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# FATIGUE MODIFICATION OF TA15 TITANIUM ALLOY WELDMENTS BY AN ULTRASONIC IMPACT TREATMENT

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## ABSTRACT

The welded components of TA15 titanium alloy were ultrasonically impact treated. The fatigue lives were investigated under the same test conditions. The fatigue strength was determined by stair-step method and the residual stresses were analyzed by an X-ray diffraction stress tester. The results show that the fatigue properties of TA15 titanium alloy welded components are sensitive to the surface treatment and ultrasonic impacting can prolong the fatigue lives. The effect of fatigue strength improvement mainly depends on compressive residual stresses and grain refinement.

## 1. INTRODUCTION

Welding is a main jointing method of different metallic components and the fatigue property is a critical issue of the application of welded components. Many surface enhancement processes such as shot peening (Ali, An, Rodopoulos, Brown, O'hara, Levers and Gardiner, 2007), laser peening (Hatamleh 2009), and water jet peening (Tönshoff, Kroos and Marzenell, 1997), were employed to increase the fatigue properties of welded components, and recently ultrasonic impacted peening has been developed and used by aircraft manufacturers (Liu, Wang, Deng, Xia, Huo, Wang and Gong, 2014). Compared with the conventional shot peening which is widely employed in industry, ultrasonic impacting uses the head of a ball to impact the critical local positions of welded components, as shown in Fig. 1. The objective of this work is to investigate the residual stress field induced by the ultrasonic impacting with the focus on its effect on the fatigue performance of welded components.

#### 4. CONCLUSIONS

The welded components of TA15 titanium alloy were ultrasonically impact treated with the characterization of microstructure, the measurement of surface residual stress, fatigue properties and the observation of the fracture surface. The following conclusions can be drawn.

(1) Welding induces tensile residual stresses, while ultrasonic impacting can introduce compressive residual stresses in the surface layer.

(2) An ultrasonic impact treatment increases the fatigue life with an enhancement factor of 1.73 under 500MPa.

(3) An ultrasonic impact treatment increases the fatigue strength from 321MPa to 361MPa by 12.4%.

(4) Fatigue cracks initiate at the surfaces for the welded specimens, while for ultrasonic impact treated samples, most of the cracks initiate at the defects beneath the surface.

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#### REFERENCES

- Ali A., An X., Rodopoulos C.A., Brown M. W., O'Hara P., Levers A., Gardiner S., (2007). The effect of controlled shot peening on the fatigue behaviour of 2024-T3 aluminium friction stir welds. *International Journal of Fatigue* 29, 1531-45.
- Altenberger I., Sano Y., Cherif M.A., Nikitin I., Scholtes B, (2006). Residual stress state and fatigue behaviour of laser shock peened titanium alloys. *Materials Science Forum* 524-5, 129-134.
- Gao Y.K., (2007). Shot-peened surface residual stress relaxation during fatigue for ultra-high strength steel. *Transactions of Materials and Heat Treatment* 28, B08, 102-5.
- Gao Y.K., (2011). Improvement of fatigue property in 7050 - T7451 aluminum alloy by laser peening and shot peening. *Materials Science and Engineering A* 528, 3823-8.
- Gao Y.K., Li X.B., Yang Q.X., Yao M., (2007). Influence of surface integrity on fatigue strength of 40CrNi2Si2MoV2A steel. *Materials Letters* 61, 466-9.
- Gao Y.K., Wu X.R., (2011). Experimental investigation and fatigue life prediction for 7475-T7351 aluminum alloy with and without shot peening-induced residual stresses. *Acta Materialia* 59, 3737-47.
- Hatamleh O., (2009). A comprehensive investigation on the effects of laser and shot peening on fatigue crack growth in friction stir welded AA2195 joints. *International Journal of Fatigue* 31, 974-88.

- Liu Y., Wang D.P., Deng C.Y., Xia L.Q., Huo L.X., Wang L.J., Gong B.M., (2014). Influence of re-ultrasonic impact treatment on fatigue behaviors of S690QL welded joints. *International Journal of Fatigue* 66, 155-60.
- Tönshoff H.K., Kroos F., Marzenell C, (1997). High-pressure water peening – a new mechanical surface-strengthening process. *CIRP Annals-Manufacturing Technology* 46,113-6.
- Zhang X., Hansen N., Gao Y., Huang X., (2012). Hall-Petch and dislocation strengthening in graded nanostructured steel. *Acta Mater.* 60, 5933-43.