100 Influence of material microstructure and thermal residual stresses on macroscopic fracture parameters and elastic properties of metal-ceramic composites

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This paper investigates the interplay between material microstructure and processing-induced thermal residual stresses (TRS) in particulate bulk MMC's with the main objective to explore their combined effect on the macroscopic fracture toughness and material properties (*E* modulus, bending strength) of the composite. The materials under consideration are hot pressed chromium-alumina bulk composites doped with rhenium, the use of which is motivated by their potential applications in transport and energy sectors. The reported research includes the processing of MMC by powder metallurgy techniques (HP and SPS), 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. Several compositions of $Cr(Re)/Al_2O_3$ system and different particle sizes were used in the sintering process to assess the effect of microstructure on the TRS. Spatial distributions of TRS measured by ND are taken as supporting information when interpreting the results of K_{IC} measurements in a four point bending test. Numerical micro-CT based models were developed to predict the TRS, Young's modulus and bending strength with account of TRS-induced damage of the ceramic phase of MMCs. A good predictive capability of these TRS models was achieved which may become important considering the cost of beam time for ND experiments at neutron sources. Finally, the large pool of experimental data and modelling results is discussed and the conclusions are drawn as to the TRS/microstructure effect on the fracture toughness of the MMCs in question.