Effect of mechanical activation on combustion characteristics of Al–CuO powder mixture

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Abstract. This paper presents the results of experiments carried out to reveal the influence of the initial parameters of the thermite mixture Al–CuO on the signs of a chemical reaction between its components. Initial parameters were the characteristics of the starting components, preparation conditions and characteristics of the mixture and samples, experimental schemes, methods of initiation. The most important parameter was the preliminary mechanical activation of mixture. The prepared mixture with controlled porosity was placed in experimental assemblies and a chemical reaction was initiated. Values and tendencies of the brightness temperature and the propagation rate of reaction area were determined for different initial parameters of mixture and initiation conditions. The reaction in the volume of the experimental assembly goes into flare combustion in open space. Values of brightness temperature at the stage of flare formation have a stochastic character, determined by the random distribution of reaction sites in the initial volume of the components. A high-speed camera, a pyrometer, photoelectronic and electrocontact sensors were used as diagnostic tools. The final goal of the study is to optimize parameters of mechanical activation of mixture for its effective applying in various conditions.

1. Introduction

The high reactivity of nanoenergetic materials can significantly increase the rate of energy release in combustion and detonation processes, which makes it possible to use similar compositions in the development of advanced explosives, propellants, and microenergetic devices. Thermite compositions based on a mixture of metal powders and powdered oxides of other metals are of interest due to the significant exothermic effect (up to 20 kJ/g) during their chemical interaction. However, the power of this effect is limited both by the propagation speed of the chemical interaction wave and by the low bulk density of reaction sites in solid mixtures. The speed of chemical interaction wave depends on many factors, and the volume density of reaction sites is determined primarily by the effective contact surface of reactants. To increase the contact surface of reagents are used such methods as: ultrasonic mixing of nanosized powders, electrochemical deposition of submicron metal-oxidant layers, etc [1]. One of relatively new methods for preparing thermite compositions is the preliminary mechanochemical activation of a micron-sized particles mixture in ball mills [2]. Initial components in this process are mixed, ground, and acquire new crystal structure defects. This leads to an increase in the contact surface...
of reagents at submicron and nanoscale levels. Thus, by means of the preliminary mechanical activation of initial mixtures, it is possible to set the rate of chemical energy release necessary for a particular application. In the present work, tendencies of the chemical interaction between thermite composition 2Al–3CuO under different conditions of its realization are investigated. The ultimate goal of the study is to optimize the parameters of mechanical activation of this composition for effective application in different conditions.

2. Characteristics of components and mechanochemical activation condition

The industrial pyrotechnic powders of Al PP-2L with flake particles \((50–100) \times (2–5) \mu m^2\) and CuO (chemically clean, crystalline particles 20–50 \(\mu m\) of irregular fragmentation form) were used as initial components. Aluminum content in the mixture was from 18 to 25 wt %. Mixture and activation of components were carried out into two types of spherical mills: in a Aronov’s vibration mill or in a planetary mill “Activator-2sl” with steel pans with spheres [3]. The mass of spheres was 200–300 g. For mixtures in vibration and planetary mills designations Al–CuO(v) and Al–CuO(p), respectively, are used. Single loading of powders was 10–25 g. The activation was carried out by 60-seconds cycles at total time of 1–20 min. To characterize mechanochemical activation in various types of activators, a value called “dose of activation” \(D_a = J_t_a\) (kJ/g) is used, where \(J\) (W/g) is the specific power rating of the activator, \(t_a\) (s) is the activation time. The maximum power rating for Aronov’s mill is 3.7 W/g, and for “Activator-2sl” mill is 9.7 W/g. Further, in results are given both activation time and dose. In some experiments were also used mixtures with a bismuth oxide and hafnium additives and nanosized Al and CuO powders.

As a result of activation, a polydisperse mixture of large conglomerates of flat Al fragments (1–10 \(\mu m\) in cross section) with submicronic CuO particles was received. Owing to dispersion in sizes, forms and strength characteristics of particles, conglomerates were unordered structures with numerous, but separated contact points of components. These contact points of components, presumably, can serve as primary nucleation sites for a chemical reaction \(2Al + 3CuO \rightarrow Al_2O_3 + 3Cu + E\), where \(E\) (J/mole) is exothermic effect.

3. Characteristics of mechanically activated mixture

The starting powders and their activated mixtures were analyzed by x-ray diffraction, electron microscopy and thermogravimetric analysis [3]. At diffractograms of initial and activated Al–CuO(v) mixtures, the lines of 4 phases Al, CuO, Cu_2O, Cu were recorded. In the initial CuO sample a noticeable amount of Cu_2O and traces of Cu are presented. After mechanical activation the phase composition of the composite does not change, however, the content of Al and CuO phases decreases while Cu_2O and Cu phases increases. This indicates a partial reaction between components during the activation. The Al_2O_3 phase was not recorded; it may be in amorphous state.

Thermal analysis of activated mixtures under slow heating (10 K/min) was carried out using differential scanning calorimetry (DSC) and thermogravimetry (TG) on a Netzsch STA 449 C Jupiter Thermal Analyzer in combination with a quadrupole mass spectrometer QMS 403 C Aelos [3]. The mass change and thermal state curves trajectory suggests that the slow controlled heating of activated mixtures leads to the onset of exothermic heat release until the melting point of Al particles. At temperatures below 500 °C, there is a weak exothermic effect. The main heat release is observed in the temperature range of 550–700 °C. Figure 1 shows a comparison of the area of the “main” exothermic effect at different activation times for an Al–CuO mixture with a ratio of 19/81 by weight (stoichiometric). The data on the thermal effect are given in relative units due to a significant excess of values in relation to calibration ones. For each activation time two experiments were performed, as a result experimental points in figure 1 were obtained. It
Figure 1. Exothermic heat effect of reaction in a mixture of Al–CuO(v) mixture with a ratio of 19/81 by weight depending on activation time $t_a$ (activation dose $D_a$) in the heater temperature range of 550–700 °C. Experimental points were obtained by integrating DSC data, the curve was obtained by B-spline interpolation of experimental data.

can be seen, the dependence is extreme. The maximum heat release in the Al–CuO(v) mixture corresponds to an activation time of 8–10 min ($D_a$ from 1.8 to 2 kJ/g).

4. Temperature values and ignition delay
Temperature values and ignition delay allow estimating the optimal conditions of the activation mode at minimal cost. In addition, it allows one to control the quality of the activated mixture with a sufficient degree of reliability. For this, an express-method was used to determine the temperature of a hot surface ($T_{ign}$), when igniting a sample of the control mixture [3]. Together with $T_{ign}$ the ignition delay is determined. As a rule, the ignition delay increases (or, at least, remains unchanged) with a decrease in $T_{ign}$, and at a certain minimum value of $T_{ign}$ an irreversible disruption of the ignition process occurs. The test mixture weighing 30 mg was dropped on a copper plate heated to a temperature of 100–500 °C. The plate temperature was measured with an accuracy of $\pm 1$ °C, and the ignition delay was measured with an accuracy of 0.2 s. Data show that in most cases ignition temperatures varies from 200 to 350 °C for mixtures activated before the appearance of final reaction products ($D_a < 2$ kJ/g). Inflammation, in such cases, is accompanied by a loud and sharp pop (explosion). At high activation ($2 < D_a < 5$ kJ/g), a partial reaction in the mixture with the formation of Cu is observed. This leads to a decrease in $T_{ign}$ to 170 °C. At the same time, the sound effect decreases (weak pop), which indicates a decrease in burning rate. Figure 2 shows an example of the dependence of ignition delay of Al–CuO(p) 19/81 mixture on temperature of igniting surface at different activation times. The absence of ignition is conventionally indicated by a time of 50 s.

5. Propagation rate of the reaction area
The appearance of reaction products in the mixture during its reactivation indicates that local chemical interaction of the components in a cold, on average, medium is possible. Spreading the reaction to a large volume requires preheating the mixture due to external energy contribution
Figure 2. Ignition delay as a function of temperature of Al–CuO(p) 19/81 mixture activated in planetary mill with different activation times $t_a$.

and the primary exothermic effect. As a result, the mixture may ignite. The moment of ignition is the beginning of the propagation of the reaction (burning), characterized by optical radiation. Optical radiation allows characterizing the reaction region by the brightness temperature and propagation velocity. The speed of flame propagation of reaction is limited by processes of heat propagation and production of oxygen. Consideration of these processes is beyond frames of this work. The time of reaction after an external energy contribution, but before the mixture ignition is called an “induction period”. The value of induction period can serve as a characteristic of heat propagation at the stage of the flameless reaction nature.

6. Influence of initial conditions on the combustion process

The combustion of a compacted mixture sample was initiated by an electrical spark method in a glass tube with a diameter of 5.5 mm, figure 3(a) [4]. The porosity of samples (the percentage of pore volume in the total volume) was 50–70%. The spark gap between electrodes was 0.1–0.3 mm long and the duration of a current pulse was $\approx 1\ \mu s$ for the base. In series of experiments the current amplitude varies from 40 to 350 A. The moment of sparking was used to synchronize a high-speed camera Cordin 222-4G.

The boundary of the propagation of reaction flame and the state of the combustion zone were recorded. Under low currents through a spark ($< 150$ A), the combustion zone has a pronounced heterogeneous character. Areas of bright hot products glow alternate with dark ones, figure 3(b), left shots. The glow uniformity increases with increasing current, see figure 3(b), right shots. The choice of a moment, a scale, brightness and a contrast of shots were selected individually for the best demonstration of heterogeneities.

Based on the totality of experimental data, trends in the change in combustion characteristics were determined depending on some parameters (figure 4). Each trend, except one shown in figure 4(a), was formed according to two experiments with same other conditions [5]. Data analysis reveals for mechanically activated Al–CuO mixture the strongest influence of activation time, mixture porosity and spark current amplitude on the induction period and the rate of chemical interaction, see figure 4. Increasing of a sample porosity results in a significant reduction in the induction period with an increase in the burning rate, see figure 4(b). Increasing of a spark current leads to a significant reduction in the induction period with a slight reduction in
Figure 3. Initiating by electric spark: (a) the experimental scheme [1—the dark (no reaction) part of glass tube with mixture; 2—the glass tube with water; 3—the reacting mixture; 4—the boundary of the radiating area; 5—electrodes]; (b) inhomogeneities of reaction area in experiments with different spark currents [left shot refers to initiation with a minimum current (40 A), right one to a maximum current (350 A), respectively; each shot was taken in with an exposure of 200 ns].

7. Characteristics of the mixture combustion outside the initial sample volume
During ignition of bulk weights of mixture (≤ 1 g), the chemical interaction occurs in the form of flare combustion with a considerable scatter of reaction products, figure 5 [6]. In figure 5(a) there is a typical photograph of a flare. Due to the initial heterogeneity of bulk geometry, the glowing area does not have an exact spherical shape. Nevertheless, it is possible to characterize dynamics of glowing area in two orthogonal directions: along (diameter) and across (height) the embankment placement plane, see figure 5(b). The expansion rate of the glowing area is ≈ 100 m/s. On the basis of high-speed photographing data, electrocontact sensors signals and track marks on thin foils, the glowing area (flare) should be characterized as an expanding flow of reacting clusters and cold components of mixture in a cloud of radiating plasma of combustion products. The brightness temperature of reaction products for Al–CuO(v) mixture increased, according to pyrometric measurements, from 2400 (t_a = 2 min) to a maximum value of 3400 K (t_a = 8 min). A rough estimate of the maximum radiated energy made by the size of glowing area by the time expansion ceases gives a value of ≈ 2 J.

A similar flare burning is observed during the initiation and burning of a thermite composition placed in a shell with a free surface. Upon reaching the combustion wave of a composite in a shell, a flare is formed from reacting fragments of mixture onto a free surface.
Figure 4. Experimental tendencies depending on (a) activation time, for two mixture types (for Al–CuO(p), $t_a = 2$ min; 1—burning rate; 2—induction period), (b) sample porosity (spark gap was 1 mm), (c) spark current and (d) spark gap (porosity was 70%).

Figure 5. Combustion of Al–CuO(v) mixture on a surface: (a) typical photograph in 300 $\mu$s after initiation; (b) expansion dynamics of glowing area.

8. Characteristics of the flare burning. The electrical spark initiation

The formation of the flare was observed with electrical spark initiation of a thermite composition in a cylindrical shell with an open end, figure 6. The energy input into a spark with a value of $\approx 100$ mJ provides a burning wave with a $\approx 60$ m/s rate and induction period of 200 to
Figure 6. Characteristics of mixture combustion under electrical spark initiation depending on time $t_a$ (dose $D_a$) of mechanical activation: (a) experimental scheme; (b) the brightness temperature, for both mixtures Al–CuO ratio is 19/81 by weight; (c) the $x$–$t$ diagram of burning rate obtained by electrical sensors for Al–CuO(p), $t_a = 8$ min, average rate is 55.7 m/s; (d) flare characteristics for Al–CuO(p) [$1$—flare appearance time; $2$—induction period; $3$—burning rate].

1500 $\mu$s. In figure 6, the rate of burning wave and a number of flare characteristics depending on activation time are shown. Flare characteristics were derived from pyrometric measurements of its brightness temperature. The dependency analysis reveals the characteristic effect of preliminary mechanical activation on the ignition induction period, the dynamics of the flare and its brightness temperature. All dependencies have extremes indicating the value of the optimal activation time (the optimal activation dose). Different efficiencies of vibratory and planetary mills in achieving maximum flare characteristics are also stated.

9. Dynamic of a flare burning. Shock wave initiation

Shock-wave loading, as an initiating method for chemical reaction, is characterized by a higher (compare with the spark one) value of energy dissipated in thermite composition volume ($\approx 20$ J). This initiation method is used, as a rule, when it is impossible to initiate a chemical reaction by another method due to the low porosity of the sample. Therefore, the shock wave energy excess (60–80 J) is defining in the formation of the flare outside the sample volume. The dynamics of flare combustion was investigated after shock-wave initiation of pressed thermite
Figure 7. (a) The experimental scheme for shock-wave initiation of pressed thermite tablets: 1—steel cylinder; 2—detonation cord; 3—HE charge; 4—steel piston; 5—thermite tablet; 6—steel plate; 7—potential electrodes. (b) The $x$–$t$ diagram of Al–CuO(v) flare dynamics (orifice area $S_0$ was a half of tablet area $S_t$, $t_a = 5$ min): 1—front (490 m/s); 2—conductive front (164 m/s); 3—center (145 m/s); 4—back (37 m/s); 5—radius.

Tables in cylindrical steel tubes with an internal diameter of 8 mm. Samples made under different activation time was pressed into tablets of different porosity weighing 1 g. The experimental scheme is shown in figure 7(a) [7]. It consisted of a cylindrical steel tube, mounted on a steel plate coaxially with the orifice hole. The orifice area $S_0$ was changed in the range from 0.1 to 1 of the tablet area $S_t$. In most cases the mass ratio of HE charge, piston and tablet was kept constant 1 : 1 : 1. The detonation wave of HE charge formed a shock wave in the piston, which loaded the thermite tablet. As a result a chemical reaction was initiated in local points of tablets. At the border with air, the reflected rarefaction wave dispersed the sample and thrown its material with nucleation sites for reaction through the orifice into free space. Thus, the material and exothermic content of flare was formed.

The formation of flare in a free space was recorded using a high-speed camera Cordin 222-4G. The $x$–$t$ diagram of flare area was received by high-speed photographing data, electrocontact sensors signals and pyrometric measurements, figure 7(b). The data shows that the flare reached ≈ 700 mm in length during 1100 $\mu$s and ≈ 100 mm in diameter during 200 $\mu$s. Then the glowing area was decreasing due to the active burning of initial mixture clusters. The optical radiation of flare implied the presence of ionized particles in the stream. However, the evaluation of the electrical resistivity of the stream, based on conduction current measurements between potential electrodes, given a value $\sim 10^7$ $\Omega$ mm$^2$/m, which indicates a rather low plasma density.

It was assumed that initial parameters of the sample (size of particles, dose of preliminary mechanical activation, porosity) can affect the initiation and the behavior of chemical interaction between components and, accordingly, the dynamics of the glowing area. To obtain a response, eight experimental assemblies containing thermite tablets with different initial parameters were assembled into an integral construction for simultaneous initiation, figure 8 [7]. The combustion of flares is shown in figures 9 and 10, parameters of samples are given in tables 1, 2 and 3.

The data processing of upper part of frames in figures 9 and 10 indicates that neither the activation dose, neither the tablet porosity, nor the dilution with an inert material did not affect the dynamics of glowing area during first few hundred microseconds. Then, the longitudinal section size of glowing area decreased and especially quickly for tablets with a 8 and 10 minutes activation dose, which, according to [1], have a highest burning rates. Dilution of initial mixture with additives burning in air (HfC$_2$F$_4$) increased the area and the burning time, see figure 10.
Figure 8. Eight experimental assemblies containing Al–CuO samples for simultaneous shock-wave loading by electric detonator.

Figure 9. Simultaneous shock-wave loading of eight assemblies containing Al–CuO(p) samples differ in porosities and activation times. 1st, 8th, 16th frames correspond to 50, 800 and 2000 µs, respectively. Parameters of samples are given in tables 1 and 2.

Figure 10. Simultaneous shock-wave loading of eight assemblies containing Al–CuO(v) samples differ in porosity. 1st, 8th, 16th frames correspond to 50, 600 and 2000 µs, respectively. At 4 o’clock position in the assembly one 2 g Al–CuO tablet was placed (instead of a 1 g steel piston and 1 g Al–CuO tablet), the reaction of did not start. Parameters of samples are given in tables 1 and 3.

The experimental data on propagation rate of glowing area after shock loading of thermite tablets with different initial characteristics are summarized in tables 4–7.
Table 1. Mass maintenance of components in figures 9 and 10.

| Mixture No. | Components                        | Mass ratio of components |
|-------------|-----------------------------------|--------------------------|
| 1           | Al+CuO                            | 19/81                    |
| 2           | Al+Bi₂O₃                          | 15/85                    |
| 3           | Al–CuO (19/81)+Hf–C₂F₄ (80/20)    | 50/50                    |

Table 2. Parameters of samples in figure 9; samples are indicated according to their position on the clock; mixture number is given in table 1.

| Clock position (hour) | 1 | 2 | 4 | 5 | 7 | 8 | 10 | 11 |
|-----------------------|---|---|---|---|---|---|----|----|
| Mixture No.           | 1 | 1 | 2 | 3 | 1 | 1 | 1  | 1  |
| Activation time (min) | 10| 6 | 12| 8 | 12| 2 | 20 | 4  |
| Porosity (%)          | 21| 15| 20| 22| 12| 17| 27 | 19 |

Table 3. Parameters of samples in figure 10.

| Clock position (hour) | 1 | 2 | 4 | 5 | 7 | 8 | 10 | 11 |
|-----------------------|---|---|---|---|---|---|----|----|
| Mixture No.           | 3 | 3 | 1 | 1 | 1 | 1 | 1  | 3  |
| Activation time (min) | 8 | 8 | 8 | 8 | 8 | 8 | 8  | 8  |
| Porosity (%)          | 31| 40| 40| 35| 32| 24| 15 | 28 |

Table 4. Trends of the outflow rate under shock loading of 1 g of pressed Al–CuO(v); S₀ and S₁ are areas of orifice and tablet.

| Parameter                      | Value range | Result                                      |
|--------------------------------|-------------|---------------------------------------------|
| Activation time t₀             | 2–20 min    | Average rate to the moment of 300 µs: 475 ± 15 m/s |
| (S₀ = S₁, porosity 15–22%)     |             |                                             |
| Mixture porosity               | 15–35%      | Initial rate: 620 ± 20 m/s                  |
| (S₀ = 0.5S₁, t₀ = 8 min)       |             |                                             |

Thus, the data of tables and photographs show that, as a result of shock loading of termite tablets with different initial parameters, the chemical interaction of mixture components is initiated and it is flared beyond the experimental assembly. However, against expectations, the dynamics of flaring during first 600 µs turned out to be quite conservative with respect to variations in initial parameters of tablets. For samples from nanosize components (see table 5), decreasing in the initial flow rate and a faster completion of the chemical interaction were observed. This may be due to the greater dissipation of the initiating shock wave energy in a tablet with a larger specific surface of particles.

The dynamics of dispersed tablets and glowing areas outside the orifices (with alike sections) are similar due to the constancy of explosive charge energy. Apparently, the process of mutual
Table 5. Trends of the outflow rate under shock loading of 1 g of pressed Al–CuO(v): $S_0 = S_t$, $t_a = 8$ min.

| Initial size of particles | Average rate at fixed times (m/s) |
|---------------------------|----------------------------------|
|                           | 250 µs  | 500 µs  | 700 µs  |
| Nanosize                  | 590     | 563     | 386     |
| Microsize                 | 645     | 527     | 480     |

Table 6. Trends of the outflow rate under shock loading of 1 g of non-pressed Al–CuO(v) of bulk density: mixture porosity 60%, $t_a = 8$ min.

| Orifice area | Result                       |
|--------------|------------------------------|
| $S_0 = 0.5S_t$ | Initial rate: 675 ± 15 m/s    |
| $S_0 = S_t$   | Average rate to the moment of 600 µs: 474 ± 15 m/s |

Table 7. Trends of the outflow rate under shock loading of 1 g of non-pressed Al–CuO(v) of bulk density: mixture consists of thermite and sand; $S_0 = S_t$, $t_a = 8$ min.

| Sand content (%) | Outflow rate (m/s) to the moment of 600 µs |
|-----------------|------------------------------------------|
| 25              | 466                                      |
| 50              | 460                                      |
| 75              | 270 (middle part of the stream)          |

displacement of particles during shock-wave loading leads to the activation of a chemical reaction on the contact surface of metal and oxidizer particles, exceeding the effect of preliminary mechanical activation. Thus, the stability of energy and structural conditions of shock loading of thermite tablets levels differences in technological preparation.

10. Parameters of a flare burning. The shock wave initiation

In contrast to spark initiation, shock-wave ignition is characterized by the almost absence of a burning stage in the volume of a thermite tablet. This is because of the lack of a time interval between shock-wave loading and dispergating of the tablet material. Therefore, the ignition of mixture occurs outside the primary tablet volume. In this case, the burning rate and the brightness temperature of the flare can significantly depend on the external conditions specified by the geometry of the space. So, at the front of the flow and its lateral surface, the brightness temperature of flare can grow more slowly and turn out to be lower than when flare was formed by already burning clusters of mixture during spark initiation. To estimate the brightness temperature of flare, pyrometrical measurements were performed at wavelengths of 500, 600, 700 and 800 nm in same experimental assemblies with different flare geometry, figure 11.

The different geometry in figures 11(a, b) was to reveal the effect of unloading of the density of components on the brightness temperature of the flow front. Experiments have shown that in a wide channel, see figure 11(a), the rate of flare formation is 10% more than in a narrow channel, see figure 11(b).
Figure 11. The schemes of assemblies for pyrometry measurements: (a) in a short wide channel; (b) in a short narrow channel; (c) in a long wide channel; 1—thermite tablet; 2—HE charges; 3—detonator.

Figure 12. (a) The effect of activation time on the brightness temperature of Al–CuO(ν): 1—spark initiation; 2—shock-wave initiation; shock-wave data is the same as in figure 6. (b) The distribution of the temperature of the flare front along the outflow direction of tablet material.

The geometry in figure 11(c) was to measure the brightness temperature and its dynamics on the side surface of flare. A channel length of 40 mm limits the duration of reliable pyrometric measurements. Therefore, the moment of reaching the maximum brightness temperature realized in such setup may go beyond the bounds of reliable measurement. This is probably why the maximum brightness temperature in these experiments [red curve in figure 12(a)] has a lower value and locates below a similar dependence for electrospark initiation (section 8). In addition, it was found that at the stage of flare formation, temperature values in a number of experiments have a stochastic character, determined by the random distribution of reaction sites in the initial volume of components.

The maximum brightness temperature of flare at beginning of the long wide channel equals to ≈ 3380 K, see figure 12(a). A further decrease in the brightness temperature of the flow is
≈ 1.65 K/µs, figure 12(b). The speed of the flare front corresponds to the data in tables 4 and 5. Thermal action (in the form of blue-violet tint) on a stainless steel 0.1 mm thick foil on a channel wall was fixed at a distance of 450 mm. For a stainless steel this color of tint corresponds to a temperature of 600 °C. The estimation of the absorbed energy with an exponential temperature distribution in the foil and a constant value of the heat capacity gives a value of ≈ 100 J.

Thus, experimental results indicate that short-term (1–2 µs) shock-wave loading of a porous thermite tablet from Al and CuO powders mixture weighing 1 g is accompanied by energy dissipation of ≈ 20 J, leads to the initiation of chemical interaction between components and followed by flare combustion for up to 3–4 ms.

11. Conclusions
On the whole, the results of the work have shown that preliminary mechanochemical activation is promising for obtaining rapidly burning Al–CuO thermite compositions initiated by the electric spark method. The highest reactivity, the burning rate and the temperature of products for mixtures based on industrial micron components were obtained with an activation dose of ≈ 2 kJ/g. Dependencies of the induction period and the propagation rate of combustion front are determined depending on mixtures porosities and the value of initiating pulse. The non-stationary pulsating combustion mode was observed under a low initiating current level. For mixtures studied results generally showed the prevailing character of filtration mechanism in the combustion propagation. During shock-wave initiation, the mixture afterburning occurs into a cloud of dispersed mixture components and hot products with temperatures above 3000 K.

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