A NEW METHOD OF INVESTIGATION OF COMBUSTION PROPAGATION MECHANISM IN POROUS NANOTHERMITES

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Abstract: The paper reports the results of new experimental studies of the mechanism of combustion wave propagation in Al/CuO nanothermites (NT) in closed tubes made of quartz glass with the use of porous inert barriers and transfer of combustion through them. To improve spatial resolution in these experiments, along with a Phantom Miro color camcorder LC310 manufactured by Vision Research Corp. (USA), a black-and-white camera of Japanese production Photron Fastcam SA-Z 2100K with increased (in the visible spectral range) sensitivity and the ability to perform video recording at a rate of up to 1 million frames per second at a fixed frame exposure $\sim$ 158 ns was used. The experiments used viscose, hollow glass microspheres, sodium chloride powder, and quartz sand as inert barriers. During the passage of barriers from viscose and microspheres (up to 40 mm), the composition located behind the barrier was initiated, while the propagation rate of the luminous front (which is associated with the combustion rate in NT) decreased; however, after leaving the barrier in NT, it was restored to the initial value. The barriers from salt powders and quartz sand (fraction size $\sim$ 80 μm) of similar length stopped further propagation of the combustion reaction. The study of the propagation of the combustion reaction through the barriers made it possible to clarify the developed model of porous NT combustion.

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

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Figure Captions

Figure 1 Components of inert barriers: (*a*) 16-micron viscose fibers; (*b*) microspheres 60–80 μm in diameter; (*c*) silicon sand (80-micron fraction); and (*d*) NaCl (80-micron fraction)

Figure 2 The schematic of experimental setup: *1* — control computer; *2* — control unit; *3* — laser diode; *4* — lens; *5* — protective screen; *6* — quartz tube with NT mixture and inert barrier; *7* — neutral filter; and *8* — Phantom Miro camera LC310 or Photron Fastcam SA-Z 2100K

Figure 3 Photograph of tubes with viscose barriers (above) and hollow glass microspheres (below): *1* — quartz tube; *2* — partitions (used only for air barriers); *3* — plastic plugs; and *4* — initiation point

Figure 4 Filmogram of combustion reaction propagation in tube completely filled with NT mixture. The interval between frames is 1.67 μs, without filter ($d = 4$ mm and tube length 63 mm)

Figure 5 The change in the rate of propagation of the combustion reaction along the axis of the tube

Figure 6 Ignition and combustion zones of porous NT mixture

Figure 7 Width of ignition zone along the tube axis. Time from the moment of initiation / distance along the tube axis from the point of initiation: *1* — 25 μs / 3,9 mm; *2* — 28/4,8; *3* — 40/9,8; *4* — 105/47,1; *5* — 113/52,1; and *6* — 115 μs / 53,6 mm

Figure 8 Rate of propagation of the combustion reaction in a tube with a microsphere barrier: (*a*) barrier length 14 mm [19]; and (*b*) barrier length 34 mm

Figure 9 Filmogram of the propagation of the combustion reaction in a tube with a quartz sand barrier. The interval between frames is 1.67 μs, without filter, obstacle length 30 mm

Figure 10 Filmogram of the propagation of the combustion reaction in a tube with a salt barrier. The interval between frames is 2.7 μs, without filter, obstacle length 23.5 mm

Figure 11 Photographs of a tube with a salt barrier (NaCl) preserved after experience

Figure 12 Photographs of a tube with a NaCl barrier before (*a*) and after (*b*) experiment. Dimensions are in millimeters

Figure 13 Filmogram of the propagation of a combustion reaction in a tube with a barrier of 80-mircon glass microspheres [19]. The interval between frames is 2.7 μs and filling length is 14.4 mm

Table Caption

Characteristics of the inert barrier components used

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