Effect of Ca and Zn Additions on the Mechanical Properties of Mg Produced by Powder Metallurgy

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Abstract. Magnesium and its alloys are among important research topics in view of their excellent biocompatibility.In this study mechanical and microstructure properties of hot sintered Mg-Zn-Ca alloys were studied.The effects of the addition of different amounts Ca and Zn were added to the base material has been processed by powder metallurgy method.resulting microstructures densities and compression test behaviors of the Mg-based alloys were studied.Visual inspection using SEM (Scanning Electron Microscope) analyses indicates that the microstructure of the composite is also greatly effected by these parameters. In addition, EDS (Energy Dispersive X-Ray Spectroscopy) analyses were performed for reliable determination of the chemical composition.

Keywords: Biodegradable; Magnesium alloys; Hot sintering.
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INTRODUCTION

Magnesium is an basic trace element in the human body. Daily allowance of 426 mg/kg. Lack of mg interrelated with osteoporosis, diabetes mellitus, and atherosclerosis [1-3].

It shows great biocompatibility. The use of metallic materials for medical implants is not a new or recent one. It traced back to the 19th century [4].

Al is not suitable for use in biomaterials in large amounts hence, it is related to Alzheimer's disease and because it pilings up in bone.

It has also been reported that Zr accumulates in the liver and also, rare earth metals are unsuitable since they too accumulate in bone [5]

Biodegradable mg is widely used in medical devices such as stents.plates, screws, and pins as well as in orthopedic applications due to their comparable mechanical properties to natural bone, good biocompatibility and biodegradability [6].

Resurgence in the field of biodegradable Mg implants represents a potential paradigm shift in biodegradable materials for use as stents as well as in orthopedic applications due to their comparable mechanical properties to natural bone, good biocompatibility and biodegradability [7–10].

Calcium is also a very important element in the human body [11]. The degradation rate of the Ca containing compounds more than 1000 mm/year [12] was too high for

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practice. Zn is considered an essential mineral in the human body it displays a much slower degradation behavior than Mg. For this reason, in this study we focused on the Mg-Ca-Zn ternary system. The objective of this study to introduce of the mechanical behavior of composite and microstructure materials.

EXPERIMENTAL PRECEDURES

Gas atomised Mg powders with avarage grain sizes of about 63 μm and purity 99% were utilized in this study. A mixture of Ca and Zn powder was prepared with different calcium content (of 0,67wt% and 1,34 wt%), and with differeent zinc content (of 3,1 wt% and 6,2 wt%) respectively.with the help of a V-blender by mixing it for 1 h.High-strenght graphite die with 10 mm in inner diameter and 60 mm in height was using for samples sintering process.Mixed powders were put into graphite die and hot press sintered under pressure of 30Mpa in argon atmosphere. Sintering time was 25 min followed by furnace cooling. Standard metallographic techniques were employed for preparing samples for micro structural examination. Metallographic samples were prepared from the widthwise cross-sections of the investigated composites. All samples were gently grinded. The images were obtained by using Jeol Trade JSM 5910 SEM and Oxford Inca 7274 EDS was used to identify phases present in the samples. Samples put in the device then vacuumed. Scanning samples were watched on the computer monitor and photographed. Backscattered electrons were used for Sem images. The samples were conductive for this reason they didn't coated with gold. Quantitative data can also be obtained by comparing peak heights or areas in the unknown with standard material. Fort he compressing test the cylindrical samples were determined in accordance with ASTM test method B 925-08 using Zwick Roel Model 2100 tensile testing machine with a 0,5 mm/min testing speed. The ends of a specimen should be flat and parallel. In this study this requirement necessitated the machining and grinding of the ends of the specimens.

RESULTS and DISCUSSION

PHASE and MICROSTRUCTURE ANALYSIS

Microstructural characterization studies were conducted on metallographically polished samples to investigate morphological characteristics of particles, and size and distribution of secondary phases. Reveal micro structural features such as particle boundaries the evolution of microstructure after sintering is shown in Fig 1.

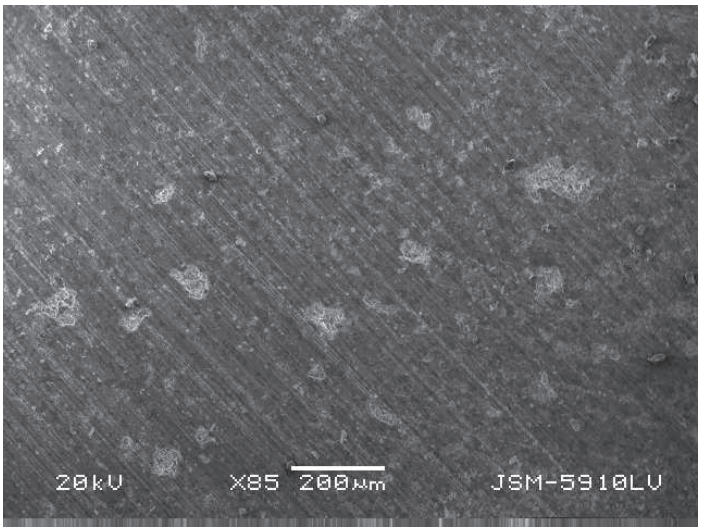

Figure 1. The bright region represents the calcium regions while black one as the magnesium.

Interfacial integrity in terms of debonded regions and the presence porosity can be seen in Figure 1. This also been supported by the experimental porosity results obtained using density measurement. Despite the fact that the bulks and the sizes of the phases arising in the interfaces are much smaller than the other phases.

EDS ANALYSIS

Figure 2 shows microstructure of chosen sample. Energy dispersive spectrograph. Qualitative data obtained by comparing peak heights in the unknown with standard material. EDS revealed that all produced composites contained, magnesium, oxygen and zinc.The point 1 and 2 are shown in Fig.2.

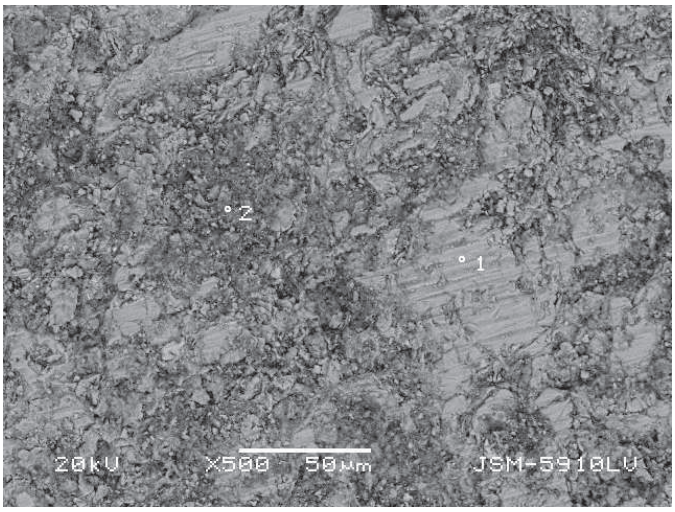

Figure 2. Illustrates EDS patterns for a set of replication which was chosen randomly. XRD pattern of all samples produced according to the created design showed.

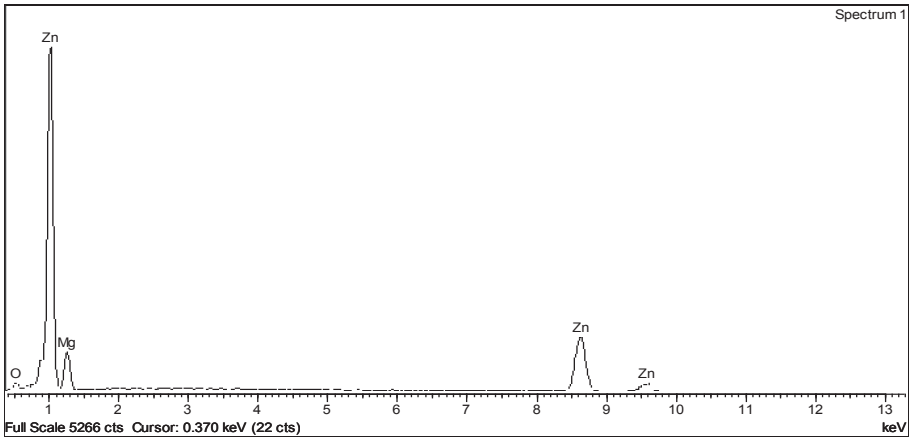

Figure 3. Presents the EDS results of point one.

The peak was identified zinc and magnesium (Fig. 3). This point occurred due to the chemical activity of matrix and reinforcement compounds. Additionally the EDS peaks of sample in the grey color area was an intermetallic compound between the zinc and magnesium occurred during sintering process.

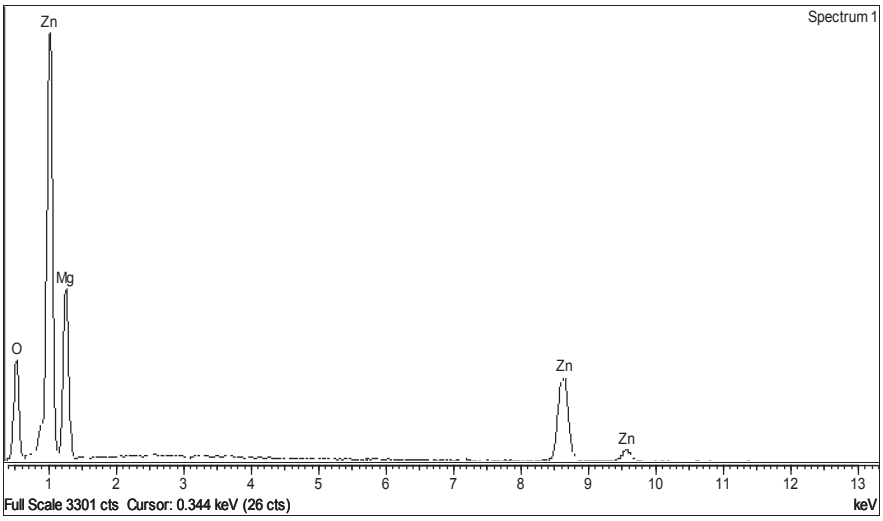

Figure 4. Presents the EDS results of point two.

The peak was identified magnesium and zinc (Fig.4). This point occurred due to the chemical activity of matrix and reinforcement compounds. Additionally the EDS peaks of sample in the grey color area was an intermetallic compound between the zinc and magnesium occurred during sintering process.

COMPRESSIVE CHARACTERISTICS

The results of ambient temperature compression tests revealed a significant improvement in ultimate strengthThe results of ambient temperature compression tests revealed a significant improvement in 0.2% yield strength (Figure 5) and ultimate compression strength of magnesium with an increase in amount of calcium Also, samples exhibited a significant increase in ultimate strength when compared to monolithic magnesium ultimate strength 18 MPa. But the noted that from the parameters the best value was observed on the Mg-1,34Ca-3,1Zn alloy. The bonding between Mg-Ca and Zn was weaker than the strength of bonding the magnesium matrix particles, moreover the magnitude of the weak interfaces were insufficient to cause ― boundary slip‖ deformation. The strength increased linearly according the calcium content.

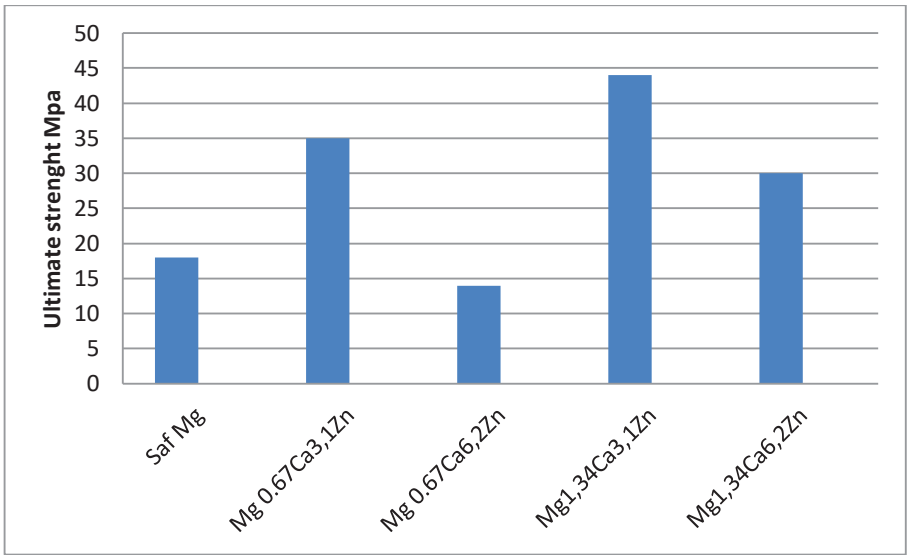

Figure 5. Compressing testing results of MgxCa-yZn.

CONCLUSION

The Mg–Zn–Ca alloys were fabricated suscesfully and significantly improve its mechanical properties when compared with the pure mg.

Distinct lack of porosity indicating near dense deposition.

Consistent material properties across the deposit.

Future studies to improve the biomechanical properties, evaluate the cytotoxicity investigate the in vivo biocompatibility will help further the current research.

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