Title	Environmental Benign Brass Alloys Dispersed with Graphite Particles Fabricated Via Solid-State Sintering Process
Author(s)	Kondoh, Katsuyoshi; Imai, Hisashi; Umeda, Junko et al.
Citation	Transactions of JWRI. 2008, 37(2), p. 87-89
Version Type	VoR
URL	https://doi.org/10.18910/12842
rights	
Note	

Environmental Benign Brass Alloys Dispersed with Graphite Particles Fabricated Via Solid-State Sintering Process†

KONDOH Katsuyoshi*, IMAI Hisashi**, UMEDA Junko**, KOSAKA Yoshiharu***, and KOJIMA Akimichi***

Abstract

Sintered Cu-40mass%Zn (brass) alloys with a high tensile strength and excellent machinability have been developed via a powder metallurgy (P/M) process. They are environmentally benign because fine graphite particles are included instead of lead (Pb) to improve their machinability. The effect of the content and particle size of the graphite on the mechanical properties and machinability are investigated in this paper. When applying a conventional P/M process consisting of the cold compaction and hot extrusion to consolidate elementally pre-mixed mixture of Cu-40mass%Zn and graphite powder, the addition of 1 mass% graphite particles with 5~10 μm in diameter is suitable to obtain a high tensile strength and good machinability at the same time

KEY WORDS: (Brass) (powder metallurgy) (sintering) (sintering) (hot extrusion) (machinability)

1. Introduction

Cu-40mass%Zn (brass) alloys have a good balance of strength and ductility at room temperature, non-magnetic properties, excellent malleability and machinability, which are strongly required in fabricating industrial components. It also shows a superior corrosion resistance in neutral and acidified NaCl solution [1)]. It is well known that lead (Pb) is one of the hazardous materials and should be reduced in the use of products. It is, however, necessary to add 1~4 mass% of Pb for the improvement of the machinability of Cu-40mass%Zn alloys used for the water supply parts and electrical products. From a viewpoint of the environmentally benign issues, Pb-free brass alloys with a good machinability should be developed. It is also well known that graphite particles are environmentally benign and not expensive materials. The addition of them to the metals can reduce and stabilize the friction coefficient under dry sliding condition. Previous works reported the use of the graphite particles instead of Pb as the additives into brass alloys was investigated in the conventional casting process [2-5)]. It was difficult to uniformly disperse them in the matrix of a cast brass billet because the large difference of the specific gravity between the graphite and brass alloy causes the floatation of the graphite particles in the molten brass alloy and their segregation in the cast billet [5)]. In this study, P/M process is employed to prepare brass alloys uniformly dispersed graphite particles because there is very limited effect of the large difference of the specific gravity on the segregation of the graphite particles in the elemental mixture powder. The effect of the particle size and content of the added graphite particles on the mechanical properties and machinability of P/M extruded Cu-40mass%Zn-graphite composites is investigated.

2. Experimental

Water-atomized Cu-40mass%Zn alloy powders without Pb, Bi and Cd, having a mean particle size of 245 μm, were used as the raw materials. It was useful to prepare metallic powder with refined microstructures, which would improve the mechanical properties [6)]. Graphite powders with a mean particle size of 5 μm, 15 μm, and 50 μm were employed as the additives. The maximum content of graphite particles in the elemental mixture of brass and graphite powder was 1.2 mass%. After ball-milling the mixture for 3.6 ks, each one was compacted at room temperature by the 2000kN hydraulic press machine. The green compact was heated at 1033 K for 2.4 ks in nitrogen gas atmosphere and immediately hot extruded as rod materials with 10mm in diameter. The short heating time of 2.4 ks is applied in hot extrusion because Zn vaporization easily occurs during heating and the composition at the surface of the green compact changes. Optical microstructure observation and tensile tests of each extruded brass alloy were carried out.

† Received on December 26, 2008

* Professor
** Specially Appointed Researcher
*** San-etsu Metal Co. Ltd.

Transactions of JWRI is published by Joining and Welding Research Institute, Osaka University, Ibaraki, Osaka 567-0047, Japan

Concerning the machinability evaluation, the comparison of the machining time to drill a 4.5mm diameter hole with 5mm depth in each material by applying 9.8N load was evaluated. After 10 drilling tests, the mean machining time is used as a machinability parameter of each brass alloy in this study.

3. Results

Figure 1 shows optical microstructure of P/M extruded brass alloys with various contents of graphite particles, compared with the extruded Cu-40mass%Zn cast alloy. Even when containing 1.2mass% of graphite particles, they are uniformly dispersed in the matrix and no segregation of them is observed. The mean grain size of P/M materials is 8~10 μm, which is finer than that of the extruded brass cast alloy with a mean grain size of 18 μm. This is because the refined microstructures by the rapid solidification during the atomization are maintained in the extruded materials.

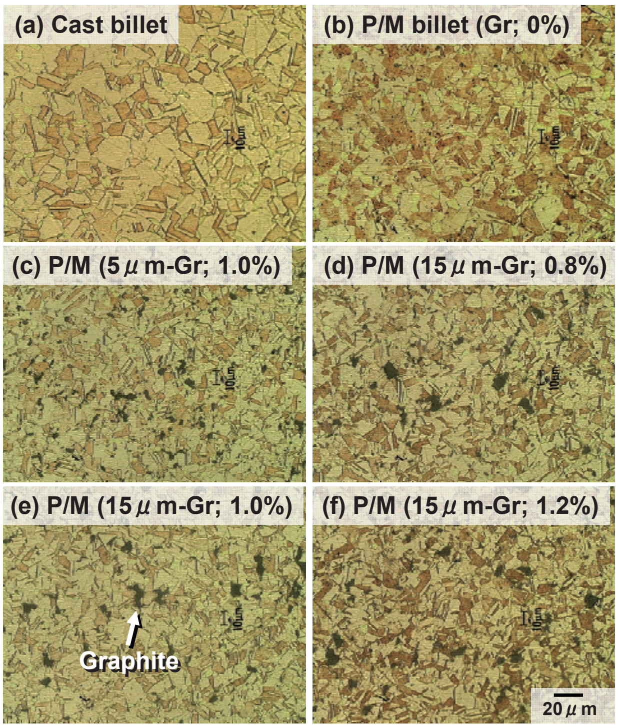

Fig.1 Optical microstructures of hot extruded Cu-40%Zn alloys by using cast billet (a) and P/M billets with various contents of graphite particles (b)~(f). (unit; mass%)

Figure 2 indicates a dependence of the tensile test results on the content of the graphite particles. In the case of 0mass% graphite content, P/M brass alloy shows a superior tensile strength to extruded brass cast alloy due to its fine grains as mentioned in Fig.1. There is no remarkable decrease of tensile strength when adding 1.2mass% graphite. However, its elongation gradually decreases with increasing the graphite content because a poor ductility of graphite particulates causes the decrease of the elongation of the composite. **Figure 3** shows a fractured surface of the tensile test specimen containing 0.5mass% graphite particles with 5 μm. Small and uniform dimple patterns are observed at the brass matrix. It means a good bonding between the primary brass alloy powders by hot extrusion and results in high tensile strength. However, a poor bonding between the graphite particle and primary brass powder also causes the decrease of the ductility of the P/M materials.

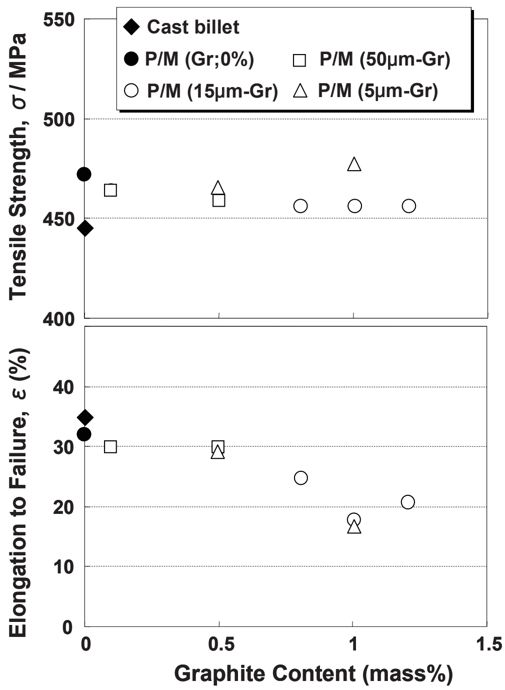

Fig.2 Tensile property dependence on graphite particle content of P/M extruded Cu-40%Zn alloys; (a) Tensile strength and (b) elongation to failure.

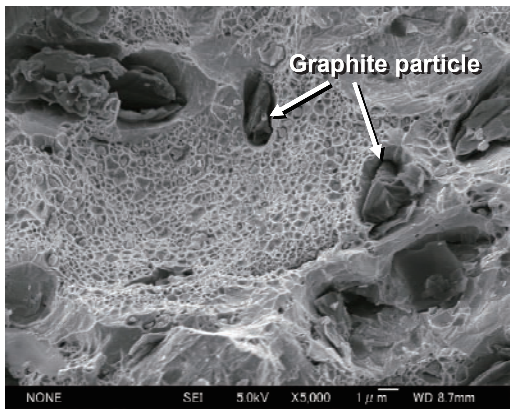

Fig.3 SEM observation on fractured surface of tensile test specimen of P/M extrude brass alloy with 0.5 mass% graphite size of 5 μm in diameter.

Figure 4 shows a dependence of the machining time in the machinability test by drilling holes on the graphite particle content of P/M brass alloys. The performance of the conventional brass alloy containing Pb is shown as a broken line. In the case of 0.1mass% graphite contained in the P/M brass, it was impossible to drill a hole in the specimen demonstrating a very poor machinability. The machining time proportionally decreases with increase in the graphite content. When containing 1.2mass% graphite particles, the machining time is almost same as that of the brass with Pb alloy. Accordingly, the addition of graphite particles is effective to improve the machinability of P/M brass alloys. However, their elongation is smaller than that of a conventional brass alloy containing Pb.

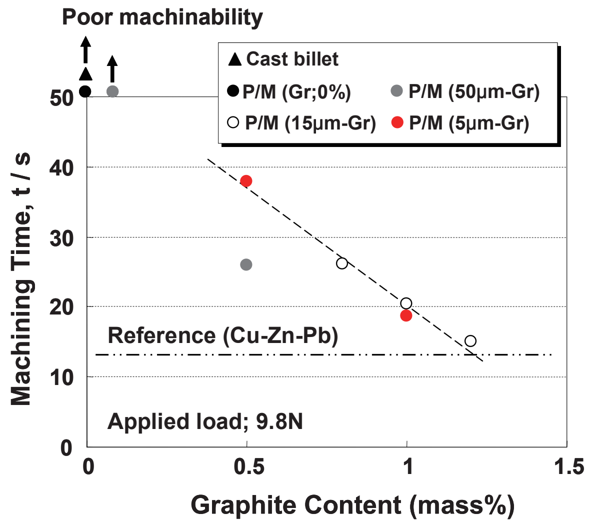

Fig.4 Dependence of the machining time in drilling hole test on graphite particle content of P/M brass alloys, compared with Cu-40mass%Zn-3mass%Pb alloy.

4. Conclusion

A powder metallurgy process is available to prepare extruded Cu-40mass%Zn brass alloys uniformly dispersed fine graphite particles. The increase of the graphite particle content causes the decrease of a ductility of the wrought alloy while the tensile strength is higher than the conventional brass alloy prepared via ingot metallurgy process. The machinability strongly depends on the graphite content and about 1mass% content is enough to serve the same machinability to P/M brass alloy as the conventional brass alloy containing lead.

References

1) S. Kumar, S. Narayanan, A. Manimaran and M. S. Kumar, Effect of lead content on the dezincification behaviour of leaded brass in neutral and acidified 3.5mass% NaCl solution, Materials Chemistry and Physics, 106 (2007) pp.134-141.
2) P.K.Rohatgi, S. Ray, D. Nath and N. Church, Lead-free Machinable Copper Alloy Castings Containing Graphite, AFS Transactions, 100 (1992) pp.1-9.
3) A. Saigal and P.K. Rohatgi, Machinability of Cast Lead-Free Yellow Brass Containing Graphite Particles, AFS Transactions, (1996) pp.225-228.
4) P.K. Rohatgi, J. Kim, J. Sobczak, N. Sobczak, Casting of copper alloys containing dispersed graphite particles in rotating moulds, Foundryman, 91 (1998) pp.167-170.
5) T. Kobayashi, T. Maruyama, K. Nakao, Y. Murakami, Structure and machinability on hot extrusion material of Pb free Cu-Zn system alloy which dispersed fine graphite particles, Journal of the JRICu, 42 (2003) pp.223-228.
6) O.D. Neikov, Yu.V. Milman, A.I. Sirko, A.V. Sameljuk, A.V. Krajnikov, Elevated temperature aluminum alloys produced by water atomization, Materials Science and Engineering A, 477 (2008) pp.80-85.