11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

CHARACTERISATION OF COHESIVE ZONE MODELS BY MICROMECHANICAL EXPERIMENTS

Joseph Goldmann and Volker Ulbricht

Institute of Solid Mechanics, Technische Universität Dresden, 01062 Dresden, Germany
joseph.goldmann@tu-dresden.de, volker.ulbricht@tu-dresden.de, mfk.mw.tu-dresden.de

Key words: *cohesive zone model, interface, pullout test, singe fibre fragmentation test*

While fibre reinforced plastic composites are used succesfully in an increasing range of applications, they still hold an enormous potential for optimisation. This is especially true for complex geometries and loading situations, where it becomes impossible to always keep fibres aligned with the tension direction. In such cases the effective material behaviour of the composite may not be dominated by the fibre anymore, but by the matrix or even by the interface between fibre and matrix.

In order to study the effective material properties in such situations by analysing the microstructure one must characterise the consituents first. Hence this work shall contribute to modelling the behaviour of the interface in fibre composites. A prerequisite therefor is characterising the sole fibre and matrix as well. From an engineering point of view such a characterisation has to be able to display all relevant phenomena, but still simple enough to be applied to a representative volume element. The latter is a limiting fact, especially considering damaged volume elements. Therefore the formulations chosen here are purely phenomenological including cohesive zone (CZ) models for the interface.

Several micromechanical experiments have been developed to find the properties of the interface, such as Pullout, Microdebond, Single Fibre Fragmentation (SFFT) or Microindentation Tests. Evaluation of such test has been – and still is – performed often by analytic models making some assumptions on the strain and stress state in the test specimen. One widely used model is the shear-lag model in case of the SFFT. It reduces the interface properties to a single strength value. Still it is a difficult task to deduce reliable values. For experiments and evaluation in a round-robin programme see e.g. [1].

Another way is modelling the microstructure by FEM simulations describing the interface by means of CZ elements. This approach is applied here to Pullout (Fig. 1) and SFFT experiments (Fig. 2). Experimental results are obtained with a material combination of glass fibres in epoxy resin. The FEM simulation features a non-linearly enhanced generalised Maxwell model as in [2] for the matrix as well as a linear elastic material model with Weibull distributed strength values for the fibre. Regarding the interface the ability of the CZ framework to reproduce the Pullout and SFFT is analysed. In case of the Pullout one criterion for a suitable CZ model might be the ability to reproduce the pullout force versus displacement measurement as shown in Fig. 1 (b). This leads to restrictions on selecting a traction-separation curve. Strength, displacement at maximum traction and displacement at failure in mode I and mode II respectively are identified to be relevant parameters. Therefore those are the independent parameters of the applied CZ model. The interaction of the parameters is shown to govern the qualitative behaviour of the simulations in situations with eigenstrains caused by temperature or humidity influence.

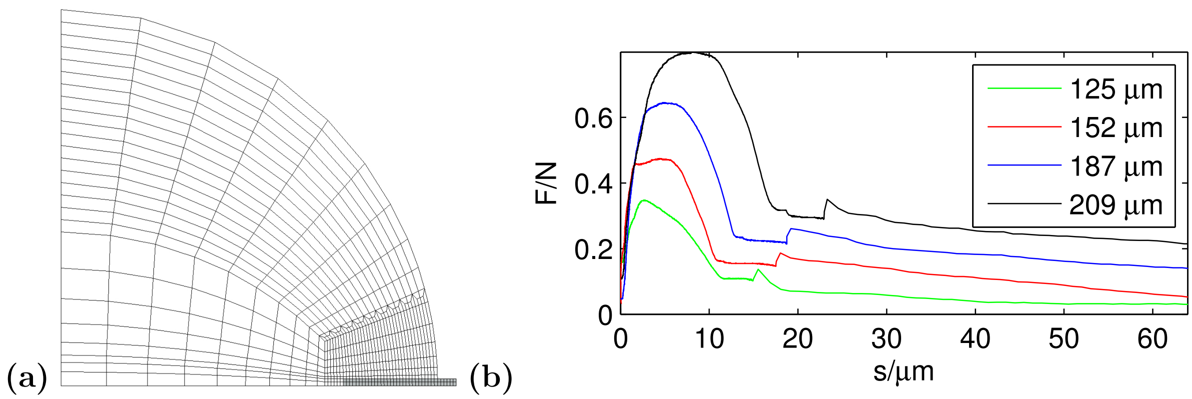

Figure 1: **(a)** Axisymmetrix FE mesh of a Pullout specimen consisting of fibre (grey) and drop of matrix resin elements (white). The fibre end on the lower right is pulled out. The mesh is very coarse for displaying reasons. **(b)** Typical experimental curves of force F at fibre end versus Displacement s of fibre end. Results obtained at different embedded fibre length are specified in the legend.

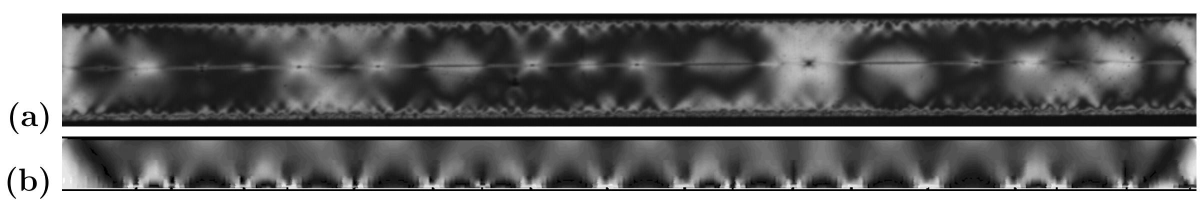

Figure 2: **(a)** Photoelastic picture taken from a SFFT experiment. **(b)** Computed photoelastic picture from axisymmetric SFFT simulation.

Acknowledgement

The present study is funded by the German Research Foundation (DFG), grant UL 121/14-1. This support is gratefully acknowledged.

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