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Analyzing the Effect of B4C/Al2O3 on the Wear Behavior of Al-6.6Si-0.4Mg Alloy Using Response Surface Methodology

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ABSTRACT

The current study deals with the development of a hybrid metal matrix composite and studies their wear characteristics. Suitable wt - % of Al_2O_3/B4C was reinforced into Al-Si-Mg alloy and the composites were fabricated using liquid metallurgy route. The developed composites were analyzed for their wear behavior by using a wear testing apparatus. Three process parameters including applied load, sliding distance, and velocity were chosen for carrying out the wear experiments. The influence of the reinforcement on wear rate was investigated through response surface methodology methods. The formulation of the regression equation was done and the effect of each experimental parameter was studied. Results from the investigation illustrate that the wear rate was found to decrease and then increase with the increasing wt-% of reinforcement and the wear rate was found to increase with an increase in the sliding distance but the wear rate was found to decrease with an increase in the sliding velocity. The worn-out surface of the hybrid composite was characterized using SEM.

KEYWORDS

A356 Alloy, Hybrid Metal Matrix Composites, LM25 Alloy, MML, Response Surface Methodology, SEM Analysis, Wear Behaviour

INTRODUCTION

Due to the unique combination of properties exhibited by Al and its alloys, makes Aluminium one among the most versatile, economical and tempting material for a wide range of applications. Aluminium and its alloys find applications in aviation and automobile industries. One of common applications of Al is in the manufacturing of pistons in the automobile industries. The properties exhibited by these alloys are as follows - Moderate strength, good castability, and low hardness. Among the mentioned properties, hardness plays an important parameter in the designing of certain components for automobile applications. Due to low hardness of the alloy, it makes them prone to wear due to this demerit they have limited applications in conditions subjecting to wear. So, this

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study aims at improving the wear resistance by reinforcing hard phased particles.B_4C which might found to be a reassuring ceramic material fitting to its lofty strength, low density (2.5 g/cm^3) extreme hardness and better chemical resistance. Along with Al_2O_3 (3.95 g/cm^3) which possesses mediocre to towering mechanical strength, very high compressive strength and high hardness it is also used as a reinforcement in this research work.

Hybrid metal matrix composite (HMMC) is a combination of a single matrix and two or more reinforcement. They hold lofty strength to low weight ratio and have prospective applications in the automobile and aviation industries. Hybrid metal matrix composites (HMMC) are nearly always on the more expensive side than the traditional materials they are substituting. As a result, these composites are found where justification of added cost really means. The single reinforced composites are now replaced by second-generation composites which are termed HMMC. The scope of its application will certainly increase as the production costs are on the lower side.

BACKGROUND

Many kinds of research are conducted on improving the wear properties of LM25 alloy and some of the research envisaged by different authors are listed below:

R. K. Uyyuru et al. (2007) swotted on the tribological behavior of liquid fabricated Al-Si/SiC composites in opposition, to the automobile brake pad material using the pin on disc wear tester as per ASTM G-99 benchmark. In this investigation, the authors were able to give an inverse correlation between the wear rate and sliding speed for the developed composite. It was observed from the study that multiplying normal load wear rate was seen to be on an incline,on stark contrast to friction coefficient which decreased. morphology and topography near the debris of the developed composites were characterized by SEM and XRD. It was also noticed that a worn-out layer forming between the pin and disk greatly affects the wear behavior of the composites.S. A. Kori et al. (2009) conducted a study on improving the mechanical behavior of A356 alloy by addition of minor elements like Cu and Mg. It was observed from the study conducted that, by addition of Cu (0.1-0.5 wt-%) to LM25 alloy increased its mechanical performance. The addition of alloying elements refined the grain structure hence the properties were found to improve. The improvement in the property is due to the partial refinement of the α – Al dendrites and solid solution hardening. J. B. Yang et al. (2004) studied the fabrication and properties of A356/Al_2O_3 /graphite particulate hybrid composites. Micro graphite and Al_2O_3 were reinforced into the matrix and the composites were manufactured by stir casting technique. A uniform distribution was observed by utilizing this particular type of manufacturing operation. The tribological behavior improved by the addition of Alumina and graphite into the matrix. It was inferred from the investigation that the addition of graphite into the matrix improved the wear resistance of the composite. The wear debris of the developed composite was found to become small as the graphite content was increased.Manoj Singla et al. (2009) investigated the effect of SiC on the mechanical behavior of Al alloy using stir casting technique. In this investigation the SiC ceramic particles were added by varying the volume fraction of SiC from 5w-% to 30wt-% indifference of 5. It was noted from the research that the addition of SiC into the Al matrix improved the hardness and impact resistance properties drastically. The improvement in the properties of the composites is attributed to the dispersion hardening happening in the developed composite. R. Dasgupta and S. K. Bose (1995) conducted a research on the addition of Cu into Al-Si-Mg alloy. In this investigation the authors analyzed the formation of $CuAl_2$ phase in the developed alloy. The presence of intermediate phase in the alloy enhanced the hardness and wear resistance of the developed alloy in the investigation. F. Karimzadeh et al. (2011) conducted a research on reinforcing boron carbide in to Al matrix and in the research conducted by the authors, the authors observed an increase in the wear resistance by the addition of B_4C. The weight percentage of boron carbide added into the matrix was in the amount of (5wt-%,10 wt-%, and 15 wt-%). The composite material was fabricated by the process of liquid metallurgy route.K. M. Shorowordi et.al (2006) conducted a study on the wear behavior of composites

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