FEATURES OF HIGH-TEMPERATURE COMBUSTION OF LAMINATE METAL SYSTEMS

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Deep understanding the mechanism of high-temperature combustion in metallic systems is important both for predicting the combustion of rocket fuels [1] and for conducting the directed SHS of functional inorganic materials [2]. High temperatures in combustion waves (about 3000 K and more) often lead to the melting of condensed phases, initial components and products. Here, the effects of capillary convection in melts play an important role. It should be noted that these effects have not been fully investigated yet. Another important aspect is nonthermal emission phenomena in reaction waves [3, 4]. At present, there is no comprehensive understanding of these phenomena which can not be explained in the framework of available models for heterogeneous combustion [2].

This work represents a complex study of the thermal, structural, and emission dynamics during the combustion of Ni-Al, Cu-Al, Ti-Al wire composites (media: argon, oxygen, air) and Ti, Ni, Al wires (medium: argon, air).

Combustion was initiated by fast passing an electric current through a sample placed between electrodes until melting and breaking of the central part. Two combustion waves in the form of drops of reacting melts were propagated along the sample towards the electrodes. The process was monitored by high-speed video recording, spectrometry, spectral pyrometry and electroprobe plasma measurements [5].

The studies have shown that there is the complete melting of metals and reaction products in the combustion wave. This is confirmed by the high value of the measured maximum combustion temperature (2500÷5600 K, the maximum value corresponds to the synthesis in oxygen). Propagation of waves is accompanied by specific hydrodynamic and emission effects.

Hydrodynamic effects. The processing of video recording data showed that the combustion rate of the systems increased from 0.20 to 0.92 m/s during the transition from the inert to oxidizing media. The data obtained demonstrate that high values of combustion rates are caused by capillary convection of melts in the reaction wave [6]. The conclusion is confirmed by the observations of dynamics for the development of flows in the form of liquid circulation cells (vortices, ordered cells (polyhedrons) with a size of up to 0.2 mm) on the surface of the drops of reacting melts. The velocity of flows is ~ 2 m/s.

Emission effects. Analysis of video recording has shown that components evaporate uniformly over the entire surface of a reacting drop during the combustion of composites in Ar. During the combustion of composites in oxidizing media, evaporation is supplemented by jets from the reacting drop. Here, apparently, there is the boiling of a melt. In some cases, jets are accompanied by the dispersion of the drop (Cu-Al, Ni-Al). Jets of vapors burn and form the clouds of dispersed particles (gas-and-dust phase). A feature of the formation of a gas-dust phase is the effect of twisting the jet streams around a reacting drop. This indicates strong electrical polarization of the system (drop and gas-and-dust phase). The potential difference between the drop and the gas-and-dust phase, according to the calculations, is not less than (2÷3) 10^3 V. The atomic and molecular spectra of Al, Ni, Al^+, Cu, Ti, AlO, NiO, CuO and other particles are observed during reaction transformations. The measured current-voltage characteristics of emission current showed that the electron temperature of plasma reached the level of (1.5÷20) 10^4 K.

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