

XRD AND MORPHOLOGY ANALYZES OF HIGH-NITROGEN Fe-Cr-Mn ALLOY POWDERS SYNTHESIZED BY MECHANICAL ALLOYING

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[ENGINEERING OF BIOMATERIALS 138 (2016) 95]

Introduction

Nowadays, nickel-free high-nitrogen austenitic stainless steels are attractive materials in the biomedical field. They can be substitutes for Cr-Ni stainless steels, due to biocompatibility, good corrosion resistance and mechanical properties [1-3]. Nickel is an element occurring in conventional steels. It's a toxic element which causes allergies [4]. Nitrogen can be a replacement for nickel. The addition of N not only stabilizes the austenite phase but also causes beneficial effects on the steel properties, such as better corrosion resistance and improved mechanical properties and [3,4].

Materials and Methods

A prealloyed Fe-Cr powder were mechanically alloyed (MA) with 18%Mn (in wt.%) powder with powder size 45 μ m and purity of 99,95%. MA process was performed in a high-energy ball mill Pulverisette 5 (Fritsch, Germany) equipped with a stainless steel jar and balls with a rotation speed of 250 rpm, in pure nitrogen atmosphere (99.998%). Ball to powder weight ratio of 10:1 was used. At selected times a small amount of as-milled powder was taken out for further morphology and XRD analyses. To minimize air contamination of the powder, loading and unloading of the powder was performed in an argon glove box. MA process was conducted up to 150 h until the solute elements peaks in XRD patterns had disappeared. The crystallite size was determined by measuring the Bragg peak width at half the maximum intensity using Sherrer formula [5]. The powder morphology was studied using scanning electron microscopy (SEM), equipped with an energy dispersive spectrometry (EDS) system.

Results and Discussion

The morphological changes exhibited during mechanical alloying are presented in FIG. 1.

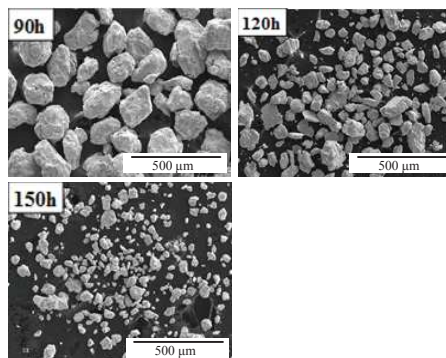
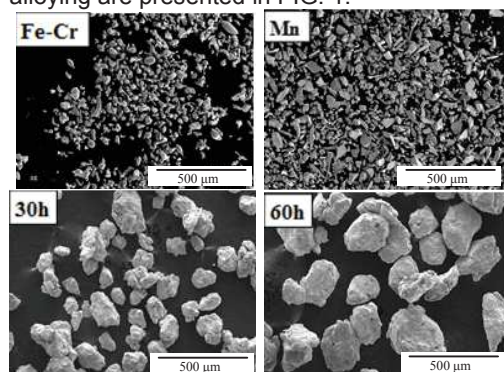


FIG. 1. SEM images of as-milled Fe18Cr18Mn powders at different processing times: 30, 60, 90, 120 and 150h.

The particles of unmilled Fe-Cr powder are irregular in shape and particles of Mn powder are flattened. At the early stage of the process (30h) the particles are deformed, but after 90h particles are more oval in shape. After 120 hours, two types of particles are observed, the small ones are more regular in shape, while the bigger ones are deformed. The particle size increases until 60 hours of a milling time and then decreases. After 150 hours size of a single particle reaches 9.86 μ m. Cisneros M.M. et al. [4] shows similar researches, but he presents various shapes of powders at different times of milling.

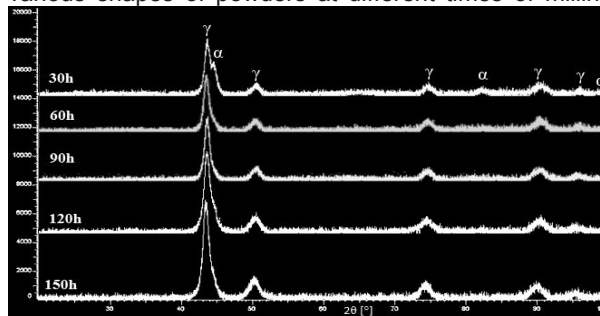


FIG. 3. XRD pattern of Fe-18Cr-18Mn powder milled.

After 30 hours of MA under argon atmosphere, at the first peak the austenitic-ferritic phase occurs, but after 60 hours, when the atmosphere is changed into nitrogen, the ferritic structure disappears and the dominant crystalline phase is austenitic (FIG. 3). With progression of the MA process the intensity of the XRD peaks is increased. Amini R. et al. [3] shows that after 24 hours of MA in nitrogen atmosphere the dominant phase at the first peak is ferrite. However, in his research, powders with less amount of manganese were analysed (8% Mn and 18% Cr). After 60 h the crystallite size was 10.30nm, then decreases and after 150 hours of MA it reached 8.38nm.

Conclusions

The nickel-free austenitic stainless steel Fe18Cr18Mn was produced by mechanical alloying under argon atmosphere for the first 30h and then under nitrogen atmosphere. In the beginning of researches the particle size was 45 μ m, and after 150 hours milling it reached 9.86 μ m. The material structure was transformed from an α -phase into γ -phase. The intensity of XRD peaks increased along with duration of the MA.

References

- [1] E. Salahinejad, R. Amini *et al.*, Powder Technol. 215-216 (2012) 247–253.
- [2] M. Sumita, T. Hanawa *et al.*, Mate. Sci. Eng. C 24 (2004) 753–760.
- [3] R. Amini, M.J. Hadinafard *et al.*, J. Mater. Sci. 44 (2009) 136-148.
- [4] M.M. Cisneros, H.F. Lopez *et al.*, Metall. Mater. Trans. A 33A (2002) 2139-2144.
- [5] A. Khorsand Zak, W.H. Adb. Majid *et al.*, Solid State Sci. 13 (2011) 251-256