8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

THE EFFECT OF RESIDUAL STRESSES ON ELASTIC AND ELASTIC-PLASTIC BIMATERIALS WITH INITIAL CRACK PERPENDICULAR TO THE INTERFACE

*** Bojan I. Medjo[1], Marko P. Rakin[1], Otmar Kolednik[2,5], Narendra K. Simha[4] and Franz Dieter Fischer[3,5]**

[1] Faculty of Technology and Metallurgy, Karnegijeva 4, 11000 Belgrade, Serbia
* bojanmedjo@gmail.com
marko@tmf.bg.ac.yu

[2] Erich Schmid Institute of Materials Science, Austrian Academy of Science, A-8700 Leoben, Austria
kolednik@unileoben.ac.at

[3] Institute of Mechanics, Montanuniversität Leoben, A-8700 Leoben, Austria
mechanik@unileoben.ac.at

[4] University of Minnesota, MMC 289, Minneapolis, MN 55455, USA

[5] Materials Center Leoben, A-8700 Leoben, Austria

Key Words: *bimaterial, residual stresses, crack driving force, inhomogeneity*

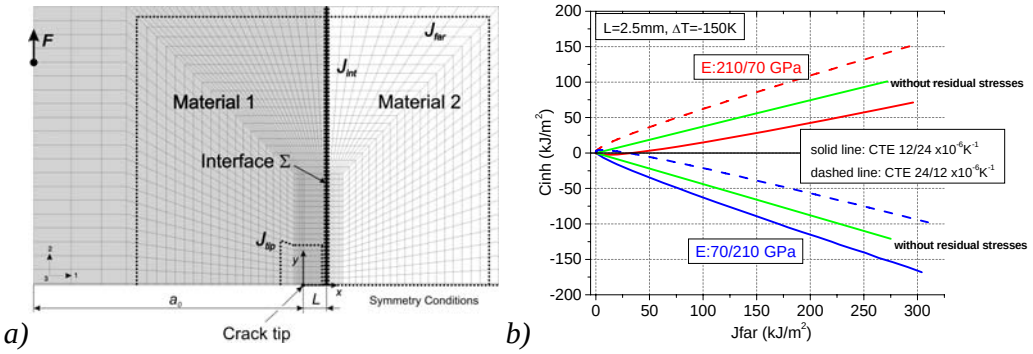
ABSTRACT

The analysis of various heterogeneous material structures (composites, welded joints, etc.) should include the effects of residual stresses. In recent papers, the concept of material forces [1,2] was used to investigate the effect of inhomogeneities. It was shown [3-7] that material inhomogeneities in the direction of the crack extension induce an additional crack driving force term, referred to as the material inhomogeneity term, C_{inh}. The effective crack driving force, J_{tip}, is then given by: $J_{tip} = J_{far} + C_{inh}$, where J_{far} is far-field J-integral. For engineering applications, it is important to predict whether the effect of residual stresses is significant or it can be neglected. This effect was analysed in [7] for elastic material and CTE inhomogeneity, and here we present results for elastic and elastic-plastic materials and coupled inhomogeneities (CTE and E).

For this analysis we used FE model of pre-cracked CT specimen made of bimaterial with a sharp interface (Fig. 1a). The model was cooled and then loaded mechanically. FEA was carried out using ABAQUS (www.simulia.com). C_{inh} was obtained using post-processing procedure based on the concept of configurational forces.

The influence of inhomogeneities is more prominent when the crack tip is closer to the interface. Material inhomogeneity term, C_{inh}, is negative (shielding) if a crack grows towards stiffer and/or higher-strength material. CTE ratio less than 1 decreases the values of C_{inh}, thus improving the fracture resistance (Fig. 1b). Smaller CTE ratio also has favourable effect for elastic-plastic bimaterial – the plots are similar to Fig. 1b, but C_{inh} vs. J_{far} curves approach some saturation values.

Obtained results can be used for optimization of fracture behaviour of inhomogeneous structures with sharp interfaces. For instance, it is possible to modify material combinations in a multimaterial structure intentionally to increase its fracture resistance.



a) *b)*

Fig. 1: a) FE model; b) bimaterials with/without resid. stresses with coupled inhomogeneity in CTE and E

ACKNOWLEDGEMENTS

MR, OK and FDF acknowledge gratefully the financial support by the Österreichische Forschungsförderungsgesellschaft mbH, the Province of Styria, the Steirische Wirtschaftsförderungsgesellschaft mbH and the Municipality of Leoben under the frame of the Austrian Kplus Programme (Proj. SP18-WP3). BM and MR acknowledge gratefully the financial support by the Serbian Ministry of Science (proj. OI 144027).

REFERENCES

[1] G.A. Maugin, *Material Inhomogeneities in Elasticity*, Ch. and Hall, London, 1993.

[2] M.E. Gurtin, *Configurational Forces as Basic Concepts of Continuum Physics*, Springer, Berlin, 2000.

[3] S. Suresh, Y. Sugimura, Tschegg, "The growth of a fatigue crack approaching a perpendicularly-oriented, bimaterial interface", *Scr. Metall.* 27, 1189–1194, (1992).

[4] R. Pippan, K. Flechsig and F.O. Reimelmoser, "Fatigue crack propagation behaviour in the vicinity of an interface between materials with different yield stresses", *Mat. Sci. and Engng A*, Vol 283, pp. 225-233, (2000).

[5] N.K. Simha, F. D. Fischer, O. Kolednik and C.R. Chen, "Inhomogeneity effects on the crack driving force in elastic and elastic-plastic materials", *J. of the Mech. and Phys. of Sol.*, Vol. 51, pp. 209-240, (2003).

[6] O. Kolednik, J. Predan, G.X. Shan, N.K. Simha and F.D. Fischer, "On the fracture behaviour of inhomogeneous materials – a case study for elastically inhomogeneous bimaterials", *Int. J. of Sol. and Struc.*, Vol. 42, pp.605-620, (2005).

[7] M. Rakin, O. Kolednik, N.K. Simha and F.D. Fischer, "Influence of residual stresses on the crack driving force in bimaterials with sharp interface", *Proceedings of the 11th International Conference on Fracture*, (2005).