COMBUSTION TRANSFER THROUGH INERT BARRIERS IN HIGH-POROSITY NANOTERMITES

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Abstract: The paper presents the results of an experimental study using high-speed video recording of the combustion propagation through inert barriers in Al/CuO nanothermites placed in closed shells (tubes) made of quartz glass. Viscose and air gaps were used as inert barriers. When the luminous front (which the present authors associate with the burning rate) passes through the barrier made of viscose, its propagation velocity drops noticeably but after it enters the nanothermite, its propagation velocity recovers to the original value. As for the air gaps, when the luminous front expands into the air, its speed increases by a factor of 2–3, then the normal mode of propagation is established. The presence of air gaps in a tube with a thermite mixture makes it possible to significantly reduce the mass of this mixture with a slight decrease in the average burning rate compared to a completely filled tube of the same length.

Keywords: nanothermites; inert barrier; porosity; pressure gradient; burning rate

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Figure Captions

Figure 1 Sample of nanothermite mixture (black) separated by an inert viscose barrier (grey)

Figure 2 The scheme of the experiment: *1* — control computer; *2* — control interface; *3* — laser diode; *4* — lens; *5* — protective glasses; *6* — tested sample; *7* — neutral light filter; and *8* — Phantom Miro LC310 camera

Figure 3 The sequence of high-speed frames of combustion propagation in a thin-walled tube ($h_{\mathrm{glass}} = 1$ mm)

Figure 4 The rate of combustion propagation determined in different sections of a thin-walled tube

Figure 5 The scheme of a compound charge for studying combustion propagation in an nanothermite mixture (I, III) with a barrier (II): *1* — quartz tube; *2* — partitions made of viscose (only for air barriers); *3* — plastic end caps; and *4* — area of laser initiation

Figure 6 The sequence of high-speed frames of combustion propagation in a tube with an air gap (without light filter)

Figure 7 x–t diagram of video recording of combustion propagation in tubes with one (*a*) and two (*b*) air barriers

Figure 8 The rate of combustion propagation in nanothermite mixture determined in different sections of a tube with one (*a*) and two (*b*) air barriers

Figure 9 The sequence of high-speed frames of combustion propagation in a tube with a barrier made of viscose (without light filter)

Figure 10 The rate of combustion propagation determined in a tube with a barrier made of viscose

Figure 11 Macrostructure of the initial highly porous Al/CuO LT mixture

Figure 12 The model of combustion propagation in nanothermite mixture: A — initial low-density nanothermite mixture consisting of micron-sized porous conglomerates; B — the hot jet ignition zone where the reaction is initiated on the surface of individual conglomerates, and they are destroyed; zone width Δx is the base at which the glow grows; C — the combustion zone where the reaction occurs over the entire contact surface of nanoparticles and the substance can be in any phase state; a rapid increase in pressure begins with a maximum gradient due to which hot jets are injected into zone B

Table Caption

The velocities of combustion propagation in nanothermite mixture with different types of barriers

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