STUDY OF FACTORS AFFECTING THE ONSET AND DEVELOPMENT OF EXPLOSIVE TRANSFORMATION IN HIGHLY DISPERSED SECONDARY EXPLOSIVES INITIATED BY LASER RADIATION

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Laser initiation of secondary high explosives (HEs) is of interest for many applications requiring high reliability and safety. Practical application of laser initiation has long been hindered by low sensitivity of the majority of secondary HE to laser radiation in the infrared spectrum [1, 2]. Application of the modification technology using fulleroid carbon nanomodifiers is a promising trend to reduce the threshold sensitivity of secondary HEs to laser radiation. The addition of carbon in concentration from fractions to several percent increases sensitivity of secondary HEs to laser radiation by an order of magnitude [3].

The paper presents the results of comparative studies on laser initiation of highly dispersed secondary HE perchlorate (5-nitrotetrazolato-N^2) pentaamminecobalt(III) (NCP according to the international classification [4]), modified by astralene (NCP-m).

The initiating pulse source is a 200 W laser module with a fiber output based on 20 W semiconductor laser diodes (LDs) with a radiation wavelength of (915 ± 5) nm.

The schematic diagram of the experimental assembly for laser initiation of tested samples is shown in Fig. 1.

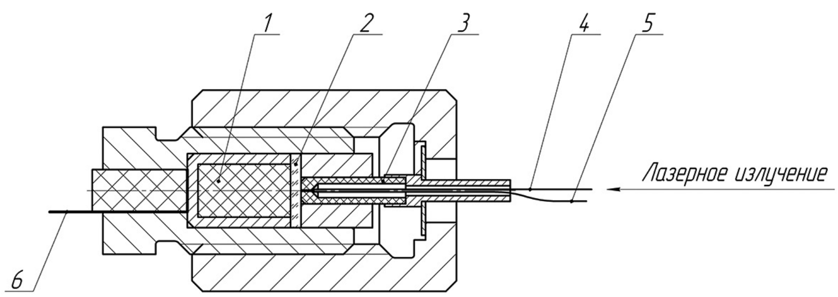

Fig. 1. Schematic diagram of experimental assembly

1 – tested HE sample, *2* – optical support, *3* – optical connector, *4* – initiating optical fiber, *5* – recording optical fiber; *6* – electrical contact pin

In the experiments, the induction time, t_{ind}, (time interval from the initiating pulse to the onset of the explosive transformation process) and the response time, t_{oper}, (time interval from the initiating pulse to early formation of the output shock-wave pulse) were recorded. For each thickness of the optical support (light spot diameter, *d*) for the NCP-m samples, the threshold density of initiation energy, W_{cr}, was determined by the ratio of energy, E_{cr}, to the area of the radiation spot at the interface between the optical support and the HE (Fig. 2).

The initiating pulse parameters and values of the recorded explosive transformation characteristics are given in Table 1.

Fig. 3 gives the representative pressure profiles at the explosion front in the tested HE samples made of NCP and NCP-m initiated by laser radiation.

The results have shown that the introduction of 0.2% astralene into NCP HE allows reducing the threshold initiation energy from 4 mJ down to 0.2 mJ. At the same time the pressure amplitude on the explosion front increases from 4.5 GPa for the NCP samples to 10 GPa for the NCP-m samples while time, t_{ind}, decreases. The increase in diameter of the irradiated area of the tested NCP-m samples from 0.13 mm to 2.77 mm results in the decrease in threshold initiation energy density from 1.53 down to 0.31 J/cm^2. The obtained results can be explained both by the increased absorption of radiation quanta by astralene nanoparticles (the proportion of the absorbed energy can reach 90%) and by creation of conditions, when laser

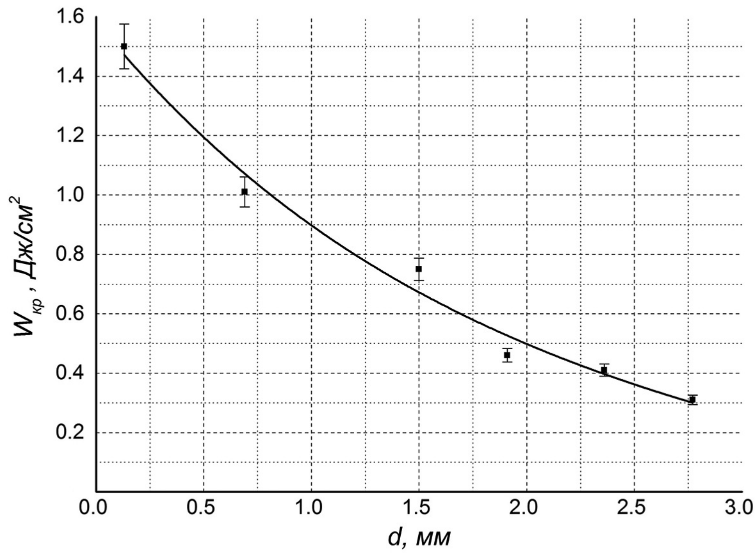

Fig. 2. Threshold energy density, W_{cr}, of initiating the NCP-m samples vs. light spot diameter, d

Table 1

The comparative results of laser initiation parameters of pressed HE samples made of NCP and NCP-m

HE	τ_{puls}, µs	E_{cr}, mJ	d, mm	t_{ind}, мкс	t_{oper}, µs	P, GPa
NCP	100	4.0	0.13	56.2	62.9	4.5
NCP-m		0.2		28.5	34.8	9.9

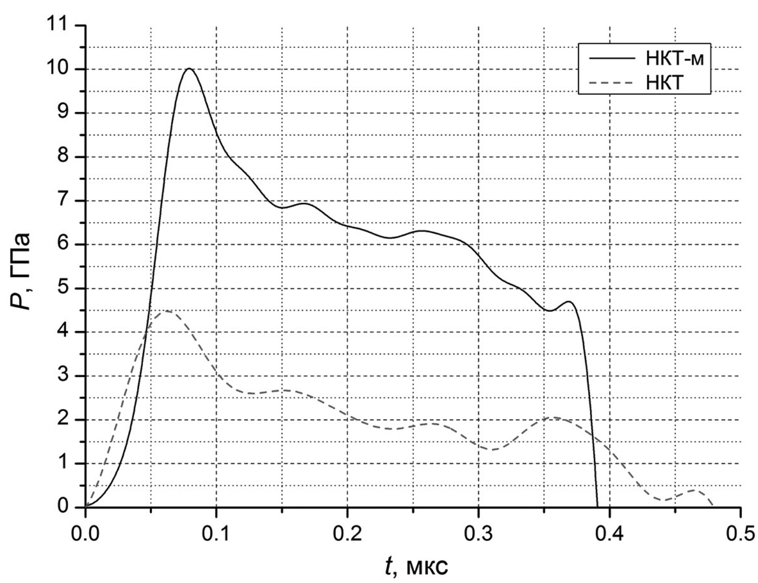

Fig. 3. Pressure profiles on explosion front in pressed samples made of NCP and NCP-m HE

radiation affects astralene particles via luminescence leading to the transition of molecular oxygen into high-stable singlet-excited state with the life time of an order of dozens and hundreds milliseconds, thus, ensuring favorable conditions in the initiated HE for more active formation and development of the deflagration burning reaction with subsequent transition to detonation [5, 6]. The results obtained with NCP-m HE samples enable determining an optimal relation of initiating pulse parameters and high-speed response in the process of designing executive components of initiation systems based on secondary HEs with laser initiation using small-sized cheap semiconductor laser diodes.

References

1. **Zegrya, G. G.**, Savenkov G. G., Zegrya A. G., et al. // Zhurnal tekhnicheskoi fiziki [Journal of Technical Physics]. – 2020. – Vol. 90, No. 10. – P. 1708–1714. (in Russian).
2. **Tarzhanov, V. I.** Fast initiation of HE. Special detonation modes [Text] : collection of scientific articles. – Snezhinsk : RFNC – VNIITF Publishing, 1998. – 168 p.
3. **Abdrashitov, G. O.**, Averyanov A. O., Balmakov M. D., Ilyushin M. A. et al. // Zhurnal prikladnoi khimii [Journal of Applied Chemistry], 2019, vol. 92, No 2, pp. 217–222 (in Russian).
4. **Pat. No. 2729490.** Initiating composition and method for its production [Text] / Batalov S. V., Ageev M. V., Fedotov S. A., Smirnov A. V., Vedernikov Yu. N. ; 2020. (in Russian).
5. **Belousov, V. P.**, Belousova I. M., Budtov V. P. et. al. // Opticheskii zhurnal [Optical Journal]. – 1997. – Vol. 64, No 12. – P. 3–37. (in Russian).
6. **Didukov A. I.**, Kulagin Yu. A., Shelepin L. A., Yarygina V. N. // Kvantovaya electronika [Quantum Electronics]. – 1989. – Vol. 16, No. 5. – P. 892–904. (in Russian).