The Magnetic Chemical Preparation and Properties of the Al_3Zr/6A02 Aluminum Matrix Composites

Lei Jiao[1,a],Zhongzhong Zhang,Hua Shang,Yao Gao,

School of Materials Science and Engineering, Jiangsu University, Zhenjiang, Jiangsu 212013, China

[a]jiaolei@sina.com;

Keywords: Al3Zr/6A02 alumium composite materials,Combination of magnetic field,Magnetic chemical preparation,Wear properties

Abstract. The effects of the magnetic field on microstructures and wear properties of aluminum matrix composites are studied based on K2ZrF6-Al system. The results show that under the combination of magnetic field, melt can generate a forced exercise, which promotes melt dynamics changes in conditions, and thus playing the role of refined particles, changes in morphology and distribution. The SEM images of worn surface show that there is a serious adhesion and deformation within the 6A02 matrix alloy, which is adhesive wear and delamination abrasive, and the wear type of Al3Zr/6A02 composite materials is abrasive wear. Mechanical properties of Al3Zr/6A02 composites are greatly improved under the effect of the combination of magnetic field, and the tensile strength increases from 239.8MPa to 400.6MPa with a 67% increase. The area of plastic deformation is reduced, but is still ductile fracture.

Introduction

With the development of high technology, there is an increasing requirement on the material aviation, aerospace and military departments with small anisotropy, uniform structure, easy shaping, low cost and other advantages. In situ synthesis process can be divided into the state of the original reaction phase gas - liquid reactions , liquid - solid reaction , liquid - liquid reactions [1-3].In situ reaction particles have merits including fine particles, uniform distribution in the matrix, as well as the particle surface is not contaminated, and good substrate wettability and adhesion, which attracts more and more attentions of scholars at home and abroad [4-6]. Studies on material properties under the combined magnetic field not only has the important theoretical significance, but also has important economic significance.

Wear is one of common mechanical consumption, at the same time, wear is also extremely complex failure process. Because of the material characteristics, the workpieces to the work environment, friction sliding, sliding speed, stress size and mode of action, the workpiece surface condition and other factors, the wear failure could not be avoided [7]. Therefore, this experiment studies the microstructure of Al_3Zr reinforced 6A02Al composite material, and has found that the wear property under the combination of magnetic materials is superior to that without adding any magnetic field, and wear belongs to boundary lubrication.

Experimental Procedures

Matrix with 6A02Al,the composition is as follows:

Composition	Zn	Mg	Cu	Zr	Fe	Si	Mn	Cr	Ti
6A02	0.2	0.45-0.9	0.2-0.6	/	0.5	1.0-1.7	0.15-0.35	0.15	0.15
Experiment	/	1.2	0.2	/	/	1.5	0.5	/	0.15

Table 1 The chemical composition of the 6A02 matrix alloys

The raw material is 6A02 aluminum alloy, and reactants is fluoride of potassium

titanate(K2ZrF6）powder(Purity> 99%).First test with the reactants K2ZrF6 powder into the electric oven temperature to 473K, insulation, full removal of the water of crystallization, and then cooling, grinding, the particle size <200 μm in the powder material to add. After taking 3kg of 6A02 aluminum alloy, graphite crucible of the resistance furnace heated to 1053K, thermal insulation. Gas slag, respectively, into the three same crucible in a resistance furnace in situ reaction. The other two moved to the Figure 1 shows the magnetic field generating device, the combination of magnetic fields and single magnetic field effect in the aluminum melt.

Table 2 the experiment parameters in the different magnetic field

Magnetic field	Excitation current	Reaction time	Frequency	Phase
There is no magnetic field	250A	20min	5Hz	3
A single magnetic field	250A	20min	5Hz	3
Combined magnetic field	250A	20min	5Hz	3

Composite metal casting machining into tensile specimens at room temperature, the DWD-200 computer control electronic universal testing machine for tensile tests. The experimental results for the three specimens of the average. Interception of the fracture surface of fractured, JXA-840 scanning electron microscope on the fracture morphology analysis.

Results and Discussion

Microstructures of the Particles.

Figure1 is the image of 6A02Al-K_2ZrF_6 system in the initial reaction temperature of 1023K, the amount of powder was added to 10% of the melt mass of the composite spectra. The figure 3 shows that the material contains elements of both Al and Zr, and Al elements were significantly higher than that of zirconium element.

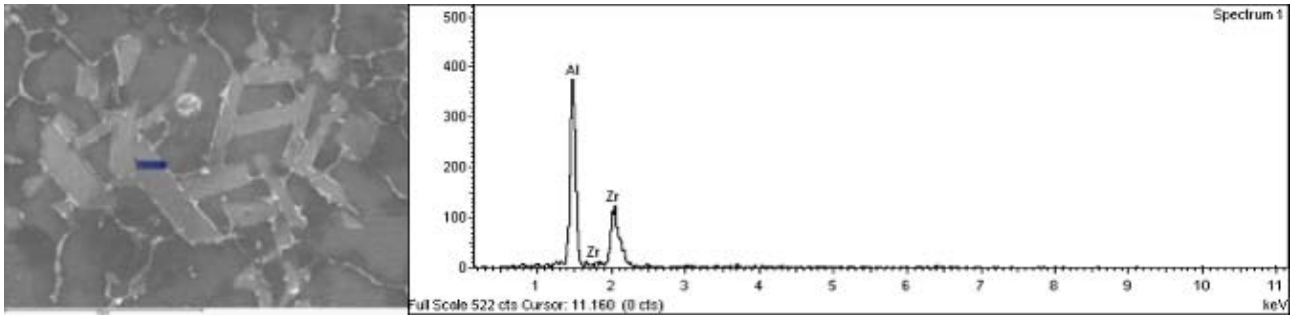


Fig. 1 The spectra of Al3Zr6A02Al composite

$$3K_2ZrF_6+13Al \rightarrow 3Al_3Zr+3KAlF_4+K_3AlF$$

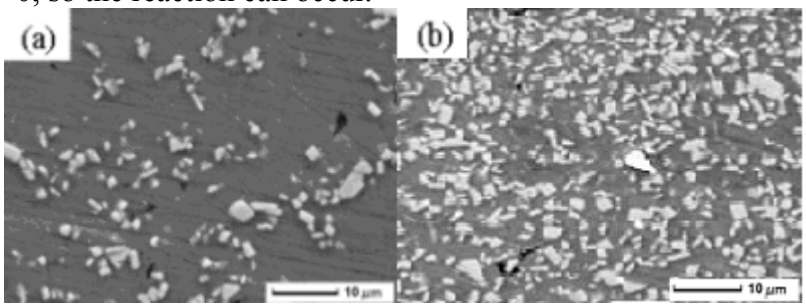
System aluminothermic reduction reaction, present in the solution group were Al, Zr, so the problem is transformed into thermodynamics. The metallurgical, chemical reaction is:

$$[Zr] + 3\ Al \rightarrow Al_3Zr.$$

The Al_3Zr Gibbs free energy, and the results are as follows:

$$\triangle G^0(Al_3Zr) = -3345926.8602+189.563T$$

Because △ G <0, so the reaction can occur.

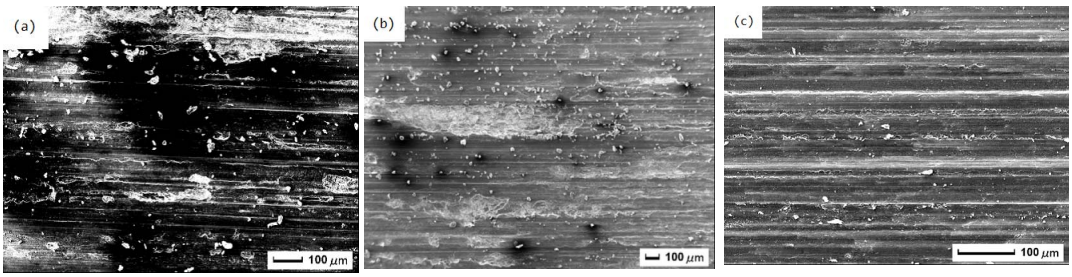


(a) Single magnetic field (b) Combination of magnetic field

Fig.2 SEM images of Al_3Zr6A02Al composite materials

It can be seen from Figure2, the Al_3Zr particle morphology in Single magnetic field have no sharp corners,Its distribution becomes more uniform, the particles were smaller, the combination of magnetic field effect is more obvious.The magnetic field Al_3Zr particle morphology compared with the combined magnetic field, Al_3Zr particle size distribution is more uniform, a rapid increase in particle volume fraction of melt center, In addition, with the combination of magnetic particles of the sharp corners of Al_3Zr occurred more blunt-technology, which is very beneficial to improve the performance of the composite.

Wear Property .



(a) non- magnetic field; (b) Single magnetic field; (c) Combination of magnetic field

Fig. 3 The EMS images of worn surface

Fig.3 shows the sliding speed is 0.42m / s load of 85.6N, the sliding time of 90min when the wear of 6A02 aluminum alloy matrix and a single magnetic field and the combination of magnetic composite sub-surface SEM image. It can be seen from Fig.3(a), subsurface at the 6A02 alloy matrix with a crack, the crack occurred in the sub-surface and surface extension connected to another part of the crack. Wear surface due to friction and heat to heat up, the surface layer to soften, resulting in plastic deformation and flow, the initiation of the crack and extension in the sub-surface. And abrasive wear is obvious; From Fig.3(b) shows the worn surface of the composite sample and a single magnetic field than the pure matrix alloy in the formation of smooth, local small tear pit. However, due to the enhanced presence of particles, reducing the direct contact of the aluminum alloy with wear parts and separated into discontinuous point on the gold substrate adhesion points to reduce wear surface to reduce adhesion avulsion and quantity . According to the wear surface morphology determine the wear mechanism is mainly abrasive wear and a small amount of delamination wear; We can see from Fig.3(c), the combination of the magnetic field increases the wear of the composite sample surface than that imposed by the electromagnetic stirring of the specimen wear surface more smooth, without tearing pit, surface contours clear furrows. This is so hard off the worn surface of the composite enhance the role of the abrasive particles in the friction process. Larger loads under pressure into the friction surface of the composite, and slip occurred along the rubbing direction, the worn surface of the furrows. To judge from the morphology of the abrasive wear.

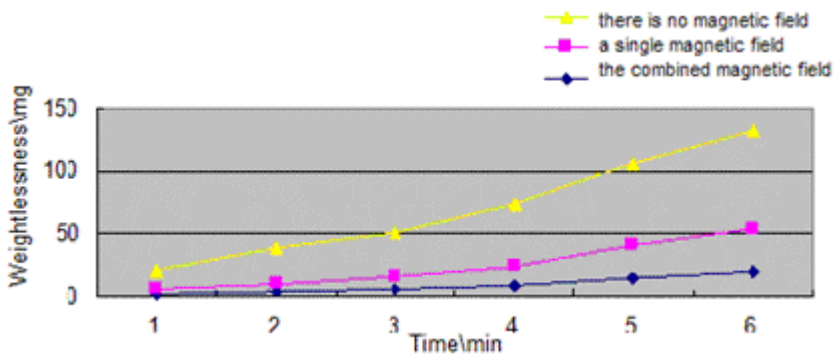


Fig.4the relationship between wear weight loss and wear time

Fig.4 is the diagram between friction weight loss and friction time when the sliding velocity is 0.42m / s, the load of 60.2N 6A02Al matrix composites in the absence of a magnetic field, a single magnetic field, the combination of magnetic field.Fig. 7 shows that with the extension of the wear of time, a linear relationship between the amount of wear of the material in time, material wear rate

of increase will soon wear the late, without magnetic field, wear time of 90 min, without the magnetic field of materials wear as 79.8mg, the combination of magnetic field for the 22.3mg, it is more than three times the combined magnetic field, material wear resistance significantly increased.

Conclusions

(1) This experiment compares volume fraction of Al_3Zr/6A02 composites under different external fields, which are the absence of a magnetic field, a single magnetic field, and the combination of magnetic fields, and the results show that the size and distribution are different, but the best is synthesized under the combination of magnetic field.

(2) The worn surface of pure matrix alloy is adhesive wear and delamination wear, and of the composites without electromagnetic stirring is mainly abrasive wear and a small amount of delamination wear, while of the composite electromagnetic stirring is totally abrasive wear.

Acknowledgments

This work was supported by a project funded by the priority academic program development of jiangsu higher education institutions(PAPD)，‘Jiangsu provincial college 2012 students' practice innovation training program (Contract No.1201220073)’ and ‘Jiangsu provincial college 2011 Graduate students scientific research innovation plan program’.

References

[1]Nakata H,lnoue T , Mori H , et al. *Improvement of Billet Surface Quality by Ult ra-high-frequency Electromagnetic Casting[J].ISIJ International,* 2002,42 (3) :264-272.

[2] Mikucki B A , Mercer W E , William G G , et al. *Ex-truded magnesium alloy reinforced. With ceramic particles[J] . Light Metal Age* , 1990 , 48 (6) : 12 -16.

[3] H.X. Zhu, Z.J. Li, G.X. Zeng,etc. *Sliding wear behavior of casting aluminum matrix composites [J]. Special casting and non-ferrous gold,* 1994 (1) : 4261.(In Chinese)

[4] W.L. Wang, J.H. Wu and G.D. Zhang. *Friction and wear properties of aluminum matrix composites [J]. Metal trans.,* 1998; 34 (11) : 1177-1182. (In Chinese)

[5] Gaoke Zhang, Hong Chen.*Material preparation and processing of magnetic chemical research and application [J]. J silicate bulletin*, 2002, (1) :34-37. (In Chinese)

[6] Koczak M J, *Premkumar M K. JOM[J]*, 1993, 1: 44

[7] Mohanty P S, *Samuel F H and Gruzleski J E. Metall Mater Trans[J],* 1995, 26B: 103