Characterization of phase transformations in Ti-xCo alloys

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Abstract

This study aimed to determine the composition effect on the phase transformations and hardness in Ti-xCo alloys. The results suggest that their mechanical behavior can be specifically tailored by controlling their phase transformations.

Key words:
Titanium alloys, microstructure, hardness.

Introduction

Titanium (Ti) alloys are very attractive engineering materials due to their outstanding properties, such as high strength to weight ratio, elevated corrosion resistance, and biocompatibility1. Depending on composition and thermoprocessing route, these alloys exhibit a variety of phases that directly affect their mechanical behavior2, so a comprehensive understanding of phase transformations in Ti alloys is of paramount importance for proper controlling of their mechanical properties.

As an alloying element, Cobalt (Co) promotes stabilization of the $\beta$ phase and formation of the Ti$_2$Co intermetallic compound. Although some investigations on Ti-Co alloys reported interesting mechanical properties3, many of the influence of addition of Co in Ti is still unknown. Therefore, this study intends to evaluate the composition effect on the phase transformations and hardness in Ti-xCo ($x = 2, 4, 6$ and $8.5$ wt.%) alloys.

Results and Discussion

The produced samples were solution treated at 1000 °C for 1h and cooled at different rates: FC (furnace cooling), AC (air cooling), and WQ (water quenching). Figure 1 shows the Vickers hardness values obtained for each condition. For the FC and AC samples, the hardness increased with Co content. However, this increase was more pronounced in the AC samples. The FC samples exhibited coarse microstructures composed by $\alpha$ and Ti$_2$Co phases. The AC samples presented similar microstructures, but they were much more refined due to the higher cooling rate. Figure 2a and b depict the FC and AC microstructures for the Ti-6Co alloy, respectively. It should be noted that the volume fraction of Ti$_2$Co increases with Co content.

The WQ process caused the hardness to increase significantly, except for the Ti-8.5Co alloy. Observation of WQ microstructures showed that 6 wt.% of Co was enough to avoid martensite formation during quenching, as shown in Figure 2c.

Figure 2. Microstructures of the Ti-6Co alloy after solution heat treatment and (a) FC, (b) AC, (c) and WQ.

The WQ samples were further aged at 500 °C for 1h. This heat treatment led to hardness values varying from around 370 to 460 HV when Co content varied from 2 to 8.5 wt.%, respectively.

Conclusions

The composition coupled with the thermal history had a great influence on the morphology, distribution and fraction of the phases formed. Accordingly, a large range of hardness values was obtained, suggesting that the mechanical behavior of Ti-Co alloys can be specifically tailored by controlling their phase transformations.

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References


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