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Processing and wear behavior optimization of B_4C and rice husk ash dual particles reinforced ADC12 alloy composites using Taguchi method

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Abstract. The composite material comprises either two or more constituents having dissimilar physical and chemical properties. The composite is prepared by various techniques, but the stir casting method has been widely used, as it is simple and cost-effective. In the present work, the composites from ADC12 Aluminum Alloy-Boron Carbide (B_4C) (wt.5%) and varied wt % of Rice Husk Ash (RHA) were developed with the help of the stir cast technique. Composite having 3, 6, 9 wt.% of RHA were considered for the wear analysis. The wear analysis of hybrid composites was studied with the help of Taguchi method and also optimum values were determined. The tribological study was conducted on the Pin on disk testing apparatus under dry sliding conditions. The L27 orthogonal array has been preferred in the present work to include three factors and three levels. The selected factors are Speed (N), Load (W), RHA, and wear depth as system output (yield). Analysis of variance has been carried out to know the parameters' influence and level of contribution to the wear loss. For, the validation of the analysis results the experimental test was carried out for the optimum values. To understand the wear mechanism in composites the samples were analyzed using Scanning Electron Microscopic (SEM) and it has been observed that both abrasive, as well as adhesive wear, did occur on the contact surface of the specimens.

Keywords: ADC12 Alloy, B_4C, rice husk ash, microstructure, wear, optimization, Taguchi

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1. Introduction

More recently, extensive research work has been conducted on agro based waste products because these agro-waste products are easily available, less dense, have reduced cost and are environmentally friendly. Several research studies show that Agro based waste byproducts

like maize stalk ash, bamboo leaf ash, corn cob ash, RHA, bagasse ash, and bean shell waste ash have been used as reinforcing materials to increase the Wear and Mechanical characteristics of aluminium-based composites. The latest sophisticated materials are an aluminium alloy matrix supplemented with SiC and B_4C particulate [1,2]. Hard materials are commonly used as reinforcements due to their ability to improve qualities such as tensile and compression strengths, as well as their advantages in tribological applications. Reinforcements with appropriate particles are commonly used to improve mechanical qualities. B_4C and RHA fibres have also been used as reinforcing materials in MMC because of their high strength and low density. Aluminium MMCs made by solidification processes with these particulates as reinforcing material represent a class of low-cost, suitable materials for a variety of engineering applications in the automobile industry, such as brake pads, bushes, and bearings [3,4]. The aluminium metal matrix material reinforced with B_4C has the potential to develop a material with improved thermal conductivity, incredible mechanical capabilities, and good damping behaviour at high temperatures [5]. However, there is a wettability problem between aluminium and the B_4C-RHA reinforcements, and oxidation of the particles at high temperatures causes industrial problems and material cavitation.

At increased temperatures, current research on AMMC with ceramic reinforcement particles has revealed an increase in wear resistance and improvements in mechanical properties [6,7]. Due to the presence of B_4C, matrix deformation, load distribution, and micro defects that frequently occur along the friction track could be effectively prevented.

From the literature, it is clear that numerous investigators conceded the investigations on hybrid composites using aluminium alloys of different series such as 1xxx -7xxx as matrix material but from literature, it is very rarely seen that usage of aluminium alloy ADC12 as matrix material. Further combination of reinforcements like boron carbide and agro waste product RHA containing oxide in the development and characterization of hybrid MMCs was not done.

In the present work, samples of ADC12 Aluminum Alloy-B_4C-RHA composites were prepared using stir casting. For the preparation of composites ADC12 aluminum alloy is used as matrix material, B_4C particles, and RHA particles were used as reinforcing materials. The tribological properties of ADC12 aluminum alloy-B_4C-RHA AMCs were studied by Taguchi's technique. It has been understood that the rate of wear in composites was influenced by the amount of RHA (reinforcing material) used and wear parameters like the sliding speed and applied load. Pin on Disk wears testing apparatus was used to find out the wear of the composite samples which were initially developed by stir casting method [8,9]. The design of experiments was planned and conducted as per the L27orthogonal array by Taguchi technique. The agro-waste derivatives were found very much influential as reinforcing materials [10] on properties of composites materials and also promising resources for the aluminium based metal composites on a large scale. In recent times, several investigations were aimed at the optimization of the production parameters and wear parameters.

2. Taguchi method

Taguchi method [11-13] is a powerful technique for designing of experiments to obtain a high yield from the process or system using orthogonal arrays (OA). Taguchi techniques are strategically ordered experiments to minimize deviations in the desired quality. It is a logical and easy statistical approach to finding popular designs for better execution, high quality, and less expensive. The Signal-to-Noise Ratio (S/N Ratio) is determined from the output response in Taguchi technique (experimental results-wear loss). The signal-to-noise ratios were calculated with the following goals in mind: smaller is better, nominal is best, and larger is