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Effect of microstructure and thermal residual stresses on fracture behaviour of metal-ceramic composites

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In this paper the influence of material microstructure and thermal residual stresses on the macroscopic fracture toughness, Young's modulus and bending strength of metal-ceramic composites is studied.

The investigated materials were: (1) Cr/Al_2O_3 composites (MMC and cermets) with various proportions of the starting powders prepared by hot pressing, and (2) Al_2O_3/Al infiltrated composites with different volume fractions of the aluminium phase. The two groups of composites (particulate vs. infiltrated) were chosen to examine the effect in question because of their significantly different microstructure.

In the case of hot pressed Cr/Al_2O_3 composites local thermal residual stresses are generated during cooling from the sintering temperature to RT due to number of factors such as (i) differences in the coefficients of thermal expansion of the ceramic and metal phase, (ii) differences in cooling speeds in different parts of the material, and (iii) irregular shapes of pores causing stress concentrations.

The same problem of formation of thermal residual stresses occurs in the infiltrated Al_2O_3/Al composite with metal and ceramic phases forming spatially continuous networks throughout the structure (also called Interpenetrating Phase Composites, IPCs).

The fracture toughness and bending strength measurements were performed in a four-point bend test on SEVNB specimens. The microstructural characterization and crack growth analysis were done using scanning electron microscopy.

Our results show that the fracture toughness and other mechanical properties investigated in this study strongly depend on such microstructural features like the amount and distribution of metal and ceramic phase and the type of microstructure (particulate vs. infiltrated). On the other hand the stiffness of reinforcement and matrix, the volume fraction and the grain size of the reinforcement, difference in grain sizes between matrix and reinforcement have an effect on thermal residual stresses distribution, which in turn have an effect on the macroscopic fracture parameters and the crack growth path.

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