Boundary integral equations for systems of interface cracks under dynamic loading: effects of the cracks' closure

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The systems of linear cracks between two dissimilar elastic isotropic half-spaces under dynamic (harmonic and impact) loading are considered. The system of boundary integral equations for displacements and tractions at the interface is derived from the dynamic Somigliana identity, and the integral kernels are fundamental solutions of the elastodynamics in the frequency domain, that can be obtained from the Green's fundamental displacement tensor [1].

To take the crack faces' contact interaction into account we assumed that the contact satisfies the Signorini constraints and the Coulomb friction law. Because of the cracks' faces closure the traction vector at the crack's surface is the superposition of the known initial traction caused by the external loading and the contact force that appears in the contact zone, that is unknown beforehand and changes in time, depending on the parameters of the external loading (type of the loading, direction, magnitude, frequency, etc.), mechanical properties of the bi-material and the friction coefficient at the cracks' surfaces and must be determined during the solution process.

The normal and tangential components of the external loading, the displacement discontinuity and the tractions at the interface are approximated by the exponential Fourier time series. For every Fourier coefficient number the appropriate system of linear algebraic equations can be obtained from the boundary integral equations and solved numerically, so the displacements and tractions in the form of Fourier exponential series with a finite number of the members can be found. During the numerical solution divergent integrals of various order (hypersingular, singular and weakly singular), depending on the type and order of the used space approximation, are regularised and calculated.

The problem is solved numerically using the iterative process – the solution changes until the distribution of physical values which satisfies the contact constraints is found [2]. The numerical convergence of the method with respect to the number of the Fourier coefficients and mesh size is analysed.

The distributions of the displacements and tractions are obtained and the dynamic stress intensity factors are computed as functions of the parameters of the incident loading and properties of the bi-material. The results are compared with those obtained neglecting the cracks' closure. The effects of material properties and values of the friction coefficient on the distribution of stress intensity factors (opening and shear modes) are presented and analysed. Special attention is paid to the effects of the mutual location of the cracks.

References

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