REGISTRATION OF ELECTRIC CHARGES IN THE REACTION ZONE OF THERMITE MIXTURE

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Abstract: The article presents a study of chemical reaction manifestations in linear charges of a porous mechanically activated mixture of aluminum and copper oxide powders under electric spark initiation. The conditions for formation and parameters of an electric discharge are described. Experiments with control of electric charge generation in the electric field of up to 5 kV/m in local areas of the reaction zone were conducted. Formation of a conduction zone wave in the reaction channel with a charge content of 1–20 mC was detected. Based on the obtained data, electrical conductivity values were determined in the range of 1000–6000 S/m. The lifetime of the conductivity zone decreases from $\sim$ 2000 to $\sim$ 500 μs with a decrease in the probing electric field to 1 kV/m. The range of variation of electrical conductivity values is the same for nano- and microsized mixtures. No relationship between electrical conductivity values and spark initiation energy was found. Optical radiation in local areas of the reaction zone was controlled. During combustion of microsized mixtures, the phase velocities of the conductivity and optical radiation zone fronts correlate with each other in the range of 30–80 m/s. During combustion of nanosized mixtures, the phase velocities of similar zones are 150–300 m/s.

Keywords: electric charges; thermite compositions; electric spark initiation; combustion wave

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Figure Captions

Figure 1 Calibration dependence of the voltage drop across a 0.1-ohm shunt on the load resistance of the measuring circuit at a charging voltage of the control capacitor in the measuring circuit of 10 V

Figure 2 Typical measurement and processing results: (*a*) oscillograms of the voltage across the current shunt resistance and the voltage across the control capacitors in two charging cross sections (1 and 2); (*b*) oscillograms of the photodiode signals in three charging cross sections; (*c*) sequential photographs of the development of the torch of burning products from the channel with the mixture charge; (*d*) assembly diagram and x–t diagrams of the expansion of the torch of products and the propagation of the front of the zones of conduction and optical radiation; and (*e*) result of processing electrical signals 1 and 2 (see Fig. 2*a*) in the form of a change in the electrical conductivity of the conduction zones in two cross sections of the mixture charge

Figure 3 Scheme of generation of electric charges and optical radiation during interaction with excited reaction products

Figure 4 Scheme of the sequential production of energy-saturated pentatomic aluminum oxide molecules

Figure 5 Schematic of assembly (*a*) and dependences of the maximum electrical conductivity (*b*) and the moment of radiation appearance (*c*) on the energy of electric spark initiation

Figure 6 Schematic of assembly (*a*), typical oscillograms of voltage signals on shunts (1) and control capacitors (2) at different distances from the initiation point (*b*) and the results of their processing: (*c*) approximation of the electrical conductivity change and (*d*) electrical conductivity values at the moment of maximum voltage on the shunts

Figure 7 Schematic of assembly (*a* and *c*) and the influence of the mixture charge density on the value of generated electric charge (*1*), the average current of these charges (*2*), and the electrical conductivity at the moment of maximum voltage on the current shunt (*3*) (*b*)

Figure 8 Schematic of assembly with central charge initiation and reaction propagation to the open and closed channel ends (*a*) and typical results of signal processing: x–t diagrams of the conduction zone front for mixtures with nano- and microsized components (*b*); electrical conductivity values at the moment of maximum voltage on the shunts (*c*); and average values of the current of the electric charges at different points of the conduction zone (*d*)

Figure 9 Photographs of the spatial heterogeneity of reaction propagation in porous linear (*a*) and disk-shaped charges (*b*)

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