Heat treatment effect on metal matrix composite with brass matrix and fly ash

Aminnudin Aminnudin^{1,}, Moch. Agus Choiron²*

¹Mechanical Engineering Department, Universitas Negeri Malang, 65145 Malang, Indonesia

²Mechanical Engineering Department, Brawijaya University, 65145 Malang, Indonesia

Abstract. Metal matrix composite (MMC) is a combination of two or more materials using metal as a matrix. In this paper we used brass as the matrix and fly ash as for the particle. The fly ash used is fly ash which is produced from coal combustion in the Paiton power plant. Fly ash composition in the MMC are 5% and 10%. The MMC was produced with gas furnace. Heat treatment to MMC was done at 350 and 400 °C. Hard testing process, tensile test and impact test are carried out at MMC before heat treatment and after heat treatment. From the test results showed an increase in hardness, tensile strength and impact test showed the heat treatment process at a temperature of 350 °C. Heat treatment at a temperature of 400 °C does not improve the mechanical properties of MMC

1 Introduction

Composite is material consists of two or more different phases or materials [1] [2]. One material used as a matrix while the others material as a reinforcement. The materials for the matrix are metals[3][4][5][6], ceramics [7] and polymers [8] [9].

Metal composite matrix (MMC) is a composite that uses metal as a matrix. MMC is a combination of two or more materials have a combination of mechanical properties between these phase/materials[1]. Metals has lower strength than the reinforced material but the metal has ductility higher than the reinforced material. This combination make the MMC has ductility but has higher strength than the matrix (metals)[10].

The mechanical properties of the MMC are affected by matrices types (metal types)[11][12][13], reinforcing particles and bonds between the matrix and the reinforcing particles[14][15]. Generally, high strength metals resulting high strength MMC, but these depend on the properties of particles and bonds between the matrix and the particle.

Mechanical properties of MMC can be modified by heat treatment[16]. Heat treatment on metal will change the microstructure and mechanical properties, the Heat treatment can increasing or decrease the mechanical properties of metals, depend on the purpose of the

* Corresponding author: aminnudin.ft@um.ac.id

heat treatment. On MMC the heat treatment intended to increasing the mechanical properties of MMC[17].

In this research, research on the effect of temperature and holding time for mechanical properties of brass MMC

2 Material and Methodes

The Metal used for matrix in this MMC research is technical brass, the brass composition was:

Table 1. Brass Composition

Material	QTY (%)
Aluminium (Al)	0,8
Silicone (Si)	0,39
Phosphore (P)	0,1
Calcium (Ca)	0,11
Scandium (Sc)	0,081
crom (Cr)	0,046
Manganese (Mn)	0,045
Ferro (Fe)	0,707
Nickel (Ni)	0,61
Cuprum(Cu)	48,73
Zinc (Zn)	26,0
As	0,47
Nb	20
Tin (Sn)	1,3

The reinforcing particles used are coal burning ash residue. Fly ash is obtained from PLTU Paiton, Probolinggo – Jawa timur. The composition of the fly ash is as follows

Table 2. Fly Ash Composition

Material	qty (%)
Magnésium (Mg)	3,0
Aluminium (Al)	9,8
Silicone (Si)	21,6
Kalium (K)	1,79
Calcium (Ca)	27,4
Titanium (Ti)	1,24
Vanadium (V)	0,049
Croom (Cr)	0,075
Mangananese (Mn)	0,32
Ferro (Fe)	30,8
Nickel (Ni)	0,04
Cumprum (Cu)	0,057
Zinc (Zn)	0,04
Sr	0,3
Molybdenum (Mo)	2,1
Baryum (Ba)	0,57
Eu	0,2
Yb	0,05
Re	0,3
(Hg)	0,2

The casting process was done by using furnace with LPG fuel and without protective gas. Th fly ash added to the furnace when the brass molten, after added of fly ash the mixture of them mixed using mechanical stirrer. The stirrer has rotation speed 500 rpm. The liguid metal (MMC) pouring the mold at temperatur 1100 °C (Figure 1). The mould used for this research are made from low carbon steel. The result of MMC casting can be seen in figure 2.

Fig. 1. MMC Pouring in the Metal Mold

Fig. 2. MMC from Casting Process

After the MMC molding process is cut with a length of 10 mm, while the width and height according to the metal mold used. After the hardness was measured using the Rockwell-B method with a 10 kgf minor load and a major load of 100 kgs and a duration of 15 seconds indentation.

Fig. 3. Hardness Test Sample

The tensile test process is performed using ASTM-E-8 standards. The size of the test specimens can be seen figure 3.

Fig. 4. Tensile Test Standard

The standard size of tensile test is:

- G (length) : 25.54 mm
- D (diameter) : 6.35 mm
- R (radius) : 4.76mm
- A : 31.75 mm

Fig. 5. Tensile Test speciment after Tensile Test

The Impack test was done with ASTM E23 - 16b standart.

The heat treatment process was done by using electric resistance furnace, this furnace nit using protective gas. MMC was heated at 350, 400 and 450 °C while the holding time was 30 minutes and followed by quench with water.

3 Result and Discussion

The hardness testing result for the MMC can be seen in Figure 5. The hardness of MMC higher than the brass, the highest harness of MMC is happen in MMC with fly ash 5%, at MMC with 10% fly ash the hardness slightly decrease.

Fig. 6. Hardness of MMC

Data of tensile test on MMC with brass matrix can be seen in figure 6. The sensile strength of MMC with 5% fly ash is highest compare with the brass and MMC with 10% fly ash.

Fig. 7. Tensile Strength of MMC

Fig. 8. Elongation of MMC

The elongation of MMC as in its tensile strength increased in MMC with fly ash by 5% and 10%. The increase of elongation at fly ash 5 and 10% is caused by flow (flow) on the matrix, whereas in MMC with levels of 15 and 20%

Fig. 9. MMC Impact Energy

Heat treatment of MMC increases tensile strength, highest tensile strength increase at 350 C heating. Higher heating of mechanical properties is still inferior to brass without the addition of fly ash, therefore in subsequent processes no testing is done.

Heat treatment on improving the ductility of MMC especially at fly ash 5 and 10%. The ductility of MMC heat treated at 400 °C is equal to untreated MMC.

Fig. 10. Effect of Heat Treatment to Hardness of MMC

The impact test is performed to determine the toughness of a material. The results impact test of MMC test are can be shown in figure 10:

Fig. 11. Effect of Fly Ash to impact energy

Material toughness is the ability of materials to absorb energy before the material is broken. Material has high impact energy steel has tough properties, the MMC with fly ash 5 % has highest impact energy compare to brass and MMC with 10% fly ash. The increasing

impact energy caused by combination of high tensile strength and ductility of materials. The combination of these two properties causes the material to be more tougher.

Fig. 12. Effect Heat treatment to Impact Energy

Heat treatment at 350 °C increasing the impact energy of MMC. The increasing of impact energy caused by increasing of hardness and elongation of MMC. The increasing of hardness and elongation of MMC caused by microstructure change[18]. The Effect of heat treatment of MMC matrix brass and fly ash to microstructure must be investigated in the future research.

4 Conclusion

Heat treatment process to MMC at 350 increasing hardness, tensile strength and Impact strength. Heat treatment at 400 C not affected to mechanical properties of MMC.

References

1. W. D. Callister, D. G. Rethisch, W. D. J. Callister, D. G. Rethwisch, W. D. Callister, Jr., and D. G. Rethisch, 7th ed. Danver: John Wiley and Sons, **94** (2007)
2. J. Mussig and K. H. AG, O. Faruk and M. Sain, Eds. Elsevier Ltd, pp. 35–85 (2014)
3. J. Bas, G. Beltran, and G. Fontaine, Evolution (N. Y.), **173**, pp. 239–242, (1993)
4. Z. Wang, S. Scudino, M. Stoica, W. Zhang, and J. Eckert, J. Alloys Compd., **651**, pp. 170–175, (2015)
5. D. Cikara, M. Rakin, and A. Todric, FME Trans., **7**, pp. 151–155 (2009)
6. S. Boshnakova, I. Markovska, and D. Rusev, no. i, pp. 14–18 (2015)
7. X. Chen, I. J. Beyerlein, and L. C. Brinson, J. Mech. Phys. Solids, **59** (9), pp. 1938–1952 (2011)
8. S. Ashworth, J. Rongong, P. Wilson, and J. Meredith, Compos. Part B Eng., **105**, pp. 60–66 (2016)
9. R. A. Braga and P. A. A. Magalhaes, Mater. Sci. Eng. C, vol. 56, pp. 269–273, 2015.
10. K. Daneshjou and M. Ahmadi, Trans. Can. Soc. Mech. Eng., **30** (3) pp. 321–327 (2006)
11. J. Goni, P. Egizabal, J. Coletto, I. Mitxelena, I. Leunda, and J. R. Guridi, Mater. Sci. Technol., **19** (7), pp. 931–934 (2003)
12. B. AlMangour, D. Grzesiak, and J. M. Yang, J. Alloys Compd., **706**, pp. 409–418 (2017)
13. S. Cho, I. Jo, H. Kim, H. T. Kwon, S. K. Lee, and S. B. Lee, Appl. Surf. Sci., **415**, pp. 155–160 (2017)

14. K. M. Shorowordi, T. Laoui, A. S. M. A. Haseeb, J. P. Celis, and L. Froyen, *J. Mater. Process. Technol.*, **142** (3), pp. 738–743 (2003)
15. S. E. Hernández-martínez, J. J. Cruz-rivera, C. G. Garay-reyes, and C. G. Elias-alfaro, *Powder Technol.*, **284**, pp. 40–46 (2015)
16. R. Dong, W. Yang, Z. Yu, P. Wu, and M. Hussain, *J. Alloys Compd.*, **649**, pp. 1037–1042 (2015)
17. A. Rezaee, A. Kermanpur, A. Najafizadeh, and M. Moallemi, *Mater. Sci. Eng. A*, **528** (15), pp. 5025–5029 (2011)
18. Y. Lee, B. Yeon, S. Hyun, and K. Kang, *Mater. Lett.*, **89**, pp. 279–282 (2012)