EQUATIONS OF STATE OF MATERIALS FOR SOLVING PROBLEMS OF HIGH ENERGY DENSITY PHYSICS

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Interest in studying the behavior of various substances in fast-moving processes at high energy densities is due to the need to know the equation of state of the medium to close the equations of motion. The equation of state determines the functional relationship between the thermodynamic characteristics of a substance and each other, and such a function must be known in the entire range of states realized in the process under consideration. In particular, during a high-speed collision of solid bodies, a rapid increase in pressure, internal energy and density of the material occurs in the shock wave, and in the subsequent isentropic unloading wave, the compressed and heated substance expands and cools. Taking into account possible phase transformations improves the quality of description of material properties in gas-dynamic modeling of intense pulse processes.

In the present paper, various variants of equation-of-state models that can be used to solve fundamental and applied problems in high energy density physics are considered. In canonical form, the equation of state is defined on the basis of a function of the thermodynamic potential upon the variables in which its total differential is written. In particular, it is convenient to use the specific free energy as a function of specific volume and temperature. A version of such a thermodynamically complete equation of state is proposed for a number of metals, taking into account melting and evaporation over a wide range of pressures and temperatures. For numerical modeling of adiabatic processes, the equation of state in the form of the dependence of pressure on specific volume and specific internal energy can be used. This equation of state, formulated in a simple form convenient for practical application in calculations, is proposed for a variety of structural materials based on elements, organic and inorganic compounds.

The results of calculations of the thermodynamic characteristics of different materials using the proposed equations of state are presented in comparison with available data from experiments with waves of shock compression and isentropic expansion. The adequacy of these equations of state to the available experimental data is demonstrated. The developed equations of state can be effectively used to solve various problems of high energy density physics.