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Research Article

INVESTIGATION OF GAS PRESSURE EFFECT ON POWDER CHARACTERIZATION OF AZ31 ALLOY PRODUCED BY GAS ATOMIZATION METHOD

Mehmet AKKAŞ*[1], Kamal Mohamed EM KARA[2], Tayfun ÇETİN[3], Mustafa BOZ[4]

[1]*Kastamonu University, Dept. of Mechanical Engineering, KASTAMONU;* ORCID:0000-0002-0359-5142
[2]*Karabuk University, Department of Manufacturing Engineering, KARABÜK;* ORCID:0000-0003-0992-7753
[3]*Karabuk University, Department of Manufacturing Engineering, KARABÜK;* ORCID:0000-0001-8060-344X
[4]*Karabuk University, Department of Manufacturing Engineering, KARABÜK;* ORCID:0000-0001-9148-0748

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ABSTRACT

In this study, the effect of gas pressure on the shape and size of the AZ31 alloy powder produced by using the gas atomization method was investigated experimentally. Experiments were carried out at 840°C constant temperature, in 2 mm constant nozzle diameter and by applying 4 different gas pressures (5, 15, 25 and 35 bar). Argon gas was used to atomize the melt. Scanning electron microscope (SEM) to determine the shape of produced AZ31 powders, XRD and XRF analysis to determine the phases forming in the internal structures of the produced powders and the percentages of these phases and a laser measuring device for powder size analysis were used. The general appearances of AZ31 alloy powders produced had general appearances of complex, ligament, acicular, droplet, flake and spherical shape, but depending on the increase in gas pressure, the shape of the powders is seen to change mostly towards droplet and spherical.
Keywords: Gas atomization, AZ31 alloy powder, gas pressure, powder morphology, nozzle.

1. INTRODUCTION

Due to its high specific strength and light weight advantages, magnesium alloys are extremely important in defense industry and transport sector [1]. Magnesium and its alloys also have high thermal conductivity, high dimensional stability, good electromagnetic protection, high damping, good machinability and easy recycling [2-3]. Because of these advantages, Mg alloys are increasing day by day in different sectors such as automotive, aviation, computer, sporting goods, mobile phones. In addition, its use as an implant material has begun to be widespread in terms of low weight and metabolic compatibility [4-5]. Magnesium is alloyed since it has low strength and toughness values without alloying. For this reason, alloys are generally alloyed with elements such as aluminum, zinc, zirconium and rare earths to enhance the strength, corrosion and fire resistance of magnesium [6-7]. Because of the increased strength in alloying materials, the need

[*] Corresponding Author: e-mail: mehmetakkas@kastamonu.edu.tr, tel: (366) 280 29 58

for powder metallurgy production of materials and alloys with low formability, such as magnesium, has become a necessity.

Composites can be obtained by powder metallurgy method, which can provide properties such as surface abrasion resistance, surface friction and surface stresses at high temperatures. The technique of powder production by powder metallurgy is done by 4 different methods. These; mechanical methods, chemical methods, electrolysis method and atomization method. Among these production methods, gas atomization method is most widely used to obtain fine and spherical powders. The most important reason for the desirability of the spherical powder is that the powder-powder contact must be homogeneous and versatile at the pressing and sintering stages [8].

Atomization is defined as the disintegration and solidification of molten metal into very small droplets with water, air and gas pressures or mechanically. Therefore, 4 different divisions are separated as atomization process, water atomization, gas atomization, centrifugal atomization and vacuum atomization. However, producing more than half of the produced metal and nonmetallic powders by gas atomization makes this method superior. In the gas atomization, gases such as air, nitrogen, argon and helium can be used as pressure fluid to break up the liquid metal bundle [9-10]. In fact, it is possible to produce all kinds of metal and alloy powders which can be melted by gas atomization method.

The most widely used method for obtaining fine and spherical powders in metal powder production techniques is the gas atomization method [11]. In this method, the production parameters of the gas pressure affect the physical and chemical properties of the powders. For gas atomization, to disintegrate the liquid metal bundle as pressurized fluid, gases such as air, nitrogen, argon and helium can be used. Nozzle is a geometric structure that reduces the pressure while increasing the velocity of the fluid. Nozzle geometry, it is very important in the atomization process because it controls the gas flow. Check the size and distribution of the powder by changing the nozzle design and geometry It is possible to [12]. High pressures increase the energy of the gas, and overheating reduces the viscosity of the melt and produces smaller size powder. they provide [13]. However, this may not always be economic. Therefore, closely matched nozzles are used for efficient atomization and fine dust production [14]. In free-fall atomization systems, the liquid metal falls under the effect of gravity about 50-200 mm below the ladle, and in closely matched nozzles, it immediately meets the pressurized gas at the end of the flow pipe [15, 16].

In this work, small and spherical powders were tried to be produced in order to increase the pressability and sinterability of the powders produced. For this purpose, powder production was carried out by the gas atomization method of AZ31 alloy, which is widely used in the automotive and aviation industries.

2. EXPERIMENTAL STUDIES

Experimental studies were carried out at the Gas Atomization Unit at Karabük University Faculty of Technology Department of Manufacturing Engineering Department. The Gas Atomization Unit is composed of seven basic parts. These; Melting furnace, Atomization tower, Nozzle and nozzle holder, Dust collecting unit, Gas pressure ramp, Cyclones and Control panel.

Powder size analyses were performed by using the Mastersizer 3000 model device at the Bartın University Central Research Laboratory. The working principle of the device is that red and blue laser lights are sent on the sample. Particle size analysis was made according to ISO 13320:2009 standard with Mie theory. The SEM images and EDX analyses of the produced AZ31 alloy powders were taken from the "Carl Zeiss Ultra Plus Gemini Fesem" brand device from Karabuk University Institute of Iron and Steel Research Laboratories. The powders were poured on "carbon tape" and coated with gold for the images taken from SEM. Crystalline phases present in gas atomized powders were determined by X-ray diffractometry (XRD, RIGAKU-Ultima IV).

In the chemical analysis of prod uced AZ31 alloy powder, X-ray fluorescence spectrometry (RIGAKU ZSX Primus II) was used.

For the powder production, AZ31 alloy was obtained in the mass from Varzene Metal A.S. and Table 1 shows the chemical composition of the obtained material. Determination of chemical composition was made by XRF (X-Ray Fluorescence Spectroscopy) analysis. Powder production at different gas pressures was performed by using argon gas in AZ31 alloy powder production. As a result of powder production studies, the effect of gas pressure on the particle size and distribution and the shape of the produced powders were investigated.

Table 1. Chemical composition of AZ31 ingot

Element	**Mg**	**Al**	**Zn**	**Mn**	**Si**	**Fe**	**Cu**
Content (%)	Balance	2,85	1,67	0,61	0,22	0,019	0,001

Experiments were carried out at a constant temperature of 840 ° C, 2 mm nozzle diameter and 4 different gas pressures (5, 15, 25 and 35 Bar). Argon gas is used as the atomizing gas. Powder size analyzes were performed with the Mastersizer 3000 model device in the Central Research Laboratory of Bartın University. Dimensional values of AZ31 alloy powders produced are given in Table 1 as Dv (10), Dv (50), Dv (90) and specific surface area. Gas is known to have an important influence on the powder size and shape of the gas pressure in powder production by atomization method. As shown in Table 1, the highest gas pressure value in this study is 35 bar.

Table 2. Dimensional values of magnesium alloy AZ31 powders

Processing Temperature (°C)	Nozzle Diameter (mm)	Gas Pressure (bar)	Dv (10) µm	Dv (50) µm	Dv (90) µm	Specific Surface Area (m²/kg)
840	2	5	65,1	232	773	41,97
		15	45,3	135	392	64,17
		25	32	92,8	255	94,98
		35	18,1	46	99,2	186,7

As a result of experiments in the production of AZ31 dust by gas atomization method, the effect of gas pressure is clearly seen. The powder size values given in Table 2, in which the particle size of powders produced by the gas pressure gauge is reduced, is clearly understood.

When Table 1 is examined, it is seen that the powders produced are in the range of 18.1 to 773 µm and the lowest average powder size (Dv50) is 46 µm in 35 bar gas pressure. 10% of the dust produced in the 35 bar gas press is below 18,1 µm, while 90% consists of dust below 99,2 µm. The mean powder size (Dv50) of the powder produced in the 5 bar gas pressures is 232 µm, while the average powder size (Dv50) is reduced to 46 µm when the gas pressure is increased to 35 bar.

In this work, SEM images of AZ31 powders taken from powders produced at different gas pressures are given in Figure 1.

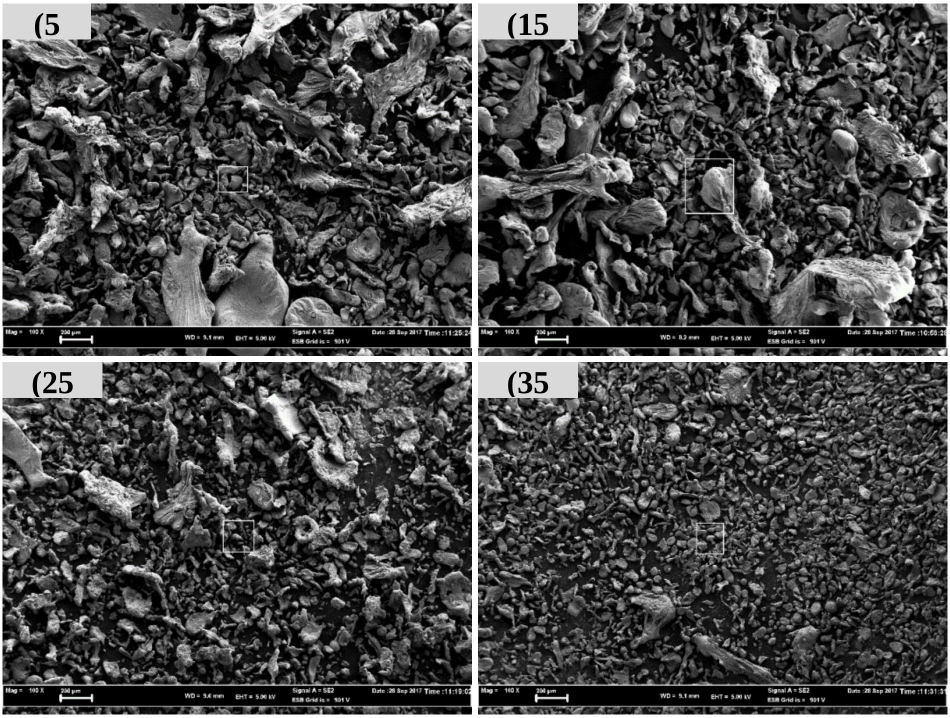

Figure 1. SEM images of AZ31 powders produced at different gas pressures.

As the SEM images given in Figure 1 are interpreted, as the gas pressure increases, the powder size shrinks. The reason for the reduction in the powder size due to the gas pressure can be interpreted as the lowering of the average powder size value in the metal dust production since higher energy transfer to the melt metal at higher gas pressures is provided.

Figure 1 shows that due to the increase of gas pressure from the SEM images, the powder shape changes from ligament, rod and complex shape to drip and spherical. Specifically, the powders produced at 35 bar gas pressure and SEM images in Figure 1 are seen to be significantly smaller and the shape is dripping and spherical. Figures 1 5 bar and 15 bar show that the powders are ligaments and complex shapes. The most important reason for this is that the atomization gas pressure is low and the atomization tower is not high enough. Because the dust particles before the time to globalize the atomization tower is solidified by multiplying the base.

The general appearance of the powders produced is shown by the SEM images given in Figure 2.

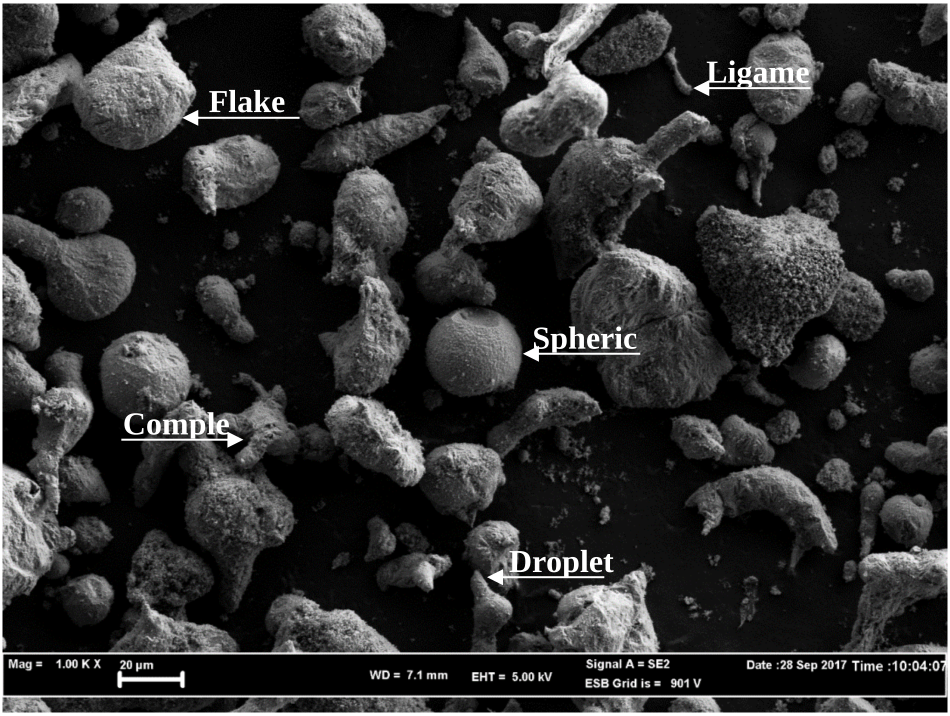

Figure 2. Overview of produced magnesium alloy AZ31 powders.

When the SEM images of Figure 2 are examined, it has been determined that the general appearance of the powders is complex, ligament, flake, droplet and spherical.

When Fig. 2 was examined, a small proportion of the powder was seen to be spherical. The most important reason for this was associated with the fact that the atomization tower was not at the sufficient height. This is because the powder particles solidified by hitting onto the base of the atomization tower before they could find time to become spherical. When the powders randomly solidified under the effect of atomization were examined in detail, it was observed that small particle powders formed on large particle powders. [17-19].

The XRD graph of the magnesium alloy AZ31 powder produced is given in Figure 3.

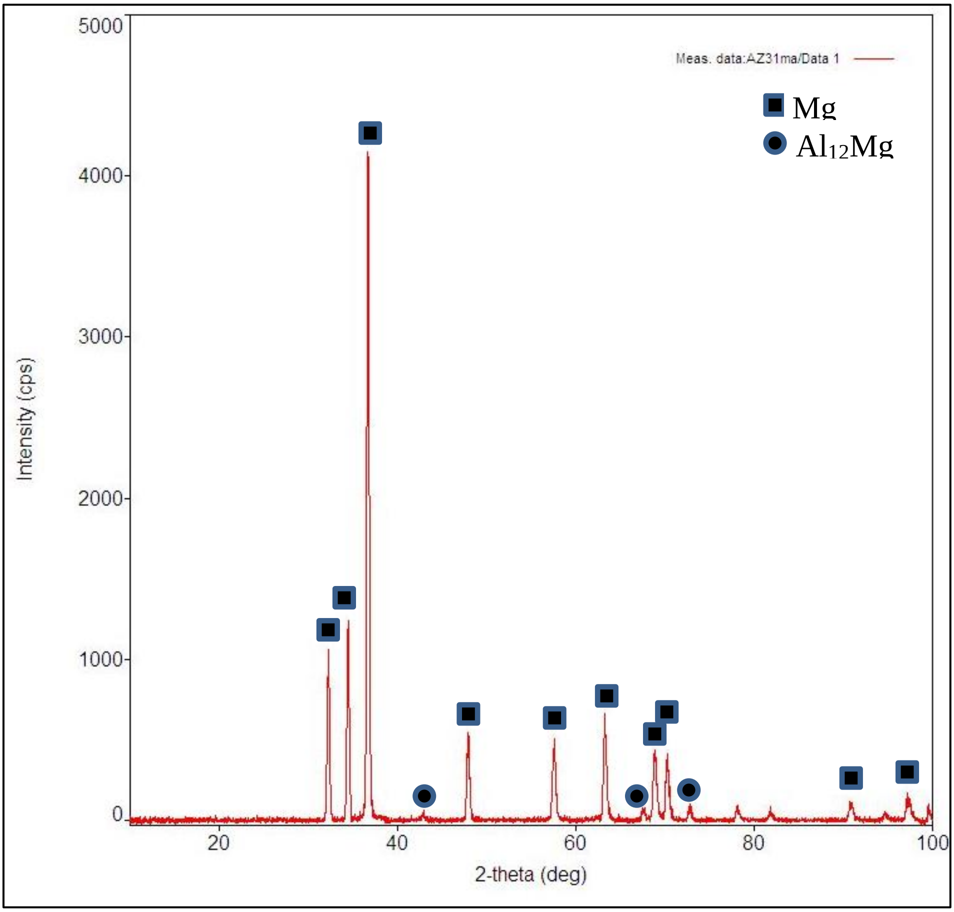

Figure 3. XRD graph of AZ31 magnesium alloy powder produced.

On the XRD graph of the produced magnesium alloy AZ31 powder in Figure 3. Mg and $Al_{12}Mg_{17}$ phases were detected. As a result of the XRD graph shown in Figure 4, it is interpreted that Mg and Al elements form $Al_{12}Mg_{17}$ compound during solidification. In addition, XRF analysis was carried out to determine the chemical analysis of the powders produced. The results of the analysis are given in Table 3.

Table 3. XRF analysis result of AZ31 magnesium alloy powder produced.

Element	**Mg**	**Al**	**Zn**	**Mn**	**Si**
Content (%)	Balance	2,75	1,62	0,61	0,22

According to the results given in Table 2, the chemical analysis of the produced AZ31 alloy powder is 2.75% Al, 1.62% Zn. 0.61% Mn, 0.22% Si and the remaining Mg.

3. RESULTS

The following results were obtained in this study conducted on the characterization of AZ31 powder produced by the gas atomization method applying different parameters.

✓ Powders in different shapes and sizes were obtained with gas atomization method. The smallest powder size was obtained at 840 °C, in 2 mm nozzle diameter and at 35 bar gas pressure.

✓ It was observed that the powder size decreased for Dv,50 from 232 µm to 46 µm depending on the increasing gas pressure (Table 1).

✓ With increasing gas pressure, it was found that the powder shape changed from the ligament and the acicular to the droplet and spherical structure. Shares of individual kinds of shape of obtained powder were determined in relation to total surface of the material.

✓ It was determined from XRD and XRF results that the produced AZ31 alloy powder was composed of α and β ($Mg_{17}Al_{12}$) phases in the structure.

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