Thermal fracture of a bimaterial with an arbitrary finite number of partially insulated cracks and a heat source

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Bimaterials (it could be, e.g., laminated composites or bimaterial compounds) are used in different engineering structures and subjected to mechanical and thermal loadings. Due to differences in thermal and mechanical properties of the constituent materials high residual stresses arise near interfaces which lead to delamination and debonding along the interface and the formation of the interface crack. Crack interaction problems in homogeneous materials have been extensively investigated and a large number of solutions have been obtained (see review Petrova, Tamuzh, Romalis, 2000). Systems of thermally insulated cracks in functionally gradient/homogeneous bimaterials under the influence of a heat flux have been considered in (Petrova, Schmauder, 2011).

In this work a boundary-value problem of the interaction of the system of internal cracks and an interfacial in the bimaterial under the influence of the heat source is considered. Model of partially insulated cracks is used. It is assumed that the input thermal conductivity coefficients of the surfaces of internal cracks ($\eta(x)$) and interfacial crack ($\eta_0(x)$) are different functions, which take values from 0 to 1, where 0 corresponds to the case of thermally insulated cracks, and 1 - the case of full thermal conductivity surface cracks. Such a model of partially insulated interfacial crack is used, for example, in (Lee, Park, 1995).

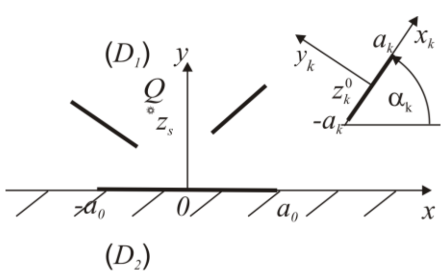

Fig.1

It is assumed that at the interface of the materials there is a crack length is $2a_0$ and in one of the materials there is a system of N cracks of length $2a_k$ and that at some point z_s in the field $y > 0$ (D_1) is placed a heat source Q (Fig. 1). In this work we consider uncoupled problem of thermoelasticity, the solution of which consists of solving the problem of heat conduction for a two-component material, and solving the elastic problem.

To determine the stress-strain state in a two-component elastic plane, caused by the effect of inhomogeneous plane stationary temperature field, we construct a system of singular integral equations. The resulting system of equations is solved by the method of a small parameter, when the interface crack is much larger than the internal cracks (the small parameter is the ratio between sizes of the internal and interface cracks). Asymptotic analytic expressions for the derivatives from functions of the displacements discontinuities on the lines cracks and stress intensity factors, as well as the critical heat flux at the crack tip up to the second approximation of a small parameter have been obtained.