Prediction of fatigue crack propagation in laser shock peening induced residual stress fields with experimental validation

S. Keller[a∗], M. Horstmann[a], N. Kashaev[a] and B. Klusemann[a,b]

[a] Institute of Materials Research, Materials Mechanics
Helmholtz-Zentrum Geesthacht
Max-Planck-Straße, 21502 Geesthacht, Germany
e-mail: soeren.keller@hzg.de, web page: http://www.hzg.de

[b] Institute of Product and Process Innovation
Leuphana University of Lüneburg
Universitätsallee 1, 21335 Lüneburg, Germany
e-mail: benjamin.klusemann@leuphana.de - Web page: http://www.leuphana.de

ABSTRACT

The importance of high residual stresses on fatigue crack propagation (FCP) is well known. The application of laser shock peening (LSP) makes use of the residual stress effect on FCP by introducing compressive residual stresses with a high penetration depth in metallic structures. While beneficial compressive residual stress may result in a retardation, tensile residual stresses may lead to an acceleration of the fatigue crack propagation and have to be treated with care. As residual stress fields always contain region with tensile and compressive residual stresses, the question of an optimized residual stress field aiming on the retardation of fatigue cracks arises. This work investigates the influence of LSP on FCP of aluminium alloys using C(T)100 specimens. An efficient multi-step simulation to predict FCP in LSP-induced residual stress fields [1] is demonstrated, where the afford of the high dynamic LSP process simulation is strongly reduced [2]. The multi-step simulation is validated with a novel 'experimental simulation' by applying predicted stress intensity factors to an untreated specimen experimentally. Mechanism of the crack acceleration and retardation are investigated and linked to crack closure effects. Numerically predicted areas of crack closure will be shown and can be found at the crack surfaces of the experiments.

REFERENCES

[1] Keller, S. and Horstmann, M. and Kashaev, N. and Klusemann, B. Experimentally validated multi-step simulation strategy to predict the fatigue crack propagation rate in residual stress fields after laser shock peening. *Int. J. Fatigue* In Press. (2018) https://doi.org/10.1016/j.ijfatigue.2018.12.014.

[2] Keller, S. and Chupakhin, S. and Staron, P. and Maawad, E. and Kashaev, N. and Klusemann, B. Experimental and numerical investigation of residual stresses in laser shock peened AA2198. *J. Mater. Process. Tech.* (2018) **255**:294–307.