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TRHACIA TECHNIKA 2024

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Thank you for participating in the 32th International Conference, the promotion of vocational training in the field of legislation, science, research and practice for drilling and blasting workers and related industries.

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Obsah – *Contens*

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Zoznam prednášok – *List of Papers*

IPARI ROBBANÓANYAGOK ALKALMAZÁSÁNAK LEHETŐSÉGEI VÉDELMI TERÜLETEN[1]

INDUSTRIAL EXPLOSIVES IN DEFENCE APPLICATIONS

László SZALKAI[2]

Kivonat:

Elődeink hatékony kutatása által széles világ nyílt ki számunkra a robbanóanyagok kialakulása terén. A fekete lőpor feltalálása óta számtalan új robbanóanyag látott napvilágot, azonban időnként a szerencse vagy a múltba történő visszanyúlás eredményezte az új, az adott feladatra megfelelő robbanóanyag megalkotásához. Kutatómunkám alatt igyekszem felkutatni azokat az alternatív robbanóanyagokat, melyek adott esetben a nyílászárók erőszakos nyitására is alkalmasak lehetnek.

Írásomban a robbanóanyagok kialakulásának rövid történeti áttekintését követően a katonai, illetve rendvédelmi célokra alkalmazható ipari robbanóanyagok vizsgálatát végzem el és eredményébe beavatom az olvasót. Igyekszem összefoglalni azokat a robbanóanyagokat, amelyek alkalmasak lehetnek ezen feladatok végrehajtására.

Kulcsszavak: *robbanóanyagok, ipari robbanóanyagok, katonai rendvédelmi felhasználás.*

Abstract:

Through the effective research of our ancestors, a wide world of explosives has opened up to us. Since the invention of black powder, countless new explosives have been created, but sometimes it has been a matter of luck or a reach back into the past to find a new explosive that is right for the job. During my research, I try to find alternative explosives that can be used to forcibly open doors and windows.

After a brief historical overview of the development of explosives, I will examine industrial explosives for military and law enforcement applications and present the results. I will try to summarise the explosives that may be suitable for these applications.

Keywords: *explosives, industrial explosives, military law enforcement use.*

INTRODUCTION

The development of gunpowder goes back centuries. Around 700 A.D. this mixture of natural materials was already known in remote China. Gunpowder was created by using the right proportions of naturally occurring substances. This strategically important invention was produced from the grinding of saltpetre, sulphur and charcoal, although it was initially used only for entertainment purposes. It was first used for military purposes around 1000 A.D. against Mongol troops in the Far East.[3]

After the battle, the Mongols made further modifications to the chemical composition of gunpowder - higher nitric oxide content - to make their conquests of China and the East a success. Although gunpowder was already known to the Arabs around the 1200s, it was not until the early 14th century that it was first used in firearms in Europe.

According to various references in literature, it was invented for Europe by an English monk Roger Bacon (1214-1292) in 1249, using a mixture of 7 parts saltpetre, 4-4 parts charcoal and sulphur. The proportions of the ingredients of the gunpowder mixture have varied over the centuries,

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[3] The third son of Genghis Khan, who was Grand Khan of the Mongols after his death in 1229-1241. His death from a heart attack saved Western Europe from total Mongol conquest.

depending on the technical development of the time, the place where it was used and the way in which it was used. It was first used as a cannon fuse in England in 1326, and records of its use at the Battle of Cressy in 1346 have survived. It was not used by the French until the 1980s, as the use of the firearm in battle was not sufficiently chivalrous.

A significant historical fact is Guy Fawkes' London bomb plot to smuggle over 1,600 kilograms of black powder into the basement of the Houses of Parliament to assassinate King James I. After his plan failed, he was convicted of treason and executed. [1] The first industrial use of black powder was the explosion of the Tyrolean mining master Weindl Gáspár in 1627 at Selmecbánya (Szélakna, Upper Bíber tarn), the idea being the brainchild of Baron Montecuccoli, who wanted to introduce the knowledge of mining the castle walls. Thanks to its successful application, it spread rapidly across Europe. The Canal Du Midi tunnel in Malpas, France, had already been formed by blasting.

Over time, the production of black powder has undergone continuous development. Between 1777 and 1778, Lavoisier experimented, and then Berthollet's mixture appeared, containing 16 parts of saltpetre, 1 part of sulphur and 3 parts of charcoal. In 1882, the Rottweil gunpowder already contained 77 parts of saltpetre, 3 parts of sulphur and 20 parts of rye straw carbon.

EVOLUTION OF INITIATING EXPLOSIVES

Mercury fulminate was discovered by the Dutchman van Drobbel in 1630, but was first used after its "reinvention" by the British Edward Howard in 1799, which was an accident of error. It was reinvented by the British Edward Howard in 1799, an accident of error. It was patented in 1807 as a primary explosive, attributed to the Scotsman Alexander J. Forsyth. [2]

The sthynic acid used as a base for TRNSZ was first produced in 1808 (Chevreuil), but it was not until the production of trinitro-resorcinol in 1871 that it became a widely produced explosive. Curtius invented lead azide in 1891. It was used in fuses in 1906, proposed by the Russian colonel A. A. Solonina as a substitute for mercury fulminate. Industrial production started in 1908.

HISTORY OF THE DEVELOPMENT OF BRILLIANT EXPLOSIVES

Nitrocellulose was discovered by the German Christian Friedrich Schönbein and was then used for medical wound disinfection. And Ascanio Sobrero discovered nitro-glycerine during his research into cardiac medicine. As nitro-glycerine proved to be a very explosive substance, many experiments were carried out to make it safe for treatment, but it took a chance event to produce the finished product.

The researcher Alfred Nobel also conducted experiments to improve the safety of handling hazardous substances. As far as was technically possible at the time, the compound was transported in glass balloons, which were placed in silica beds for safety reasons. On one occasion during transport, the stopper in the top of one of the bottles fell out and the spillage mixed with the silica, forming a resinous substance. This material was tested by Nobel and found to retain its explosive power, although its sensitivity to mechanical stresses was significantly reduced. Subsequently, Nobel patented the world's first treatment-proof explosive[4] in 1867. The resulting material was called gurdinamide.[5]

[4] Some literature gives 1866 as the date of invention.
[5] From the name of the diatomaceous earth Kieselgur.

In 1846, Alfred Nobel created the first metal-sleeved, mercury fulminate detonator to initiate nitro-glycerine charges, replacing the earlier black powder-filled detonators. At that time, precisely timed detonations could be carried out with the so-called black powder Bickford fuse. In addition, an explosive was needed with a flame sensitivity sufficient to be detonated by the fuse and an energy sufficient to detonate a nitro-glycerine charge perfectly. Nobel found mercury fulminate suitable for this purpose and created the first copper-sleeved fuse.[6]

In 1876, after Nobel had created gurdinamide, he encountered a new problem, as the powerful primer previously used for nitro-glycerine was unable to initiate it. As a solution, he produced a series of mercury fulminate-filled primers scaled from 1 to 10 strengths. Their charge weights ranged from 0.3 grams to 3 grams. The 8th member of the series, containing 2 g of charge, was capable of initiating a dynamite charge. This range of sizes has been used around the world ever since.[7]

From that time onwards, new explosives appeared in the public domain. In 1875 Nobel created explosive gelatine by chance, and in 1884 the Frenchman Paul Vieille created the first pure military nitrocellulose gunpowder.

Subsequently, the British also created their own smokeless gunpowder, which became known as ballistite and cordite. At this time, 1888-89 was written. The hidden military potential of peruvic acid, previously used only for dyeing silk and wool, was discovered in the German chemist Herman Sprengel. As a result, picric acid-collodion-based melinite was created (by Eugen Turpin), which led to the breakthrough in the development of artillery ammunition with picric acid explosive charges. Subsequently, a succession of picric acid military explosives such as British lyddite, Russian Silotwor, in the Austro-Hungarian Empire Ekrazit, Japanese Simoze and German Sprengkorper appeared in various countries.

The explosive trinitrotoluene (trotyl, TNT)[8] was introduced by the German C. Haussermann in 1891, although it had already been invented in 1863 by the German chemist J. Wilbrand. Initially used by the German military industry to charge high explosive mine shells from the early 1900s, it was first used in the 1905 Russo-Japanese War. The US began using it for military purposes in 1912. It is a stable and reliable explosive, but after several decades it can pose a life-threatening challenge to bomb makers. [3][4] During the First World War, it had to be produced on such a scale that the factories could no longer meet military demand, so amatol, a variant of ammonium nitrate, was used in ammunition. This explosive was developed in England in 1915 and required Favier's 1884 invention, the ammonium nitrate explosive. Tollens discovered nitro-pentate (PETN)[9] in 1891. The German Hans Henning discovered hexogen in 1899 while researching medicines, but it was not patented as an explosive until 1920 by the German E. von Herz.

It was not used on a mass scale until World War II. Hexogen is known as Royal Demolition eXplosive (RDX) in England, Research Department eXplosive in the USA and Canada, T4 in Italy, but is also marketed as cyclonite. Its production cost is significant, approximately 2-4 times the price of TNT. Nevertheless, it is one of the most important military explosives in the world today. [5]

The SEMTEX plastic explosive, which has excellent explosive properties, was invented by Stanislav Brebera of the Czech Republic in Pardubice in 1966. The company initially produced

[6] Copper was needed not for aesthetic reasons, but because of the mercury fulminate, which, in contact with other metals (especially if it gets wet), will break down and lose its sensitivity.
[7] The explosive energy of each size 8 primer should be equivalent to the explosive energy of 2 grams of mercury fulminate.
[8] It is also known as trinitrotoluene.
[9] Pentaerythritol tetranitrate; also known as pertitrite, ten and corpent.

various military and industrial explosives under the names Semtin Glassworks, then VCHZ Synthesia, and later Explosia.

The industrial SEMTEX 1A and SEMTEX 10 explosives contain 94% nitro-pentate and only 5% hexogen, while the military SEMTEX 1H explosives contain almost 50-50%.

Currently, these types of explosives are also used in law enforcement applications to create the most scaled cutting charges. One such product is the Dioplex MK 50 linear cutting charge.

Advantage:

- can be scaled to the specific use location;
- can be prepared in a short time;
- adaptable to the technical equipment of the operational units.

It is also an excellent material for filling various 3D-printed parts for customized cartridges, where its advantages are also evident. The additive process allows the production of focused (punching), stretched (cutting) and mandrel (cutting) fillings, in which Semtex is very efficient [6][7][8].

In my study, due to space constraints, it was not possible to cover all explosives, but I have tried to examine the compounds of major military importance. Some explosives are used not only in military applications but also in industry, and vice versa.

LOW EXPLOSIVES FOR INDUSTRIAL USE

One of the best-known types of industrial explosives is the ammonium nitrate and diesel oil explosives (ANFO[10], ANDO[11]), whose discovery is linked to the 1947 explosions in seaports in the United States (Texas City)[12] and France (Brest)[13]. [9] In this incident, it was found that ammonium nitrate, which was transported in paper bags, mixed with an additive of about 0.8-1.0% paraffin and petroleum derivatives to protect it from moisture, had ignited. The explosion was so powerful that it immediately attracted the attention of the experts. The explosive, known in Europe as ANDO and in America as ANFO, was developed, mainly for industrial use, and is made from 94% ammonium nitrate and 6% diesel fuel, even if mixed at the explosion site. [10]

ANDO is an industrial explosive used specifically for earth and rock blasting (surface mining), with surprisingly good performance. It is used in prefabricated 1-2.5 kg cartridges, in 25 kg bags or by on-site mixing. The use of this explosive in the military field may be justified by its advantageous properties:

- it is cheap and made from available indigenous components;
- it can be produced on site;
- its earth explosive capability is close to that of trotyl;
- insensitive to external physical effects, safer to transport;
- oxygen balance close to zero, less toxic;
- fills the holes perfectly, thus improving the charge utilisation factor;
- does not require special expertise to manufacture.

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[10] Ammonium nitrate and „diesel oil”.
[11] Ammonium nitrate and „fuel oil” (the latter is the name for diesel oil in the USA).
[12] The explosions on board the SS Grandchamp and the SS Highflyer on 16 and 17 April 1947 killed 567 people.
On 28 July 1947, the SS Ocean Liberty exploded.
[13] On 28 July 1947, the SS Ocean Liberty exploded.

Disadvantages:

- can be stored for a short time (max. 3 months);
- sensitive to moisture.

In summary, ANDO has only a partial use as a substitute explosive in military applications, but its easy availability in emergency situations requires consideration on the basis of the above-mentioned advantages. Law enforcement applications in peacetime are not practical, its applicability in urbanised areas is of concern, and its assembly and mounting on hatches is cumbersome.

About ten years later, the discovery of Melvin A. Cook and H. E. Farnham marked a new stage in the development of industrial explosives. [11] His invention was the explosive brain, which he presented to the public in 1958. Explosive charges are mainly aqueous solutions of ammonium nitrate and other nitrates mixed with combustibles (aluminium powder, glycol, etc.) and sensitizers (TNT, nitro-penta, hexogen). They can be filled and mixed on site, pumped from tanker trucks into the borehole. They are 3 to 6 times more effective than ANDO/ANFO and have the advantage of being able to be filled into water boreholes, but they detonate precariously below 4 degrees Celsius. [11][12]

The third stage in the development of industrial explosives was the emergence of emulsion explosives. In 1964, the first emulsion explosive was introduced in the United States, but its real success began in the early 1980s. In this new explosive, very small diameter droplets of ammonium nitrate solution (Ø 10^{-4} mm) were coated with a thin layer of oil in a special manufacturing process to create a waterproof explosive. Due to the special emulsifying agent, it does not lose its explosive properties even at -25-30°C. The emulsion itself does not contain any explosive ingredients and only becomes an explosive after the addition of a sensitising agent. This sensitizer is a hollow sphere of glass or plastic, a few microns in diameter. The glass beads generate a concentration of energy, or hot spot, in the hollow particles inside them, due to the high and rapidly propagating pressure created by the shock wave generated when the explosive charge explodes, which is sufficient to detonate the adjacent explosive part and propagate the chain reaction. The amount of glass bead mixed into the emulsion also controls the initiation capability of the explosive produced and its adaptation to the external temperature.

APPLICATIONS OF THE TYPES OF EXPLOSIVES

High explosives are mainly recommended for use in the demolition of solid structures. Medium explosives were used for all types of demolitions (metal, rock, earth, wood) and for filling anti-personnel and anti-tank mines. Low explosives were used in earth or rock blasting, in chambers and in drilled holes, and were used to fill anti-personnel and anti-tank mines, among other things. As you can see, different types of explosives can be used for many different blasting tasks, the increase in gas volume, detonation velocity, brisance, among other things, influences the place of use, from filling the primer to rock blasting tasks. I will illustrate with some examples the types of explosives according to their place of use. [13]

High explosives and their uses:

- hexogen: in primers, in second charges, in burr fuses, in plastic explosives;
- hexotol: in cumulative charges (hexogen-trotyl mixture);
- ten: in primers as a secondary charge, in priming fuses and as a detonator in ammunition;
- tetryl: detonator in ammunition, second charge in primers;

- explosive gelatine (93% dynamite): explosive functions. [14]

Medium explosives and their uses:

- trotyl: filling of ammunition types, production of explosive bodies: 200 g small and 400 g large shells, 75 g cartridges;
- picric acid: assembly of ammunition;
- melinite (picric acid): loading of tank shells, explosive charges of the same size and weight as trotyl;
- plastic explosive: phlegmatised nitropenta-based 'bricks' weighing 1 kg.
- French mixture: cast of 80% picric acid and 20% dinitro naphthalene, data identical to melinite. [14]

Low explosives and their use:

- Ammonium nitrous explosives: those ammonites (amatols) containing at least 20-25% TNT; charges for earth explosives, anti-tank mines and various demolition mines.

The use of explosives with a propelling charge (gunpowder):

- black (smoky) powder: charges for shrapnel and signalling mines, making timed fuses;
- smokeless powder: as rocket propellant.[14]

INDUSTRIAL EXPLOSIVES IN DEFENCE APPLICATIONS

The requirements for explosives for defence and law enforcement purposes allow the use of explosives and detonators that have a sufficiently high degree of brittleness and workability, insensitivity to physical impact, long-term physical and chemical stability (shelf life of at least ten years), a certain level of water resistance, and the ability to function independently of external temperatures. [15]

On the basis of the information gathered in the course of my investigation, I would like to highlight two areas which may be suitable for both defence and law enforcement tasks in the performance of the task expected to be performed with explosives or substitute explosives. Of course, it is necessary to distinguish them from peacetime equipment or technical solutions on a case-by-case basis, but we must take account of the fact that they can be used.

High explosives are mainly used in industry for the demolition of structures and the destruction of buildings.

TESTING OF CUMULATIVE AND CUTTING CHARGES

Research in different countries has shown that different metals can be used as fillers to achieve different effects for cumulative charges of the same mass and design. Experiments have also shown that the cumulative effect is not only for concentrated charges, but also for linear cutting charges with longitudinal design, among others. [16]

These types are used by both industry and the military, although their initial use was dominated by military applications, but industry soon found their potential in guided explosive detonation.

[14] Introduced by MN MÜF measure 36/1986 (HK. 23), as a supplement to the Explosive Ordinance No. 3 of the Ordinance No. 213 of the Ministry of Works.

Linear cutting charges are available in both rigid and flexible designs. They use high-yield, brittle explosives such as HMX, RDX, PETN, etc.

In military practice, the latest flexible (pliable) cutting charges are more suitable, as they follow exactly the shape of the structure to be blown up, which is secured by means of an adhesive film. The jet-forming metal insert is mostly made of lead. The charge can be tailored to the required size on site.

Advantageous properties:

- reduction of the time required to assemble steel structures for blasting;
- environmentally friendly blasting;
- long shelf life (suitable for military applications);
- suitable for technical rescue as well as for bomb disposal.

In the course of my research, I have found that from a law enforcement perspective, cutting charges are also applicable tools. They can be used to cut through metal fasteners in locations where other systematic opening tools would not achieve the desired purpose or would take longer to execute than expected. Some foreign law enforcement units have over ten years of experience in this type of demolition. When recapturing an aircraft, a cumulative charge is used to deactivate the emergency slide so as not to impede the free ascent of the operational units. Specialised linear cutter charges, both pre-assembled and of the type that can be prepared on site, are known and used by law enforcement. I believe that developments in this direction will advance the successful outcome of military and law enforcement operations, and even further, thinking about the implementation of specific situations, the possibilities offered by 3D printing can be envisaged. [17] A charge shape specifically designed to engage the target could be developed for faster engagement.

Low explosives

A group of low-yield, brrizantine explosives mainly used for military, earth-blasting applications, whose working capability (due to their high specific gas volume, resulting from their thrust effect) is superior to that of, for example, trotiles.

For earth explosive demolition missions requiring the use of large quantities of ammonium nitrate-based industrial explosives, high-yield, high-gas-generating, high-yield, high-yield industrial explosives could be used at least as effectively as trotyl. An important requirement for their use is that they should be usable “in all times and in all circumstances”. This statement limits its full application.

Its advantages are:

- cheap and easy production, even in field conditions;
- less explosive consumption than C-4 explosives;
- fills the full extent of drilled holes and mine cavities, greater workability;
- insensitive to external physical effects, can only be initiated by a primer charge;
- oxygen balance close to zero, less toxic.

Disadvantages:

- short shelf-life in the mixed state (maximum 3 months), so cannot be stocked;
- highly sensitive to moisture.

My investigation has led me to the conclusion that ammonium nitrate-based explosives are not suitable for law enforcement purposes because they are not suited to tactical and technical activities. Even the mass of the explosive required to initiate it exceeds the charge required to open the hatches. The explosive brain was first developed in the second phase of the development of industrial explosives, consisting of aqueous solutions of ammonium nitrate and other nitrates mixed with flame retardants (aluminium, glycol, etc.) and sensitizers (TNT, nitro-penta, hexogen). It has the same use as ANDO, but it can now be filled into aqueous boreholes, but only works reliably up to +4 °C. [14]

Advantages:

- cheap production;
- waterproof, explosion properties are not affected in a wet environment.
- It can also be mixed on site, so the advantages of storage and transport mentioned for ANDO are also present in this case.

Disadvantages:

- it solidifies below +4 °C and detonates precariously;
- it conducts electricity, which can cause "standstill" in case of a faulty electrical network.

Overall, the military use of the warhead as an emergency explosive would make it suitable for earth-blasting missions. The only limitation to its use as a back-up explosive is its inadequate detonation capability at temperatures below +4 °C. [14]

The sensing additive is a hollow sphere of glass or plastic, a few microns in diameter, whose role in the emulsion is to generate a concentration of energy in the hollow spheres when the primer is exploded by pressure. This is sufficient to detonate the adjacent explosive part and thus propagate the chain reaction. The emulsion fills the holes to their full extent, thus improving the working capacity and reducing the consumption of explosives. [18]

The advantages of emulsion explosives:

- they are waterproof;
- good specific explosive gas volume;
- safe to store and handle;
- inert, can be initiated with a minimum of 200 g TNT explosive;
- good oxygen balance.

They may be suitable for use in military applications, as their working capacity may in some cases be higher than that of currently used trotyl charges. From a material point of view, it is cheaper to produce explosives than those currently in the system. From a military point of view, it could be suitable for some demolition missions.

Its use in law enforcement is not recommended because it does not fit in with the task execution of operational units.

SUMMARY

Since the invention of black powder, countless new explosives have been developed, not all of which are suitable for widespread use. Many of them are designed for a specific explosive task. In some cases, they have been popularised by military developments, and in others by developments in the explosives industry.

In my research, I have tried to summarise alternative explosives for military and law enforcement applications in specific fields. I wanted to summarise concise information on these explosives in a way that would make even a lay reader think about the wide range of explosives available for certain defence applications. All of this becomes truly appreciated - though it should never be so - when our peaceful lives, our available resources, are suddenly disrupted, dried up and we have to improvise with creative and alternative solutions.

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