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3D-FINITE ELEMENT SIMULATIONS OF WEDGE SPLITTING TEST OF ZrO_2-Y_2O_3 CERAMIC DOUBLE CANTILEVER BEAM WITH CHEVRON NOTCH

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Zirconia ceramics are materials of great scientific and practical importance because of their combination of properties: high strength, chemical inertness, good abrasion and wear resistance, as well as high melting point and high electrical resistivity. Due to their excellent properties, ceramics are used in a wide range of applications, including the chemical industry, machinery, electronics, aerospace and biomedical engineering.

However, the fracture toughness of zirconia ceramics is the major property that needs to be enhanced in order to satisfy high requirements for advanced applications in industry and medicine. To overcome the inherent brittleness of these ceramics, ceramic matrix composite materials in particular zirconia-alumina composites are being developed [1]. Since metallic inclusions limit the high temperature application of ceramic composites or its application in an aggressive environment, ceramic-ceramic composites should be all-purposes composites.

With the era of miniaturization of devices, fracture toughness characterization of the components is a main issue in materials research. The traditional method of fracture toughness determination can not apply for fracture toughness estimation of such a brittle material.

For this purpose it is necessary to develop new methods of fracture toughness determination, free from restrictions imposed on the sizes of specimens in standard methods of testing. One of such a method is the wedge splitting method of the double cantilever beam with chevron notch.

The present contribution concentrates on the analysis of numerical modelling of the wedge splitting method which is used for the experimental determination (estimation) of fracture toughness. Finite element simulations allow to analyze the stress distribution in front of the crack tip and to assess the efficiency of the experimental method of testing.

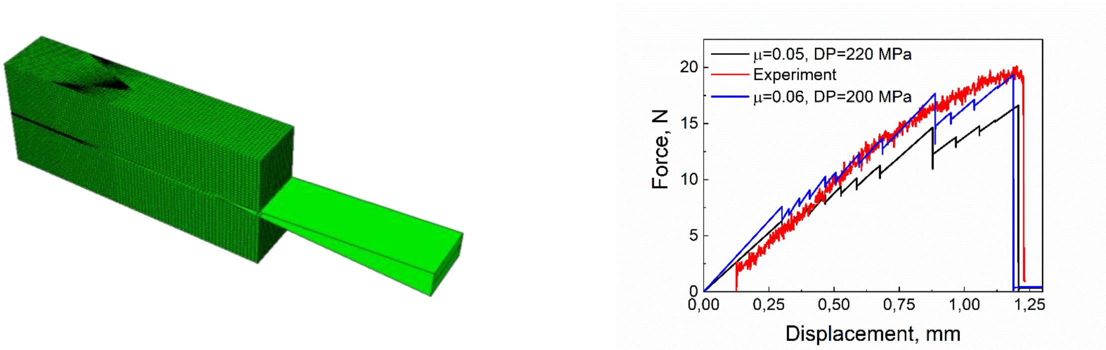
The specific fracture energy determined in an experiment was taken as input parameter for cohesive zone method simulations of crack propagation.

Wedge splitting of a double cantilever beam with Chevron notch (Fig. 1) has been simulated with the FEM using two methods: a Cohesive Zone Modelling (CZM) approach and the Element Elimination Technique (EET) [2]. The results of these simulations have been compared with exprimental findings.

For the cohesive zone modelling approach, the different-traction-separation laws were implemented in the Finite Element Software ABAQUS and the resulting force-displacement curves were obtained. For the traction-separation law the fracture energy, which is the area under the traction-separation curve has been taken from the wedge splitting experiment [3].

The cohesive strength has been defined by inverse modelling by comparison of the results of simulations with the resulting Fore-Displacement curves. By such an approach the maximum force value, achieved in experiment has been obtained in simulations but the match of the shape of the Force-displacement curve obtained in experiment and in simulations has been not achieved with this method.

In EET the maximum principal stress has been taken as the criterion of crack initiation. The friction coefficient between the wedge and the arm of the DCB was found to affect drastically the results of simulations. The best match of the calculated and the experimental Force-displacement curve has been achieved in simulations with the EET-technique (Figure 1b).



а) б)

Fig. 1. The scheme of loading and the FE-mesh of a DCB with chevron notch (a); Comparison of the Force-Displacement curves obtained in two simulations with two different friction coefficients (?) using the EET with an experimentally obtained one.

Conclusions

- Simulations of DCB-wedging of the specimen from ceramics with chevron notch have been performed with the finite element method applying the Cohesive Zone modeling approach and the Element Elimination technique.
- By variation of cohesive strength and keeping the fracture energy constant as obtained in experiment, constant force-deflection curves have been obtained and compared with experimental ones.
- The influence of different parameters of the traction-separation law (the shape of the TSL was assumed to be bilinear, trapezoid, with cohesive strength and stiffness obtained from …) on the Force-COD-curve has been analyzed.
- Overall, the trend, peak load and COD of the present numerical results obtained with the calibrated cohesive parameters matches well the experimental result.
- With the Element Elimination technique by variation of the maximum principle stress and friction coefficient a better match to the experimental Force-Deflection curve has been achieved. The reason could be that no restrictions were imposed on the crack path (as it is in typically required in the CZM approach).

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