Simulation of fatigue crack growth in CT-specimens using an extended phase field formulation for brittle fracture

Christoph Schreiber*, **Charlotte Kuhn**† **and Ralf Müller***

* Institute of Applied Mechanics
Technische Universität Kaiserslautern
Postfach 3049, 67653 Kaiserslautern, Germany
e-mail: schreibc@rhrk.uni-kl.de, web page: https://www.mv.uni-kl.de/ltm

† Computational Mechanics
Technische Universitt Kaiserslautern
Postfach 3049, 67653 Kaiserslautern, Germany

ABSTRACT

A large number of catastrophic accidents of technical structures like airplanes, trains, pressure vessels or even turbine rotors motivates further research and development within the area of cyclic fatigue failure. This phenomenon is known since the middle of the 19th century. However, corresponding numerical tools are still rather less incorporated within development processes of technical structures. To describe the fatigue life of a component until macrocrack initiation the stress or strain live approach is mainly considered, where similar load cycles are combined to collectives to estimate the amount of damage by means of so called Wöhler lines. Another important and widely used tool for fatigue crack growth estimations is Paris' law [3], which describes the growth behavior of a macrocrack.

The aim of this work is to computationally model the initiation and extension of a crack that is driven by cyclic mechanical fatigue by means of an appropriate phase field model. Generally, the framework of phase field modeling provides several benefits for the numerical simulation of a crack path. The method was so far applied to quasi static fracture [1] in brittle and also in ductile materials. Models incorporating inertia effects (dynamic fracture) or effects caused by an anisotropy of the fracture resistance were also developed. A first approach of a phase field model for fatigue failure was presented by Alessi et al. in [2]. However, considering the variety of influence factors on the fatigue phenomenon, this area is clearly still at the beginning.

The total internal energy formulation is enhanced, accounting for irreversible processes caused by cyclic loading and unloading. This leads to crack extension even for small load amplitudes. Within the talk, the governing equations including the new driving force mechanism in terms of the damage will be presented. Numerical examples are discussed and results of fatigue crack growth simulations are compared to important corresponding phenomenological methods like Paris' Law.

REFERENCES

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