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EFFECT OF EXTRUSION ON MICROSTRUCTURE OF AZ31 TYPE MAGNESIUM

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The use of magnesium as structural engineering material has been becoming more widespread. It promises an important future as a main structural material especially in fields such as aviation and automotive because of its higher mechanical properties and lower weight. In this study, the microstructure of extruded AZ31 type material was investigated. The change of grain size was examined by using optical microscope and SEM microscope and EDX data mapping were obtained. The change in the microstructure was investigated. It was observed that grain size was reduced after extrusion and the alloy elements' distribution was homogeneous.

Keywords*: AZ31, Extrusion, Microstructure, Optical Microscope, SEM, EDX Analyze*

1. Introduction

Magnesium is a metal which took shape substantially with twinning mechanism due to its tight arrangement hexagonal lattice structure and therefore whose cold forming is rather restrictive. [1,5,9,12,17] However, when raised up at certain operating temperatures its shaping is rather easier. Moreover, it shows AA6061 type aluminum character; nevertheless, it is slightly less ductile. Rao et al.[22] studied on the internal structure of AZ31 magnesium which is the greatest problem that has been encountered at the time of shaping of AZ31 magnesium. They revealed that the direction of the fiber structure was at "1010" direction, which was parallel to the direction of extrusion. However, the same samples, which were deformed at the operating temperature of 450^0C, have the same direction. For magnesium material has a tight arrangement hexagonal structure plastic parameters was affected by dynamic recrystallization mechanism, consequently, it is significant in terms of possessing the knowledge of the shaping characteristics of the material. Rao described the said change of direction, which was suggested it in his study, with the dynamic recrystallization effect. Likewise, in another study carried out in relation with the internal structure; however, Kang et al. [14] have examined the change in the internal structure and mechanical characteristics on the relation of grain size after shaping the AZ31 type magnesium materials by Equal Channel Angular Pressing (ECAP) method. In their experimental works they obtained even and uniform grains size, diameter of which were less than 3µm. As the result of tests conducted at different temperatures, Kang et.al. have concluded that best uniform grain distribution and the higher micro hardness values was observed at lower temperature experiments. At the same time various studies have been carried out in relation with the extrusion which is a method containing great number of deformation. Usually researches have been focused on the impact of the rate of extrusion on the product quality and the operation parameters. They have examined samples which were obtained with the extrusion process carried out at various temperatures from room temperature up to 300 ^{0}C. Below 200 ^{0}C, it has been observed that samples were damaged. In the processes conducted between 200^{0}C and 300^{0}C temperatures however although shaping (formation) has been realized, to take AZ31 and ZK 60 products from the mold cavity has been impossible, and eventually samples have been also damaged. Thus, there has not been any chance and opportunity to evaluate the samples and process parameters.

Likewise, in a similar study Chen et al. [1] selecting different ratios (7-24-39-70-100) have examined mechanical characteristics and grain structure of the products obtained at 250 ^{0}C operating temperature with AZ31 type magnesium extrusion method. They have expounded that the grain distribution was homogenized with the increasing extrusion rate and their mechanical characteristics at room temperature were significantly affected. It has been observed that the higher extrusion rates (>39) played a much more active role in comparison with relatively low extrusion rates (25<). In their study, it was revealed that a certain amount of critical extrusion rate where the homogeneity of the grain distribution and their mechanical characteristics could be improved. Formation of dynamic re-crystallization and texture has been used to explain the effect of extrusion rate on the micro-structure and mechanical characteristics for AZ31 type magnesium alloys.

When the literature is examined, the effect of extrusion ratio on microstructure and mechanical properties has been active research area for many researchers and in recent times an increasing number of studies have been carried out. [21], [23]

2. Material and Method

In the present study, the change in the microstructure of the AZ31 type magnesium material subjected to extrusion was investigated before and after deformation. The chemical composition of AZ31 type magnesium used in the study is given in Table 1.

Table 1. Chemical Composition of AZ31 Magnesium

Al	**Zn**	**Mn**	**Si**	**Cu**	**Ca**	**Fe**	**Ni**	**Other**	**Mg**
3.1	1.2	0.2	0.05	0.05	0.04	0.005	0.1	0.4	Balance

Workpiece at Ø20X40mm sizes obtained from extruded magnesium billet has been used as the raw material. Before the test the material has been subjected to annealing process at 400^{0}C for 60 minutes [1] in order to make grain size homogeneous and to eliminate internal stresses. The sample which was cut by using precision cutting machine in order to examine the internal structure has been subjected to the process of taking to Bakelite and then to the process of etching. Before the etching process samples are cut vertically and abrasive/grinding process has been made by means of sandpapers nos. 320-600-1000 and 2400 and then their surfaces have been polished by using broadcloth and diamond paste and then they made to be ready for optical microscope examination. And then by using a solution composed of the mixture of 10.0ml acetic acid, 2.0–2.5g picric acid, 10.0ml pure water and 79.0ml ethanol, etching has been made for the purpose of making the grain structure conspicuous in the internal structure. [9]

Optilca view of microstructure of the workpiece before experiments was given in Fig. 1

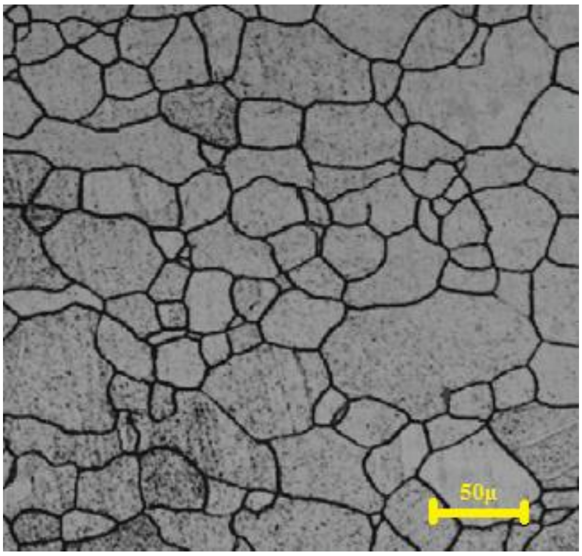

Figure 1. Optical view of microstructure before deformation

In the experimental study, the workpiece diameter was Ø20mm and the exit profile is circular with Ø10.6mm diameter. The die land length is 6mm. and die setup can be seen in Fig. 2.

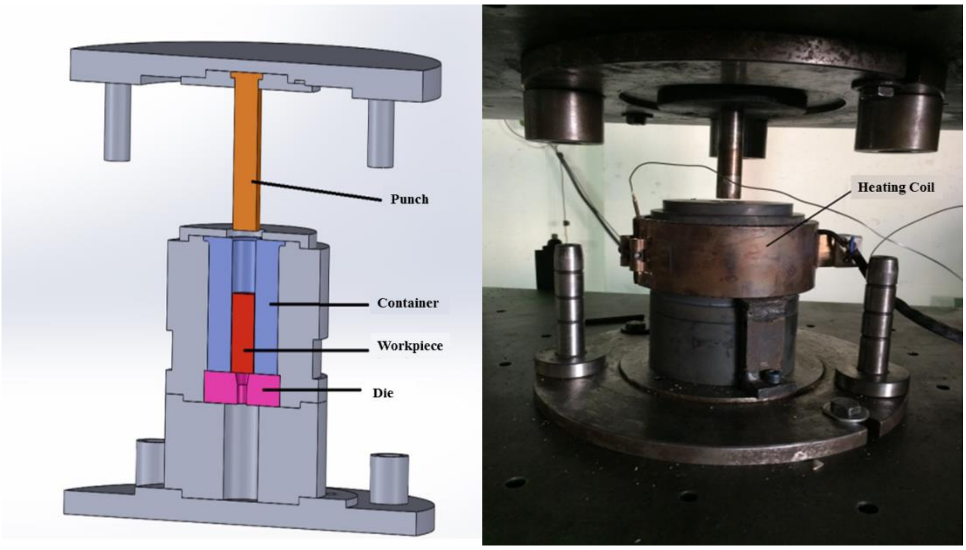

Figure 2. CAD model and view of die set-up

3. Results and Discussions

Tests have been realized at 300^0C of process temperature. [9] The reason why this temperature was chosen is that magnesium and its alloys possessed tight package hexagonal structure at room temperature and there is too little sliding system. Therefore, its shaping is hard, however when raised to higher temperatures, sliding planes show an increase and eventually sliding systems which are suitable for shaping and in adequate number emerge. A PLC controlled, 150 metric ton capacity hydraulic press has been used. At the time of the test press punch speed has been selected as 5 mm/sec. The stock value required for obtaining the product is 30 mm. and the product in 10.6 mm. dia. and 500 mm. long obtained thereafter has been cut and its microstructure has been examined by means of an optical microscope. The Sample's micro structural display obtained by means of a micro-microscope, to which processes related with taking to Bakelite and etching is furnished in the Fig. 3.

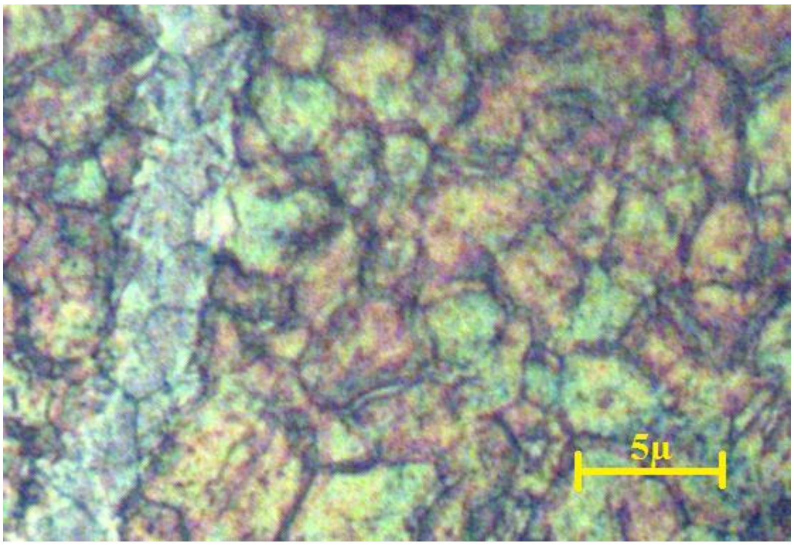

Figure 3. Optical microscope view of microstructure after deformation

It is seen that the grain size is homogeneous due to its high extrusion ratio and is measured as about 7-8μm levels. Due to the coaxial deformation by the direct extrusion method, a homogeneous distribution is observed on the surface. Image analysis was performed and the average grain size was calculated to be 7.2 μm.

An internal structure image obtained by scanning electron microscopy before deformation is given in Fig. 4.

When the EDAX mapping images were obtained. Small sized elements distributed within the magnesium matrix are shown in the Fig. 4. It has been clearly observed that layouts of the basic elements, showing distribution within the magnesium matrix, were changed, but that the homogenization of distribution was not deteriorated. Following the present process wherein coaxial deformation (change of shape) is the matter, as it is shown in the Fig. 5, it has been determined that visual density of the elements was increased and the symbols became conspicuous (growth) because of elements' getting nearer with one another.

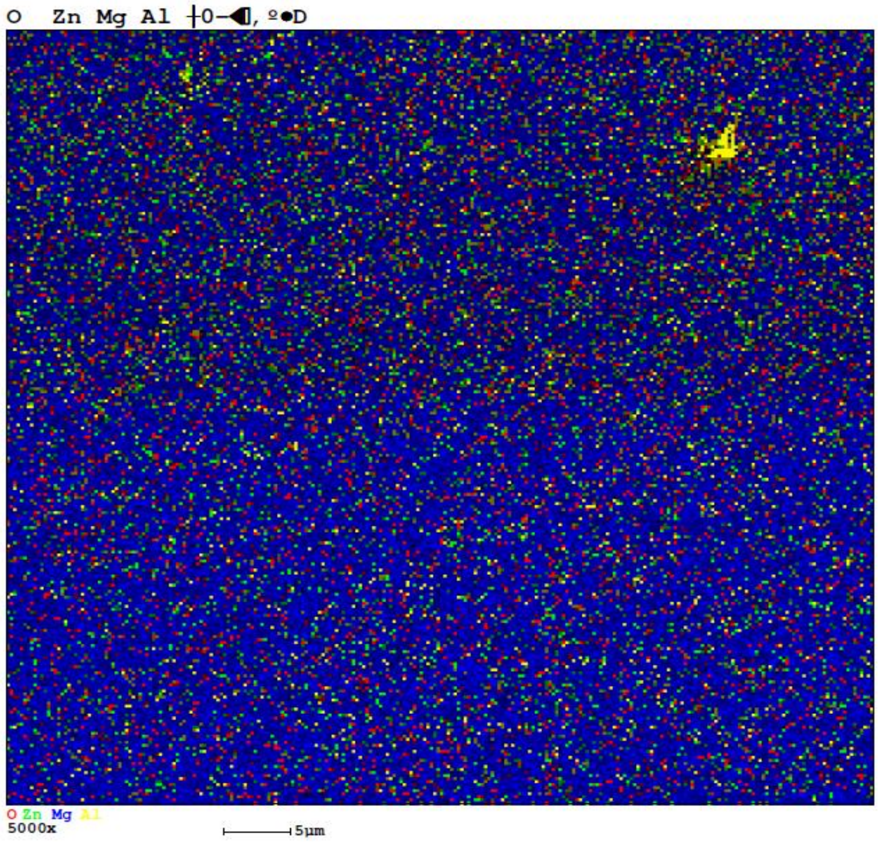

Figure 4. EDAX mapping photo of microstructure before deformation (green:Zn, blue:Mg, yellow:Al)

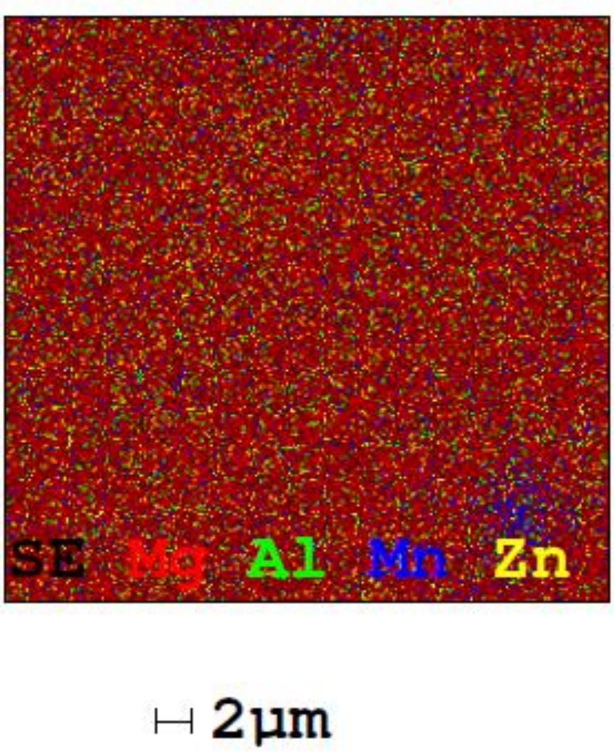

Figure 5. EDAX mapping photo of microstructure after deformation

4. Conclusion

Magnesium has been becoming main structural engineering material especially in fields such as aviation and automotive. Forming of magnesium is a very active research area for the metal industry. Because of that, in this study, effect of extrusion process on the microstructure was investigated. The change of grain size was examined and analyzed optical microscope and SEM. Obtained results was given as follows:

1- It was observed from the extruded samples that the grain distribution can be defined as homogeneous which is the result of the extrusion process having coaxial stress components.
2- The EDAX mapping views showed that layouts of the basic elements were changed homogenously.
3- The study can be expanded by including mechanical tests to determine the effect of the change in grain size on mechanical properties.

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