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The effects of the dispersant on the Powder Morphology of Nb-Ti-Cr-Si Based Ultrahigh Temperature Alloy

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Abstract: The effects of the process control agent on the powder morphology of Nb-Ti-Cr-Si based ultrahigh temperature alloy were investigated. The results showed that the alcohol as a dispersantt reduced the powder agglomeration, and the stearic acid as a dispersant reduced the agglomeration of the powder greatly.

Keywords: powder agglomeration ; agglomeration ; dispersant

INTRODUCTION

Nb-silicide based ultrahigh temperature alloys have been studied as alternative materials to Ni-based super alloys because of their high melting points, low densities, and favorable mechanical properties[1-4]. However, a major barrier to their practical applications is their poor high temperature oxidation resistance[4-6]. In order to achieve a balance among properties of good creep strength, excellent oxidation resistance and acceptable fracture resistance, the volume fraction and the morphology of each constituent phase must be controlled reasonably. It was found that addition of a higher content of Cr improved the high temperature oxidation resistance due to formation of the Laves phase[4-8], so the new Nb–Ti–Cr–Si based alloys have attracted ever increasing attentions. Their phase constituents are Nb solid solution (Nbss), $(Nb,X)_5Si_3$(X represents Ti,Hf and Cr elements) and Cr_2Nb. Among these three phases, Nbss is introduced to improve the ambient temperature fracture resistance, while the silicide and Laves phases are introduced to improve high temperature creep strength and oxidation resistance.

However, the Nb-Ti-Cr-Si based alloys possessed worse room temperature fracture toughness and higher temperature strength but better high temperature oxidation resistance than two phases Nb–Si based alloys. So some new technologies were applied to improve the fracture toughness such as directional solidification and powder metallurgy method, and the shortcoming of directional solidification is microstructure uniform and crakes in the alloy[9]. However, the powder metallurgy could overcome this shortcoming. But the powder agglomeration problem existed in the process of powder metallurgy. The harmful agglomeration would make the ultra-fine powder re-gathered into larger particles, different morphology, or even sintering state which reduce the mechanical properties[10-12]. This paper puts forward the measures to solve the problem of powder agglomeration. The effects of dispersant as alcohol and stearic acid on the agglomeration of Nb-Ti-Cr-Si based ultrahigh temperature powders were investigated.

1. EXPERIMENTAL METHOD

The pure Nb, Ti, Cr and Si powder with purity of more than 99.99% were selected. The powder were carried at 10, 20, 30 and 40 h on the high energy ball mill respectively and the rotational speed was 200 r/ min. The micostrual morphologies were compared without the addition of dispersant, the addition of alcohol and stearic acid. The x-ray diffraction experiments showed that no compounds were formed under various ball mills. The morphology of the microstructures was measured by scanning electron microscopy (SEM).

2. RESULTS

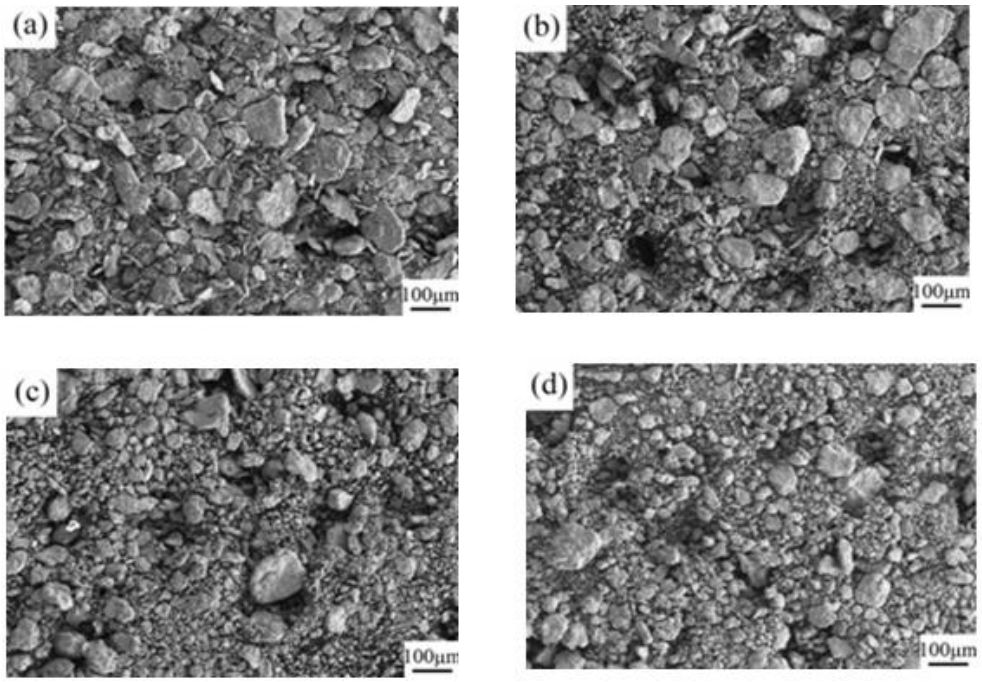

Fig 1: The SEM of the ball mill powder with different time at speed 200rpm

2.1 The morphology of powder without dispersant: Figure 1 shows the SEM image of the powder at a speed of 200r/min for 10, 20, 30 and 40h. The morphology for 10h shows a large sheet, and the slice between the gaps is small, so the distribution of particle is wide, and the agglomeration phenomenon is not serious. After ball mill for 20h, the powder agglomeration is aggravated, and the large sheet morphology changed into smaller particles, so the nucleation formed and the nuclear grown up. The gap between the particles is more obvious. It can be seen that the powder agglomeration is aggravated with time increase, and the power agglomeration with large particles was caused by the attraction force.

2.2 The morphology of powder with alcohol dispersion: Figure 2 shows the SEM image with alcohol dispersion with ball mill for 10h. It can be seen that the distribution of the particles is more uniform, and the powder aggregation is eliminated. The distribution range of particles is narrow. However, the powder agglomeration is aggravated with ball mill time increase, and the large particles are presented. The gap between the particles is obvious, even forming serious agglomeration, which affected its mechanical properties. Analyze the reason, the powder after ball milling was placed for a long time, so the alcohol is volatile, and the role of dispersant was loss. The powder is easy to absorb the O, CO and so on, so the powder agglomeration was presented once again, and the powder agglomeration was more serious.

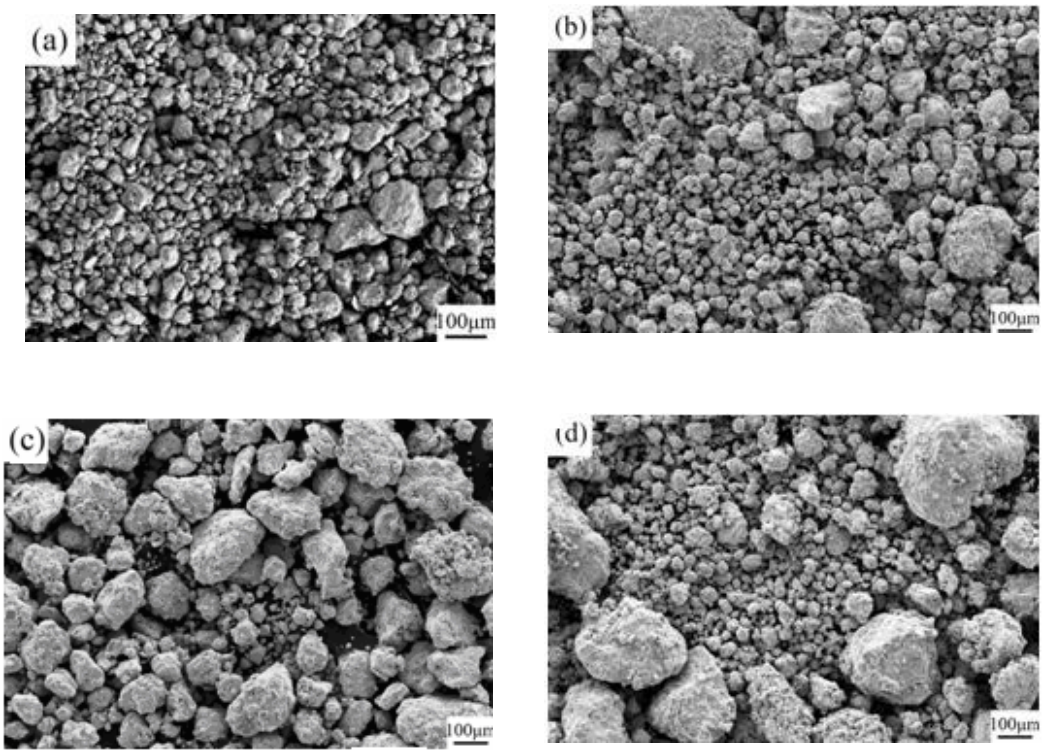

Fig 2: The SEM of the ball milling powder with different time at 200rpm with addition of alcohol

2.**3 The morphology of powder with stearic acid:** Figure 2 shows the SEM image with addition of stearic acid with ball milling for different time. It can be seen that the particle size was uniform, and the agglomeration of powder was reduced for a certain, but some large particles were presented and the agglomeration was not eliminated. With the ball milling time increase, the particle size is distributed uniform, and the particles is bright with smaller gap. So the agglomerate of powder is eliminated, and the powder shows spherical morphology which is the idea morphology.

Compared with the experimental results of different dispersant, it was found that the dispersant as alcohol could deal with the problem of powder agglomeration, but not lasting. Because the alcohol evaporates, the amount of dispersant was reduced during the ball milling. The amount of dispersant to the agglomeration effect is different.

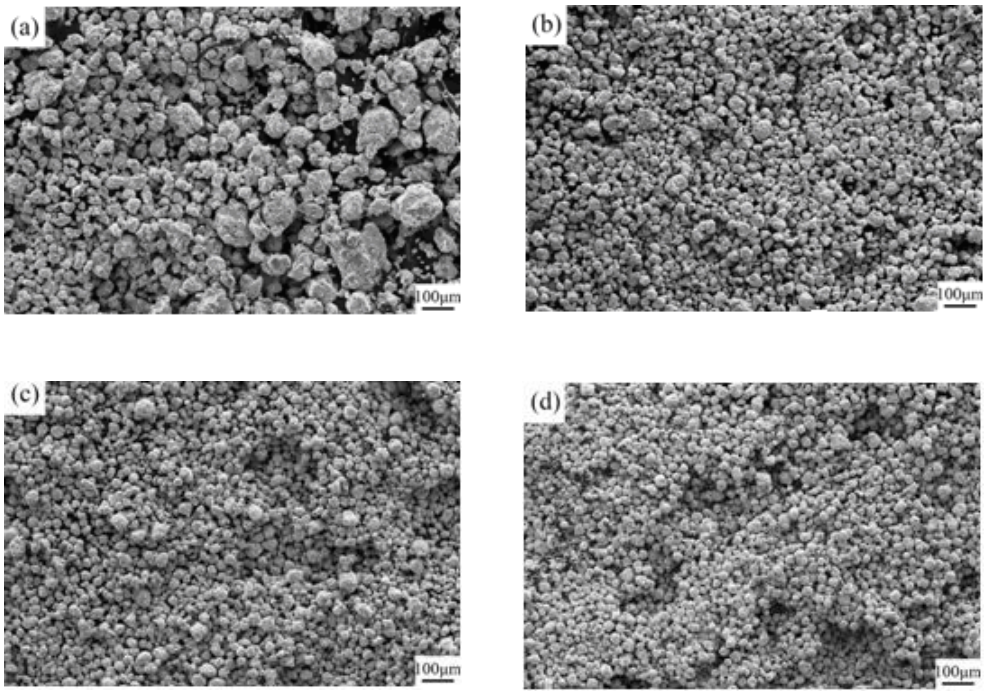

Fig. 3: The SEM of the ball mill powder with different time at speed of 200rpm

Compared with the experimental results of no dispersant and with addition of stearic acid, it was found that the stearic acid is a kind of dispersant for the Nb, Ti, Cr and Si powder

Compared with the results of alcohol dispersant and stearic acid, it was found that the alcohol was volatile easily, and the powder could be effected by the O_2 and CO_2 in the air, but the stearic acid is not affected. The morphology of the powder after treatment with stearic acid is clear and is distinguished. There is no coarse particles, and the size of particle is distributed uniformly.

3. RESULTS

- The alcohol as a dispersant, with the ball milling time increase, the agglomeration is more serious.

- The stearic acid as a dispersant, the powder agglomeration greatly reduced, indicating that the alloy powder is a good dispersant stearic acid.

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