High cycle fatigue behaviour of structural adhesive joints

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ABSTRACT

The use of cohesive zone models (CZM) together with special cohesive zone elements (CZE) to calculate the mechanical behaviour of adhesively bonded joints today is widely used. Whereas the static behaviour even under high strain rates can be modelled accurately due to a lot of different CZM the modelling of the fatigue behaviour of adhesively bonded joints is object of a lot of current research activities.

In general there are three different approaches available. First is a cycle by cycle approach [3]. This means that the fatigue model is integrated according to time numerically for each cycle. This provides very detailed information of the degradation process even for complex loading histories but is due to the extensive computational effort only applicable to low cycle fatigue calculations. Additionally no assumption must be made about local load ratio since every single load cycle is calculated individually.

A different approach is a cycle jump strategy [5, 6]. This approach uses a combination of damage and fracture mechanics to model the damage evolution during fatigue loading. The third approach is based on the maximum fatigue load [2, 4].

All these approaches use a traction separation law to model the static behaviour of the adhesive joints in combination with an evolution law to model the degradation process. The latter two approaches do not take viscous effects directly into account. These effects are smeared in the fatigue degradation rate.

Rheological model

Matzenmiller [1] proposed a model which is able to take creep as well as fatigue damage into account. The model consists of a parallel set of three rheological Maxwell elements (Figure 1). The left two elements represent the creep behavior whereas the right element represents the hysteresis behavior due to short time excitation.

The material parameters for the model were derived from fatigue tests with sample geometries that allowed relatively homogenous stress states. The test results were then split into a creep and fatigue response.

The fatigue behaviour with this model was calculated using a time scale instead of a cycle-based scale and the numerical results were in good accordance with experimental results. Due to the use of time scale however structural calculations with fatigue degradation could easily exceed an econmical range.

To overcome this drawback the fatigue degradation rate of this model was modified according to a cycle based approach.

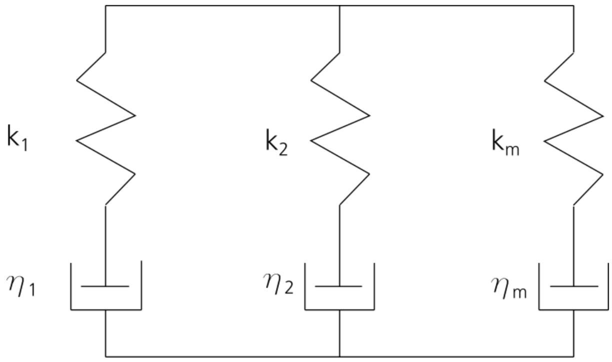

Figure 1: Set of parallel Maxwell elements

Conclusions

The use of a rheological model to introduce creep effects into the calculation of high cycle fatigue behavior of adhesively bonded yields good accordance with test results. It requires a lot of fatigue experiments under different loading conditions and load ratios. A method of splitting the experimental information and numerical results with the model will be presented.

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