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Particle Size Characterization of Ferritic Oxide Dispersion Strengthened Alloy Powders

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Abstract

Ferritic oxide dispersion strengthened (ODS) alloys are candidate materials for use in extreme applications due to their excellent high temperature strength. $Fe_{81}Cr_{16}Mo_3$ and $Fe_{81}Cr_{16}Al_3$ alloys were ball milled for various durations with 0.5 wt. % Y_2O_3 nanometer sized particles prior to consolidation via spark plasma sintering (SPS). The particle size characterization was completed using optical microscopy, scanning electron microscopy (SEM), and laser scattering. The median particle size of $Fe_{81}Cr_{16}Mo_3$+0.5 wt. % Y_2O_3 powder increased from 9μm to 31μm after 16 hours of milling and then decreased to 28.9 μm after 40 hours of milling. On the contrary, the median particle size of $Fe_{81}Cr_{16}Al_3$+0.5 wt. % Y_2O_3 powder decreased from 13.2 μm to 6.1μm after 16 hours of milling and increased to 20.4 μm after 40 hours of milling.

Disciplines

Materials Science and Engineering

Particle Size Characterization of Ferritic Oxide Dispersion Strengthened Alloy Powders

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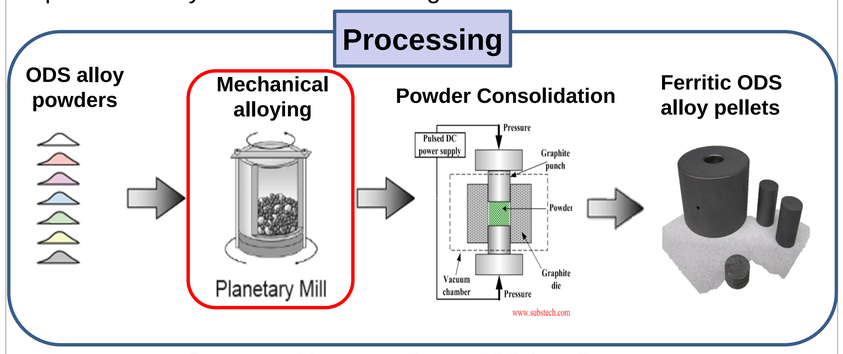
Introduction

Ferritic oxide dispersion strengthened (ODS) alloys are attractive candidates for applications in the high temperature industries due to their:

- superior elevated temperature strength,
- creep resistance, and
- irradiation resistance.

The dispersed oxide combine with other elements to form nano-meter sized features which are stable up to very high temperature. These features are important to the microstructure because they impede dislocation motion [1]. In this study, the effects of ball milling on the particle size distribution of two ferritic alloys was characterized to gain insight into sintering mechanisms during consolidation. The processing steps of the alloys are shown in the figure below.



Processing Methods of Ferritic ODS Alloy Powders

Experimental Methods

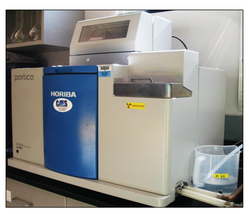
$Fe_{81}Cr_{16}Mo_3$ with 0.5 wt% Y_2O_3 (FCMY) and $Fe_{81}Cr_{16}Al_3$ with 0.5 wt% Y_2O_3 (FCAY) alloys were separately milled in a Retsch Planetary Ball Mill PM100 at 500 RPM for 16 hours and 40 hours. The particle size characterization of FCMY and FCAY was completed using following techniques:

- Scanning electron microscope (SEM).
- LA-950 Horiba laser scattering particle size analyzer (PSA).

The steps for particle size characterization of FCMY and FCAY using LA-950 laser scattering PSA wet method are:

- Set the parameters for measurement:
  - Refractive Index: 1.8-0.5i
- Fill LA-950 with DI water.
- Activate circulation and agitation.
- Depress alignment to get proper alignment.
- Depress Blank to take a background reading of the dispersant.
- Transfer 2-3 grams of sample to the funneling area.
- Take measurement when distribution is stable.

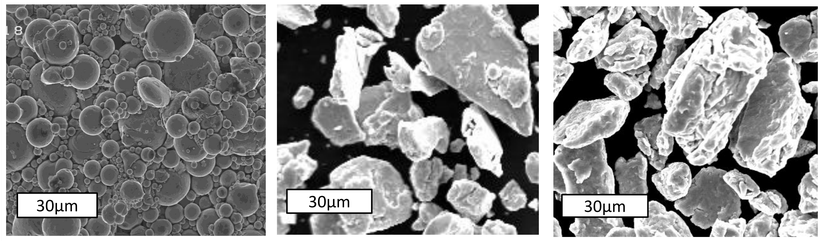
Retsch Planetary Ball Mill PM100



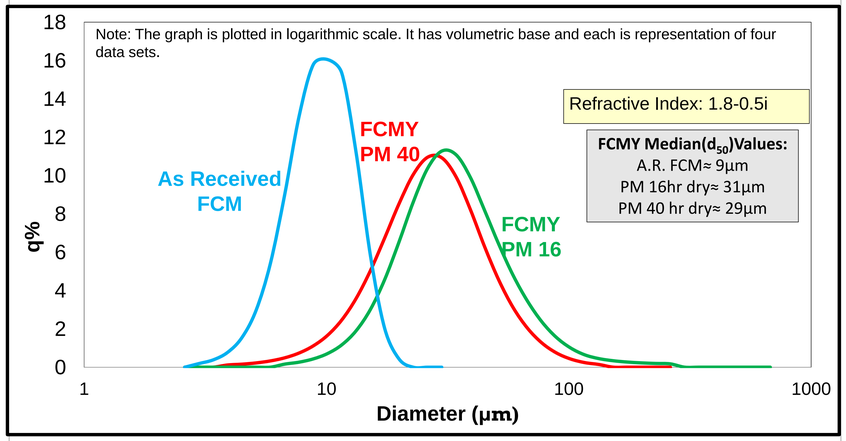
LA-950 Horiba Laser Scattering Particle Size Analyzer (PSA)

Results

Particle Size Characterization- $Fe_{81}Cr_{16}Mo_3$ Alloy



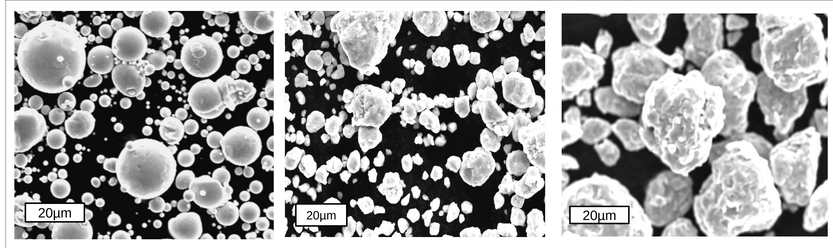
SEM image of as-received FCM | SEM Image of FCMY milled for 16 hours | SEM Image of FCMY milled for 40 hours



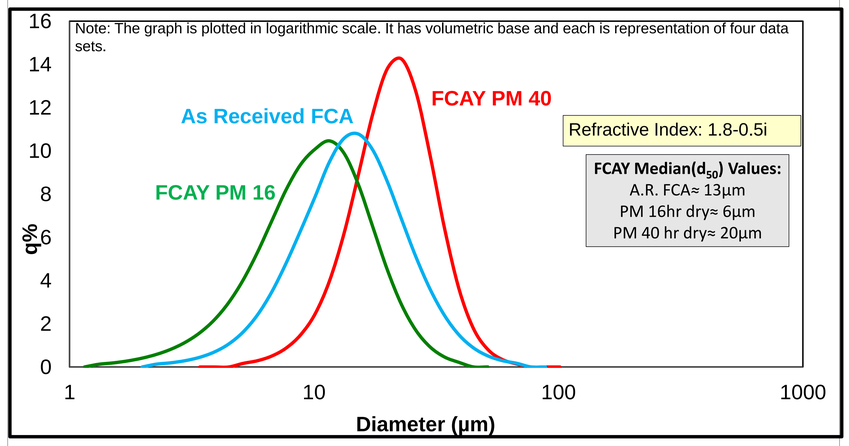
Particle size distribution of as-received FCM, FCMY milled for 16 hours and FCMY milled for 40 hours

FCMY	As Received	16 Hour Milling	40 Hour Milling
Median values	9 µm	31 µm	29 µm

Particle Size Characterization-$Fe_{81}Cr_{16}Al_3$ Alloy



SEM Image of as-received FCA | SEM Image of FCAY milled for 16 hours | SEM Image of FCAY milled for 40 hours



Particle size distribution of as-received FCA, FCAY milled for 16 hours and FCAY milled for 40 hours

FCAY	As Received	16 Hour Milling	40 Hour Milling
Median values	13 µm	6 µm	20 µm

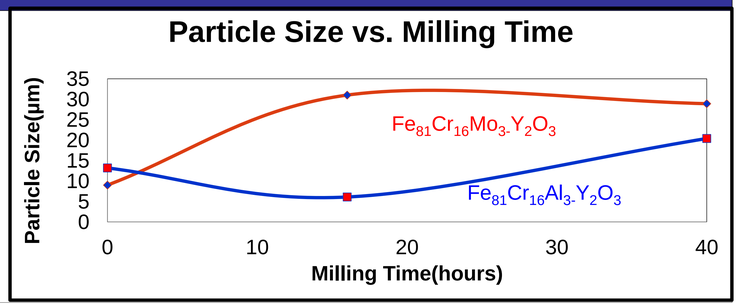
Conclusions

FCMY

The median particle size increased with milling. The increase in particle size is presumably from cold welding.

FCAY

The median particle size decreased after 16 hours of milling. This decrease is due to breaking of particles into smaller pieces from the impact of milling media.
The median particle size increased after 40 hours of milling time. The increase in particle size is presumably from cold welding.



References

[1]. Yingli Xu, Zhangjian Zhou, Ming Li, Pei He, “Fabrication and characterization of ODS austenitic steels, ” *Journal of Nuclear Materials* (2010)

Acknowledgements

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