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FLAME PROPAGATION IN WEIGHTLESSNESS ABOVE THE BURNING SURFACE OF MATERIAL

Abstract

The condensed fuel burning in an oxidant gas flow occurs in investigations of various processes, for example: burning of fuel in hybrid engines; interaction of hypersonic flying vehicles with the atmosphere; exo- and endothermic reactions in chemical engineering; spreading of flame over the fuel surface, the origination of explosions and the propagation of detonation in unmixed two-phase systems of the gas-film type. For all of the above processes it is necessary to calculate the heat and mass transfer between a chemically reacting gas layer and a reacting, melting, subliming, or otherwise destructing, surface. The methods of investigations in this field are very complicated, because the motion of a gas is governed not only by force and temperature fields but also by chemical processes depending in turn on velocity and temperature fields. This requires a conjugate solution of dynamic, thermal and diffusional problems with allowance for the equations of chemical kinetics, multi-component diffusion and variability of thermophysical properties of a medium with distributed parameters. The process incorporates the thermochemical destruction of the surface when vapours of fuel substances, comprising the surface material, diffuse into a boundary layer and react chemically with the external flow. The results of numerical studies of flame propagation in weightlessness above the burning surface of material including unsteady-state transition stage are presented. A mathematical model is developed accounting for the peculiarities of diffusion combustion of fuel in the flow of oxidant, which is composed of oxygen-nitrogen mixture. Three dimensional unsteady-state simulations of chemically reacting gas mixture above thermochemically destructing surface are performed. The results show that the diffusion combustion brings to strongly non-uniform fuel mass regression rate in the flow direction. Diffusive deceleration of chemical reaction brings to the decrease of fuel regression rate in the longitudinal direction.

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