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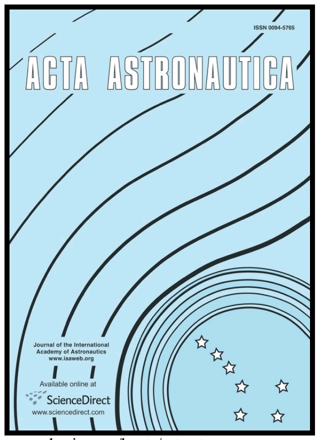

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Ignition of a polymer propellant of hybrid rocket motor by a hot particle

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Abstract
The ignition of polymethylmethacrylate (typical model propellant of the hybrid rocket motor) by a hot particle in a shape of parallelepiped, polyhedron, disk is investigated numerically. The initial temperature of a heat source varied within the range 950–1150 K, size of particle – within the range 2–6 mm. It is established that varying these parameters influenced significantly the main characteristic of the process – ignition delay time under ignition conditions close to critical. For considered shape of particles, ignition delay time is in ascending sequence: parallelepiped, polyhedron, disk. Three polymer ignition regimes, which characterized by the initial temperature of a heat source, ignition delay time and a location of an ignition zone in a vicinity of a hot particle, are emphasized. It is illustrated that taking into account the dependence of thermal and physical characteristics of polymethylmethacrylate on temperature, the ignition delay time increased due to augmentation of energy accumulated by a subsurface layer.
Keywords: hybrid rocket motor, polymer propellant, hot particle, ignition, mathematical simulation.

Nomenclature and units

a	thermal diffusivity ($m^2 \cdot s^{-1}$)
C	specific heat ($J \cdot kg^{-1} \cdot K^{-1}$)
D	diffusion coefficient ($m^2 \cdot s^{-1}$)
E	activation energy ($J \cdot mole^{-1}$)
k	pre-exponential factor (s^{-1})
l	order of accuracy of numerical scheme
m	number of time steps
N	number of spatial steps
n	serial number of spatial step
Q_1	volatiles enthalpy of oxidation ($J \cdot kg^{-1}$)
Q_1^{ign}	heat accumulated by gas mixture at $t=t_d$ (J)
Q_1^{ox}	heat released as a result volatiles oxidation at $t=t_d$ (J)
Q_2^0	heat accumulated by hot particle at t=0 (J)
Q_2^{ign}	heat accumulated by hot particle at $t=t_d$ (J)
Q_3	polymer enthalpy of thermal decomposition ($J \cdot kg^{-1}$)
Q_3^{dec}	heat spent on polymer thermal decomposition at $t=t_d$ (J)
Q_3^{ign}	heat accumulated by polymer at $t=t_d$ (J)
R	perfect gas constant ($J \cdot mole^{-1} \cdot K^{-1}$)
S	relative error of integration in one dimensional case (%)
S_{err}	relative error of integration in two dimensional case (%)
S_{max}	total error (%)