts [6]. Factors affecting wear rate include types of loading, types of motion and temperature, contact area, sliding distance, lubrication and material properties. Using tool continuously can cause damage or wear inside it such as fatigue and twisting as found in many productive industries such as textile industry [6].

1.1. Major causes of wear

It was found from studies that friction was the major cause of wear [9]. The properties of the surfaces to be designed and develop are the hardness, corrosion resistance and wear resistance [10, 11]. Low hardness materials exhibit high wear rate which result to deceasing the service life span and efficiency of the machine component. The wear rate increases even at low load. Friction stir technique was used to refine the surface structure [11, 12].

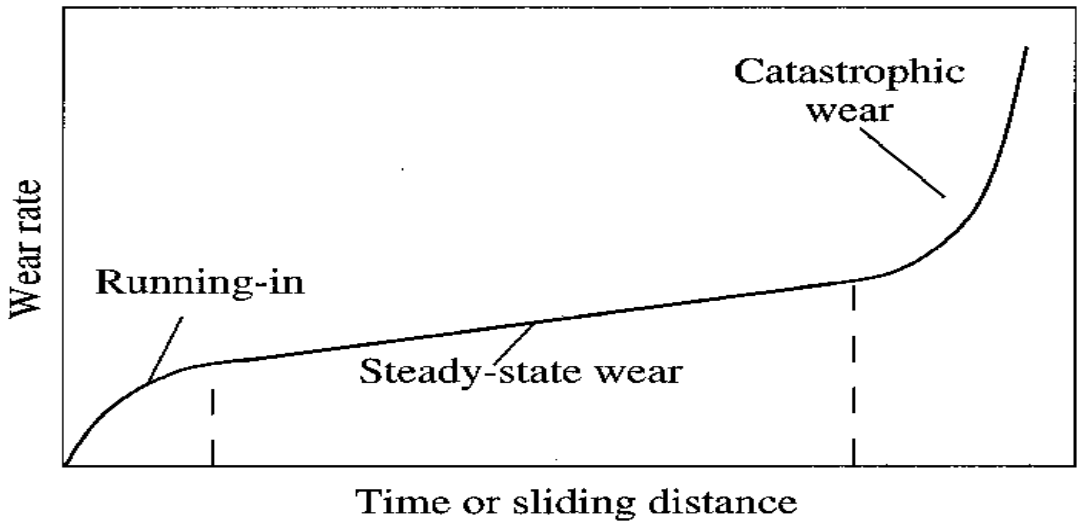

Figure 1: Typical wear rate against the time or sliding distance [14].

1.2. Precautionary measures for evaluating wear

Evaluations of wear are mostly done using weighing and dimension change measurement. It is hard to weigh when the volume of worn surfaces is minimal in comparison with the weight of the component. Some of the wears are not uniformly distributed over the surface thereby measuring the wear at each given point instead of the entire surface. The learning of worn surfaces using microscope or surface topography methods is a necessity for the evaluation of wear. It is necessary to pay attention to the type of wear which helps in determining the life span of the components (Figure 1). The most crucial part of the evaluation step is to identify the basic mechanism of the wear process.

Firstly, identify the causes of failure and location of the surface damage. Verify if the failure is as a result of continuous wear or sudden damage. Worn out or failed component do not usually give information on the causes of wear in service. Comparison is made between components that has not experience failure and worn or unworn component. This will enable us to identify surface features that appeared during production and service conditions [14].

2. Wear behaviour of aluminium matrix composites

Wear behaviour of Aluminum metal matrix composites has been carried out by several authors due to their application such as bearing material, brushes and contact strips in the manufacturing industry. Different reinforcing particles like SiC, Al_2O_3, Al_3Ti have been used to reinforce aluminium alloy via friction stir processing (FSP). [13] Pramod *et al*., [11] studied wear behaviour of Al7075 Metal Matrix Composites reinforced with Al_2O_3 using Artificial Neural Networks. The matrix is Al7075 alloy having high strength and toughness as its properties but it has limitation of poor resistance against wear. The fabrication of metal matrix composite was done by the assistance of vacuum stir casting method. The authors observed that application of the impact load and reciprocating distance will increase material shortage in positions of wear-altitude for the parent alloy and its reinforcement. The report affirmed that increasing the reinforcement will decrease the loss of the material [13].

Peddavarapua *et al*., [16] examined dry sliding wear behaviour of AA6082 reinforced with 5%SiC and AA6082 reinforced with 5%TiB_2 by comprehending the wear behaviour for the different sliding speeds and applied loads. The author has revealed that the mass loss as a result of wear in the mating parts leads to substantial dimensional changes which lead to disastrous failure of parts in the manufacturing industry. The report affirmed that abrasive wear dominate more in nature than the adhesive. AA6082 %TiB_2 show most extreme wear at higher load. The authors further demonstrated that strengthening with TiB_2 gives better wear resistance than SiC reinforcements The author fail to determine the causes of slight increase in wear with speed which caused the normal mechanism of delamination wear [14].

Kandeva *et al.* [15] studied the wear effect of adding discontinuous TiC micro particles, before and after heat treatment to the continuous aluminium alloys $AlSi_7$ obtained by casting. Scientific results were obtained for large amount of wear, tribological rate and wear resistance of the alloys with unequalled weight percentage of micro particles. The authors have revealed that reinforcing an aluminium alloy with TiC micro particles leads to noticeable wear resistance increment. Furthermore, reinforcing cast alloy with 15% weight micro particles leads to maximum wear under equal operational performance with 5% weight micro particles [15].

Prasad and Ramachandra [16] studied the abrasive wear behaviour of aluminium reinforced with fly ash using squeeze casting method. He examined the effect of process parameter on wear resistance and hardness of squeeze cast LM6 aluminium-flyash composite. He studied the effect of reinforcement content and squeezes pressure on the hardness and wear rate of the composite material. The result of the experiment for the hardness and wear rate of the composites were compared to base alloy manufactured by squeeze casting. The authors revealed that resistance due to wear of the composites are of higher quality to the base alloy produced by squeeze casting method. The result of the experiment show uniform and equitable distribution of flyash in the aluminium matrix composites. However, the authors observed small accumulation of flyash particles at some areas in the composite samples. [16].

Shanmugasundaram *et al.,* [17] examines the influence of reinforcement in improving the hardness and wear properties of AA6063 aluminium alloy when reinforced with tungsten carbide utilizing gas tungsten arc as heat provider. The authors noticed that the application of the heat on the base metal surface will lower the hardness of the fusion with regard to the base metal. The study confirmed the uniform distribution of Tungsten Carbide over the AA6063 Surface and tungsten carbide composite. Furthermore, WC particles stick properly to the aluminium matrix with clear boundaries. The authors did not deduce the most effective method to improve WC particles through the hardness and wear properties of the material.

Industries are faced with the challenges posed by wear, which has decrease the life span of the machine parts, increasing the maintenance cost and also result to producing low quality materials and breakdown of machine [17]. Metal parts protection from wear depends on the strength of metal and metal work phases. Surface defect have had significant affect on friction. Several methods have been utilized to enhance wear resistance. This includes application of lubricant, keeping the load, temperature and speed as low as possible, increasing the contact area to reducing depth of wear by spreading the wear volume, selecting proper alloy in an unlubricated system. Wear have also been used to decrease wear rate by creating a coolant chamber containing water so as a cool and reduce friction between contacting surfaces [18].

Conclusion

In conclusion, aluminium metal matrix composites were produced through the addition of reinforcements to increase its mechanical properties and reduce wear rate. Surface hardness of considerable number of composites indicated prevalent outcomes than parent alloy. The impact load, reciprocating speed and displacement of reinforced materials on tribological rate of aluminium composite is contemplated. The production of aluminium matrix composite by the combination of pure aluminium with different reinforcement under different production route yielded favourable result in reducing wear rate in materials. The reinforcement of aluminium alloy using stir casting technique is faster accurate and yielded favourable result. The authors use costly ceramic reinforcements but there is a lack of work regarding using agro industrial waste which is readily available and cheaper to reinforce aluminium alloy. Attention will be directed toward using sustainable materials processing and manufacturing to reduce wear rate of sliding components of machine parts.

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