Synthesis of Mg-based alloys with a rare-earth element addition by mechanical alloying

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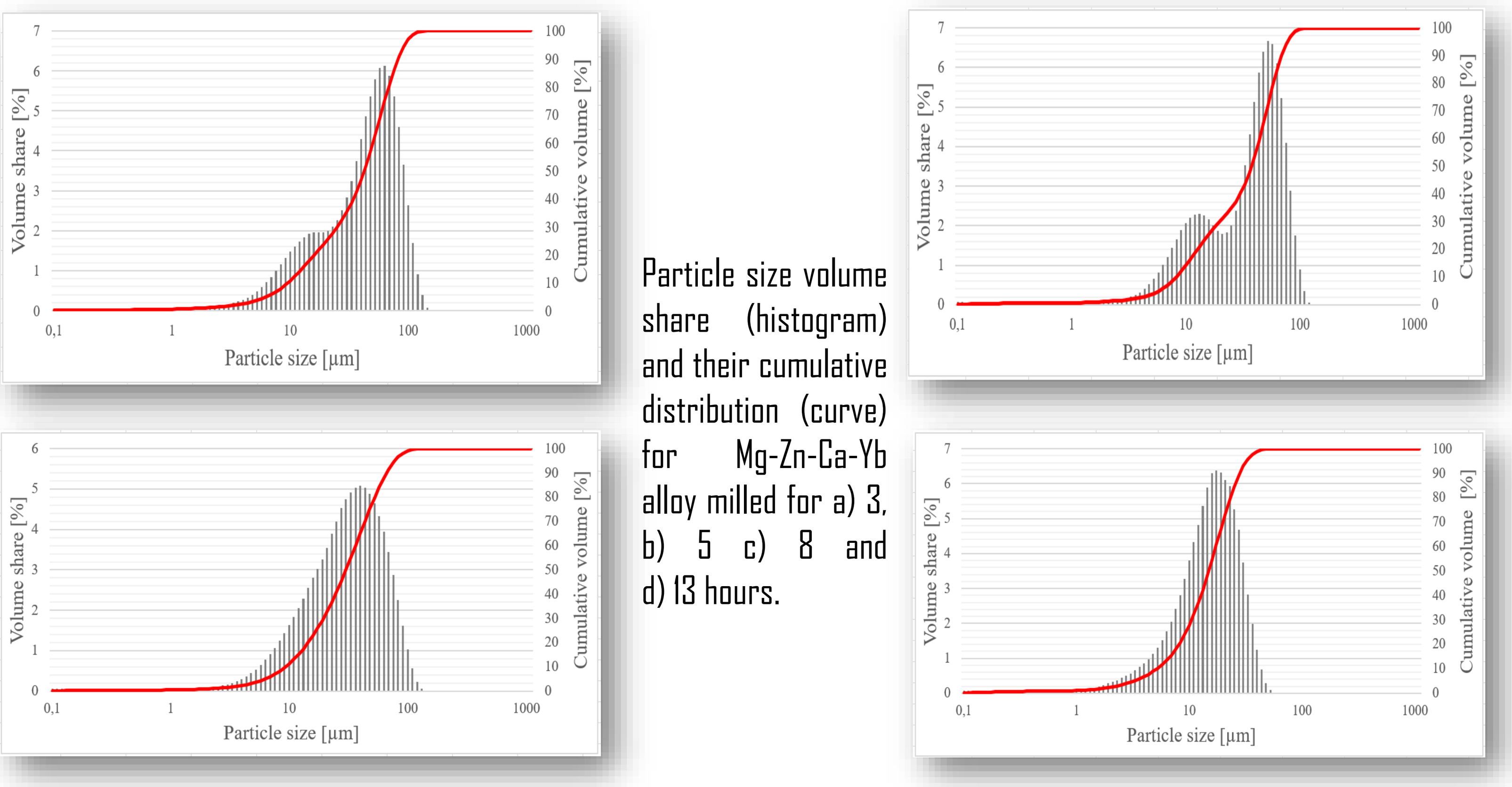
ABSTRACT

Magnesium-based alloys are widely used in the construction of the automotive, aviation and medical industries. There are many parameters that can be modified during the synthesis in order to obtain an alloy with the desired microstructure and advantageous properties. Modifications to the chemical composition and parameters of the synthesis process are of key importance. In this work, Mg-based alloy with a rare-earth element addition was synthesized by mechanical alloying (MA). The aim of this work was to study the effect of milling times on Mg based alloy with a rare-earth addition on the structure and microhardness. A powder mixture of pure elements was milled in a SPEX 8000D high energy shaker ball mill under an argon atmosphere using a stainless steel container and balls. The sample was mechanically alloyed at milling times: 3,5, 8 and 13 h with 0.5 h interruptions. The microstructure and hardness of samples were investigated. The Mg-based powder alloy was examined by an X-ray diffraction (XRD), scanning electron microscopy (SEM) and a Vickers microhardness test. The results showed that the microhardness of the sample milled for 13 h was higher than that of milling time of 3, 5 and 8 h.

AIM

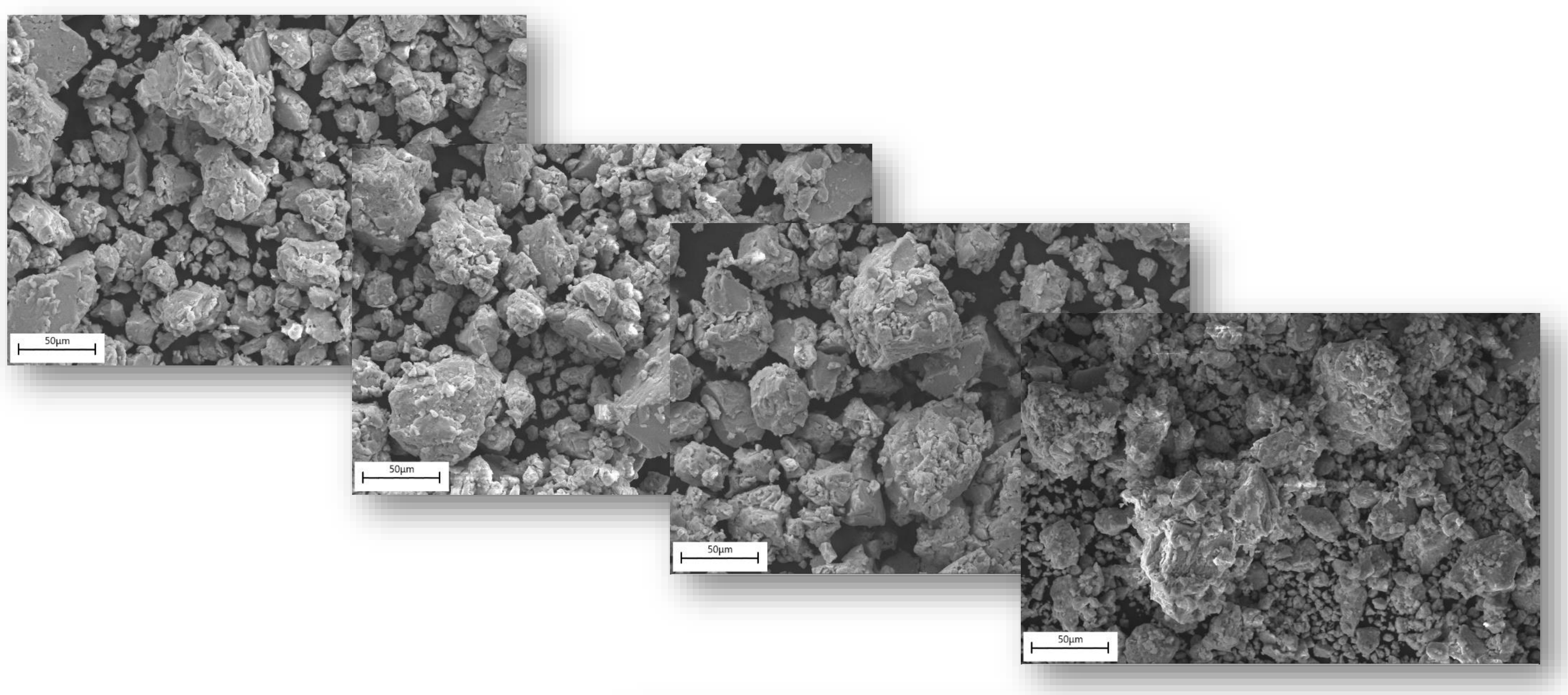
Synthesis of Mg-based alloys with a rare-earth element (ytterbium) addition by mechanical alloying to study the effect of milling times on the structure, morphology and microhardness

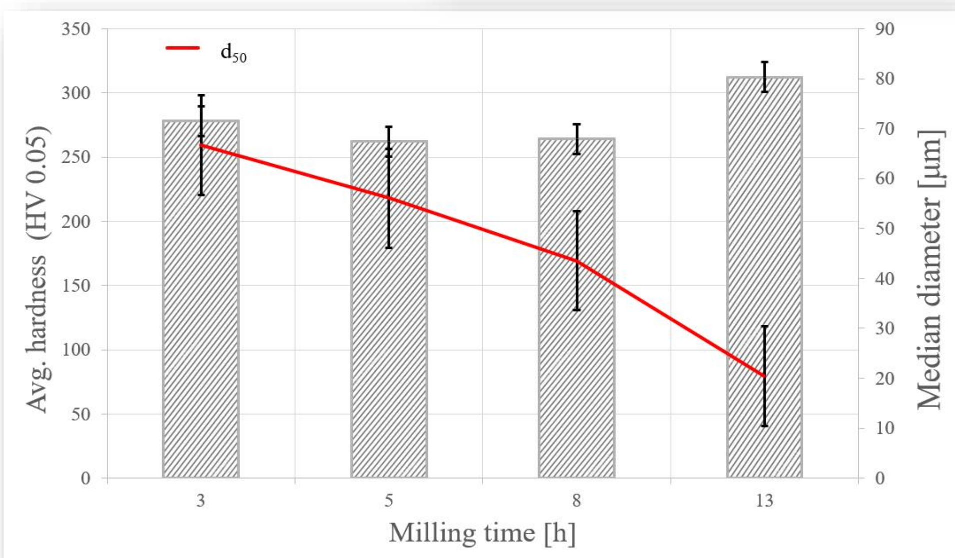
RESULTS



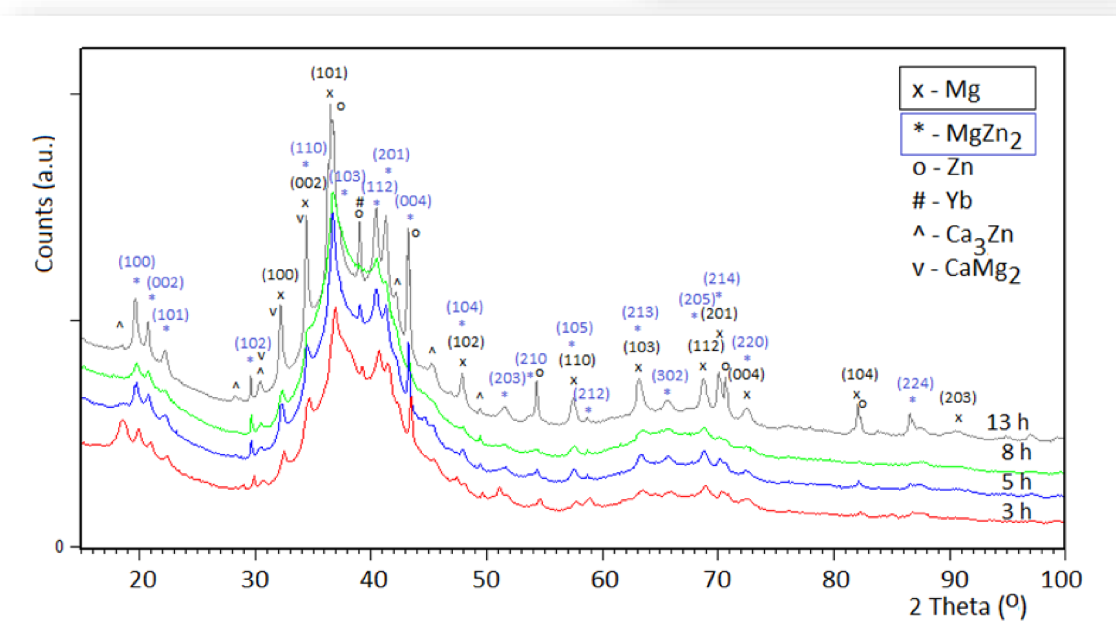
Particle size volume share (histogram) and their cumulative distribution (curve) for Mg-Zn-Ca-Yb alloy milled for a) 3, b) 5 c) 8 and d) 13 hours.

SEM images of the Mg-Zn-Ca-Yb powders milled for 3, 5, 8 and 13 h





Effect of milling time on microhardness (HV) and median diameter (d_{50}) determined for each powders



X-ray diffraction patterns of the Mg-Zn-Ca-Yb powders milled for 3, 5, 8 and 13 h

METHODOLOGY

The high purity elements (> 99.5%) Mg, Zn, Ca and Yb, were mechanically alloyed in a dual high-energy ball mill (SPEX 8000D). We conducted mechanical alloying (MA) in an argon atmosphere, for a different duration of 3, 5, 8 and 13 h. The constituent phases of the mechanically alloyed powders were examined by the X-ray diffraction (XRD) technique (PANalytical Empyrean Diffractometer) was analyzed. The powder morphology in a scanning electron microscope (SEM, Zeiss SUPRA 35) was studied. The energy-dispersive spectrometer EDS (Trident XM4 EDS with 20 kV of accelerating voltage) analysis was carried out on the samples. Particle size analysis using ImageJ Software was done. For the determination of particle size distribution (PSD) of powders laser particle size measuring instrument (Fritsch Analyssette 22 MicroTec+) was used. The microhardness tests were carried out on polished samples using a Vickers hardness tester (Future-Tech FM700) with a a load 50 grams of force applied for 15 second.

CONCLUSIONS

The XRD diffraction pattern analysis showed that the milling process (gradually for 3, 5 and 8 hours) leads to formation two main nanocrystalline phases: α-Mg solid state solution and and intermetallic $MgZn_2$ phase. The crystallite size of both phases are in a range of 200 – 400 Å.

The compositional homogeneity of the alloys remained consistent with the intended chemical composition.

The alloy milled at 13 hours of milling time provided the highest value of microhardness which was 312 HV. The saturation of hardness is related to the narrow dispersion of particle sizes ((d_{10}= 6.5, d_{90}=41 µm) occurring in the last stage of MA. The particle sizes of the powders decreased with increasing milling time. The values of the median diameter (d_{50}) were calculated 66, 56, 43 and 20 µm for Mg-Zn-Ca-Yb after 3, 5, 8 and 13 h milling time, respectively.

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