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The effect of alloy powder morphology on microstructural evolution of hot worked P/M FeAl

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ABSTRACT

Purpose: This paper presents the results of the research focused on the influence of both the starting FeAl alloy powder particle characteristics and the thermomechanical processing parameters on the microstructural evolution of these materials.

Design/methodology/approach: Fully-dense FeAl alloy powder compacts were tested in compression on servo-hydraulic Gleeble testing machine, at the temperature range of 700°C to 1100°C, and at strain rates of 0.1 s^{-1} and 10 s^{-1}. After processing, the microstructure of each deformed specimen was examined using optical microscopy.

Findings: Considerable strain rate sensitivity of the investigated alloy was observed, especially with reference to microstructural development. The use of alloy powders in thermomechanical processing of FeAl alloys can substantially enhance the possibility to control both the microstructure and mechanical behavior of these alloys.

Research limitations/implications: The influence of starting FeAl alloy powder particle morphology and processing strain rate on the microstructural evolution of investigated alloy was discussed.

Practical implications: The results of this research could be directly employed in the design of deformation schedules for the industrial processing of FeAl alloys.

Originality/value: FeAl alloy powder morphology influences the thermomechanical processing of P/M FeAl alloys, what was proved in this paper.

Keywords: Metallic alloy; FeAl alloys; Strain rate; Microstructural evolution; Powder metallurgy

MATERIALS

1. Introduction

Iron aluminides are widely investigated for potential structural and non-structural applications [1, 2] because of their low density and good oxidation and corrosion resistance [3]. Moreover, FeAl alloys are nonmagnetic, and possess a relatively high electrical resistivity making them potentially attractive for heating element applications. These materials can be produced by both cast techniques [4-7] as well as various powder metallurgy (P/M) methods can be used to produce these materials. Fully dense FeAl products have already been successfully fabricated by both extrusion [8, 9] and cold rolling [10, 11] of alloy powders. The room temperature mechanical properties of these alloys, particularly the combination of ductility and strength, are known to be sensitive to the processing-induced microstructure [12]. In this respect, powder metallurgy methods are very promising, since much finer microstructures can be produced.

Recent studies have pointed out the importance of starting powder particle nature (particle shape, size or powder surface oxide content) in relation to the processing of P/M FeAl alloys [13-15]. This research is primarily focused on evaluating the influence of both the starting FeAl powder particle characteristics

structure, where the oxides are in general fewer in number and more agglomerated.

Hot compression at a strain rate of 10 s^{-1} caused comparable level of the grain refinement in both investigated materials even at 800°C (Fig. 5b and Fig. 6b). Moreover, the structures of both the water and gas-atomized powder material processed at 900°C are more uniform and finer-grained than those of the materials deformed at the lower strain rate of 0.1 s^{-1}. Average grain size of 4 μm was obtained for the water atomized and gas atomized materials processed at 900°C. From a comparison of Figures 4c and 6c one can see that the gas-atomized material deformed at 900°C at the higher strain rate underwent less grain growth. This is presumably the result of the shorter time at temperature due to faster overall test time.

At higher processing temperatures (above 900°C), considerable grain growth could be noticed, more evident in the case of gas-atomized powder material (Figures 3d,e÷6d,e).

4. Conclusions

- FeAl alloy powder morphology substantially influence the thermomechanical behavior of P/M FeAl alloys;
- None of investigated powder materials (water and gas atomized powder samples) deformed at the strain rate of 0.1 s-1 recrystallized at 800°C. At higher processing temperatures, dynamic recrystallization resulted in grain refinement, with subsequent grain growth, more evident in the case of the gas atomized powder material;
- Deformation at a strain rate of 10 s^{-1} caused refinement of the structure in both investigated materials even at 800°C.
- At higher processing temperatures (above 900°C), considerable grain growth could be noticed, more evident in the case of gas-atomized powder material, what can most likely be attributed to the vastly different oxygen contents of the starting powders. Due to the highly irregular nature of the water-atomized particle shapes, there are much greater amounts of oxide, presumably increasing the stability of the structure of this material.

Acknowledgements

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