Combustion mechanism of ammonium perchlorate-ferrocene mixtures

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Abstract

Researchers deal with the regulation of the ballistic characteristics of solid propellants based on ammonium perchlorate (AP) since their first appearance. One of the most effective catalysts of combustion of such fuels are ferrocene (Fc) and its derivatives. High efficiency of ferrocene derivatives connected with the fact that, well distributed in the binder, they are a source of fine Fe_2O_3, formed during the oxidation of ferrocene cycle in the combustion wave. Despite the large number of studies on the mechanism of catalyst action, some issues remain controversial. In this connection in the present work a comparative study of combustion of pressed mixtures AP (20 ÷ 90%) with ferrocene has been done.

Burning rates of AP/Fc mixtures were measured in a window constant-pressure bomb of 1.5-liter volume in the 0.1-20 MPa pressure interval. Samples to test were prepared as pressed cylinders of 0.8-0.9 TMD confined in transparent acrylic tubes of 7 mm internal diameter. A video camera was used to determine the character of the combustion process as well as the burning rates. Temperature profiles in the combustion waves of AP/Fc mixtures were measured using Π-shaped thin (7 μm) tungsten-rhenium thermocouples.

It is shown that, depending on the component ratio in the tested compositions, along with the usual gas-phase combustion model a rather unusual condensed-phase combustion model is realized, when the heat for propagation of the combustion process is not released in the condensed phase at the surface temperature controlled by the more volatile component, but in the condensed phase of hardly volatile component at its vaporization temperature. At that time AP, this hardly volatile component, is already in the foam/aerosol layer.

Effect of ferrocene depends on the combustion mechanism of tested mixtures: in the systems, burning by the gas-phase combustion mechanism, Fc additive differs little from hydrocarbon fuel, but in systems that obey condensed-phase combustion model, the effect of the Fc additive is significant. And depending on the ratio of the components in these compositions ferrocene first acts simply as highly reactive fuel, and only in the compositions with a large excess of fuel the burning rate increases as a result of catalyst of combustion by iron oxide on soot carcass.