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Self-Peening of Titanium Alloys with Ti-Based Shot

INTRODUCTION

Surface contamination from shot peening is a well accepted, but less often reported, consequence of shot-based surface modification processes. Residue from shot material on treated surfaces has been reported to decrease corrosion performance for Al, Fe and Mg alloys [1-3]. It would seem logical that using shot media with a similar chemical composition to the target material, i.e., self-peening, could be a possible solution to minimize surface contamination incurred by shot peening. Since Ti alloys are often used in corrosive environments (from chemical processing to biomedical implants), offering a self-peening solution for these alloys may be particularly helpful to assuage any fears about surface chemical contamination. This study shows a new process to harden Ti powder that can then be used as shot media for self-peening. The performance of the Ti-shot was evaluated in regards to the surface composition after shot peening and the residual stress evolved from shot peening, and then compared to peening with glass bead media.

CREATING TITANIUM SHOT

Production of the Ti-based shot media requires a single step and low temperature heat exposure that allowed for controlled oxidation. The process did not cause the sintering of titanium particles. The same process was applied to a bulk piece of commercially pure grade 2 Ti (Cp-Ti) that had an approximate composition to the powder to measure compositional changes and hardness changes resulting from the processing (see Figure 1-c). Compositional measurement shows that a large concentration of oxygen is present near the surface. This has resulted in nearly the tripling of the surface hardness in relation to the as-received hardness of the titanium, and even surpassed hardness of Ti21s after age hardening. Nanoindentation hardness measurements performed on the processed Ti powder coincide with the bulk measurements. SEM microscopy of the powder shows that the surface is covered in small islands of titanium oxide (see Fig. 1 a-b). Consequently, the tripling of the hardness of the processed Ti powder is caused by solute hardening from oxygen ingress into titanium and oxide islands on the surface.

SELF-PEENING TITANIUM

Specimens of Ti-64 were shot peened with glass beads (SiO_2) and Ti-shot. The SiO_2-shot had an average diameter of 300 µm and the Ti diameter was, on average, 100 µm, and densities of 2.52 and 4.50 g/cm3, respectively. All specimens were peened with a propelling pressure of 80 psi for 40 seconds on test coupons 20 mm x 20 mm x 1.60 mm. The compositional measurements from Glow Discharge Spectrometry (GDS) (see Fig. 2-a) show that shot peening caused penetration of contaminants from shot media as trace amounts of Si (SiO_2-shot) could be detected 14 µm from the surface. Specimens peened with Ti showed a significantly decreased content of oxygen on the surface, and lesser penetration when compared to the specimen peened with SiO_2. Residual stress profiles produced in each specimen are presented in Fig. 2-b. The residual stress from both SiO_2 and Ti-shot is similar

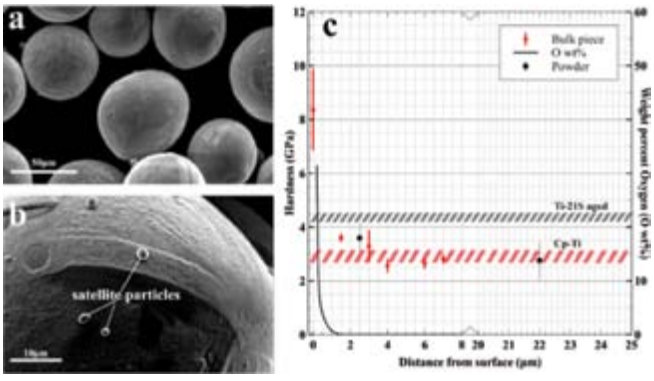

Figure. 1 Scanning electron microscope images (taken with a secondary detector) show (a) surface of treated powder and (b) higher magnification image of surface showing small oxide domains. (c) Oxygen concentration and hardness measurements of treated titanium. Red band shows average range of hardness of Cp-Ti. Grey band shows average hardness range of age hardened Ti-21S, a particularly hard Ti alloy. The surface of the oxidized Ti shot exceeds the hardness of bulk materials.

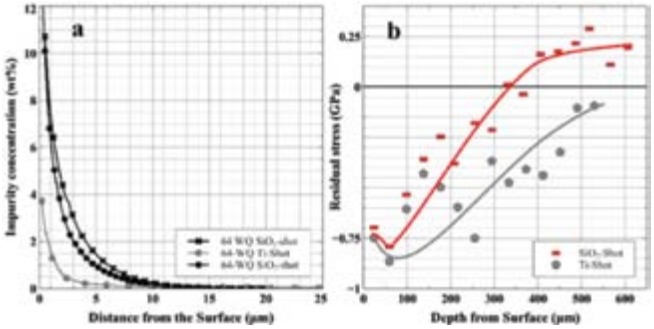

Figure. 2 (a) Glow Discharge Spectrometry quantitative depth profiles comparing surface contamination, and (b) Residual stress measurements of Ti-64 peened with glass and Ti.

in magnitude and penetration, with the smaller Ti-shot producing slightly more compressive residual stress.

CONCLUSIONS

The newly developed Ti-based shot media has been successfully produced and used to peen Ti alloys. Use of Ti-shot clearly minimized the introduction of contaminants to the peened surfaces, providing a proof of concept for justifying the interest in self-peening. Self-peening could eliminate the need of subsequent cleaning processes after peening. The residual stresses produced from Ti-shot were similar to those produced with SiO_2-shot, even though SiO_2-shot was significantly larger. The higher density Ti-shot can achieve similar residual stresses to lower density shot while keeping shot size small and consequently decreasing possible surface roughness. Our next steps will be a comparison to iron-based shot and exploring the effectiveness on larger Ti-shot.

ACKNOWLEDGEMENTS

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