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DETERMINATION OF CRITICAL THERMO-MECHANICAL LOADS FOR INTERACTING CRACKS IN FUNCTIONALLY GRADED THERMAL BARRIER COATINGS

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The work is devoted to the problem of thermal fracture of a structure consisting of a functionally graded coating on a homogeneous substrate (FGC/H) with a weak layer between them and subjected to thermo-mechanical loading. Functionally graded materials (FGMs) are special type composites, which consist of a graded pattern of material composition and/or microstructures. The properties of FGMs vary continuously in a spatial coordinate through the depth of the layer.

The theoretical formulation is based on the method of complex potentials, which leads to the basic equations in integral form, i.e to singular integral equations. Thermo-elastic problems for FGC/H structures for the cases of the influence of thermal loading (cooling by ΔT) and an additional mechanical load is performed. It is assumed that thermo-mechanical properties of the functionally graded coating (FGC) are continuous functions of the thickness coordinate. The resulting integral equations are solved numerically by a method based on Chebyshev polynomials.

The main attention is paid to the determination of critical loads for systems of interacting cracks in the FGC. The properties of the FGCs vary in the direction of the coating depth, and the fracture toughness of the FGC also changes in the same direction. Using a fracture criterion (e.g. maximal hoop stress criterion), the angles of deviation of the crack propagation are calculated, and then the critical loads are obtained to determine when this propagation starts. Different combinations of thermal and mechanical loads (including purely thermal and purely mechanical loads) are investigated with respect to critical loads at crack tips, and the influence of the material gradation (including changing fracture toughness) on critical loads for systems of cracks is also studied.

The proposed model in combination with a detailed parametric analysis provides a sound basis to optimize FGCs in order to improve the fracture resistance of FGC/homogeneous systems operating under high temperatures. In this regard, potentially desirable thermal and mechanical properties of FGMs are analyzed as well as available real material combinations for advanced thermal barrier coating applications.

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