Crack onset analysis of adhesives for the CZM-VCCT method

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ABSTRACT

Crack onset plays a major role in fatigue of polymer materials. In experimental testing, an artificial initial crack is typically prepared. For studying natural crack propagation under variable amplitude loading, an additional load cycle is needed to create a natural crack front.

An application for polymers is adhesives, which are prone to interlaminar debonds. Double Cantilever Beam (DCB) is a typical experimental specimen for studying debonds. DCB testing includes two load cycles: insert and propagation cycle. During the first insert cycle, the natural crack front initiates due to the prepared pre-crack. In the propagation cycle, crack is propagated either using quasi-static or variable amplitude loading.

Cohesive Zone Method (CZM) is able to model the onset (see the figure below) and the propagation of the debond, which is described using cohesive strength and fracture toughness. This adds complexity to modelling, especially for fatigue, when two parameters are needed for the onset and propagation. Another method is Virtual Crack Closure Technique (VCCT), which requires only fracture toughness but is not able to model crack onset. Lately, a combined method of CZM-VCCT has been studied [1]. In the combined method, the onset phase is analysed using CZM and the propagation phase using VCCT.

In this work, the insert cycle during the testing of adhesively bonded DCB specimen is studied. For the combined method, CZM is applied to the crack tip and is fitted based on experimentally measured crack growth during the insert cycle. The results (see the figure below) verify that the initiation phase tends to need separate modelling in addition to the propagating crack modelling.

$$\tau = \begin{cases} K\delta, \text{ if } \delta^{max} \le \delta^{o} \\ K\delta[1-d], \text{ if } \delta^{o} < \delta^{max} < \delta^{f} \\ 0, \text{ if } \delta^{max} \ge \delta^{f} \end{cases}$$

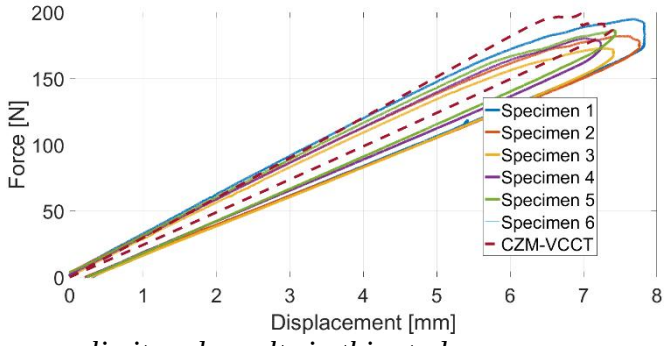

Figure 1. The CZM damage limit and results in this study.

REFERENCES

[1] Kanerva, M., Jokinen, J. The effect of computational parameters on the performance of a combined CZM-VCCT method, 29th Nordic Seminar on Computational Mechanics, 26.-28.10.2016, Chalmers.