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Dry Wear Behaviour of MAO Applied AZ31 Sheet Alloys Containing Neodymium

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Abstract

In this study, in the range of 0.2% to 0.5% Nd elements were added to AZ31 alloys produced by low pressure die casting method. The hot rolling process was applied to these produced alloys at 400 °C with 4,7 and 10 meter per minute rolling speeds at 30% deformation rate per pass. Micro arc oxidation (MAO) were applied to produced alloys. The wear resistance of samples extracted from sheets that have included different surface morphology after various Nd adding were investigated at dry condition according to ASTM G-133 of the standard test method for linearly reciprocating ball-on-flat sliding wear. The effect of MAO coating and Nd addition on wear resistance of investigated alloys was studied systematically on the base of microstructure analysis.

Keywords: AZ31, Nd, Wear, Hot rolling, MAO.

Neodim içeren MAO işlemi uygulanmış AZ31 Sac Alaşımların Kuru Ortam Aşınma Davranışı

Özet

Bu çalışmada, %0,2-0,5 arasında Nd içeren AZ31 alaşımları alçak basınçlı kokil kalıba döküm yöntemiyle üretilmiştir. 400°C'de 4,7 ve 10 m/dk hadde hızlarında paso başına %30 deformasyon miktarıyla saç malzemeler üretilmiştir. Saç malzemelere mikro ark oksidasyon (MAO) yüzey kaplaması yapılmıştır. Farklı miktarda Nd içeren saç AZ31 alaşımlarına ASTM G-133 standardına göre kuru ortamda ileri-geri hareketli aşınma testi uygulanmıştır. Hem Nd ilavesinin hem de MAO kaplamasının saç AZ31 Mg alaşımlarının aşınma direnci üzerine etkisi mikroyapısal çalışmalar ile desteklenerek sistematik olarak incelenmiştir.

Anahtar Kelimeler: AZ31, Nd, Aşınma, Sıcak Haddeleme, MAO.Bu makale, 4. International Conference on Material Science and Technology in Kızılcahamam/ANKARA (IMSTEC 2019) sempozyumunda sözlü sunum yapılmıştır

1. Introduction

Magnesium alloys have drawed excellent attention from the producer of light materials due to their excellent low density, superior specific strength and moderate corrosion resistance [1]. However, the tribological properties of Mg alloys still are under deficient conditions that limit the application areas of their [2]. To embellish the wear properties of Mg alloys, many attempts such as alloying, ion implantation and laser direct melting employed by researches. However, micro-arc oxidation (MAO) is an alternative method to develop corrosion and wear properties of Mg alloys [3]. The formed ceramic coating on the surface of metal develops the surface properties effectively where the wear loss is less than the uncoated sample [4]. Moreover, rare earth metals like yttrium and lanthanum were utilized to augment the tribological properties of Mg alloys at dry and corrosive conditions [5 and 6]. Further, to improve the high-temperature mechanical properties or corrosive resistance, the Nd can be used as an alloying element which introduces secondary phases such as $Al_{11}Nd_3$ are stable at high temperature [7]. On the other hand, how the effect of different Nd amount on dry wear properties of AZ31 Mg sheet alloys is still unclear. This study contains the dry wear test of 0.2% and 0.5% (%wt) Nd added AZ31 Mg sheets deformed at two different rolling speeds with 30% deformation rate per pass following MAO process was applied.

2. Material and Method

Electric resistance furnace which protected by Argon gas from atmosphere was employed to melt the pure Mg,Al and Zn ingots at 775°C for 1 hours following mastar alloys of Mg-Nd(%30wt) and Mg-Mn(%10wt) was added to complete the aimed compositions. To eject the liquid into mould of stainless steel with pressure of 2-3 atm at 350°C, the low pressure die casting method was utilized under CO2- SF6 mixed gas. XRF- Rigaku ZSX Primus II completed to determine the chemical content of materials. The results of XRF was detailed in Table 1. To eliminate the segregation the materials was homogenized at 400°C for 24 hours. The semi-finished metals with the volume of 12x36x60 mm have been manufactured after homogenization. To obtain 2 mm sheets from 12 mm billets, the hot rolling was applied with deformation rate per pass is 30% and the speeds of rolling is 4.7m/min and 10 m/min at 400°C. The materials was heated at 400°C for 0,5 hours and 5 minutes before rolling and between pass, respectively.

Table 1. Chemical Composition of Materials

Alloys	Al	Zn	Mn	Nd	Mg
AZ31-%0,2Nd	2,91	0,97	0,10	0,19	Bal.
AZ31-%0,5Nd	2,93	1,03	0,12	0,40	Bal.

The metallography, MAO and surface roughness processes were applied as reported our previous study[8]. Microstructure analysis were monitored by light optical microscopy (LOM – Apparatus: Nikon Eclipse MA200 with Clemex software), scanning electron microscopy (SEM- Apparatus: Carl Zeiss Ultra Plus Gemini Fesem) equipped with an energy dispersive spectroscopy (EDS). The wear test was conducted as ASTM G-133. Loads of wear test is 1N, 2N and 5N. The wear test speed is 5 mm s^{-1}, stroke and total wear distance are 8 m and 50 mm, respectively.

3. Results and Discussion

The LOM images of investigated alloys were showed at Fig. 1. As seen Fig.1, both alloys include equiaxed grains however size of some of them is larger of samples deformed at 4,7m/min rolling speed than 10 m/min. Further, the DRXs is a dominant mechanism of rolled samples at 10m/min speed. The CDRXs was just formed at 0,2Nd alloy deformed at 10 m/min speed. However, the shear band was introduced on 0,5Nd added alloy that deformed at 4,7 m/min.

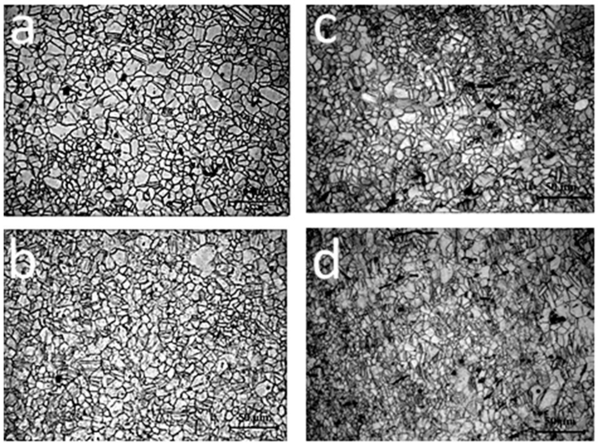

Figure.1. LOM images a) 4,7m/min, b) 10 m/min of AZ31-0,2Nd and c) 4,7 m/min and d) 10 m/min of AZ31-0,5Nd

As presented this Fig.2 the surface roughness is higher for 0,2 Nd added alloys than 0,5 Nd ones (See Fig. 3). However, high speed of rolling increased the Ra values of both alloys.

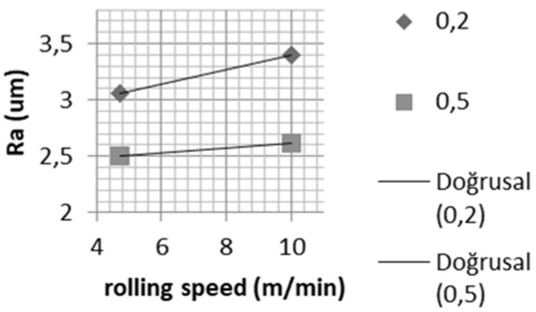

Figure.2. Surface roughness of alloys

SEM images were obtained from surface areas of alloys after MAO process illustrate the holes, cracks and islands (see Fig. 3.). The difference of rolling speed changes the size of holes as seen Fig.3 where diameter size is larger of rolled samples at 4,7m/min, whereas samples of rolled at 10m/min have finer size holes. The islands of samples 10m/min have less holes than 4,7m/min. Furthermore, the formation of cracks more observed at 0,2 Nd added alloys.

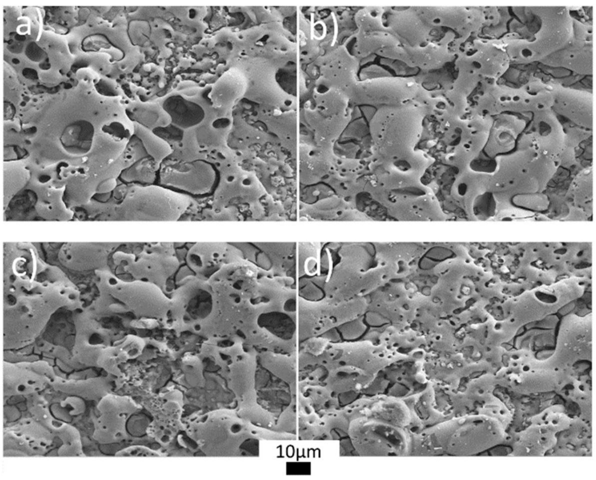

Figure.3. SEM images of MAO coated a) 4.7m/min, b) 10 m/min of AZ31-0,2Nd and c) 4,7 m/min and d) 10 m/min of AZ31-0,5Nd.

The wear test results of 0,2 Nd added alloys for deformed at different rolling speeds were showed at Fig. 4. As seen this Fig.4, the metal loss of 4,7m/min alloy occurred excessively more than 10 m/min.

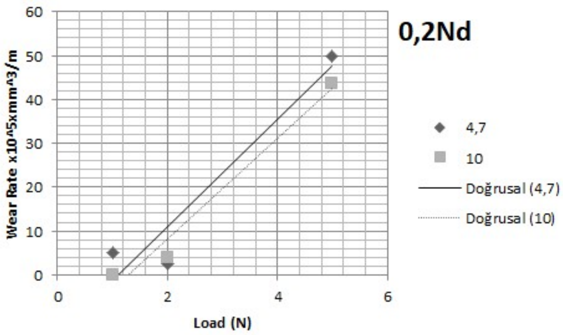

Figure. 4. Wear test result of 0,2 Nd added alloys.

The wear test results of 0,5 Nd added alloys for deformed at different rolling speeds were showed at Fig. 5. As seen this Fig.5, the metal loss of 4,7m/min alloy occurred excessively more than 10 m/min at lower loads. However, the 5N load changed the metal loss amount to increased values for 10 m/min speed rolled sample.

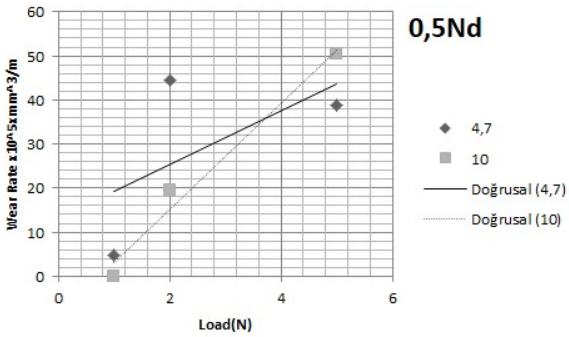

Figure. 5. Wear test result of 0,5 Nd added alloys

The wear test results of 0,2 Nd and 0,5 Nd added alloys for deformed at 4,7m/min rolling speed were showed at Fig. 6. As seen this Fig.6, the metal loss trend is lower at lower loads for sample 0,2 Nd, however it is higher at 5N load.

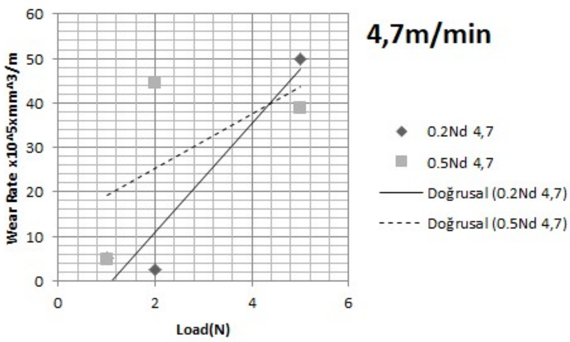

Figure. 6. Wear test result of alloys deformed at 4,7m/min rolling speed.

The wear test results of 0,2 Nd and 0,5 Nd added alloys for deformed at 10m/min rolling speed were showed at Fig. 7. As seen this Fig.7, the metal loss trend is lower sample 0,2 Nd.

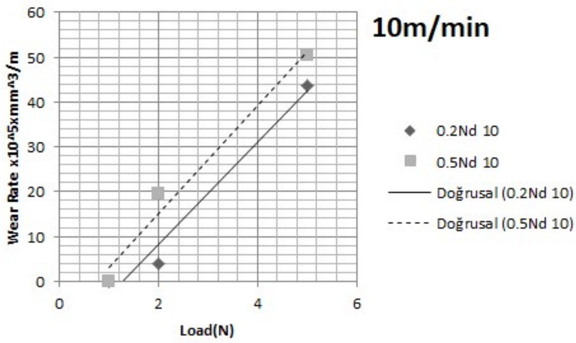

Figure. 7. Wear test result of alloys deformed at 10m/min rolling speed.

4. Conclusions

The result of this study was sequenced as following;

1. The rolling speeds effect the surface properties of MAO applied Mg alloys as regards surface roughness that have higher values at higher speeds. Similarly, alloying amount of Nd prone change surface roughness to higher values when the amount is higher.
2. Wear rate is proportional to surface roughness for 0,2 Nd alloy which have more metal loss when it's Ra values is higher. However, this situation is correct to lower loads for 0,5Nd.

5. References

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