Tribological Potential of Aluminum Alloy Reinforced with Graphite and Zinc Particles Preparation By Powder Metallurgy

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Abstract

In this paper we study microstructure and mechanical properties of Aluminum alloy as a matrix reinforced with graphite and zinc particles of weight ratio (5, 4 and 3)% graphite and (3 and 7)% zinc, the preparation technique was powder metallurgy. XRD, XRF, optical microscope and Pin-on-disc device used to results investigation. Results showed that the matrix composites wear resistance had been improved as a results of adding materials in compare to the base alloy. This addition had been made an increase in the solidity values and accordingly made improvement on the resistance wear. This improvement in the characteristic increased as there is increasing at the rate of adding. As far as the density properties is concerned the values decreased and hardness increased for the matrix composites in compare to the rate of base alloy with low rate.

Keywords: Aluminum matrix, hyper composite, graphite particles, zinc particles, bulk density and wear resistance.

الجهد الاحتكاكي لسبيكة الألمنيوم الموقاة بدقائق الكرافيت محضرة بطريقة خلط المساحيق

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المستخلص :

في هذا البحث تم دراسة الخواص التركيبية والميكانيكية لسبيكة الألمنيوم كمصفوفة مقواة بدقائق الكرافيت والخارصين بنسب وزنية (3,4,5)% للكرافيت و(3,7)% الخارصين ، التقنية التي استخدمت بالتحضير كانت خلط المساحيق. حيود الأشعة السينية، فلورة الأشعة السينية،المجهر الضوئي وجهاز النتوء فوق القرص استخدمت لتحقيق النتائج . النتائج إشارة إلى إن مقاومة البلي قد تحسنت عما هو علية في السبيكة الاساس بعد الإضافات . وهذه الإضافات حققت الاستقرار وحسنت في مقاومة أللبلي. هذه التحسينات كانت لكل النسب من الإضافات كذلك الكثافة الحجمية قد قلت والصلادة ازدادت بالمقارنة مع الكثافة الحجمية والصلادة للسبيكة الأساس.

الكلمات المفتاحية: مصفوفة الألمنيوم، متراكب هجين، دقائق كرافيت، دقائق قصدير، كثافة حجميه ومقاومة بلي

Introduction

The used of Aluminum Matrix composites has increasedin recent years, as an engineering materials application such as transport, marine, micro space system, airplanes and jet fighter, electronics industries, transportation, sensitive measurement tools and sport equipment [1]. Such application need vital characteristics in light to the high resistance ratio good wear resistance, high solidity, high solidarity, less density, stable in relation to the part in dimension when exposed to heat circumstances that have low density and enforcement particles at low cost [2,3]. Reinforced Aluminum with ceramic or metal particles lead to general new materials with improvement in the mechanical characteristic to the weight one of and solidity of and wear [4]. This has a great importance in many application e.g motors and bearings processes. One of methods to improve such characteristic is the proses of adding ceramic or metal materials. There are many scientific research that involved the addition process of ceramic or metal particles e.g (WC, Graphite, B_4C, SiC and Al_2O_3) [5]. But research on adding graphite are not quiet much, especially for Aluminum alloys and their effect on its wear characteristics. This is our main discussion in this paper. Most of matrix composites reinforced with particles are prepared by metallurgy method. This casting method is simple and cheap in compare with other methods [6]. It benefited the following, perfect to ground particles linkage, easy to control the mixture and quality as nearest to sample [7]. Many studies and researchers have been published in this field, (A. M. Hamouda et al,2007) studied tensile strength and solidity of reinforced Aluminum- Silicon alloy with different percentage of (SiO_2) of a granular size of (65) micron manufacture in plumbing mixing method, results showed that the hardness of the composites materials increase with increases of the added silicon particles (SiO_2),the tensile resistance of composite materials decrease with the increase of the added silica particles [8]. (JolHemanth, 2009) studied the mechanical characteristic wet wear cooling effect of molten silica as a reinforced materials and Aluminum alloy (A365) as a base materials size (50-100) micron with reinforced percentages of (2,6,9,12%), results showed tensile, hardness and wear resistance increase to the rate of addition of 9% [9]. Researchers (Madhu Kumar YC and Uma Shankar,2012) have studied mechanical properties of composites materials of (Al-6061) base which been added different percentages of silicon particles (SiO_2) of different granular size, these composite have been prepared by mixing plumbing, the researchers ended with the idea that increasing the addition percentage of reinforce particles would increase the tensile resistance of the composite materials to the additional percentage of 9%while the hardness increases to additional percentage of 12% [10].. Researcher (Hamid F. ,et al,2016) studied the micro structure, relative density, hardness and mechanical properties of Al/TiC/Gr, the results showed that the addition of TiC nanoparticles not only decreased the wear rate but also facilitate the formation of a stable composite[11].

The aim of this study is to discuss the wear characteristic, hardness, density and microstructure of the hyper composite from Al/Zn/graphite where Aluminum as matrix which it is preparation by mixing powder.

Experimental details:

Aluminum alloy was used as a matrix materials. Table (1) shows the chemical structure of the alloy which is analysis by used X –ray fluorescence device.

Table(1) chemical composition of Aluminum used by weight percentage.

Elements	Si	Mn	Fe	Ni	Zn	Mo	Sb	Mg	Pb	Other	Al
Wt%	0.2	0.5	0.1	0.2	0.1	0.3	0.3	1.2	0.1	traces	Balance

According to the classification of (ASTM) of the alloy a powder of zinc and graphite with granular size of (75) micron as a reinforcement was used. The composites materials had been prepared using the mixing powder method. These particles were mixed of (750 c/min) for 2 hours, then a piece of magnesium was added which in mixing to better wettability that consider as one of the important factor to ensure the better sticking between the matrix and the reinforced particles [12]. After the mixing process the samples were pressed with dia dimension (12) ml diameter and (16) height . All samples were prepared shown in table (2)

Table(2) clear the bases alloy and manufacture composites materials

No.	Composition at percentage%
1	Al pour
2	95%Al-5% Graphite
3	93%Al-4%Graphite-3%Zn
4	90%Al-3%Graphite-7%Zn

All samples were sintering in 420 ^{o}C under vacuum at rate temperature ^{o}C /mint in the heating and cooling where the samples stability at 420 ^{o}C for 2 hour. Then The grinding and polishing were made for all samples. After grinding and polishing all samples ready-made to testing.

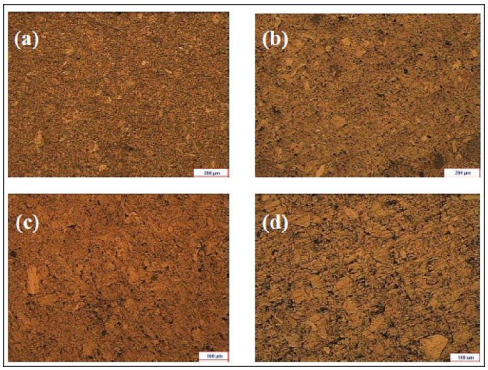
Mechanical and structure tests Wear test was by Pin-on-Disc device used (the sliding wear device) which was made locally to test the wear of the samples related. Hardness test was made for the (matrix alloy and composites materials) by using 2323 No. 1616511962). Density test was made by Archimedes theory where it calculated the samples density. The structure properties were made by used X-ray diffraction by using XRD 600, SHIMADZU,made in japan and the test of DEX was made by used XRF type SHIMADZU made in japan. The Microstructure test was made by using optical microscope attached to digital camera connected to computer type NIKON ECLIPES ME 600 made in japan.

Results and Discussion:

Figure (1) shows the optical micrograph of Al-Zn-Gr composites. The sample of aluminum pour presents in Figure(1. A) . Composite containing 0.15% graphite exhibits a homogenous microstructure; it was indicated from the distribution of graphite within aluminum as shown

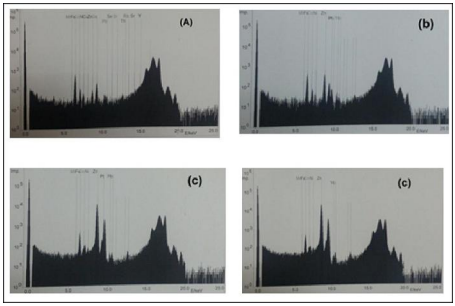
Fig. 1b.The graphite was not uniformly of distribution within aluminum because the agglomerates of graphite particles can be found in the microstructure as shown in Fig. 1c and Fig. 1d. But the agglomerates in Fig. 1b is clearly obvious compared with other samples this is due to high concentration of graphite in Fig. 1b.

Figure (2) showed the quantitate chemical analysis of micro consternate were made using energy dispersive spectrometer (EDX). The analysis showed the presence of elements like Al,Ni,Zn,Pb and also present Fe as a result of materials exchange from the partner to the composite block.

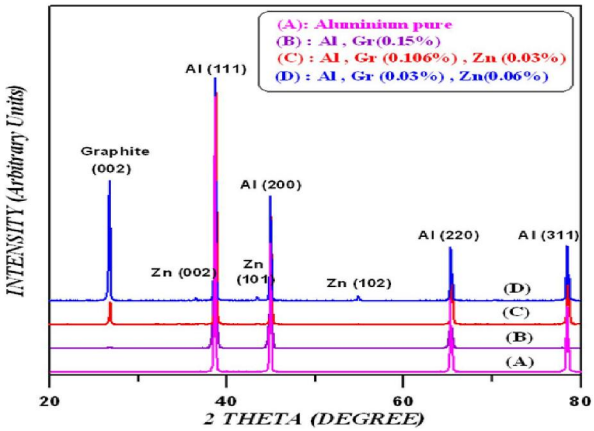


Figure(1)Optical micrographs of composites (a) pure Al, (b)95%Al-5%Gr, (c)93% Al-4%Gr-3%Zn and (d) 90%Al-3%Gr-7%Zn.

Figure (3) is represented the structure properties, it's showed the composite all samples multi-crystalline and the crystalline was appearing homogenized for all samples. Figure (1,A)shows did not appear any picks for zinc and graphite while figure(1,B,C,D) showed picks for zinc and graphite. This analysis refers to the accuracy of mixing of composites and absence of any effect of the impurities.



Figure(2) EDX analysis (A) Al pour,(b) 95%Al-5%Gr, (d) 93%Al-4%Ge-3%Zn,(c)90% Al-3%Gr-7%Zn.



Figure(3) XRD analysis for all samples.

Figure(4) shows the effect of reinforced graphite and zinc particles on the wear rate of Al alloy at gliding of (10) minute using aloud of (5,10 and 15) Newton respectively. In this figure we can notice that the wear rate wear rate value is decreased along with the increasing of addition percentage to the reinforced graphite and zinc particles. The reason for this, however, is related to the spread and distribution of zinc and graphite particles in a regular way that lead to increase the hardness of the composites material in compare to the matrix alloy. An increase in the wear rate of the composites materials and the matrix alloy when (15) Newton of load is used in compare to (10 and then 5) Newton. The reason for this increase is due to a separation of some particles of the composites materials. These separated (Debris) are the solid part which increase the wear of material. As a result, there would be an increase in the quantity of the separated particles. Again this increase is related to the friction and pressure increase with the disc device. These particles increase the wearof the sample surface. This is related to the role of zinc and graphite particles role in increasing hardness and strengthen the alloy base and reactions between these hard particles. And also due to the mobile delectations resulted from the plastic formation of the surface layers. The increase of wear rate along with the increase of load imposed happen as a result of increase in the plastic deformation at the spurs and nearby surface. Consequently delectations density increase with the increase of deformation. This would lead to raise cracks (minutes) on the metal surface. These crack meet with each other and with wear lines in parallel to the surface spacing. This cause removing parts of metal at the surface minutes layer of the metal. These parts removed easily towards the gliding forming wear debris. Thus there would be increase at wear rate. The reason is the high rate of magnesium in the Al matrix alloy, which in turn could from hard phases that agrees with the references[13].

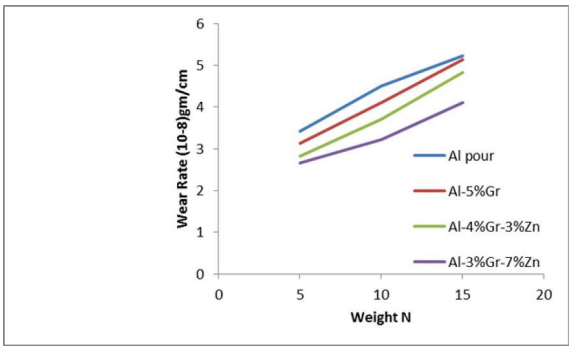
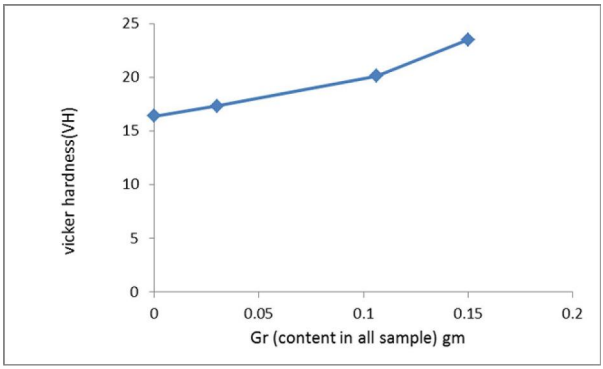


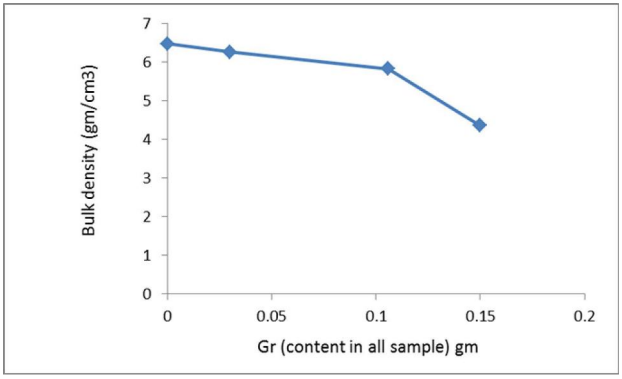
Figure (4) represented the relationship between weight, wear rate and content materials.

Figure (5) shows the relation between vickres hardness for Al alloy and the reinforced composites materials and the rate of added reinforced zinc and graphite particles. The results showed that the hardness increase when the addition reinforced particles in the composite increase. However, when we add reinforced zinc and graphite particles to the composite we would notice a reasonable increase in the hardness values. The reference [4] had proved these results. The reinforced zinc and graphite particles spreader in the base increase the composites material hardness.

Figure (6) shows the relation between the bulk density of matrix alloy and the add composites material on the one hand and the added zinc and graphite particles rate on the other hand. The value of density related to matrix alloy is decreasing gradually with low rate at the time of increasing of the added materials . The reason is that add materials is less In density the other matrix alloy. And that the magnesium added to the matrix alloy.



Figure(5) explain the Vickers hardness for all samples.



Figure(6) explain the related between bulk density and add materials content.

Conclusion:

From the results following conclusion were investigated on the mechanical properties of Al-Gr-Zn hyper composites

1- The wear rate decrease with the increase of add zinc and graphiteparticles.

2-The wear rate increases with the increases the load upon the matrix alloy and upon the composites materials when we have fixed gliding

Interval and gliding radius.

3-Hardness values increase with the increase of the added particles rate.

4-The bulk density values of the composites materials decrease in compare to the matrix alloy with the increases of the added rate of add materials.

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