Al-Nahrain Journal for Engineering Sciences (NJES) Vol.21 No.3, 2018 pp.389-392

Effect of SiC Powder Additive on Mechanical Properties of Al-Pb Alloy Produced by Mechanical Alloying

Suhair G. Hussein
Mechanical Eng.Dep.
University of Baghdad,
Baghdad, IRAQ
suhairaaffmm@yahoo.com

Adnan N. Abood
Technical Eng. College
Middle Technical University,
Baghdad, IRAQ
adnan_naama_59@yahoo.com

Nabeel Kadim Abdel Sahib
Al-Nahrain University,
Baghdad, IRAQ
n_k_alsahib@yahoo.com

Received: *28-Feb.-2018* ***Revised:*** *29-March-2018* ***Accepted:*** *30-April-2018*
http://doi.org/10.29194/NJES.21030389

Abstract

One of the major usages for Al–Pb alloy are bearing alloys because of its lubricant behavior of Pb phase component. Applications of these alloys are in heavy duty, such as boring mills, presses, lathes, milling machines and hydraulic pump bushings. In present work, SiC powder was selected as additive for improving the mechanical properties of Al-Pb alloy that produced by mechanical alloying method. The percentage weight of SiC powder are (2.5, 5,10, 15 %) which mixing together with Al- Pb alloy for two hours in ball milling device, then compacted and sintering to obtain the improved alloy, and examine the mechanical properties (compressive strength and microhardness) of produced alloy . Results show that the additive of SiC powder on the Al-Pb alloy lead to improve the microhardness which increased with increased the percentage of additive, in the other hand , the compressive strength had a reverse effective with increased the percentage of SiC powder.

Keywords: Al-Pb alloy, Mechanical Alloying, SiC Powder, Mechanical Properties.

1 Introduction

Aluminum –lead alloys are considered as bearing materials of 21st century[1].One of the major usages for Al–Pb alloy are bearing alloys because of its lubricant behavior of Pb phase component. In general, homogeneous and disperse distribution of fine lubrication phase in Aluminum matrix is important for wear properties [2]. Al-Pb bearing alloy have been used in automobile industry , and the improving of mechanical properties of this alloy such as the strength and wear properties was done by adding some alloying element such as copper and magnesium . But because of the different in specific gravity and immiscibility between Al and Pb [3] , which greatly increase the kinetic of lead segregation during melting and freezing [4] , this lead to difficult manufacturing of this type of alloys [3]. There are different methods (rapid solidification , stir cast , rheo cast , powder metallurgy , and hot extrusion) may be used to improve microstructure homogeneity and to get finer size of Pb phase in Al – Pb alloys because the homogeneous distribution of Lead in Aluminum matrix could not be easily obtained by traditional casting processes [5].

Mechanical alloying is one of the efficient methods when it compared with the previous methods because it dependent on the mechanical forces such as compressive force, shear or impact to effect particle size reduction of bulk materials. This is sometimes referred to as mechanical alloying or ball milling which is one of the mechanical alloying method had been used since 1970 to produce successfully new alloys bond on powder particles as a method for material synthesis [6]. Aluminum and its alloys are widely used in the fabrication of MMCs and have reached the industrial production stage. The emphasis has been given on developing affordable Al-based MMCs with various hard and soft reinforcements (SiC, Al2O3, zircon, graphite, and mica) because of the likely possibilities of these combinations in forming highly desirable composites [7]. P.Kumar, et al ,in 2015 , add SiC as a persentage (5% 10% 15% and 20%) by weight to aluminum alloy. Hardness and compressive strength are increased as the percentage addition of SiC increased [8]. B.Venkatesh1, B.Harish2 in 2015 get increasing in hardness of pure aluminum when adding SiC particles as10% and 15% by weight. The increasing in hardness is related to increase in SiC percentage added [9]. Ramesh B. T , et al in 2015 studied the effect of SiC addition to Al 6061 alloy. Different weight percentages (5%, 10%, and 15%) of SiC were added. The results showed that an increasing in hardness and decreasing in wear rate directly proportional to the added percentage of SiC [10]. S.E. Ede1 , et al in 2015 studied the effect of adding (SiC) in Nano particle size as a reinforcement to the produced product of AA2618 alloy. (SiC) was added as 5%, 10%, 15%, 20%, 25% and 30%, as weight to the route of casting . It showed an increase in hardness, yield strength, Young modulus ,density and tensile strength with increasing the addition of SiC. While it showed a decreasing in ductility with increasing the addition of SiC. It was observed that the addition of SiC has a limit

called critical limit. Exceeding this limit gave reverse results due to bulk formation of SiC [11]. G. Hemath Kumar, et al , in 2010 showed that the addition of SiC IN 5% to 30% of weight percentages to aluminum as base metal increasing the hardness in direct proportion with increasing SiC additive [12]. Dr. Jameel Habeeb Ghazi in 2013 investigated the effect of adding SiC to Al-Si alloy . The addition of SiC was 7%, 14% and 21% as weight percentage to the molting of the casting. Improving the mechanical properties has been obtained due to this addition represented by increasing the hardness , yield and tensile strength [13]. The aim of present study is enhancing the mechanical properties of Al-Pb alloy by adding SiC particles with various weight percentages.

2 Experimental Work

Three types of metals Al, Pb, and Cu with different particle size were used. Table 1shows the average particle size and purity of powders. These metals were mixed together with specific weight percentage (85.5%Al, 10% Pb and 4.5% Cu).

Table (1): Particle size and purity of powders

Element	Average particle size (um)	Purity (%)
Aluminum (Al)	20	99.90
Copper (Cu)	25	99.89
Lead (Pb)	95	99.86

Powder mixture were mixed in a stainless steel vial used hardened steel balls in a ratio of powder to steel ball (p/b)equal to (1/10) milled in a planetary mill with rotation speed 250 rpm with protective Argon atmosphere for two hours. The powder produced by milling was compacted by a hydraulic press 400 MPa to produce billets with rectangular cross section ($15\times15mm^2$). The billets were sintered at 450˚C with soaking time 30 minutes in a tube furnace with Argon protective (2 L /minute flow rate). The produced billets were assessment by compression strength and Vickers micro hardness test and the results were recorded.

SiC powder with average grain size (3µm) and purity of (97.9%) were selected to add to Al-Pb alloy because of that it considered the best additive to create better mechanical properties. Dependent on the previous researchers, the micro SiC was added to the starting powder at various percentage of weight (2.5, 5, 10, and 15%) respectively. The mixture was mechanically alloyed by ball milling with the same condition used and the produced powder was compacting and sintering at the same previous values. The produced alloys were assessment by the same type of tests used, and then the results obtained were compared with the results obtained before additive.

3 Result and Discussin

Fig.1 and 2 show the SEM and EDX respectively of SiC powder that added to constitutes for improving the mechanical properties.

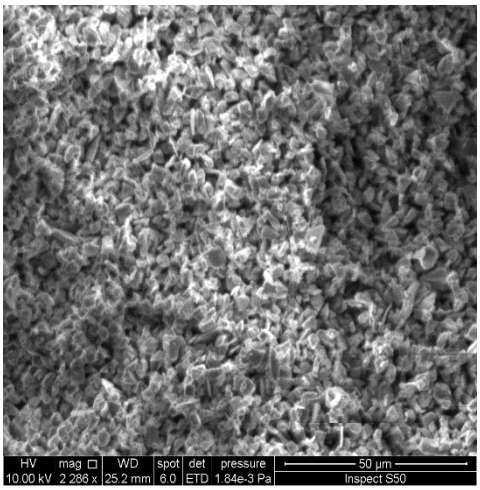

Figure 1: SEM of SiC powder

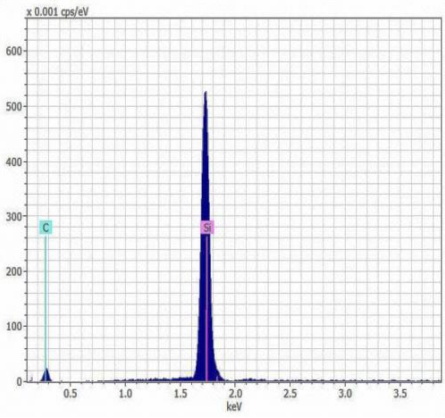

Figure 2: EDX of SiC powder

The particles of SiC powder have rectangular like shape as seen in figure 1, EDX of SiC powder indicate that high purity powder as shown in figure 2. SEM of produced alloy after mechanical alloying, compacting and sintering is shown in figure3, and from this figure it can be see the distribution of SiC particles through base matrix. The results of billets produced from mechanical alloying before adding the SiC powder were recorded in table 2. The results after additive the SiC powder showed that the micro hardness increased with increasing the percentage of addition as shown in Fig.4, and the maximum addition of SiC powder indicate 72 HV, that

is mean the percentage of improvement of micro hardness is 44% approximately.

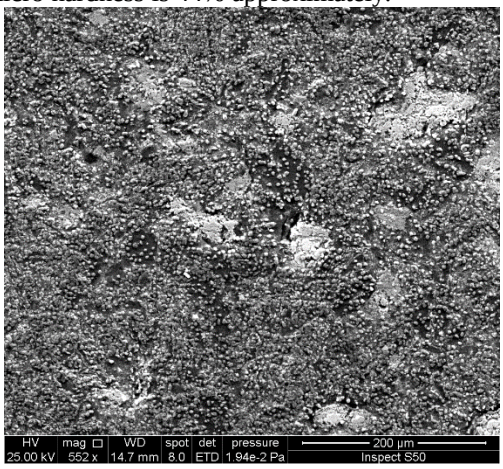

Figure3: SEM for alloy at 15 % SiC powder

Table (2): Mechanical properties of Al-Pb alloy before additive

Property	Average Hardness (HV)	Ultimate Compression strength (MPa)	Ductility %
Before additive	50	191	12.5

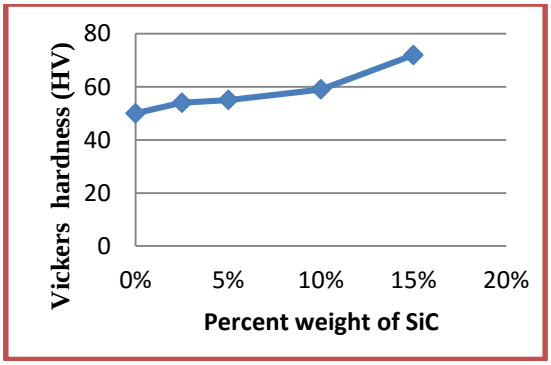

Figure 4: Micro hardness verses percentage weight of SiC powder

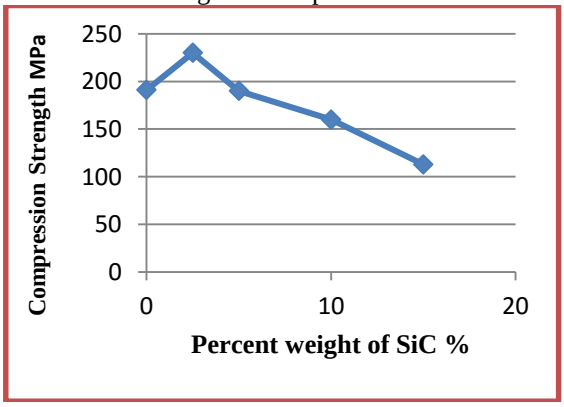

Figure 5: Compressive strength verses percentage weight of SiC powder

This raising of hardness due to hard ceramic particles of additives which led to higher hardness in produced alloy. This confirm to results of **P. Kumar, et al. [8] and B. Venkatesh, et al. [9]**. The results of compression strength for produced alloy is showed that the increasing of percentage of SiC powder associating with lowering down in compression strength except the percentage of 2.5% which has increasing in compression strength about 20% as shown in figure5 . This is due to the particle shape of SiC powder was not spherical or rounded as shown in figure1and the particles have sharp edges. These sharp edges which caused stress concentration, leading to reduce the strength with increased the percentage weight of SiC powder. This results nearby **T. A. Khalifa [14]** who used SiC powder as reinforced of AA6063 aluminum alloy.

Also, ductility of alloy after additives decreased with raising of ceramics additives as shown in figure 6 due to increasing of hardness.

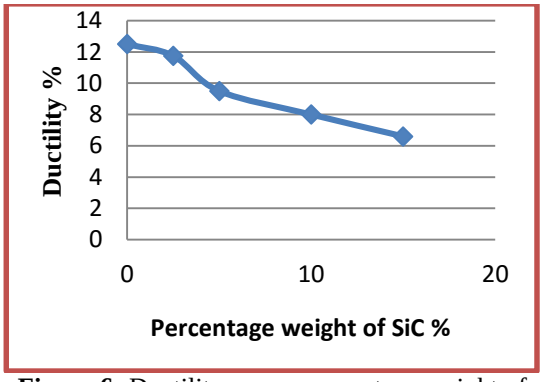

Figure 6: Ductility verses percentage weight of SiC powder

4 Conclusions

- Mechanical alloying is considered as an attractive method used to produce Al-Pb alloy.
- Addition of SiC powder in different percentages raised the micro hardness, the maximum additive led to 44% enhancement.
- In the other hand the increasing of additive of SiC powder had a bad effect on compression strength except for small quantities such as 2.5% which led to increase the compression strength about 20% , so there is recommended to use this percentage weight of SiC powder which is considered as the best percentage of additive that is combination enhancement for the compression strength and micro hardness
- Ductility is lowering down for all percentage of additives.

References

[1] Pathak J. P., "Proceeding of 2ed International conference of Industrial Tribology, Hyderabad, India, Dec1-4 1999, pp.535-537.
[2] M. Zhu∗, M.Q. Zeng, Y. Gao, L.Z. Ouyang, B.L. Li "Microstructure and wear properties of Al–Pb–Cu alloys prepared by mechanical alloying", Elsevier Science-Wear, Vol. 253, 2002, pp.832–838.
[3] Ch V S H S R Sastry and G Ranga Janardahana, "Densification behavior of Al-Pb alloys- A study of effect of Certain Process Parameters", Indian Journal of Engineering & Materials Sciences. Vol.17, 2010, pp.56-60.
[4] Voind Kumar, Albert Yanthan, P. R. Soni and T. V. Rajan "Wear Resistance of Leaded Aluminum Alloy Prepared by Mechanical Alloying", Indian Journal of Engineering & Materials Sciences. Vol.10, 2003, pp.413- 415.
[5] Hayder Ali Hussein and Adnan N. Abood" The Role of Nano Particles Additives on the wear Properties of Al- Pb alloy" Chemistry and Materials Research , Vol.7(7) 2015, pp.86-104.
[6] K. V. Nagesha, Rajanish M. and D. Shivappa, " A Review On Mechanical Alloying", International Journal of Engineering Research and Applications (IJERA), Vol. 3(3)2013, pp.921-924.
[7] Dunia Abdul Saheb, "Aluminum Silicon Carbide and Aluminum Graphite Particulate Composite", ARPN Journal of Engineering and Applied Sciences, Vol. 6(10)2011, pp.41-46.
[8] P. Kumar, S. Ranjithkumar, C. Shanmugam, M. Jayaram, Vijayakumar. S and V. Karthik, "Experimental Investigation of Aluminum Silicon Carbide Composites by Powder Metallurgy Technique", International Journal of Innovative Research in Technology, Vol. 1 (12) 2015. pp. 527-536.
[9] B. Venkatesh and B. Harish, "Mechanical Properties of Metal Matrix Composite (Al/SiCp) Particles Produced by Powder Metallurgy" , International Journal of Engineering Research and General Science Vol. 3(1) 2015, pp.1277-1284.
[10] Ramesh B. T., Arun Kumar M. B. and R. P. Swamy, "Dry Sliding Wear Test Conducted On Pin-On-Disk Testing Setup For Al6061-SiC Metal Matrix Composites Fabricated by Powder Metallurgy, IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 2(6), 2015, pp. 264-270.
[11] S. E. Ede, J. U. Odo, I. D. Adiele, J. N. Ani, C.W. Onyia and B. A. Okorie, " Effects of Silicon Carbide (SIC) Nano Particulates Addition on Mechanical Properties of Aa2618 Alloy" International Journal of Scientific and Research Publications, Vol. 5, Issue 4, 2015, pp.1-6.
[12] G. Hemath Kumar, B. R. Ramesh Bapu, R. Sagar and H. Mohit, "The Abrasive Wear Behaviour of Al-SiCp Composites for Automotive Parts", IEEE , Vol.978, 2010, pp.54-59.
[13] Jameel Habeeb Ghazi, "Production and Properties of Silicon Carbide Particles Reinforced Aluminum Alloy Composites" International Journal of Mining, Metallurgy & Mechanical Engineering (IJMMME) Vol. 1, Issue 3, 2013, pp.191-194.
[14] Tarek A. Khalifa, Tamer S. Mahmoud "Elevated Temperature Mechanical Properties of Al Alloy AA6063/SiCp MMCs", WCE, Vol.II, 2009, PP. 1 – 3.

تأثير اضافة مسحوق كاربيد السليكون على الخواص الميكانيكية لسبيكة المنيوم – رصاص محضرة بطريقة الخلط الميكانيكي

سهير غازي حسين
قسم الهندسة الميكانيكية
جامعة بغداد

عدنان نعمة عبود
الكلية التقنية /بغداد
الجامعة التقنية الوسطى

أ.د. نبيل كاظم عبد الصاحب
كلية الهندسة
جامعة النهرين

الخلاصة
ان الاستخدام الرئيسي لسبيكة المنيوم – رصاص هو في سبائك المحامل بسبب سلوك الرصاص كعامل مزيت للسبيكة. ان التطبيقات العملية لهذا النوع من السبائك عادة ماتراها في ا لمكائن الثقيلة مثل مكائن التفريز والمكابس وبطانات المضخات الهيدروليكية . في هذا البحث تم اختيار مسحوق كاربيد السليكون كدقائق مضافة للسبيكة لتحسين خواصها الميكانيكية وتتم اضافة المسحوق لمكونات السبيكة الاصلية وخلطها بواسطة عملية الخلط الميكانيكي . النسب الوزنية لمسحوق كاربيد السليكون كانت (2.5 ، 5 ، 10، 15 %) حيث تمت عملية الخلط الميكانيكي على مدى ساعتين بعدها تم كبس المسحوق الناتج ثم الانتقال لمرحلة التحميص في الفرن للحصول على السبيكة الجديدة . تم فحص الخواص الميكانيكية متضمنة فحص صلادة فيكرز وفحص مقاومة الانضغاط للسبيكة المنتجة . اظهرت النتائج ان اضافة مسحوق كاربيد السليكون لسبيكة المنيوم – رصاص يؤدي الى زيادة وتحسين في خاصية الصلادة حيث تزداد بزيادة نسبة الاضافة ، اما من ناحية مقاومة الانضغاط فأن تأثرها كان سلبيا مع مع زيادة نسبة مسحوق كاربيد السليكون .