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

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Outline

- Introduction
- LSP treatment
- Residual stress measurements
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- Conclusions

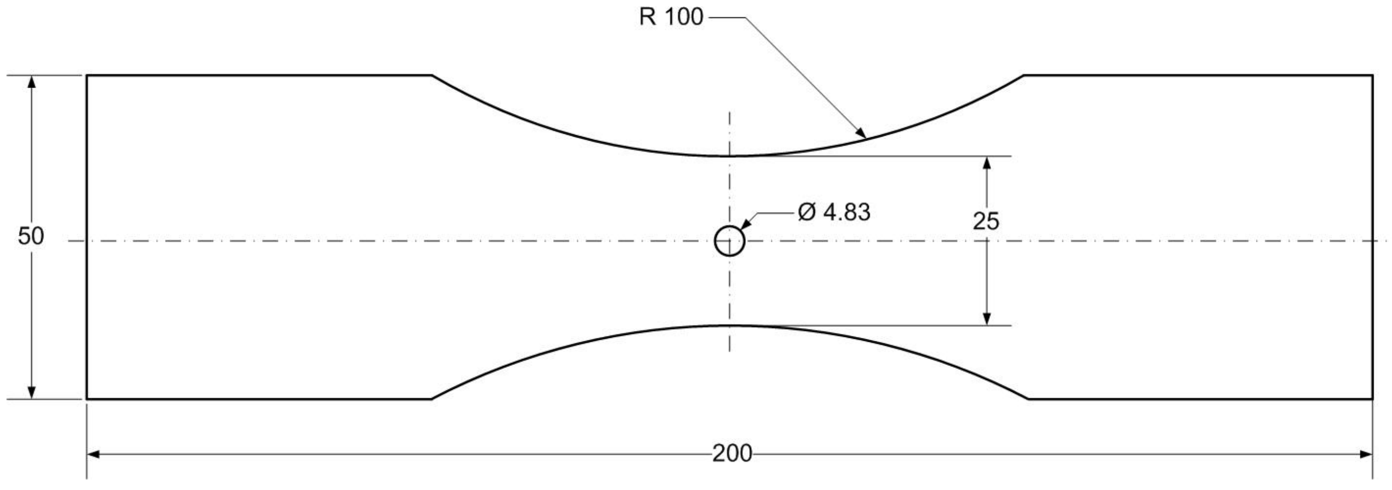
Introduction

- Previous work* on LSP treatment on thin, open-hole specimens resulted in necessity to optimize the process
- Observed reduced performance of LSP - the treatment was performed on the specimens with an open-hole already present
- An additional experimental campaign - to highlight the importance of the sequence of operations: hole drilling and LSP treatment

*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

Specimens@Bologna

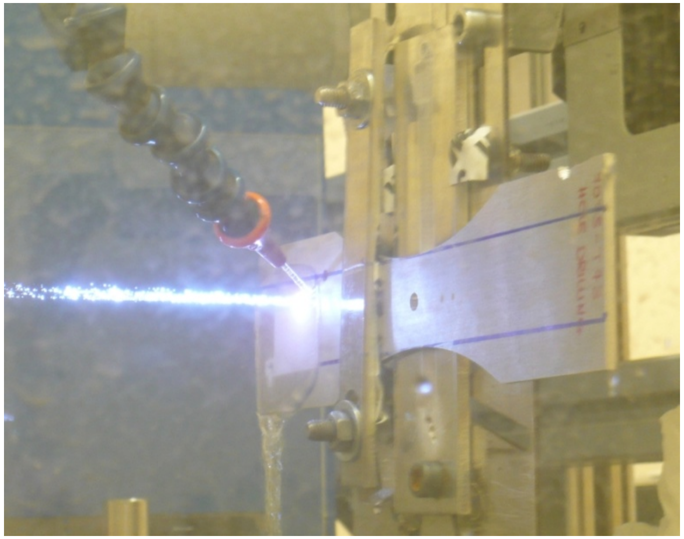
- Dog-bone specimens in AA 6082-T6
- CNC cut from a 3 mm thick sheet



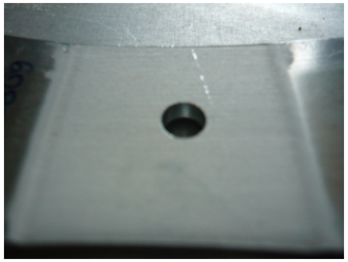
LSP Treatment@Madrid

- Process settings

Laser type	Wavelength [nm]	Output energy [J]	Pulse duration [ns]	Peen size [mm]	Laser frequency [Hz]
Nd-YAG	1064	2.8	9	1.5	10



- Peen density of 625 peens per cm square
- Two side peening, one side at the time
- Treated area –zone around the open-hole, size 25x25 mm
- Specimen fixing – two point encastre

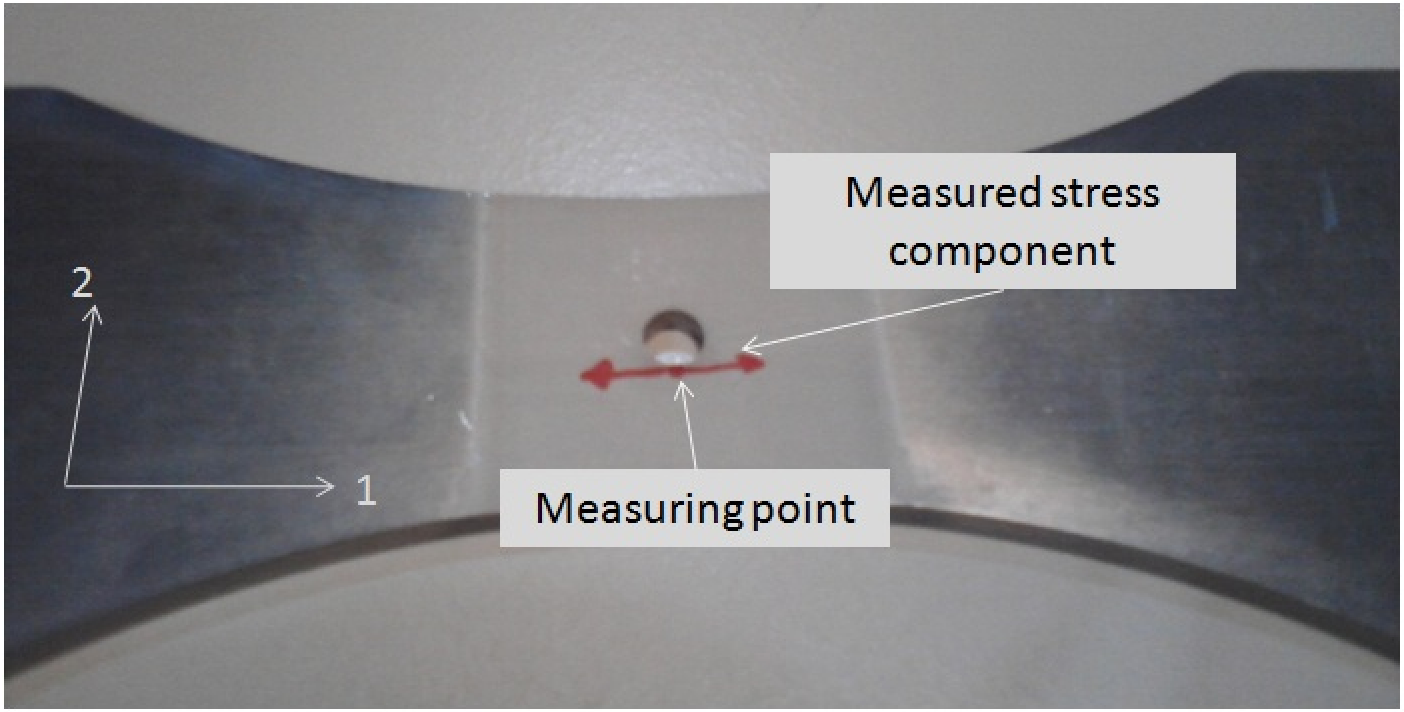


Residual stress measurements@Elettra

- Elettra Synchrotron facility, MCX Beamline, Trieste, Italy
- The residual stresses were measured at the edge of the open hole, for the two different types of specimens (specimen LSP treated with pre-existing open hole, i.e. hole before, and specimen with the hole drilled on the LSP treated area, i.e. hole after)

Residual stress measurements@Elettra

Depth [µm]	Residual stress – hole before [MPa]	Residual stress – hole after [Mpa]
50	-76	-127
125	-46	-129
250	-117	-175

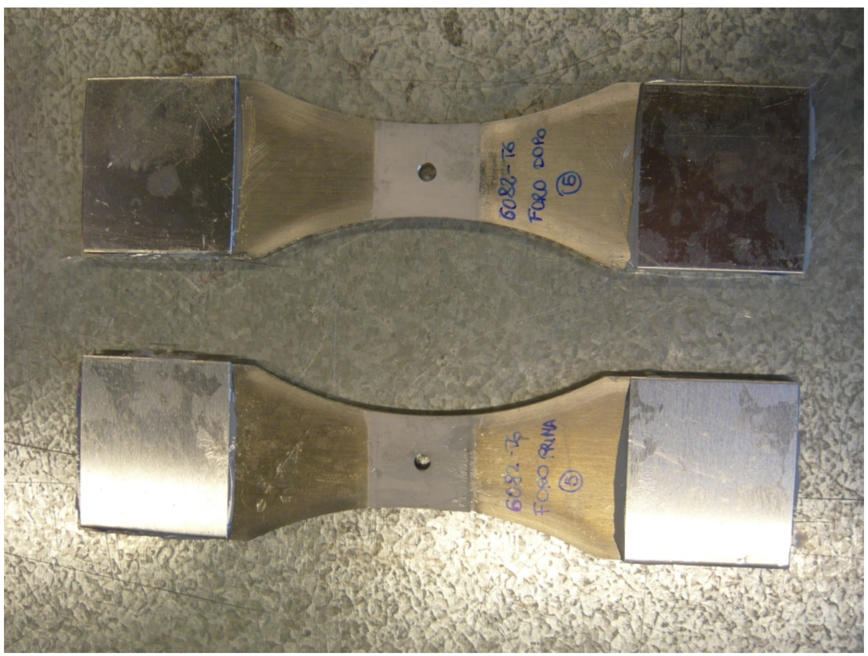


Residual stress measurements@Elettra

- Amount of compressive residual stresses is bigger in the case where the open hole is drilled after the LSP treatment
- This gives first indications on the positive effects introduced by drilling the hole only after the LSP treatment has been made

Fatigue testing@Bologna

- Additional tabs were bonded to the clamped sides of the specimens in order to avoid fretting fatigue damage

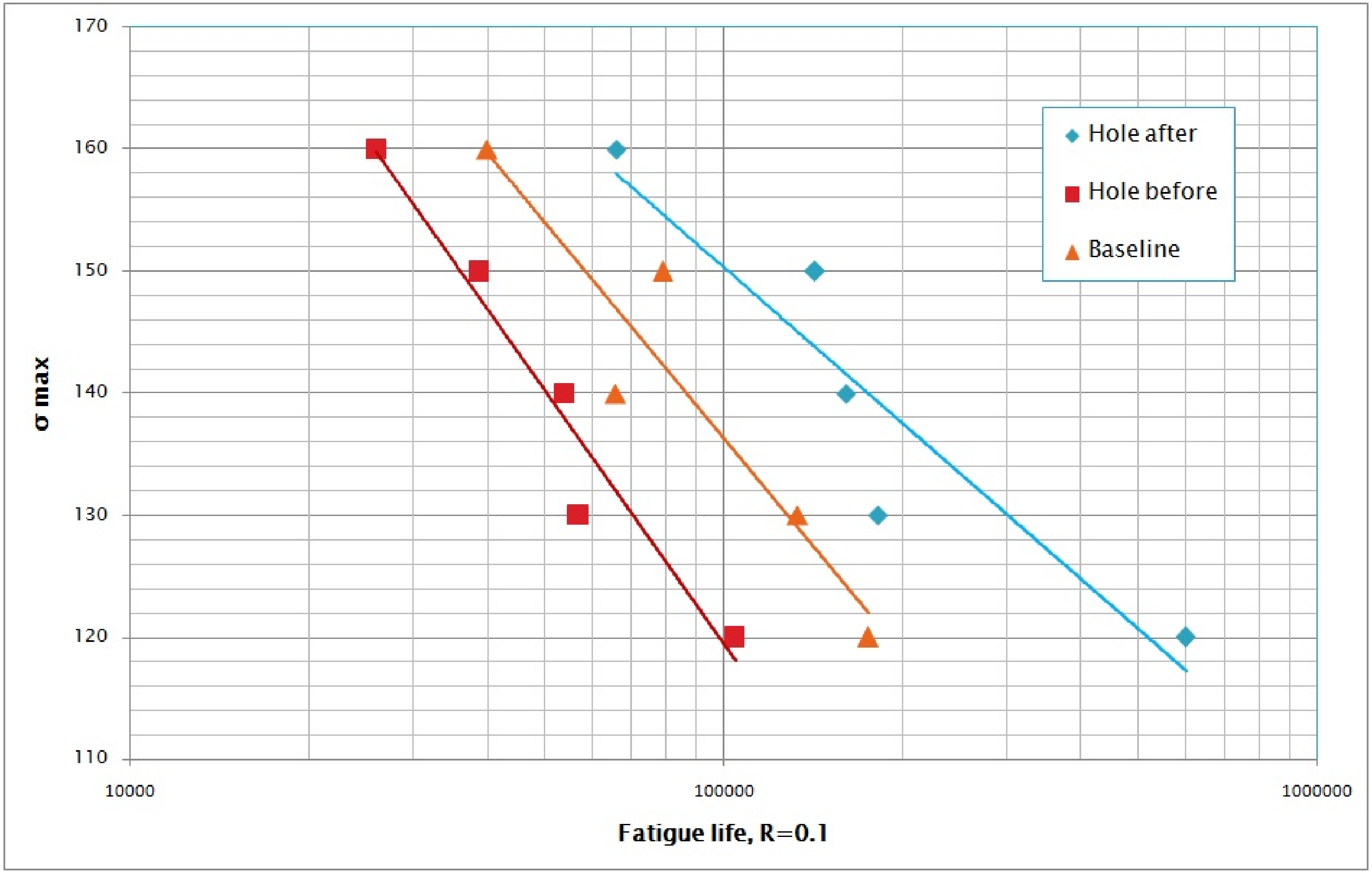


Fatigue testing@Bologna

- Maximum nominal stresses ranging from 120 MPa to 160 MPa
- R=0.1

Fatigue testing@Bologna

A total of 15 specimens was tested; five for each case (hole before, hole after, baseline)



Fatigue testing@Bologna

Fatigue lives with different operation sequences at R=0.1 (BL=Baseline)

σmax MPa	BL (10^4 cycles)	Hole before	Hole before/BL	Hole after	Hole after/BL
120	17.54	10.46	0.59	60.04	3.42
130	13.32	5.68	0.42	18.16	1.36
140	6.58	5.41	0.82	16.08	2.44
150	7.87	3.87	0.49	14.25	1.80
160	3.99	2.62	0.65	6.63	1.65

Results

- Drilling the hole after the LSP treatment can indeed increase fatigue lives of treated specimen
- The practical implications - a good solution for "in production" application, in which holes are to be drilled after the LSP treatment
- The "in service" application has proven to be impracticable due to negative effects on fatigue lives that were encountered on the specimens with the hole already present

Conclusions

- LSP needs to be optimized for every application used, specially when it comes to low thickness specimens
- The experiments in the coating-free LSP configuration have shown that the sequence of operations plays a crucial role in increasing the fatigue life of the treated specimens

Conclusions

- If the hole is realized after the LSP treatment is performed on the specimen, the fatigue life increase is up to three times more than the life of the baseline specimens
- If the hole is realized before the LSP treatment is performed on the specimen, the fatigue life is about two times less than the life of the baseline specimens
- Results submitted to Material Science and Engineering A

Future work

- Hypothesis – the presence of tensile residual stresses at the mid-section of the “hole before” specimen as the cause of premature fatigue failure (not measured experimentally due to low penetration of used synchrotron radiation)
- Scanning electron microscope investigation of fracture surfaces in order to confirm hypotesis of crack nucleation at the mid-thickness of the “hole before “ specimens

Thank you for your attention!

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