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Tribological behaviour of aluminium based hybrid metal matrix composites (Al6061/B_4C/ZrO_2/SiC)

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Abstract

This research is aimed into the use of stir casting technique to make a variety of reinforced aluminium and non-reinforced hybrid composite materials. Aluminium Metal Matrix reinforced with different volume proportions of ZrO_2 (2%, 4% and 6%) and SiC (4%, 8%, 12%) particulate by stir casting techniques. Al6061 and B_4C are selected as a base material and ZrO_2 and SiC utilized as a reinforced material. Actual density and theoretical density are calculated using the Archimedes principle and the rule of mixtures, respectively, and the porosity is measured in terms of theoretical and actual densities. It can be observed that the density of hybrid composites increases with the addition of reinforcement materials in aluminium matrix. The Pin-on-disc apparatus was used to conduct the wear experiment various sliding distance, sliding speed and applied loads. As results concluded that wear rate of Al6061+2%B_4C+6%ZrO_2+12%SiC hybrid composites are smaller than that of unreinforced aluminium alloys. From the experimental analysis the increasing reinforcements of ZrO_2 and SiC particle in aluminium metal matrix decreases the wear rate of prepared hybrid samples. Increasing the load on the abrasive disk reduces the abrasion rate on all models and decreases at a sliding speed of 4.5 m / s and then increases. However, the wear rate decreases with increasing sliding speed, while the depreciation rate increases with increasing sliding distance and load.

Introduction

The growth of aluminium metal matrix composites plays a huge revolution by last 10years in automobile, aircraft and shipbuilding industries owing to their unique structures such as high specific strength, good thermal conductivity, high resistance, and mechanical and electrical properties [1], [2], [3]. Negotiations in characteristics can also be felt in mixed hybrids, where one of the defects of rigidity is balanced by a second reinforcement. Reinforcements are different ceramics materials such as SiC, alumina (Al_2O_3), B_4C, TiO_2 and other hybrid composites [5], [6]. Tan et al. reported the effect of SiC reinforcement on al matrix, which increases strength and dilution compared to other ceramic materials [4]. Chen and others have completed further research into aluminium with SiC reinforcement, the results showing higher hardness value, lower cost fabrication and higher corrosion resistance compared to similar types of ceramic reinforcement materials [7]. Aluminum is usually upgraded with pottery such as silicon carbide and Al_2O_3 to increase elastic modulus and strength. Even though, these same potential benefits of hybrid composites are usually associated by a reduction in deformation to failure [9], [10].

Casting is one of the main essential and widely used practices for the production of various metals and alloys. Stir casting and squeeze casting are two common casting processes used to reinforce composite models with ceramic reinforcement particles. Chelladurai et al. analysed the wear morphology of aluminium LM23 with steel coated fiber reinforcement by using stir casting route [8]. Aluminum alloy 6061 alloys are widely used by the manufacturing industry due to their easy mechanical and discharge properties. with the addition of highly preferred reinforcement materials such as boron carbide (B_4C) and silicon carbide (SiC) in Aluminum metal matrix composites (AMCs) are demonstrated a high resistance, flexible thermal conduction and high corrosion resistance compared to other types of composites [11], [12]. Two dissimilar categories of elements are now processed in Aluminium matrix to create mixture lightweight structures [13]. The double strengthening components utilized in hybrid composites actually expand the physical properties while reducing the cost of composite [14]. Also demonstrate that it is being had to use in sophisticated technologies in particular area of traditional material properties [15]. MMC materials are manufactured using a variety of techniques, including PM and casting [16]. Because stir castingis manufactured at room temperature, no chemical reaction takes place in between matrix material and the strengthening element. Furthermore, substantial quantities of inorganic nanoparticles could be incorporated towards the matrix material [17], [18].

In this investigation is to fabricate the hybrid composites materials which might have developed the tribological behaviour by adding reinforcement materials such as ZrO_2, SiC and B_4C to aluminium 6061 matrix. In this investigation, Pure aluminium alloy 6061, single reinforcement (AA6061/ZrO_2), hybrid reinforced (AA6061/B_4C/ZrO_2/SiC) hybrid composite synthesised by using stir casting route. Aluminum matrix and reinforced alloys of wear behaviour in contradiction of the H13 tool steel interface area was analyzed. Non-reinforced Al6061 models were tested under relatively similar systems for comparison. The wear surface morphology was analyzed by using Scanning Electron Microscope (SEM) (Fig. 1).

Section snippets

Selection of materials

The chemical compositions of aluminum alloy (AA6061) were checked by using spark spectrometric analyzer and reinforcement material properties are (ZrO_2, SiC and B_4C) is shown in Table 1, Table 2 respectively. Because of its strong resistance to corrosion and acceptable degree of morphological qualities [19], [20] including machinability, fatigue resistance, and impact strength, this aluminum was chosen for its diverse uses in the transportation and aircraftindustries. Aluminium and B_4C was…

Density measurement

The porosity level was determined by based on the matrix and composites of density measurements. The Archimedes principles are contributed to calculate the observed density. According to the rule of mixture the theoretical density and porosity level for all samples measured by equation (1), (2), respectively.

Experimental density mathematical derivation can be expressed as follows $\rho_{Experimental} = \left[\frac{m_{air}}{m_{air} - m_{water}}\right] x \rho_{water}$

Where m_{air} and m_{water} represent the mass of the sample in air and water…

Consequences reinforcements on density of hybrid composites

Table 3 shows the illustration of comparison between experimental and theoretical densities. Different compounds of theoretical density and test density were calculated via rule of mixture and weight fractions ratio, respectively. This shows that the theoretical density is always higher than the test density due to the lack of casting. Nevertheless, as the SiC and ZrO_2 reinforcement increase, the concentration begins to increase. By the reason for increased density, addition of higher density…

Conclusion

The unreinforced Al6061 matrix and B_4C and ZrO_2/SiC strengthened hybrid composite were effectively made utilizing a stir casting technique in this work. The density, and wear characteristics of the manufactured materials were investigated. The following are the results of the research:

1. The experimental and theoretical density were estimated by using Archimedes principle and rule of mixtures respectively. It is obtained with maximum density by stir casting technique.…
2. The density pattern gradually…

…

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

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Investigations on mechanical properties of aluminium alloy Al6061 hybrid metal matrix composite

2022, Materials Today: Proceedings

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> ...Addition of more reinforcement in the molten metal will increase the viscosity which leads to the reduction of fluidity of the molten metal there for the addition of appropriate amount of reinforcement is an important consideration during the manufacturing of the MMC. The density of material will be improved by the addition of reinforcement [6,7] More than 4 % Addition of graphite micro powder with aluminium will leads to the reduction of surface hardness. Strength and hardness of the composite is increased with the addition of MoS2 reinforcement up to 4 % after that hardness and tensile strength has decreases....

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