Efficient phase-field modelling of fatigue crack propagation

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ABSTRACT

The phase-field method for brittle fracture has been applied to simulate fatigue fracture due to cyclic loading. Carrara et al. [1] proposed a variational framework including a fatigue degradation function that effectively reduces the fracture toughness, reproducing Wöhler curves and the Paris law. However, fatigue failure comes along with high numbers of load cycles, so an explicit simulation of the load path is expensive, especially for inelastic material models. Therefore, time-efficient simulation methods are required.

In this contribution, we combine the phase-field method for brittle fracture [2] with the notch strain concept [3], an empiric method to calculate the life span of components. In this way, we avoid the explicit simulation of the load cycles by executing a local cyclic damage calculation. Based on the accumulated fatigue damage, the critical fracture energy is degraded locally in order to describe the dissipation.

We can reduce calculation time further by using an elastic material model, since the notch strain concept provides a plastic revaluation of elastic stresses and strains [4]. Plasticity as the reason for fatigue crack propagation is thereby considered by cyclic stress-strain curves. The cyclic degradation of the material is characterised by standard strain-controlled Wöhler fatigue tests. Using numerical examples in 1D and 2D, it can be shown that the developed method is able to simulate fatigue crack initiation as well as propagation.

REFERENCES

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