ARCHIVES
of
FOUNDRY ENGINEERING

Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

ISSN (1897-3310)
Volume 7
Issue 4/2007

33 –38

8/4

Microstructure analysis of MCMgAl16Zn1 MCMgAl8Zn1 MCMgAl4Zn1 cast magnesium alloy

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Received 03.07.2007; accepted in revised form 16.07.2007

Abstract

In this paper is presented the structure of the cast magnesium alloys as cast state. For investigations samples in shape of 250x150x25 mm plates were used. The structure has been study in the light microscope, scanning electron microscope equipped with an electron back scattering facility. The effects of the addition of Al on the microstructure were also studied. In the analysed alloys a structure of α solid solution and fragile phase β ($Mg_{17}Al_{12}$) occurred mainly on grain borders as well as eutectic and phase with Mn, Fe and Si. Investigation is carried out for the reason of chemical composition influence and precipitation processes influence to the structure of the magnesium cast alloys with different chemical composition.

Keywords: Manufacturing and processing; Investigations; Magnesium alloys; Microstructure

1. Introduction

The material selection is preceded by the analysis of many factors like: mechanical, design, environmental, urbanization, recycling, cost, availability, and weight related issues, which may change the existing conditions and emerge the needs resulting from the supplier-customer relation [1, 2, 5-8]. The strive to decrease the weight of products becomes an important challenge for designers and process engineers. The excessive weight verifies a significant extent the possibilities of employing particular material groups. Contemporary materials should possess high mechanical properties, physical and chemical, as well as technological ones, to ensure long and reliable use. The above requirements and expectations regarding the contemporary materials are met by the non-ferrous metals alloys used nowadays, including the magnesium alloys. Magnesium alloys and their derivatives, alike materials from the lightweight family, characterize of low density and high strength in relation to their weight [1-4, 9-14]. Generally they are applied in motor industry and machine building, but they find application in a helicopter production, planes, disc scanners, a mobile telephony, computers, bicycle elements, household and office equipment, radio engineering and an air - navigation, in chemical, power, textile and nuclear industrial [15-16].

The goal of this paper is to present of the investigation results of the casting magnesium alloy in its as-cast state.

2. Experimental procedure

The investigations have been carried out on test pieces of MCMgAl16Zn1, MCMgAl8Zn, MCMgAl4Zn1 magnesium alloys in as-cast made in cooperation with the Faculty of Metallurgy and Materials Engineering of the Technical University of Ostrava and the CKD Motory plant, Hradec Kralove in the Czech Republic. The chemical composition of the investigated materials is given in Table 1. A casting cycle of alloys has been carried out in an induction crucible furnace using a protective salt bath *Flux 12* equipped with two ceramic filters at the melting temperature of 750±10ºC, suitable for the manufactured material. In order to maintain a metallurgical purity of the melting metal, a refining with a neutral gas with the industrial name of *Emgesalem Flux 12* has been carried out. To improve the quality of a metal surface a protective layer *Alkon M62* has been applied. The material has been cast in dies with betonite binder because of its excellent sorption properties and shaped into plates of 250x150x25 and cones Ø42xØ56xh120 (Fig.1). The cast alloys have been heated in an electrical vacuum furnace *Classic 0816 Vak* in a protective argon atmosphere.

Table 1.
Chemical composition of investigation alloy

The mass concentration of main elements, %						
Al	Zn	Mn	Si	Fe	Mg	Rest
4,00	0,292	0,122	0,0280	0,0111	95,5	0,0469
7,98	0,532	0,198	0,0403	0,0096	91,2	0,0401
16,10	0,617	0,174	0,0468	0,0130	83,0	0,0492

Fig. 1. Shape of the casting samples

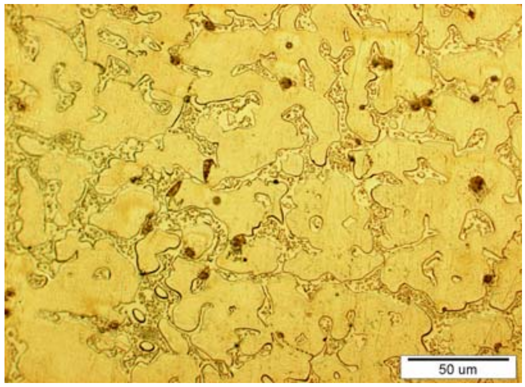
Metallographic examinations have been made on magnesium cast alloy specimens mounted in thermohardening resins. The observations of the investigated materials structure were made on the transverse metallographic microsections using the light microscope LEICA MEF4A.

The X-ray quantitative analyses of the investigated alloy were carried out on the transverse microsections on the Philips scanning microscope with the EDS energy dispersive radiation spectrometer at the accelerating voltage of 20 kV.

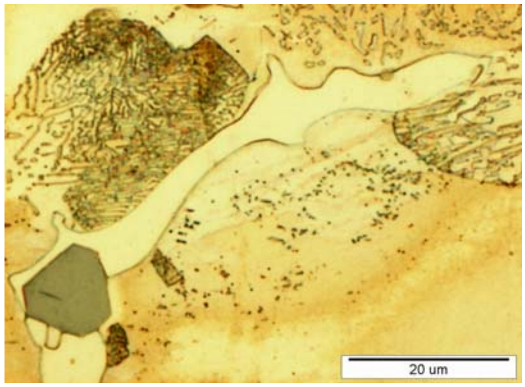
3. Discussion of experimental results

As a result of metallographic investigations made on the light and scanning microscopes it has been confirmed that the magnesium cast alloys MCMgAl16Zn1, MCMgAl8Zn1 and MCMgAl4Zn1 in the cast state are characterized by a microstructure of the solid solution α constituting the alloy matrix as well as the β – $Mg_{17}Al_{12}$ discontinuous intermetallic phase in the forms of plates located mostly at grain boundaries. Moreover, in the vicinity of the β intermetallic phase precipitations the presence of the needle eutectics (α + β) has been revealed (Fig. 2, 3). In the structure of the examined magnesium cast alloys one can observe, apart from $Mg_{17}Al_{12}$ precipitations, turning grey phases (Mg_2Si), characterized by angular contour with smooth edges in the shape of hexahedrons (Fig. 2b) and phase with the distinct aluminium, manganese, iron and silicon concentrations – AlMnFe (Fig. 4, 6).

a)



b)



c)

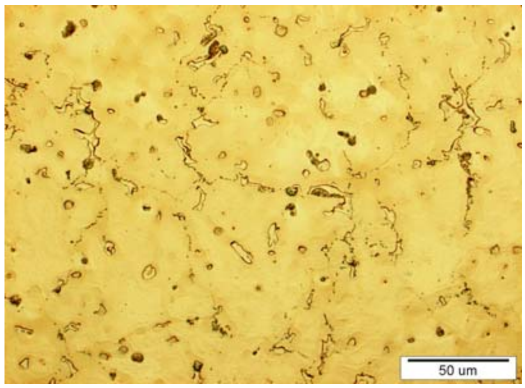


Fig. 2. Microstructure alloys: a) MCMgAl16Zn1, b) MCMgAl8Zn1, MCMgAl4Zn1

a)
b)
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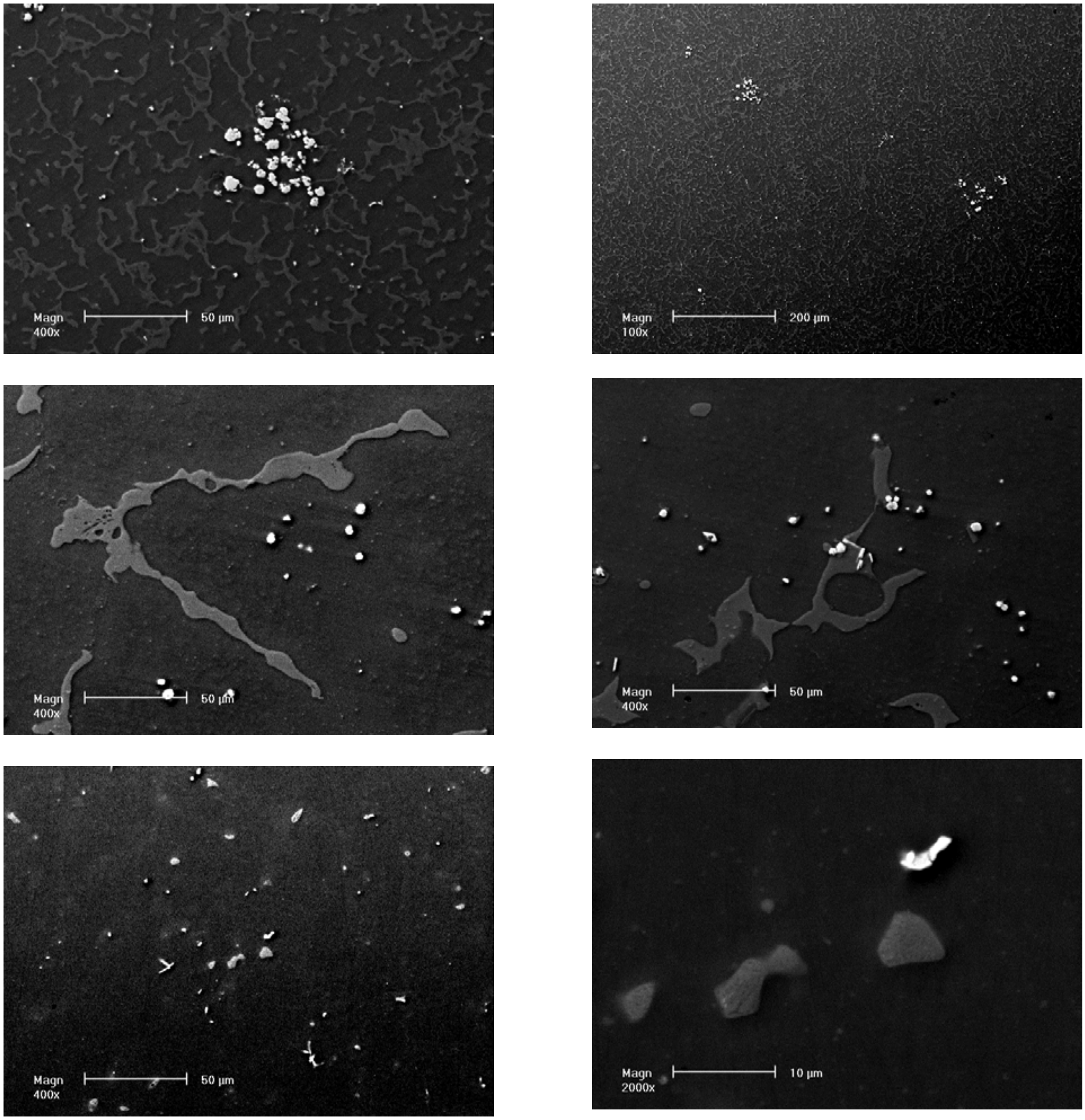

Fig. 3. Microstructure alloys: a) MCMgAl16Zn1, b) MCMgAl8Zn1, MCMgAl4Zn1

As a result of the surface decomposition of elements and the x-ray, quantitative micro analysis made using the EDS energy dispersive radiation spectrometer, the presence of the main alloy additions Mg, Al, Mn, Zn and also Fe and Si included in the magnesium cast alloys in as-cast has been confirmed (Fig. 4-6).

The information about a mass and atom concentration of particular elements in the pointwise examined micro locations of matrix and precipitations (Fig. 5, 6). The chemical analysis of the surface element decomposition and the quantitative micro analysis made on the transverse microsections of the magnesium alloys using the EDS system have also confirmed the evident concentrations of magnesium, silicon, aluminium, manganese and iron what suggests the occurrence of precipitations containing Mg and Si with angular contours in the alloy structure as well as phases with high Mn and Al concentrations that are irregular with a non plain surface, often occurring in the forms of blocks or needles (Fig. 4-6).

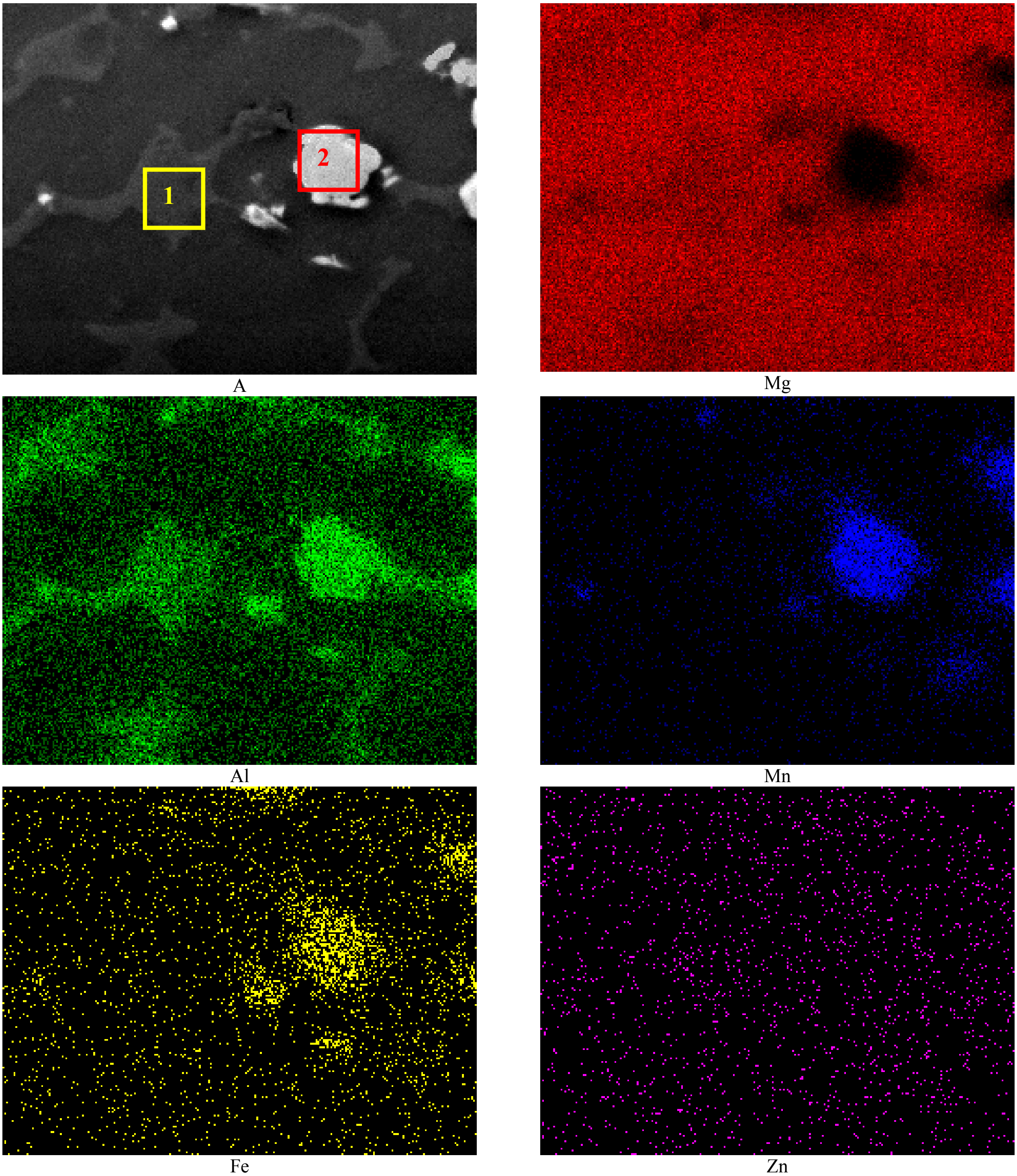

Fig. 4. The area analysis of chemical elements alloy MCMgAl16Zn1 without heat treatment: image of secondary electrons (A) and maps of elements' distribution

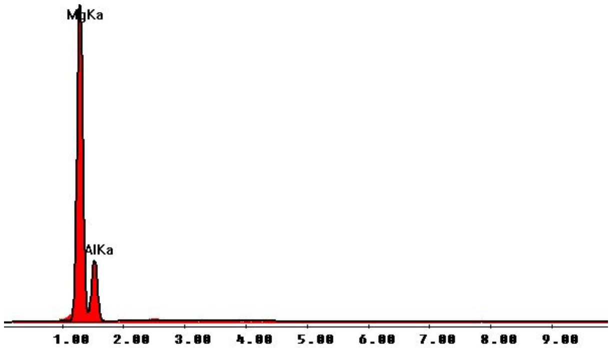

Fig. 5. Spectrum of the pointwise chemical composition analysis point 1 from Fig 4

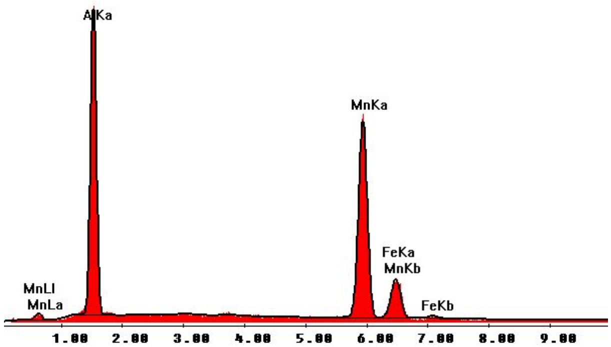

Fig. 6. Spectrum of the pointwise chemical composition analysis point 2 from Fig 4

4. Summary

The results of the metallographic examinations confirm the fact that the magnesium cast alloy MCMgAl16Zn1, mcmGaL8Zn1 and MCMgAl4Zn1 is characterized by a microstructure of the solid solution α as well as the β – $Mg_{17}Al_{12}$ discontinuous intermetallic phase located mostly at grain boundaries. Moreover, in the vicinity of the β intermetallic phase precipitations the presence of the needle eutectics (α + β) has been revealed (Fig. 2, 3). The chemical analysis of the surface element decomposition and the quantitative micro analysis made on the transverse microsections have also confirmed the evident concentrations of magnesium, silicon, aluminium, manganese and iron what suggests the occurrence of precipitations containing Mg and Si with angular contours, as well as phases with high Mn and Al concentrations that are irregular, with a non plain surface, often occurring in the forms of blocks or needles (Fig. 4-6).

Acknowledgments

This scientific work is fragmentary financed within the framework of scientific financial resources in the period 2007-2008 as a research and development project R15 0702 headed by Prof. L.A. Dobrzański

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