AGGLOMERATION OF TITANIUM METAL FUEL DURING COMBUSTION OF COMPOSITE PROPELLANTS*

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Titanium is a pyrophoric metallic fuel and can be used in pyrotechnic compositions [1] and in technological combustion compositions [2]. A specific application of the technological combustion of titanium particles in air can be the creation of a cloud of photocatalytically active TiO_2 particles for the purpose of decontaminating harmful or dangerous substances released into the atmospheric air as a result of a technogenic accident or a terrorist act [3, 4].

The aim of this work is studying the combustion behavior of titanium particles in the combustion wave of composite propellant. This is necessary to optimize the propellant formulation in terms of lowering the metal agglomeration and increasing the yield of oxide particles which are combustion products in the submicron and nanometer size ranges.

The combustion characteristics of composite propellants with titanium particles were studied. The component composition of the propellants included energetic binder, ammonium perchlorate and titanium powder. We used three types of titanium in the propellants: industrial grade PTM, porous rolled and spherical titanium.

Experiments on the combustion of composite propellants were carried out in two variants. Variant 1: combustion in a closed vessel in nitrogen at pressure of 0.35 MPa. The small-sized pressure vessel (bomb) has a volume of 0.33 liters, an outside diameter of 90 mm and maximum pressure up to 3 MPa. The bomb is equipped a pressure control system and windows with a diameter of 30 mm for video recording of the combustion process. The bomb is used to collect condensed combustion products into the liquid. The experiments were performed to determine the burning rate and the granulometric characteristics of agglomerates leaving the burning surface. A video recording of the combustion process is made at a shooting speed of 24 fps and 480 fps. The sampling of condensed combustion products was carried out in a vessel with distilled water of 100 ml volume, placed inside the bomb. Variant 2: combustion in the argon at pressures of 2.0–8.0 MPa. The burning metallic particles were captured and collected in a high-pressure flow bomb at an argon pressure of 2.0–8.0 MPa. The extinguishing of the burning particles, moving from the burning surface, was mixed with the argon accompanying flow. A metal sieve bag and an AFA-type analytical aerosol filter were used to capture and collect condensed particles. The particle size analysis of agglomerates was carried out using an optical projection microscope Carl Zeiss Pictoval.

Based on experiments on the combustion of propellants in a small-sized high-pressure vessel (p = 0.35 MPa), the composition of the propellant was determined for further research. We established the percentage of propellant components, the type and size of titanium powder, which ensures the smallest size of agglomerates in condensed combustion products.

An experimental study of the combustion of the selected model composition was carried out in a high-pressure vessel (up to p = 8 MPa) with the sampling the condensed combustion products. The burning rate law of model propellants, the dependence of the titanium agglomerates size on pressure, and the composition of condensed combustion products were obtained. This study is aimed at determining the pressure and dimensions for designing the layout of the TiO_2 generator chamber.

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