Model of thermal shock-induced damage in graphite

Bayandin Yu.V.[1,@]

[1] Institute of Continuous Media Mechanics of the Ural Branch of the Russian Academy of Sciences, Academician Korolev Street 1, Perm, 614013, Russia

[@] buv@icmm.ru

The transition to combustion of carbon materials in rocket and space technology components is preceded by intense surface heating, which may be accompanied by the generation of a stress wave (thermal shock) with subsequent ablation, delamination, or spalling. The heating rate and the nonlinear dependence of the thermal diffusivity coefficient on temperature, which itself depends on the porosity of the carbon material, determine the possibility of the metastable heat localization effect in the blow-up mode. This study is devoted to analyzing the patterns of heat localization and their connection with thermal shock mechanisms in carbon-carbon materials under intense thermal exposure. Assessing the thermal strength of a material under conditions of metastable heat localization typically requires solving a wave problem, since the blow-up time is close to the acoustic time, using specific criteria. An approach to the numerical simulation of the nonlinear thermoelasticity problem taking into account damage accumulation in graphite and considering the temperature dependence of thermophysical and physico-mechanical properties is presented. Boundary conditions for the occurrence of blow-up regimes are defined, and the dynamics of metastable localization are investigated. A comparison of numerical results with an analytical solution has been conducted, confirming the existence of two heat propagation regimes: wave and blow-up.