TRIBOLOGICAL AND MECHANICAL BEHAVIOUR OF AZ61 MAGNESIUM ALLOY

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ABSTRACT

The tribological behaviour of powder metallurgy-processed AZ61 magnesium alloy was investigated using pin-on-disc equipment. The density, porosity, hardness, microstructure and abrasive wear behaviour of the alloy were evaluated. Microstructural characterization of AZ61 Mg alloy showed normally uniform composition distribution. As compared with cast AZ61 Mg, the density and hardness values of AZ61 P/M Mg were decreased. The abrasive wear tests showed that the wear loss of AZ61 P/M Mg was increased 14% than AZ61 cast Mg. This was due to the strong particulate-matrix bonding and high hardness of the AZ61 cast Mg.
Keywords: Powder metallurgy: Magnesium; AZ61; Abrasive wear; Hardness

1. INTRODUCTION

Recently, metal matrix composites (MMCs) have been widely investigated and applied due to their promising advanced properties. Among the MMCs, magnesium MMCs are more and more attractive because of their low density, high specific stiffness and specific strength, as well as high wear resistance [1-3]. There are several methods to fabricate particulate reinforced Mg MMCs including stir casting [4], mechanical alloying (MA) [5], powder metallurgy (P/M) [6], squeeze cast [7], infiltration [8] and self-propagating high-temperature synthesis (SHS) [9]. In P/M process, the magnesium MMCs are fabricated from powders without passing through a fully melting state. Furthermore, P/M technique can attain a more uniform distribution of particulates in the metal matrix without or with less excessive reactions between the matrix and reinforcement.

The combination of its excellent properties has made TiB2 increasingly important for a wide range of applications in erosive, abrasive, corrosive or high-temperature environments [10]. During the past years, a large amount of methods have been employed for the production of MMCs. Among these methods, powder metallurgy (P/M) technique provides a number of advantages for making composites. It requires the low manufacturing temperature and can gain the uniformity in the reinforcement distribution.

In the present work, the main objective is to investigate the feasibility of the fabrication of SiC ceramic particulate reinforced magnesium MMCs by P/M technique. An attempt is made to in order to develop a more economical and simplified process for magnesium matrix composite production.

2. EXPERIMENTAL SETUP AND PROCEDURES

The composites were fabricated by the P/M process route. Magnesium AZ61 was used as the matrix material in the present investigation, and details of its composition are given in Table 1. This matrix was chosen because it provides an excellent combination of strength and damage tolerance at elevated and cryogenic temperatures. Table 2 provides the details of the SiC and graphite particulates, which were used as reinforcements. Powder mixtures with designed composition of 2.5, 5 and 7.5 vol.% SiC were mixed by ball milling for 6 h, and were cold pressed uniaxially into cylindrical preforms (18mm diameter and 20mm height) at pressures of ranging from 235 MPa. The green preforms were heated to 500 ◦C in a furnace, kept for 1 h at that temperature.

Table 1 Chemical composition of the matrix alloy

%	*Mg*	*Al*	*Mn*	*Cu*	*Zn*	*Ni*	*Si*
AZ61	Bal	5.8-7.2	0.15 min	0.05 max	0.40-1.50	0.005 max	0.05 max

Table 2 Details of reinforcements

SI.No.	*Az61(%)*	*SiC(%)*	*Gr(%)*
1	95	2.5	2.5
2	92.5	5	2.5
3	90	7.5	2.5

2.1. Density measurement

The theoretic density of Mg composite was calculated using the rule of mixtures [11]. The actual densities for the pure Mg and composite were c using Archimedes principle. The cylindrical sample was weighed in air (Wa), then suspended in distilled water and weighed again (Ww). The actual density was calculated according to Eq. (1).

$$\rho_a = W_a/(W_a - W_w) \times \rho_w \qquad (1)$$

ρ_a = Actual Density

$\rho_{w=}$ Density of water

The sample was weighed using a photoelectric balance with an accuracy of 0.1mg.

2.2. Wear testing

Dry sliding wear tests were performed by using pin-on-disc equipment (Ducom, model No: ED-201, Bangalore, India). The counter disc material was of EN31 steel. Prior to testing, the pins and disc surface were cleaned with acetone. All of the tests were performed on various applied loads of 5,10,15 and 20 N with sliding speeds of 1 m/s. A varying sliding distance of 500, 1000, 2000 was employed. After each test, the specimen and counter face disk were cleaned with organic solvents to remove traces. The pin was weighed before and after testing to an accuracy of 0.1 mg to determine the amount of wear loss.

2.3. Microstructural characterization

Microstructures of the as-cast AZ61Mg and AZ61 powder metallurgy sample were investigated using optical microscopy (OM). After the wear worm surface also investigated for the AZ61 cast and powder metallurgy sample.

Figure 1. Before wear of AZ61 cast alloy

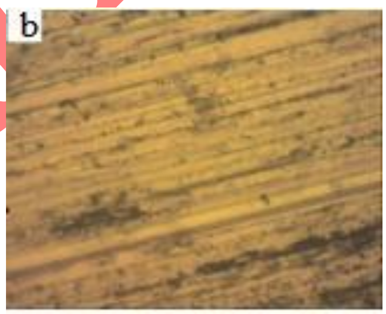

Figure 2. After wear worm surface of AZ61

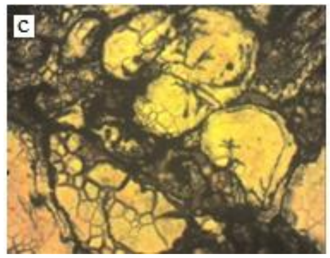

Figure 3. Before wear of AZ61 P/M Sample

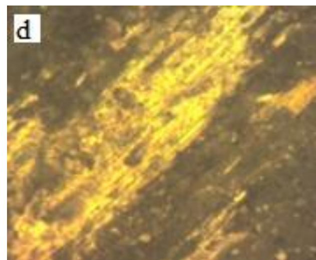

Figure 4. After wear worm surface of AZ61 P/M Sample

3. RESULTS AND DISCUSSION

3.1. Microstructure

Figs. 1 and 2 show the OM micrographs image of before and after wear of AZ61 cast mg alloy. Figs. 3 and 4 show the OM image of AZ61mg alloy powder metallurgy sample.

3.2. Porosity

In accordance with Eq. (1), the actual density of each material can be calculated; therefore, the porosity of each material can be calculated according to Eq. (2).

$$P = 1 - (\rho_a / \rho_t) \qquad (2)$$

Where P is the porosity of the material, ρ_a is the actual density and ρ_t is the theoretic density.

Table 3 shows the theoretic density, actual density and porosity of the as-cast AZ61Mg and AZ61 P/M mg alloy.

Table 3 Density and porosity values

Material Type	*Theoretic density (g/cm3)*	*Actual density (g/cm3)*	*Porosity (%)*
As cast AZ61	1.834	1.818	0.87
AZ61 P/M sample	1.790	1.750	2.23

3.3. Hardness and wear resistance

Table 4 gives the Rockwell hardness (RHN) values and wears loss of as-cast AZ61 Mg and AZ61 P/M mg. As compared with cast AZ61 Mg, the wear loss of the P/M AZ61 mg was decreased by 14%.

Table 4 Hardness and Wear loss values

Material Type	Hardness (RHN)	Wear Loss (gm) 20N & 1000m
As cast AZ61	55	0.0007
AZ61 P/M sample	51	0.0008

4. CONCLUSION

In the present investigation, the AZ61 magnesium composite was successfully fabricated by the Powder Metallurgy route. The density, porosity, hardness and optical microstructure were evaluated. The obtained density and hardness results can be summarized as mentioned above.

As compared to cast alloy the powder metallurgy sample has less density. Powder metallurgy sample have less hardness as compared to cast alloy sample.

The abrasive wear tests showed that the wear loss of AZ61 P/M Mg was increased 14% than AZ61 cast Mg alloy. This was due to the strong particulate matrix bonding and high hardness of the AZ61 cast Mg.

REFERENCES

[1] S.F. Hassan, M. Gupta, Mater. Res. Bull. 37 (2002) 377–389.

[2] H.Y. Wang, Q.C. Jiang, Y. Wang, B.X. Ma, F. Zhao, Materials Letters 58 (2004) 3509–3513.

[3] Q.C. Jiang, H.Y. Wang, B.X. Ma, Y. Wang, F. Zhao, Journal of Alloys and Compounds 386 (2005) 177–181.

[4] Q.C. Jiang, H.Y. Wang, J.G. Wang, Q.F. Guan, C.L. Xu, Mater. Lett. 57 (2003) 2580– 2583.

[5] L. Lu, K.K. Thong, M. Gupta, Compos. Sci. Technol. 63 (2003) 627– 632.

[6] H. Ferkel, B.L. Mordike, Mater. Sci. Eng. A298 (2001) 193–199.

[7] A.R. Vaidya, J.J. Lewandowski, Mater. Sci. Eng. A220 (1996) 85–92.

[8] S.K. Thakur, B.K. Dhindaw, Wear 247 (2001) 191– 201.

[9] Q.C. Jiang, H.Y. Wang, Q.F. Guan, X.L. Lin, Adv. Eng. Mater. 10 (2003) 722–725.

[10] P. Ravindran, K. Manisekar, P. Narayanasamy, N. Selvakumar, R. Narayanasamy, Materials and Design 39 (2012) 42–54.

[11] M. Merola, Mater. Sci. Eng., A Struct. Mater.: Prop. Microstruct. Process. 214 (1996) 181–185.