On the link between long and short cracks: influence of the T-stress

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RESUME

Some aircraft components, such as turbine disks, are subjected to very strict certification stages. Other than the fact that the material has a non-linear behaviour (Nickel base superalloy), the complex loading it experiences makes the definition of a fatigue cycle difficult. Moreover, during operation or maintenance those components are exposed to the creation of surface anomalies such as dents or scratches. Besides creating an initial residual stress state that is multiaxial, they create micro-cracks that lead into a significant effect of T-stress. This study aims to highlight the effect of T-stress during a mode I fatigue crack propagation and link it to the short crack effect.

The crack propagation under a loading in terms of stress intensity factor depends on its initial length. In fact, the crack growth rate of a short crack is greater than the one for the long crack [1]. Assuming that the difference between short and long cracks stems from T-stress [2], bi-axial tests have been performed in order to propagate a long crack as if it were a micro-crack. This can be done by changing the biaxiality state, i.e. creating a (K_I, T) loading specific to a micro-crack. The results about T=0 MPa to negative T-stress tests show a major increase of the crack growth rate.

Those results will be compared to the ones that arise from real short cracks. The challenge here is obtaining a mechanically short crack, meaning a large crack front but a small length. The strategy is then the following: from a drilled specimen, a fatigue loading is applied to propagate a crack to the threshold and to make it stop at a determined location. A sample containing the short crack, after EDM and polishing, is then extracted in order to apply a fatigue loading correlated to the one applied on long cracks.

The comparison of the results obtained on short and long cracks will allow us to validate the assumption that the same fatigue crack growth is obtained if the loading (K_I,T) is applied. If confirmed, it will be possible to measure short crack growth using tests on long cracks.

REFERENCES

[1] H. Kitagawa, S. Takahashi, Applicability of fracture mechanics to very small cracks or cracks at early stage, page 627-631, Boston (1976)
[2] F. Brugier, ENS Cachan, PhD thesis (2017)