MATHEMATICAL MODELING OF SOLID FUEL COMBUSTION UNDER THE ACTION OF ALTERNATING PERIODIC PRESSURE ABOVE THE FUEL SURFACE

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The report presents physical and mathematical models, solution algorithms and results of a parametric study of the combustion features of solid fuel under the action of variable periodic pressure above the fuel surface. The relevance of the problem is associated with the need to determine the patterns of change in the combustion rate of solid fuel in the combustion chamber at high rates of pressure change. The purpose of this work is to analyze the unsteady combustion of mixed solid fuel under harmonic pressure change above the combustion surface.

Metal-free solid fuel and fuel containing aluminum particles were selected for the study. The main assumptions of the combustion model of mixed solid fuel are presented in [1]. Assumptions concerning the combustion patterns of aluminum particles are presented in [2]. The problem statement is formulated based on the approaches of mechanics of two-phase reacting media [3]. When formulating the physical and mathematical model, it is assumed that the mixed solid fuel occupies the left half-space. When burning mixed solid fuel, its gasification products flow to the right. On the right boundary of the region at a distance L from the fuel surface there is a volume into which the fuel combustion products flow. The problem is formulated in a conjugate statement and is determined by the equations of conservation of mass, momentum and energy of the gas suspension components. The method for solving the problem is based on the algorithms of [4, 5].

From the parametric solution it was determined that the dependence of the combustion rate amplitude on the pressure oscillation frequency of the mixed solid fuel is not monotonic: with an increase in the pressure oscillation frequency, the amplitude of the velocity oscillations first increases and then decreases. Similar effects are observed when aluminum particles are added to the mixed fuel. The amplitude of the combustion rate of the metallized mixed solid fuel changes with a change in the aluminum particle size and the mass content of aluminum powder in the fuel gasification products. With an increase in the particle size, the extrema of the instantaneous maximum and instantaneous minimum combustion rate of the fuel shift to the region of lower frequencies. The amplitude of the velocity oscillations at a fixed amplitude and frequency of pressure oscillations strongly depends on the reaction order in the gas phase, and increases with an increase in the reaction order in the gas phase.

The work was carried out with financial support from the Russian Science Foundation grant 24-21-00071.

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