Master – Thesis

Numerical and experimental investigation of the fatigue crack growth influenced by residual stresses after laser shock peening

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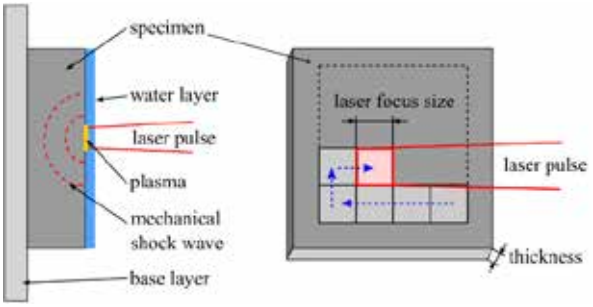
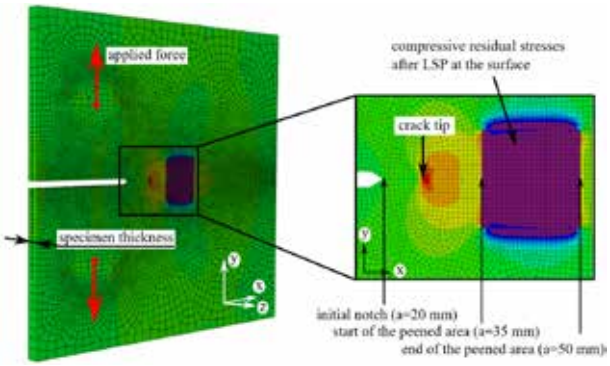
Introduction

Laser shock peening (LSP) can be used to improve the fatigue performance of light-weight structures and therefore it provides a method to treat one of the main failure causes in the aircraft industry. The idea is to introduce compressive residual stresses in critical regions of fatigue to reduce crack driving tensile stress cycles resulting in a retardation of the fatigue crack growth. The generation of compressive residual stresses causes balancing tensile residual stresses due to the equilibrium condition. This tensile residual stresses accelerate the fatigue crack. The efficient application of LSP needs the understanding of the influence of residual stresses on the fatigue crack growth behavior.



Schematic of the LS-process. Laser pulses turn material at the surface into plasma. The heat expansion of the plasma initiates shock waves, which causes plastic deformations of the underlying material.

The aim of this work is the investigation of the impact of residual stresses on the fatigue crack growth rate in C(T) specimens. Especially, the effect of the residual stress distribution over depth on the fatigue crack propagation rate has to be evaluated. A finite element model is set-up and has to be used to predict the fatigue crack propagation rate for different residual stress distributions. The finite element simulation should be supported by fatigue experiments. Residual stress profiles can be measured using the incrementally hole drilling method. The material under investigation is AA2024-T3 with 4.8 mm and 2 mm thickness. Further improvements of the simulation can be the implementation of mode II loading of the crack tip or the consideration of the crack path.



Finite element model of a C(T)-specimen with introduced residual stresses.

Tasks

- Literature research (influence of residual stresses on the fatigue crack propagation).
- Application of an existing finite element simulation using python-scripts.
- Development of the experimental design and execution of the desired experiments including fatigue crack growth experiments, LSP experiments and residual stress measurements using the incremental hole drilling method.
- Presentation of the results and documentation of the experimental work (in English or in German).
- Optional: Supporting LSP-simulation to gain a deeper insight of the physical phenomena or to enable a computational optimization process.

Remark

The scope of this work can be adapted in the direction of the experiments.

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