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# SELECTED ASPECTS OF MAGNESIUM ALLOYS MELTING TECHNOLOGY

**Abstract:**Magnesium alloys are new class of biodegradable materials usually called as bioresorbable biomaterials for orthopedic applications. The potential benefits of Mg alloys are the nearer modulus of elasticity to the bone than stainless steel or titanium, biocompatibility and bone-active properties and the elimination of necessity of a second operation to remove the implant body. Two- component Mg-Ca alloy is characterized by a solid solution limit, and creates a stable intermetallic phase $Mg_2Ca$. Studied samples were prepared by melting starting material in an induction furnace in a quartz crucible.The micro chemical analysis of samples using a scanning electron microscope with EDS was performed. Values of the microhardness of materials were compared before and after remelting.

## 1. Introduction

Metallic materials used for implants, such as plates, screws or pins used to secure the fracture, must be removed during the second surgical operation, after a time sufficient for the healing of tissues. Magnesium alloys are promising new class of degradable structural biomaterials which provide advantageous properties, eg. high strength with respect to weight of the alloy, Young's modulus nearer to elasticity modulus of bone compared with titanium implants, biocompatibility, osseointegration, improving the growth of apatite in a living body. The advantage of using biodegradable material is that there is only one operation, thereby eliminating the time and expense of a second operation and / or the cost of the new implant. Magnesium metabolism and excretion in the kidney process is a natural physiological process in the human body [1-3].

The development of appropriate biodegradable implants is a multidisciplinary challenge. Suitable time resides in the body and uniform distribution of implant constitute the biggest problem in designing of degradable materials.. The prospective patient may avoid additional operations, which lead to the reduction of risk with an unnecessary stress and complications after surgery.  Light and degradable orthopedic implants with a specific rate of corrosion may be assumed as a new generation of implant materials [1-3].

## 2. Magnesium–calcium alloys

Magnesium–calciumalloys are applicable as biodegradable materials. Calcium reduces the tendency to oxidize in the liquid state and in the state after heat treatment. As well as increases susceptibility to mechanical working. Calcium concentrations higher than 0.3% by weight promotes cracking during welding.

In the Mg-Ca alloys calcium forms intermetallic phases such as Mg2Ca occurring at the grain boundaries of the solid solution α-Mg. It also increases the strength properties and creep resistance. The best properties are obtained when the calcium concentration is about 3% by weight. Calcium allows the original grain refinement of magnesium alloys Mg-Al and Mg-Zn [6-9].

Preparation of the alloy consists of melting the components in an induction or resistance furnace and casting them into the mold. Further processing can be hot-rolling and pressing. Casting of magnesium alloys forces need to use a protective atmosphere, due to high oxidation of the magnesium during the melting. The protective layer is obtained by various methods, the inert gases or fluxes could be used. The primary task of the protective atmosphere is to protect the molten metal against to the formation of unwanted compounds [6-9].

The using of flux is designed to obtain the surface of the protective layer on liquid metal from contact with air. The next task is to remove undesirable molten oxides, nitrides and other harmful substances formed during the melting process. Fluxes are usually mixtures of various salts mainly on the basis of fluorides and chlorides of alkali metals, eg. BaCl2, CaCl2, CaF2, KCl, NaCl, MgCl2, and carnallite ($CaCo_3 \cdot KCl \cdot 2H_2O$) [1,6, 7].

Due to a huge number of disadvantages and difficulties associated with the use of fluxes, another alternative protection against oxidation of magnesium alloys is using a protective gas atmosphere. The most commonly used protective gases are dry air, argon, helium, nitrogen, carbon dioxide, sulfur hexafluoride ($SF_6$), sulfur dioxide ($SO_2$), boron hexafluoride ($BF_3$). Sulfur hexafluoride allows melting of the magnesium at temperatures above 700 ° C, while giving good results in view of the protective sealing cover the surface of the molten alloy [6-9].

## 3. Research techniques and results

Melting and casting of magnesium alloys is quite a complicated process during which an oxide layer is formed on the surface. It is a tight barrier against further oxidation. This phenomenon necessitates the use of a protective layer [4].The protective layer is obtained by various methods. Among other things, we can distinguish the use of protective gases or special protective fluxes. [4-5].

Melting the magnesium alloys with calcium was done in an induction furnace. Magnesium and calcium are placed in a quartz crucible and then introduced into the furnace. Melting temperature was 700 °C. Protective atmosphere is assured at all times during the process. The weight composition of prepared samples is presented in Table 1.

*Tab. 1. The composition of the mass of elements used for boiling the samples*

| Element | Wt. [%] | $T_t$ [$^{O}$C] |
|---|---|---|
| **Magnesium** | 95 | 650 |
| **Calcium** | 5 | 842 |

The analysis of the chemical composition of the ingot was conducted by using a scanning electron microscope (SEM) Zeiss Supra 35 equipped in energy-dispersive spectrometer (EDS).

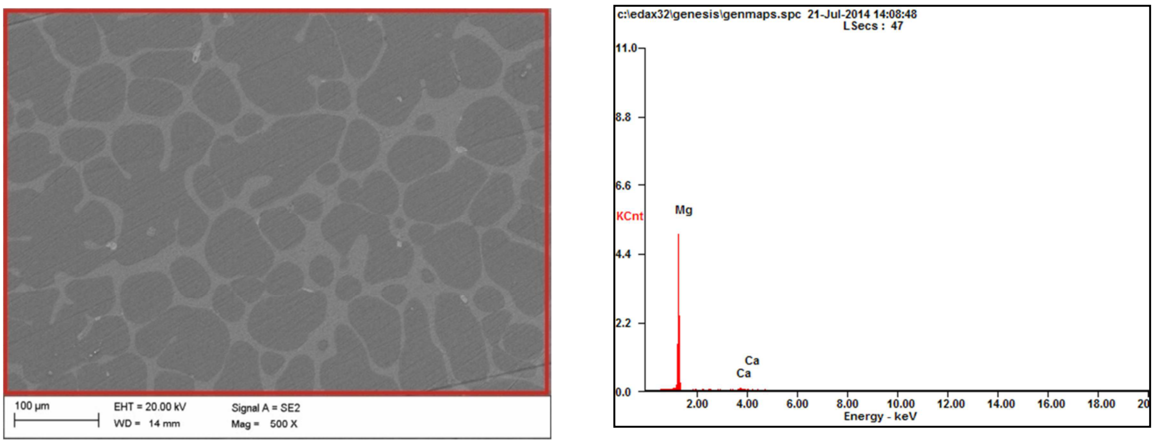


*Fig.1. Alloy structure Mg 99% by weight. - Ca 5 wt%. obtained as a result of research carried out in a scanning electron microscope SEM (a) together with the results of the chemical composition microanalysis (b)*

Table 2 presents the average microhardness of fabricated Mg-5Ca alloy with microhardness of pure Mg and Ca in as-delivery state. Alloy Mg-5%(wt) Ca showed significantly lower microhardness (HV 43) than its individual components Mg (57 HV) and Ca (81 HV).

*Tab. 2. Average microhardness valuesof pure element Mg and Ca in the form of slug in as-delivery state*

| Material | Average microhardness [HV] |
|---|---|
| Mg | 57 |
| Ca | 81 |

Results of microhardness measurements of received ingot are presented in Table 3. The fabricated ingot was seven times examined. The largest value of microhardness which occurred was 94 HV, whereas the lowest value was 52 HV. The average value of microhardness was 70 HV. These results indicate a slight heterogeneity of different areas of the ingot.

*Tab. 3. Results of microhardness measurements of Mg-5(wt%)Ca sample after resistance melting*

| Number of measurement | Microhardness [HV] | Averagemicrohardness [HV] |
|---|---|---|
| 1 | 94 | 70 |
| 2 | 52 | |
| 3 | 94 | |
| 4 | 82 | |
| 5 | 69 | |
| 6 | 76 | |
| 7 | 80 | |

## 4. Conclusion

The results obtained after preparation and examination of Mg5Ca ingot allowed to state the following conclusions:

- EDS demonstrated occurrence of magnesium and calcium elements in studied alloys. Moreover the concentration of alloying elements is almost the same as the starting composition alloy.

Mg5Ca alloy has the average value of microhardness 43 HV. The difference between the measurements of the microhardness was 13 VH. The measurements of hardness is only a preliminary study. It is necessary to conduct further examination of mechanical properties.

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