MECHANOACTIVATION AND BURNING OF ALUMINUM AND COPPER OXIDE MIXTURES[1]

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The method of preliminary mechanoactivation (MA) of mixtures of solid oxidizer and metal powders has been actively used since the beginning of the 2000s [2-5]. During MA, the components are shredded and mixed at the submicron and nano levels, and new defects in the crystal structure are formed, which makes it possible to increase the rate of chemical reaction on the surface of the reagents. As result we obtain Mechanically Activated Energetic Composites (MAEC) with increased sensitivity to thermal affect and high burning rate. In this paper new research results on the initiation and burning of MAEC Al/CuO based on micron and nanosized powders using MA are presented.

As the initial components, micron and nanosized powders were used: industrial pyrotechnic powder Al PP-2L (flake 50 ÷ 100 μm × 2 ÷ 5 μm), CuO 20÷50 μm, nanosized nAl (Alex 100 ÷ 200 nm) and nCuO (50 ÷ 80 nm). Al weight content was from 18 to 25%. In some cases, additives of various metals with catalytic effect (Hf, Ni) were also used.

Mixing and activation was carried out in the vibration ball mill of the Aronov design (energy intensity J = 3.7 W/g) or in the planetary mill "Activator-2sl» (J = 9.7 W/g) with steel drums and balls. Liquid hexane was added to reduce friction heating and to prevent the reaction. The starting powders and MAEC were analyzed by X-ray diffraction, electron microscopy and thermo-gravimetric analysis.

A number of the dependences of the combustion parameters on the activation dose D_a were determined in experiments: ignition temperature by hot surface, brightness temperature of burning products, burning rate in cylindrical channels and electrical resistivity in cloud of products. The dynamics of the expansion of products in free space during electric spark and shock wave initiation was analyzed.

To measure the ignition temperature T_i, the test powder weighing 30 ± 1 mg was placed in a container, introduced into the furnace and discharged onto the heated surface. The ignition delay was determined by a stopwatch with an accuracy of 1 sec. Depending on D_a, T_i varies from 170 ºC to 400 ºC.

The burning rate was measured in plastic and glass tubes (diameter 4-10 mm) by recording of products emission by light fiber or high speed photography. The porosity of charges was 60-70%. The initiation was carried out by heating the NiCr wire or by an electric spark. The spark energy was regulated by changing the current amplitude in the range of 1.5-50.0 mJ at duration of the current pulse 1.2 μs. Depending on D_a and the initiation method, the measured burning rate varies from 10 m/s to 700 m/s, and the product temperature is from 2000 K to 3700 K. In case of low-energy electric spark (<20.0 mJ), combustion has a pronounced heterogeneous character. The highest reactivity, burning rate and temperature of products for MAEC Al/CuO were obtained at D_a = 1.8÷2 kJ/g. With increasing D_a there is a partial reaction of the reagents at the time of activation.

In the case of shock-wave initiation of compositions in a semi-enclosed volume, the main process of energy release proceeds in the flow of products dispersed in the unloading wave. The initial flow rate of the products is more than 800 m/s. The maximum brightness temperature in the cloud of partially ionized products reaches 3700 K, the resistivity is about 10^7 Ω * mm^2/m.

The results of the work have shown the promise of preliminary mechanochemical activation for the production of fast-burning thermite compositions of Al/CuO. The use of the original nanoscale components is inadvisable, since it does not give appreciable advantages. Also it was shown, that small addition of Hf can increase the reaction ability CuO based mixtures.

REFERENCES

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