Numerical modelling of the effect of thermal residual stress on mechanical properties of metal-ceramic composites

Witold Węglewski, Michal Basista and Kamil Bochenek

Institute of Fundamental Technological Research Warsaw, Poland

In this paper a numerical model will be presented to investigate the influence of processing-induced thermal residual stresses (TRS) on the fracture (fracture toughness) and mechanical properties (E modulus, bending strength) in particulate bulk metal-ceramic composites. The materials under consideration are hot pressed chromium-alumina bulk composites with different content of alumina (30, 60 and 90 vol. %) and with two different starting sizes of chromium particles to show how the microstructure can influence on the level of TRS.

The reported research includes the processing of composites by powder metallurgy techniques (HP), microscopic analysis of material microstructure with special focus on micro-CT scanning, measurements of TRS by neutron diffraction (ND) method and numerical modelling of TRS by FEM based on micro-CT images of real material microstructure [1-3].

Spatial distributions of TRS measured by ND are considered when interpreting the results of K_{IC} measurements in a four point bending test. Numerical micro-CT based models are proposed to predict the TRS, Young's modulus and bending strength with account of the TRS-induced damage of the ceramic phase. Our micro-CT based FEM models reproduce the TRS measurements with a good accuracy which may be an asset in applications having in mind the high cost of beam time for ND experiments at neutron sources. Finally, the experimental data and modelling results are compared to assess the TRS/microstructure effect on the fracture toughness of the composites investigated.

[1] W. Weglewski, M. Basista, M. Chmielewski, K. Pietrzak Modeling of thermally induced damage in the processing of Cr‑Al2O3 composites. Compos. Part B (2012) 255‑264.

[2] W. Weglewski, K. Bochenek, M. Basista, T. Schubert, U. Jehring, J. Litniewski, S. Mackiewicz, Comparative assessment of Young's modulus measurements of metal–ceramic composites using mechanical and non-destructive tests andmicro-CT based computational modeling, Comput. Mater. Sci. 77 (2013) 19–30.