THE FINITE ELEMENT ANALYSIS OF THE CRACK GROWTH IN CERAMIC MATERIALS BASED ON B_4C

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The results of finite element modeling of the crack growth process in the microstructure of ceramic materials based on B_4C have been exhibited. A comparative analysis of calculated and experimental data was carried out. It is shown that the high energy value calculated crack growth corresponds to a high fracture toughness of the material. The developed model is useful for estimating of the strength properties of developed ceramic materials.

Crack initiation in a predetermined case requires more energy than in the real microstructure, since defects in the microstructure of the computational model are absent. On the other hand, growth of the cracks in the defect-free structure may be less energy consuming since the only obstacle will be the crack growth resistance and the availability of more strong phases. Therefore, the obtained results are more applicable for comparative analysis.

An analysis of three microstructures: boron carbide, boron carbide with titanium diboride particles, boron carbide with particles of alumina was shown (Table). The criterion for crack initiation is the maximum principal stress. The calculated target is the germination crack along the entire length of microstructural area.

Table

The calculated cases

Structure	Description of material
№ 1	Polycrystalline B_4C
№ 2	B_4C – main phase, up to 15% TiB_2
№ 3	B_4C – main phase, up to 7% alumina Al_2O_3

So, after initiation, the crack growth in the defect-free microstructure occurs in a very short time, almost without the need of additional energy from outside. This behaviour is typical for brittle ceramic materials.

Value of the energy expended in crack growth, is different for all microstructures. However, the obtained results allow to carry out comparative analysis of resistance to crack growth in the microstructural. The figure shows the energy costs of the cracks which growth through microstructure area for three ceramic samples. As can be seen, the initiation of cracks and subcritical crack growth of low-energy expenditure and require for the growth of constant increase of the external force. Reaching a critical threshold length, the crack grows practically without need to increase of the external force to complete destruction.

As can be seen, the most energy-intensive crack growth observed in the structure of number 3 and the least expenditure was in the structure of the number 1. Because of the main phase material is B_4C, it is obvious that more expenditure of energy is provided by additional phases. This expenditure can be provided both as the crack growth in a stronger phase and due to additional logistics crack at rounding of a rigid inclusion.

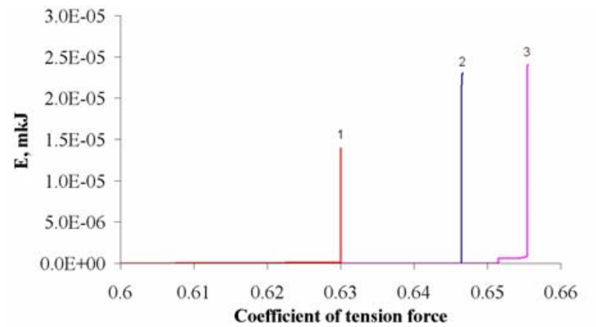

Fig. The energy expended in crack growth

The researches of ceramic materials based on B_4C with additives titanium diboride TiB_2 and alumina Al_2O_3 have been studied. By modeling the behaviour of the material at the microstructural level was shown that the additives have a positive effect on the crack growth resistance. Crack growth in the composites had intergranular nature and in the polycrystalline boron carbide transcrystalline character. The calculated results are in qualitative agreement with the experimental data.