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A Melt-Cast Composition Based on NTO and FOX-7*)

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Abstract: A melt-cast composition containing NTO, FOX-7, TNT, Al and wax was prepared and tested. The viscosity of the melted composition was measured. Its sensitivity to impact, friction, shock wave and jet impact were determined, and its thermal stability and ignition temperature were established. Some detonation properties of the composition were investigated. The heat of detonation was measured using a calorimetric bomb. The detonation pressure and velocity were determined in a plate-dent test. The results of a cylinder test were used for the determination of the Gurney energy, the detonation pressure and energy, and the so-called effective exponent of the expansion isentrope and the JWL equation of state of the detonation products.

Keywords: NTO, FOX-7, low-sensitivity explosives, melt-cast explosives

1 Introduction

NTO-based melt-cast compositions are widely used in practice. Among others, the XF® and XP® explosive families are low sensitivity melt-cast NTO-based compositions [1-2]. For example, the composition XF®13333, containing TNT (31 wt.%), NTO (48 wt.%), wax (7.5 wt.%) and Al powder (13.5 wt.%), has been already produced on a large scale and used in 155 mm artillery missiles. This munition received the NATO signature of insensibility. RDX (XF®11585) or HMX (XF®12366) have been added to increase the detonation parameters of NTO-based compositions [1]. Other melt-cast compositions containing spheroidal particles of NTO were developed on a laboratory scale in Poland [3].

*) Part of this work was presented at the 19th Seminar on New Trends in Research of Energetic Materials, held in April 2016, Pardubice, Czech Republic.

The composition named CompNTO, consisting of TNT, NTO, Al and wax, and the composition named CompNTOR, containing TNT, NTO, RDX, Al and wax, were tested. CompNTO was found to fulfill the requirements specified for explosives destined for insensitive munitions.

FOX-7 (1,1-diamino-2,2-dinitroethene, DADNE) is commonly expected to be a promising explosive combining comparatively high performance and low sensitivity, thus it is expected to be very useful for low sensitivity formulations [4]. FOX-7 can replace RDX because it has similar detonation parameters and it is less sensitive [5]. FOX-7 was applied in the TNT-based melt-cast compositions described in [6]. The non-aluminized composition named FT, containing 30 wt.% FOX-7 and 70 wt.% TNT, and the aluminized formulations FTA, containing 15 wt.% Al, 25 wt.% FOX-7, 60 wt.% TNT, were obtained and tested. For comparison, non-aluminized (RT) and aluminized (RTA) melt-cast formulations containing the same amounts of RDX and aluminium were tested. The compositions with FOX-7 had a greater thermal stability compared to the formulations with RDX. However, the detonation velocity of the composition FT was lower than that of the composition RT. The detonation velocity of the aluminized compositions was lower, by 200-300 m/s, than that of the non-aluminized ones. The FOX-7-based formulations were found to be less shock sensitive than the corresponding RDX-based formulations. However, they were more shock sensitive than melt-cast TNT. On the other hand, the compositions containing FOX-7 were less sensitive to friction and impact stimuli than TNT.

In the present work, a melt-cast mixture containing TNT, NTO and FOX-7 was prepared and the viscosity of the formulation at temperatures above the melting temperature was measured. The sensitivities to mechanical, thermal and shock stimuli were tested. Some detonation characteristics of the composition were also determined.

2 Characterization of the Components and the Composition

The first component of the tested composition was FOX-7, which was obtained by the method described in [7, 8]. Recrystallization of the synthesized product was performed according to the method proposed in [4]. Optical microscope images of FOX-7 after crystallization are shown in Figure 1.

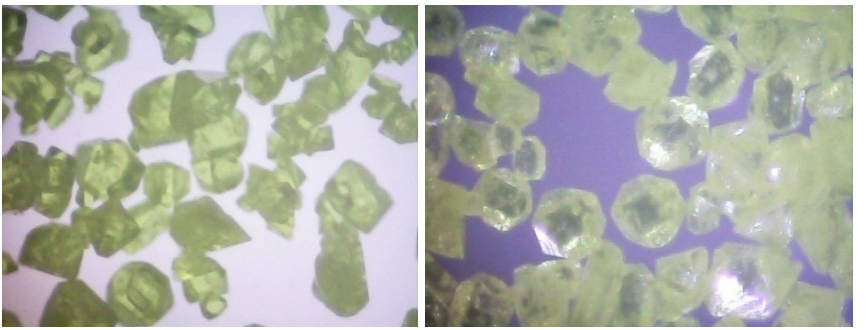

Figure 1. Optical photographs of FOX-7 after recrystallization.

The crystallization product was screened through sieves of mesh 160 μm and 300 μm and particles from this size range were used. SEM images of the sieved FOX-7 are shown in Figure 2. Optical microscopy was used to determine the particle size distribution (Figure 3). Analysis of the size distribution of FOX-7 shows that a small proportion of the particles have a diameter less than 160 μm and a much larger proportion of the particles have a diameter greater than 300 μm. The presence of the latter is probably due to the non-spherical shape of the particles and the fact that the particles in the optical images can be stuck together. In turn the appearance of small particles in the distribution may be caused by their adhering to the larger particles during sieving through the 160 μm sieve.

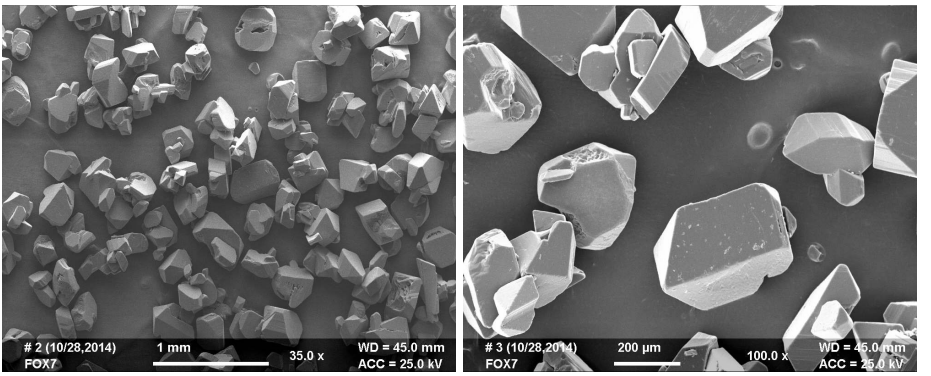

Figure 2. SEM images of FOX-7.

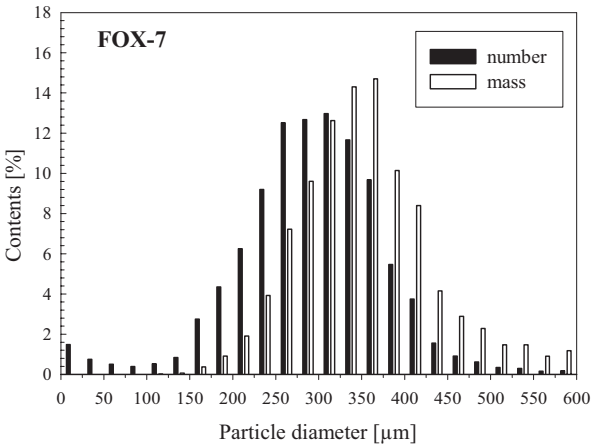

Figure 3. Particle size distribution of FOX-7.

The bulk density of the sieved FOX-7 was measured using the glass cylinder technique with a volume of 12.27 cm^3. Mean values of 0.858 g/cm^3 and 0.987 g/cm^3 were obtained for the loose and the shaken bulk density, respectively. The impact sensitivity E_{50} = 33.5 J was determined using a BAM apparatus and the Bruceton method [9], while the friction sensitivity on a Julius-Peters apparatus was greater than 360 N.

The synthesis of the second component of the composition (NTO) was carried out by the method described in [10, 11]. Spherically-shaped NTO was used in the composition. The method for obtaining spheroidal NTO is described in [12]. SEM images of the NTO used are shown in Figure 4 and the particle size distribution is presented in Figure 5.

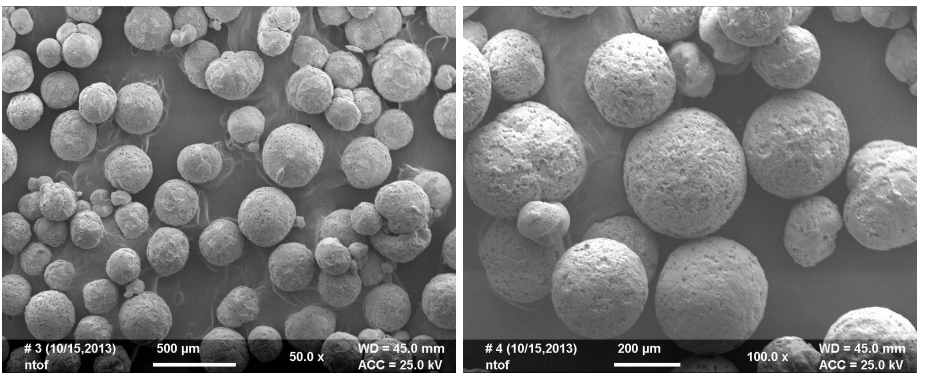

Figure 4. SEM images of particles of recrystallized NTO.

The loose bulk density of NTO was 1.0 g/cm^3 whereas the shaken one was 1.11 g/cm^3. Its impact sensitivity was $E_{50} = 61$ J, while the friction sensitivity was greater than 360 N.

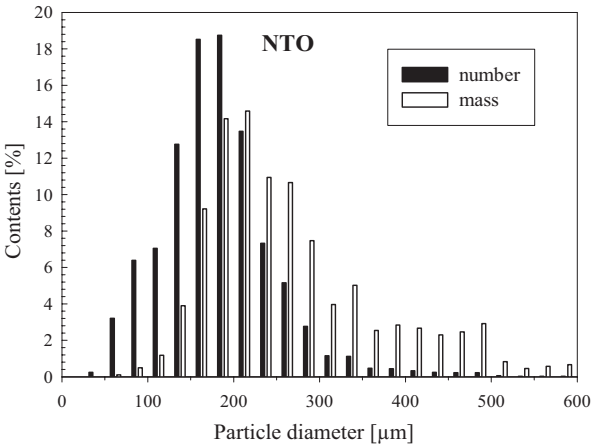

Figure 5. Particle size distribution of NTO.

Fine aluminum powder (mesh sieve of 325, particle size of less than 44 μm, purity 99.5%) was also used. The SEM images of Al powder and its particle size distribution are shown in Figures 6 and 7.

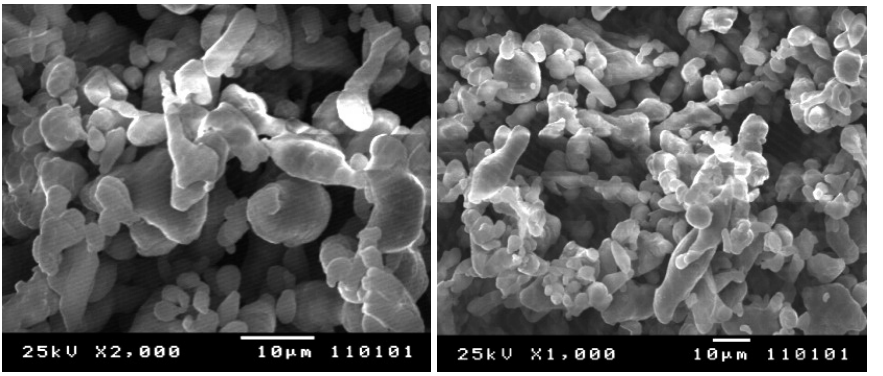

Figure 6. SEM images of aluminum particles.

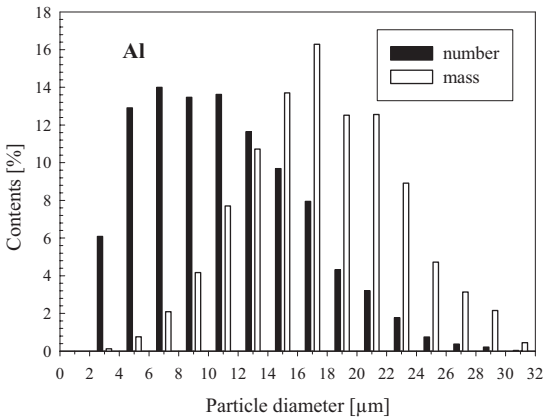

Figure 7. Particle size distribution of aluminum.

Flaked TNT and a wax, based on natural waxes with the addition of thickeners and emulsifiers, were used as melting ingredients.

The composition containing NTO, FOX-7, Al, TNT and wax was prepared on a laboratory scale using an apparatus equipped with a 50 cm^3 melter. The terminal temperature on the thermocycler was fixed at 100 °C. TNT was heated in the melter at 90 °C until it was totally melted, then wax was added continuously in small portions. The TNT/wax was homogeneous after mixing. The mixture of non-meltable ingredients, NTO, FOX-7 and Al, were then added slowly to the melter until a homogenous composition was obtained. The casting was achieved by tilting the melting box with a handle. The optimized composition was obtained with good viscosity and homogeneity (Figure 8). The new composition, named CompFOXN, contained 24 wt.% NTO, 22 wt.% FOX-7, 32 wt.% TNT, 14 wt.% Al, and 8 wt.% wax.

Figure 8. Photograph of CompFOXN.

Measurements of the dynamic viscosity were performed using a rotational viscometer made by Fungilab, model Expert R, equipped with a small sample

adapter and an integrated heating mantle. The measured viscosity of the applied wax and the mixture of TNT and wax with the same proportions as in the tested composition CompFOXN, are shown in Figures 9 and 10.

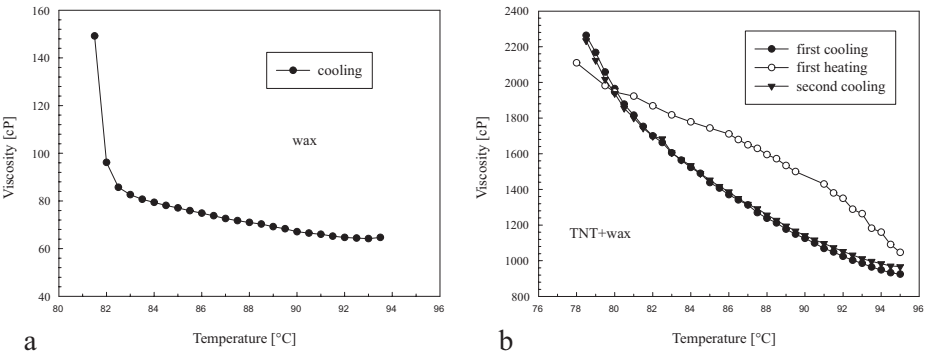

Figure 9. Results of the viscosity measurements for (a) wax and (b) TNT+wax.

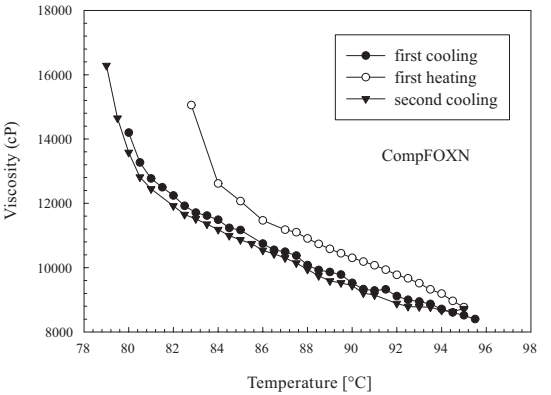

Figure 10. Results of the viscosity measurement of CompFOXN.

The viscosity of the wax was much higher than that of TNT (11 cP in 85 °C). A rapid increase in the wax viscosity was observed below 82 °C. The viscosity significantly increased when wax was added to TNT. The different dependences of the viscosity on temperature were measured for heating and cooling cycles.

The viscosity of CompFOXN was much higher than that of the mixture of wax with TNT. The reason for this increase was the greater than 50 wt.% of solid components (NTO, FOX-7 and Al) in the composition. It can be concluded from the measurements that the range of the viscosities in the temperature range 85-90 °C guarantees the proper castability of the composition during the forming of larger scale charges.

To cast the compositions on a larger scale, a 3.5 dm^3 capacity apparatus equipped with a mixer and a jacket heat exchanger was used. It served for the preparation of the composition, which could be cast directly into moulds using a bottom vent.

The density of the cast charges of the composition varied from 1.71 g/cm^3 to 1.74 g/cm^3. In order to confirm the lack of cavities inside the charges, X-ray images were taken. Typical photographs are shown in Figure 11. The casts obtained were homogeneous.

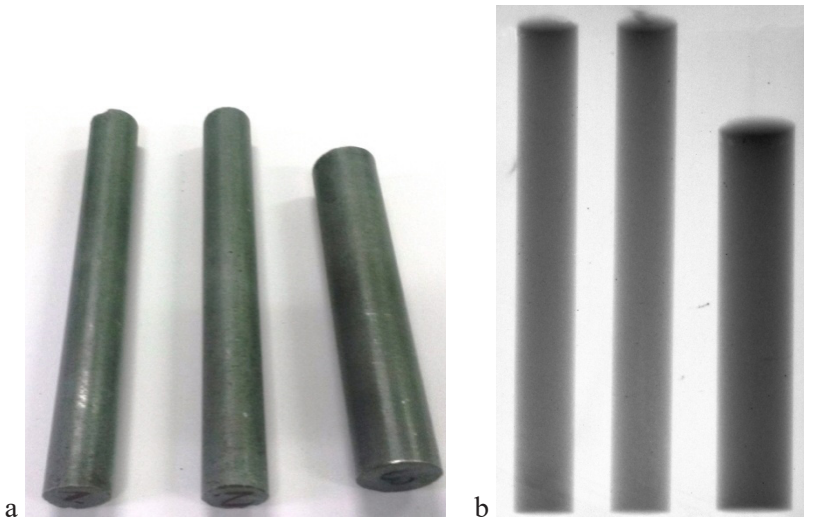

Figure 11. Images of the CompFOXN charges: (a) photographs, (b) X-ray images.

3 Sensitivity

3.1 Sensitivity to mechanical stimuli

CompFOXN was crushed and sieved in order to choose particles with sizes in the range 0.5-1 mm, which were used in the impact and friction sensitivity tests. The friction sensitivity of CompFOXN was determined on a Julius-Peters apparatus, according to the standard PN-EN 13631-3 [13]. The highest loading at which no initiation was observed in six consecutive trials was 360 N for granules less than 0.5 mm. Granules which had particle sizes between 0.5-1 mm were insensitive to friction at a loading of 330 N.

The impact sensitivity of the composition was determined using a BAM apparatus with a 5 kg hammer. The height h_{50} in which the probability of initiation

of an explosive is equal to 50% was determined. The energy E_{50} corresponding to the height h_{50} for CompFOXN was 48 J. For comparison, E_{50} for flaked TNT was 38 J.

3.2 Shock sensitivity

The shock sensitivity of the composition was determined using the gap test. The tested explosive was cast into a copper tube of 25 mm inner diameter and 30 mm outer diameter. The length of the charge was 100 mm. The mean density of the charges used in the gap test was 1.71 g/cm^3. A donor charge of phlegmatized RDX (50 mm diameter, 157 g weight, 1.65 g/cm^3 density) served as a shock wave generator. From shot to shot, the length of a polyamide attenuator (100 mm in diameter) was changed. The highest and the lowest gap values were recognized at which complete detonation and failure to detonate were observed, respectively. Complete detonation of the charge was indicated by a clean hole cut through the steel witness plate. Detonation of the composition took place at a gap thickness of 32 mm and no-detonation took place at 33 mm. For comparison, the results obtained for cast TNT in the same set-up were 43 mm and 44 mm, respectively [3].

3.3 Thermal stability and thermal analysis

The thermal stability of CompFOXN, FOX-7 and NTO was determined according to Polish Standard PN-V-04011-21 [14]. Two small samples (about 0.6 g) of each material were kept for two periods of 48 h at a temperature 100 °C in a heating chamber. After each stage, the samples were cooled and weighed. The results are presented in Table 1.

Table 1. Results of the thermal stability measurements of the tested explosives

Explosive	CompFOXN		FOX-7		NTO	
Sample number	1	2	1	2	1	2
Mass loss after 48 h [%]	0.97	1.0	0.1	0.1	0.18	0.2
Mass loss after next 48 h [%]	0.65	0.76	0.25	0.2	0.2	0.12

According to the standard [14], an explosive can be recognized as stable, when its weight loss during heating is not more than 0.3%, unless the standard of an explosive is determined differently. The main ingredient of the tested composition was TNT, which at 100 °C is molten and evaporates. This is confirmed by the result of the test on pure TNT, in which the total weight loss was 0.75%. No chemical reactions leading to changes in color took place in the samples during 96 h. Pure explosives NTO and FOX-7 are thermally stable

according to the standard [14]. For TNT and CompFOXN, the weight losses were higher than 0.3%.

For this reason another test different from the standard [14] was carried out to check the stability of CompFOXN. A 100 g sample of the composition was put into a test tube. The same quantity of a comparative inert material (NaCl) was placed in a second tube. The two tubes were then inserted into the heating chamber at 75 °C and a thermocouple was immersed in each tube. The tubes were closed with plugs. A third thermocouple was located in the heating chamber.

Samples were left at 75 °C for more than 48 h and the temperature differences between the sample of the tested explosive and the reference sample (ΔT) was recorded. The difference was less than 0.5 °C and the mass loss was 0.06%. CompFOXN can be considered thermally stable because the temperature difference resulting from the self-heating of the sample did not exceed 3 °C and the weight loss of the explosive was not greater than 0.3% [14].

The ignition temperature of the composition was measured according to STANAG 4491 [15]. Samples of 0.5 g were loaded into three test tubes which were immersed in a Wood's metal bath and the temperature of the bath was raised uniformly at a rate of 20 °C/min to a maximum temperature of 360 °C. During this heating process, the temperature at which smoke and flame were observed in the samples was approximately 241 °C.

TG/DTA analysis was carried out according to the Standard PN-V-04011-21 [14]. A CompFOXN sample weighing 6.6 mg was heated at 2 K/min to 400 °C in a nitrogen atmosphere. The TG/DTA curves obtained are shown in Figure 12.

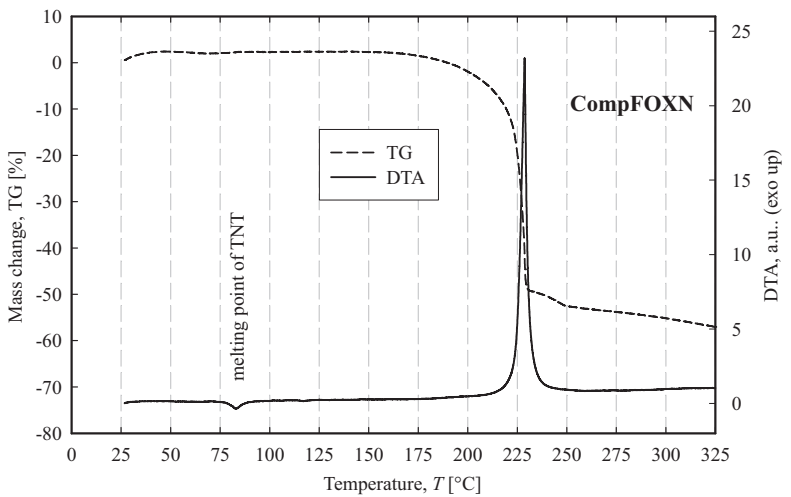

Figure 12. TG/DTA curves for CompFOXN.

From the thermogram presented in Figure 12 it follows that melting of TNT took place and the highest rate of this transformation was achieved at a temperature of about 83 °C. The second endothermic peak on the DTA curve can be assigned to the first allotropic transition of FOX-7 (α→β) at a temperature 114.4 °C [16]. There was only one peak for decomposition which starts at approximately 226.5 °C. It was accompanied by a loss in weight equal to about 54.3% of the sample mass. For comparison, the decomposition of pure FOX-7 commenced at 214.3 °C and only one peak was observed.

3.4 Heat sensitivity – fast cook-off test

The heat sensitivity of the new composition in a larger scale test with heavy confinement used the fast cook-off test [15]. In this test, a seamless steel tube with an internal diameter of 31.8 mm, wall thickness 6 mm and length 254 mm was used. Two steel end-caps of thickness 10 mm sealed the tube. The tube and end caps were weighed and then the composition mass was placed directly in the tube. The density of the charge was 1.73 g/cm^3. The filled vehicle was supported over a tray containing 2 L of petrol.

The fuel was remotely ignited and the time from fuel ignition to the reaction of the explosive was recorded (1 min and 15 s). The tube was ruptured and ejected but no fragments were observed (Figure 13a). The explosive mass found remaining inside the tube was 118.7 g. Thus, the response of the composition to fast heating was category 1 – burning [15]. By comparison, detonation of a cast TNT charge occurred in this test [3].

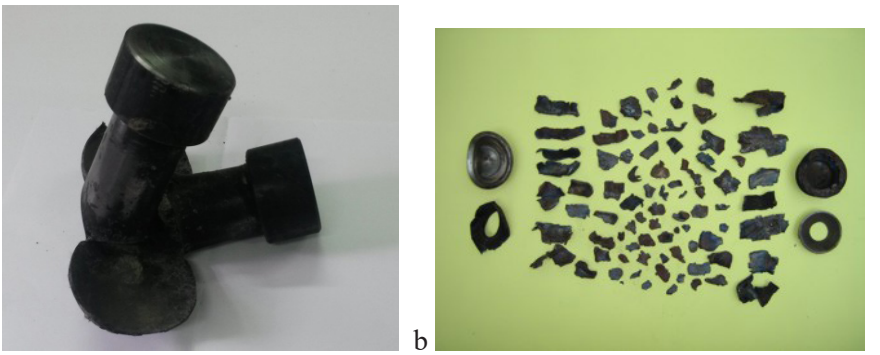

Figure 13. Results of the cook-off test for (a) CompFOXN, and (b) cast TNT.

3.5 Jet attack

The reaction of the composition to a jet attack was tested using a shaped charge made of 21.5 g pressed, phlegmatized HMX and a 14 g sintered copper liner with

a cone-shape angle of 60° and base diameter of 32 mm. The estimated jet velocity was 5750 m/s. The explosive to be tested was placed in a steel tube with the same sizes as given for the tube used in the cook-off test, but the thickness of one of the end-caps was reduced to 6 mm. The jet hit this end-cap and was parallel to the axis of the charge. The density of the cast composition was 1.73 g/cm^3.

A photograph of the tube after this test is shown in Figure 14a. The jet penetrated the charge but it did not initiate a chemical reaction in the first part of the charge. A reaction was initiated at the other end due to the reverberation of the strong shock wave generated in the composition by the tip of the jet. Some of the explosive remained inside the tube. The response of the composition to jet attack was burning. For comparison, the number of fragments after the trial with cast TNT shows that detonation had taken place after the impact of the shaped charge jet [3].

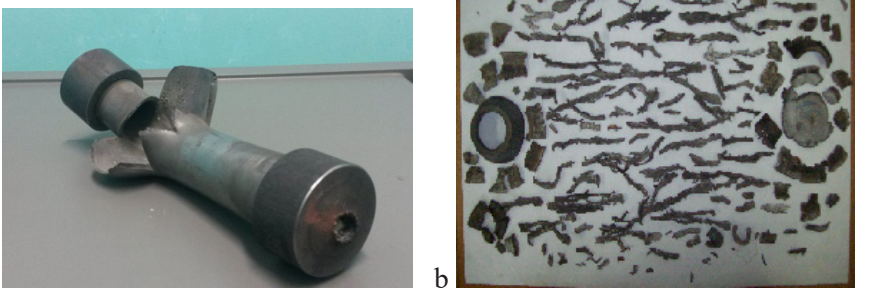

Figure 14. Result of jet impact on (a) CompFOXN, and (b) TNT.

4 Performance

Theoretical detonation parameters were estimated by using the thermochemical code CHEETAH [17] with the BKWC set of BKW parameters. It was assumed in the calculations that the density of the composition was 1.74 g/cm^3 (97% TMD). Both chemically inert and active aluminium was assumed in the calculations. The detonation velocity was 6911 m/s and the detonation pressure was 17.75 GPa for inert aluminium. The same parameters calculated for active aluminum were 6764 m/s and 19.50 GPa, respectively.

Studies of the composition CompFOXN included measuring the heat of detonation and performing a plate-dent test and a cylinder test.

4.1 Detonation heat

The calorimetric heat of detonation of the tested composition was found using the method described in [18]. The heat was measured using a 5.6 L calorimetric bomb filled with argon at a pressure of 2 MPa. The bomb was placed in a polished steel calorimeter vessel which held distilled water. The calorimeter was surrounded by a constant-temperature jacket.

A charge of 20 g of crushed CompFOXN with 5 g of phlegmatized RDX used as a booster were pressed into a pellet of a diameter of 25 mm. The pellet was hung in the center of the bomb. An electric fuse was used as a detonator. To calculate the explosion heat of the composition, the difference between the measured total heat effects and the heat released by the fuse and the booster was divided by the composition mass. The calorimetric heat of detonation was 3895 J/g. The heat determined for CompFOXN is lower than that measured for TNT, which ranges from 4019 J/g [19] to 4430 J/g [20].

4.2 Plate-dent test

Brisance, detonation velocity and pressure for the composition CompFOXN were determined in the plate dent test. In this test, a cylindrical charge of 39.6 mm in diameter and 198 mm height was used. The charge was cast into a steel tube and then removed from the tube. The density of the charge was 1.74 g/cm^3. To initiate detonation of the unconfined charge, a 50 g charge of phlegmatized RDX (40 mm in diameter, density 1.645 g/cm^3) was used. The detonation velocity was measured by using 2 short-circuit sensors. The first one was 25 mm away from the bottom of the charge, and the second was 70 mm away. The detonation velocity was 7136 m/s. The depth h of the crater in the steel plate was measured after the test. This depth is a measure of the explosive brisance. The detonation pressure at the Chapman-Jouguet point, p_{CJ}, was determined from the earlier established calibration relation between h and p_{CJ}. The results of the test were as follows: brisance value $h = 5.72$ mm, detonation pressure $p_{CJ} = 19.0$ GPa. For comparison, the same parameters determined for cast TNT in [3] were 6.07 mm and 20.1 GPa, respectively.

The measured detonation velocity and pressure for the composition were greater than the calculated parameters assuming inert aluminium. However the calculated detonation pressure assuming active aluminium (19.50 GPa) was slightly higher than that determined experimentally.

4.3 Cylinder expansion test

The observation of the expansion of a metal tube driven by the detonation products of a confined explosive charge can provide important data concerning

the amount of chemical energy released during detonation and the degree of its transfer to the surroundings. Such a test is called the cylinder test.

The acceleration process of a cylindrical copper tube driven by expanding detonation products was recorded using impulse X-ray photography. The copper tube was 250 mm long with an internal diameter of 25 mm and wall thickness of 2.5 mm. The detonation velocity was also measured in this test using short-circuit sensors. The composition CompFOXN was cast directly into the tube. Two tests were performed. One of the radiographs is shown in Figure 15.

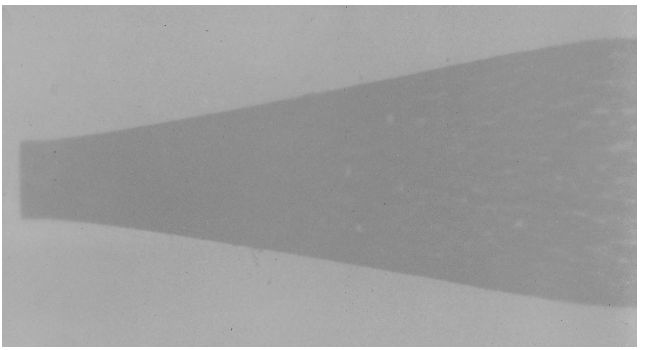

Figure 15. Radiograph of the copper tube driven by the detonation products in test 1.

From the photographs, the dependences of the external surface radius of the tube on the axial co-ordinate were constructed using the method described in [21].

4.3.1 Gurney energy and velocity

Using the method described in [21], the dependence of the tube velocity on the relative volume of the detonation products was determined (Figure 16). For comparison, the velocities of the tube calculated with the CHEETAH code were plotted on Figure 16. The calculations were performed assuming (i) total chemical inertness of the aluminium powder in the detonation products, and (ii) its chemical activity. The density of CompFOXN of 1.73 g/cm^3 was assumed in the calculations.

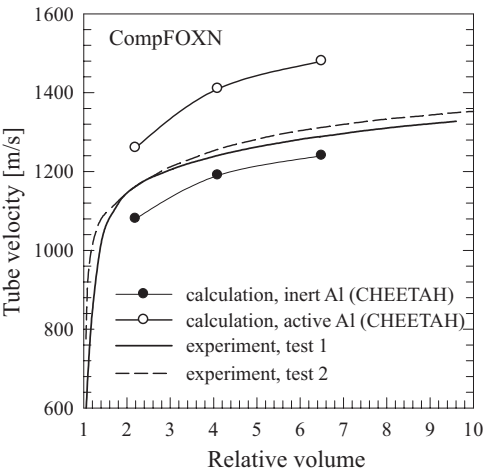

Figure 16. Dependence of the tube velocity on the relative volume of the detonation products of CompFOXN.

The acceleration ability of an explosive can be described as the Gurney energy or Gurney velocity. The Gurney energy is the sum of the kinetic energy of a driven tube and the detonation products following it [22]. The tube velocity, determined from the cylinder test results, enabled us to estimate the final value of the Gurney energy and velocity (Table 2).

The Gurney velocity obtained for CompFOXN was lower than that determined for cast TNT in [3] (2408 m/s for TNT density of 1.60 g/cm^3).

Table 2. Density, detonation velocity, Gurney energy and Gurney velocity of CompFOXN

Test number	Density [g/cm^3]	Detonation velocity [m/s]	Gurney energy [kJ/kg]	Gurney velocity [m/s]
test 1	1.72	6880	2380	2182
test 2	1.74	7047	2500	2236

4.3.2 Detonation energy

The cylinder test results can also be used to estimate the detonation energy, which is defined as the work done by the detonation products during their expansion from the volume at the Chapman-Jouquet point to infinite volume [23]. As was shown in [21], a correlation exists between the detonation energy and the tube kinetic energy:

$$\frac{e_0}{e_0^{st}} = \frac{\left(\mu + \frac{1}{2}\right)}{\left(\mu^{st} + \frac{1}{2}\right)} \left(\frac{u_L}{u_L^{st}}\right)^2 \quad (1)$$

where e_0 and e_0^{st} denote the detonation energies related to a mass unit of the explosive tested and a standard explosive, respectively, and u_L and u_L^{st} are the velocities of the driven tubes determined for a relative volume 10. The parameter μ is the ratio of the tube mass to the mass of the explosive.

In order to estimate the detonation energy of CompFOXN, TNT of density 1.59 g/cm^3 was chosen as the standard explosive. Its heat of detonation (4430 kJ/kg) was determined in [19] and the cylinder test results were taken from [24]. Detonation energies for CompFOXN estimated from tests 1 and 2 were 3740 J/g and 3870 J/g, respectively. The second value corresponds well with the heat measured in the calorimetric bomb.

4.3.3 Effective exponent of the isentrope of the detonation product

The data given in [25-27] show that the angle of inclination of the measured isentrope of the detonation products, presented on the plane of the specific volume-pressure on a logarithmic scale, is close to the angle of a line that represents an izentrope with constant exponent γ when the change in the relative volume of the product does not exceed 4. The so-called effective exponent of the isentrope determined on the basis of the cylinder test results for this range of volume variations was used to estimate the detonation pressures of the tested composition. The effective exponent of the isentrope was determined by comparison of the experimental profile of the copper tube with that obtained from numerical modelling of the expansion process [27]. In the model, the properties of the detonation products were described by the γ-constant equation of state. The experimental and calculated profiles of the copper tube driven by the detonation products of CompFOXN are presented in Figure 17. A detonation pressure of 19.5 GPa was calculated for $\gamma = 3.44$ and the parameters measured in test 2 (density of 1.74 g/cm^3 and detonation velocity of 7050 m/s).

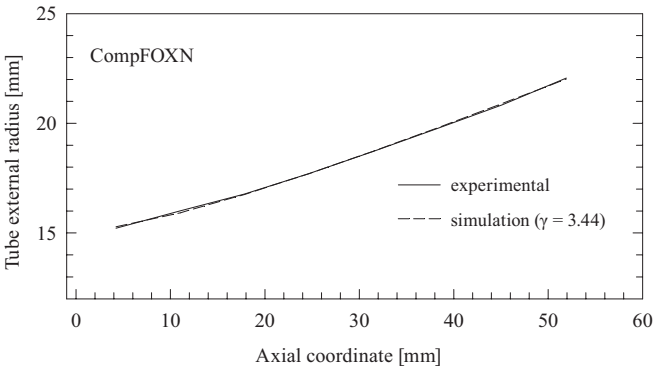

Figure 17. Comparison of the profile of a copper tube (test 2) with that obtained from the simulation with γ-constant model for the detonation products.

4.4 Determination of the coefficients of the JWL isentrope

The physical properties of the expanding detonation products can be described by the isentrope which was proposed by Jones, Wilkins and Lee in the following form:

$$p_S = A\mathrm{e}^{-R_1 V} + B\mathrm{e}^{-R_2 V} + CV^{(-1-\omega)} \tag{2}$$

where A, B, C, R_1, R_2 and ω are constants for a given explosive, $V = v/v_0$ is the relative volume of the detonation products.

Cylinder test data are commonly employed in most methods for the determination of the JWL coefficients. In the method described in [25] some connections between the JWL coefficients following from the conservation laws written for the Chapman-Jouguet point are used. As a result, parameters A, B and C are expressed as functions of R_1, R_2, ω and the density of the explosive ρ_0, detonation velocity D and detonation pressure p_{CJ}. The constants R_1, R_2 and ω are chosen by the optimization method in which the experimental dependence of the tube radius on the axial coordinate is compared with that obtained from the numerical simulation [25].

To determine the JWL constants for the detonation products of CompFOXN, the results of test 2 were chosen. The mean value of the pressure estimated in the plate-dent test and that obtained from the γ-constant model was taken as the detonation pressure in the modelling. The comparison of the experimental and calculated tube profiles are shown in Figure 18. The detonation parameters and JWL coefficients for CompFOXN are collected in Table 3.

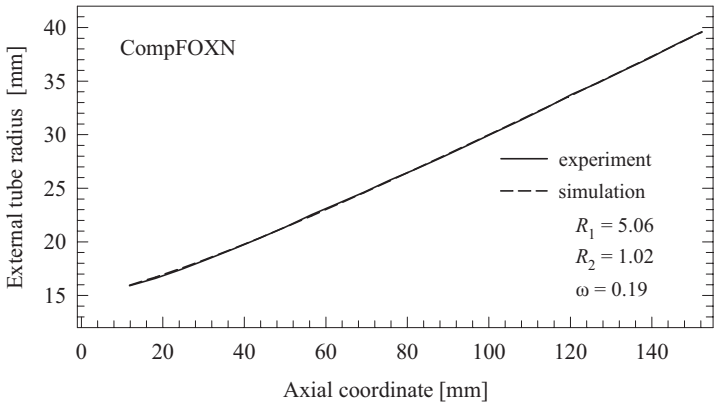

Figure 18. Comparison of the profile of a copper tube (test 2) with that obtained from the simulation with the JWL isentrope for the detonation products.

Table 3. Detonation parameters and JWL coefficients for the detonation products of CompFOXN

ρ_0 [kg/m^3]	p_{CJ} [*G*Pa]	E_0 [GPa]	R_1	R_2	ω	*A* [GPa]	*B* [GPa]	*C* [GPa]
1740	19.3	6.8	5.06	1.02	0.19	836.3509	4.321143	0.6865664

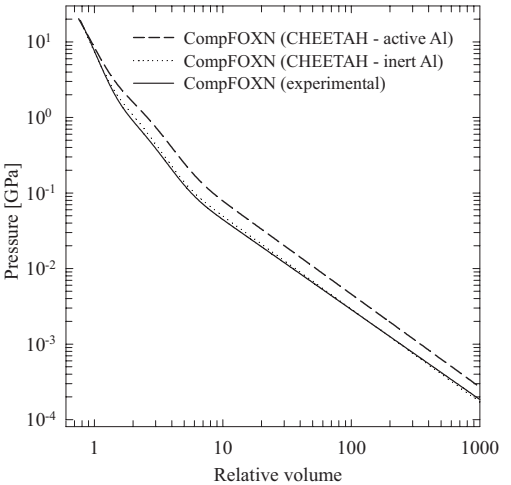

Figure 19. JWL isentropes for the detonation products of CompFOXN.

The JWL isentrope for the detonation products of CompFOXN, obtained by using the experimental results and those calculated by the CHEETAH code with the assumption of active and inert aluminium, are presented in Figure 19. The JWL equation of state, whose parameters are given in Table 3, can be used to calculate the expansion work of the detonation products, blast wave characteristics or fragment velocities.

5 Conclusions

A new melt-cast composition based on NTO and FOX-7 was prepared on a laboratory scale. This composition was characterized by good rheological properties and could be cast on a large scale at a temperature higher than 85 °C and less than 90 °C. The sensitivities to impact, shock wave, jet attack and fast heating determined for the composition are lower than those of TNT. The theoretical detonation velocity and pressure of the composition were confirmed by experimental determination. The Gurney energy, the detonation pressure and energy, the effective exponent of the isentrope and the JWL equation of state of the detonation products were determined successfully from the cylinder test data. The results of the sensitivity tests performed and the detonation parameters of the new composition indicate that FOX-7 can be used in low sensitivity melt-cast explosives and the tested composition is promising as a main charge filling destined for insensitive munitions.

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