The Effect of Sequence of Operations on Fatigue Life of LSP Treated Open-hole Aluminium Specimens

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Fastener holes in aeronautical structures are typical sources of fatigue cracks due to their induced local stress concentration. A very efficient solution to this problem is to establish compressive residual stresses around the fastener holes that retard the fatigue crack nucleation and its subsequent local propagation. Previous work done on the subject of the application of LSP treatment on thin, open-hole specimens [1] has proven that the LSP effect on fatigue life of treated specimens can be detrimental, if the process is not properly optimized. In fact, it was shown that the capability of the LSP to introduce compressive residual stresses around fastener holes in thin-walled structures representative of typical aircraft constructions was not superior to the performance of conventional techniques, such as cold-working.

This reduced performance of LSP can be attributed to different factors, including the fact that the treatment was performed on the specimens with an open-hole already present. It was shown that the effect of the presence of the hole introduced unwanted tensile residual stresses at the inner side of the hole, causing the premature fatigue failure of the specimens.

Therefore, an additional experimental campaign was defined in order to highlight the importance of the sequence of operations, which are the drilling of the hole and LSP treatment. Dog-bone specimens, Figure 1, in 3 mm thick Aluminium alloy 6082-T6 were prepared using a CNC machine and subsequently LSP treated (LPwC approach) at the Polytechnic University of Madrid, using an Nd-YAG laser with 2.8 J output energy, 1064 nm wavelength, 9 ns pulse and 10 Hz frequency.

In Figure 2, the curves showing obtained fatigue lives vs. maximum cyclic load applied are illustrated.

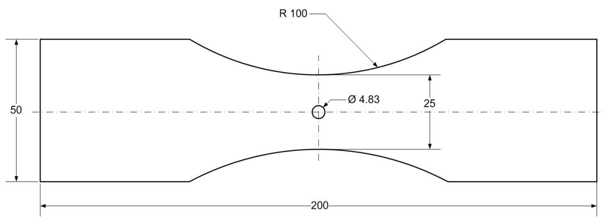

Fig. 1. Geometry of the specimen

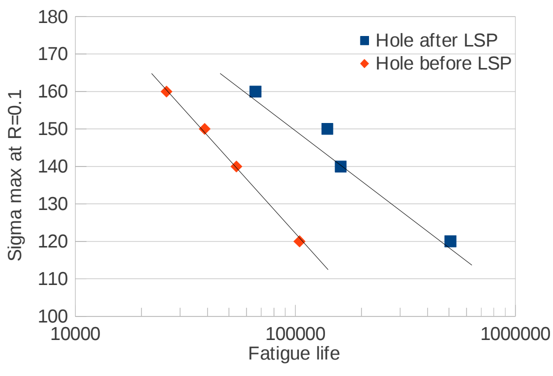

Fig 2. Fatigue lives vs. maximum cyclic load applied at R=0.1

The experimental results suggest that the LSP treatment on the pristine specimens and subsequent hole drilling causes fatigue life increase of about three times in respect to the hole drilling and subsequent LSP treatment sequence of operations. The practical implications of these findings lie in the fact that LSP, at least in the investigated configuration, cannot be applied “in service” on the fastener holes of aeronautical structures but rather “in production” on the pristine panels, prior to the drilling of the holes.

[1] G. Ivetic, I. Meneghin, E. Troiani, G. Molinari, A. Lanciotti, V. Ristori, J.L. Ocaña, M. Morales, J.A. Porro, C. Polese, A.M. Venter, “Characterisation of Fatigue and Crack Propagation in Laser Shock Peened Open Hole 7075-T73 Aluminium Specimens”, ICAF 2011 Structural Integrity: Influence of Efficiency and Green Imperatives: Proceedings of the 26th Symposium of the International Committee on Aeronautical Fatigue