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Role of A_2 and A_{50} process on the oxide dispersion strengthened ferritic alloy fabricated by mechanical alloying

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ABSTRACT

This study has investigated the effects of adding occasion of Stearic Acid (SA) on the characteristics of powder and properties of bulk with nominal composition of Fe–12Cr–2.5 W–0.4Ti–0.3Y_2O_3, which was fabricated by mechanical alloying and vacuum sintering. SA was milling with the powder mixture with 50 h (added before milling, A_{50}) or 2 h (added after 48 h milling, A_2). The resulted showed: SA could inhibit the agglomeration and retard the alloying process. Powders through A_2 process achieved alloying with high powder yield, while the A_{50} powders presented alloying extent, and the yield of A_0 powder presented low powder yield. SA added in A_{50} was almost dissolved into the matrix for the long milling duration, but SA added in A_2 was mostly volatilized during heating. A_2 bulk alloy was of better strength for the finer, more uniform grain and second phase and higher density than A_{50} bulk.

1. Introduction

Mechanical alloying (MA) is a solid state process in which the powder mixtures are mechanically milled by balls with high energy. This method was usually used to fabricate supersaturated solid solution, quasi-crystalline, amorphous nanocrystalline materials, etc. [1–5].

During MA, powder particles are made to be cold welded and fractured due to high energy collision. Thus the compressibility of powders was severe and the powder field was low because of the serious work hardening and adhesion of powders on the milling mediums [6,7]. Process control agent (PCA) is a surface additive normally used in MA process to retard the direct contact of fresh surfaces of powder particles [8–10], so the agglomeration could be effectual inhibited and powder yield could be increased.

However, PCAs are usually added into the powder mixture prior to MA, so the interdiffusion between particles would be retarded for the avoiding of cold welding [11,12]. Meanwhile PCAs containing C, H, O atoms could decompose in the long duration of milling and exist as impurities after consolidation of MA powders [13,14].

In order to optimize the characteristics of alloyed powders, mainly including alloying extent, morphology and powder yield, Stearic Acid (SA), one of the normal PCA used in the Fe-based alloys system [9,15], was added into the powder mixture in two different ways. Furthermore, the properties of bulk alloy were also investigated.

2. Experimental procedures

Elemental powders were used to prepare Fe-based alloy with nominal composition of Fe–12Cr–2.5 W–0.4Ti–0.3Y_2O_3 in wt.%. The iron powder had a purity of more than 99.5 wt.% pct, with a average particle size of 6 μm, while corresponding values for chromium, tungsten, titanium and yttrium oxide powder used were 99.95, 99, 99, 99.5 wt.% pct and 75 μm, 60 μm, 54 μm, 50 nm, respectively.

Mixture of elemental powders were mechanically alloyed in an attrition-type ball mill using stainless steel vials and balls, with the ball to powder weight ratio of 20:1. Two sizes of balls were used (6 and 10 mm in diameter) with the weight ration of 3:1, and the total weight of balls filled in each vial was 600 g. The rotational speed was 220 rpm, and milling duration was 50 h. 2 wt.% SA was added into mixture of powder in two different ways: (a) added before MA and milled together with powders for 50 h, signed as A_{50}; (b) added after 48 h MA, and milled together with powders for 2 h, signed as A_2. Powders without milling and powders milling for 50 h without SA, which were signed as A and A_0 respectively, were prepared for comparison.

A_2 and A_{50} compacts with the size of $43 \times 7 \times 4\ mm^3$ were obtained by uniaxially cold-pressed at compressive pressure of 600 MPa after MA. Then the compacts were vacuum sintered (10^{-3} Pa) at 1300 °C, 1350 °C, 1380 °C and 1400 °C respectively for 1 h.

In order to estimate the pollution caused by SA, TGA was used to investigate the residual SA in A_{50} and A_2 powders after heating, with the temperature ranged room temperature to 400 °C and Ar_2 atmosphere protection. Powders before and after milling, sintered

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