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IGNITION OF BROWN COAL BY LASER PULSES IN THE Q-SWITCHED MODE *

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In [1], the ignition of brown coal with a particle size of $d \leq 100$ μm and a bulk density of $\rho = 0.5$ g/cm^3 by laser pulses operating in the free-running mode ($\tau_i = 120$ μs) was studied. Three different stages have been determined, differing in the ignition threshold H_{cr} and the time of luminescence onset. The ignition thresholds of the corresponding stages are $H_{cr}^{(1)} = 0.47$ J/cm^2, $H_{cr}^{(2)} = 1.95$ J/cm^2 and $H_{cr}^{(3)} = 2.6$ J/cm^2. At $H = H_{cr}^{(1)}$ the glow duration practically repeats the pulse duration and the glow is associated with the heating of the particle surface up to T~3000 K [1]. When $H_{cr}^{(2)}$ is reached, along with the glow during the laser pulse, the flame glow above the sample is observed in the time interval ~ 1 – 10 ms, associated with the release and ignition of volatile substances. In the spectral range of 350–750 nm, the glow of a CO flame, excited H_2 and H_2O molecules was identified [9]. At $H = H_{cr}^{(3)}$ along with the first two glows, a flame glow is observed in the time interval of 50 – 150 ms, associated with the combustion of the coke residue at a temperature of T~1800 K [1].

Laser pulses of nanosecond duration have practically not been used to study the ignition mechanism, although the results of such experiments can contribute to the study of the primary processes of interaction of coals with an oxidizer. This paper presents the first results of studies of the impact of laser pulses of a neodymium laser operating in the Q-switched mode on brown coal particles ($d \leq 63$ μm).

When nanosecond laser pulses are applied to brown coal pellets with a density of 1 g/cm^3 (particle size 63 μm), two stages are distinguished. At the first stage, during the pulse, volatile substances are released, evaporation, vaporization, and non-linear multiplication of luminescence centers occur. The ignition threshold at this stage is $H_{cr}^{(1)} = 0.2$ J/cm^2. The second stage includes the first one and the ignition of the coke residue, the ignition threshold of which is $H_{cr}^{(2)} = 3.5$ J/cm^2. In the luminescence kinetics at $H > H_{cr}^{(1)}$ two components are distinguished: a singlet luminescence with a duration of ~ 20 ns and a second luminescence component observed in the microsecond range, which decays according to the second-order kinetics. At $H > H_{cr}^{(2)}$ ~200 μs after the laser pulse, as a result of chemical reactions, the coke residue ignites and burns in the time interval of 200 – 1000 μs. The amplitude of the flame glow during the excitation pulse increases nonlinearly with increasing energy density, which indicates the avalanche nature of the process of formation of glow centers.

REFERENCES

[1] B. P. Aduev et al., "Spectral-Kinetic Characteristics of Laser Ignition of Pulverized Brown Coal," Opt. Spectrosc., vol. 125, no. 2, pp. 293–299, Aug. 2018.

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