UTILIZATION OF EXPLOSIVE TECHNIQUES IN EARTHBOUND WILDFIRE SPREAD PREVENTION BY THE MEANS OF FOCUSED BLASTS

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Abstract

The article discusses the potential of explosives utilization in elimination of adverse impacts at the emergencies. The subject of such non-traditional approach to earthbound forest fires extinguishing is solved herein.

Key words

Explosive blasting technique, oxygen balance, shock wave, explosion, blast, outbreak, detonation wave, blast fouling, dynamic forces, carbon monoxide.

Introduction

The insufficient attention is paid to utilization of explosive techniques for elimination of fallout effects of dedicated types of extraordinary incidents matter not only in our country, but also at the same time in the whole world. So far, this issue is not regarded even as a possible complementary option to traditional methods and procedures. This fact may spring from a non-acquaintance of deeper understanding the blasting techniques principles itself. Though we live in a country where there are many first-rate pyrotechnics, firemen and blast tech-chiefs with rich skills, we always feel a presence of certain „mystery“ in the field of explosives usage and application on peace operations. For the present, only an imperceptible consideration is endowed with the subject in Europe at most international conferences and professional summits. The appointed conferences have been reputably concerned with the area of demolitions in building industry, machinery or agriculture, while still absent contributions, which would be more dedicated to problems of blast energy utilization in emergencies.

There may be a significant potential to block the earthbound fire spread by means of the charges explosion. In that case two features of high explosives can be employed namely impulse wave backwash and oxygen balance.

1 Shock (impulse) wave

The detonation is an explosive transformation, along which a shock wave springs up off the blasting explosive, which moves at the speed greater than the speed of sound. The speed of the blasting transformation at the detonation achieves the order values of thousands of meters per second.

The example of such blast is the eruptive transformation of explosives, detonating fuses or detonators, accompanied with a strong sound effect and manifesting itself with a detonating influence on the surroundings. Contemporary hydrodynamic theory of detonation comes out of presumption, that by the detonation a so-called detonation wave is formed within the explosive, which is a special case of a shock wave.

The shock wave is characterized with following typical characteristics:
1. by the speed greater than the speed of sound in the particular atmosphere;
2. by abrupt change in gas parameters (pressure, density, temperature, rapidity);
3. by the atmosphere movement (dynamic pressure), i.e. movement of particles trapped by the shock wave passage in the direction of the wave stroke.

The shock wave creation is subject of two conditions:
1. Existence of the atmosphere, in which the shock wave can arise (in vacuum the shock wave can‘t be created)
2. Sufficient pulse available in creating the shock wave.

The characteristic distinction of the shock wave is fact that the media behind the wave spreads in the direction of the wave motion. Therefore, by the drift of gasses particles from the strata incumbent immediately aft the compaction layer in the direction of impulse wave propagation, a compressed atmosphere is created from the shock wave rapid translation.

On the other side in more distant layers by virtue of that movements there raises a dilution layer, in which the pressure is lesser than the atmospheric pressure (see Fig.1). The distance from the wave front edge down to the dilution layer forepart is called the shock wave length.

Shock (impulse) wave meaning

Provided the detonating wave strikes on a perfectly rigid impediment (steel, concrete etc.), the physical atmosphere movement should immediately stop. With the rash hamper of such movement, it raises a considerable pressure on the restraint, which is possible to compare to the pressure of wind on a sail, however with an incomparable greater force. The impulse wave thus acts on the impediment partly by the increased pressure, partly by dynamic forces induced by the compressed atmosphere impact. By the strong shock waves, the dynamic forces several times exceed the pressure incidence.

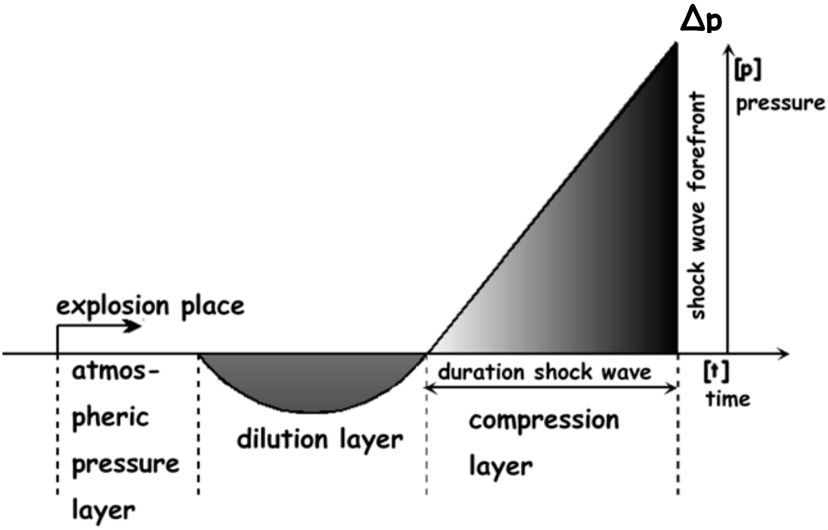


Fig. No. 1:
Spread of the shock wave in gaseous atmosphere scheme
1 - explosion place, 2 – atmospheric pressure layer, 3 – dilution layer,
4 - compression layer, Δp – overpressure at the shock wave forefront,
5 – shock wave forefront

2 Oxygen balance

The relative content of oxygen in the blast has a great influence on the explosion product composition. To its assessment a term of oxygen balance is being used, by which it is understood the surplus or absence of oxygen in the blast regarding to the amount of oxygen needed for total oxidation (burn) of carbon and hydrogen contained in the blast onto carbon dioxide and water. The oxygen balance is expressed in weight percentage ratio (i.e. in g of oxygen per 100 g of blast).

The oxygen balance (OB) can be calculated from the formula:

$$KB = \frac{16\left(c - 2a - \frac{b}{2}\right)}{M_r} \cdot 100 \qquad [\ \%] \qquad (1)$$

where ***a, b, c,*** are counts of atoms of ***C, H,*** and ***O*** within the blast, and the composition $C_aH_b\,O_c$ and M_r represent relative molar weight of the blast[1].

The oxygen coefficient can be calculated from the formula:

$$KK = \frac{c}{2a + \frac{b}{2}} \quad (2)$$

From the relations (1) and (2) is obvious, that the oxygen balance can be positive, negative or balanced (equal to zero). [1]

Example of the oxygen balance and oxygen coefficient of three explosives:

- Tritol (TNT):	KB = - 74 %	KK = 36,4 %
- Nitro-glycerine:	KB = + 3,51 %	KK = 105,9 %
- Nitro glycol:	KB = 0	KK = 100 %

The oxygen balance shows, how many g of oxygen are needed or are left over in 100 g of blast to the total oxidation of in it contained burnable elements.

The oxygen coefficient indicates a real rate of fuel elements and oxygen contained in a molecule of a blast and is a functional characteristic of the blast molecule oxygen saturation grade.

For the general practice is important, that by the blast explosion with positive or negative oxygen balance substantially greater amount of toxic gasses are being created (by positive balance carbon oxides are created, by negative balance carbon monoxide, event. carbon dioxide is being generated) than if the oxygen balance is zero. By the army explosives is this moment not so important, but at the industrial ones has a great importance. By the industrial explosives the oxygen balance is being chosen lightly positive, to be secured also oxidation of the charge hull, made of the paper impregnated with paraffin.

From the formula (1) results, that in the case of explosion of 1000 g TNT (Tritol, which is a basic army explosive with negative oxygen balance), the blast will deplete 740 g of oxygen from the atmosphere.

The air is a mixture of gasses of following volume concentration:

-78.03 % nitrogen (N2);

-20.99 % oxygen (O2);

-0.03 % carbon dioxide (CO2);

-0.95 % other gasses (argon, neon, krypton etc.).

The dry air density ς at pressure p and temperature t is specified by formula:

$$\varsigma = \frac{\varsigma_0}{\gamma \cdot t} \cdot \frac{p}{p_0} \quad (3)$$

ς_0 = 1.276 kg m^{-3},

p_0 = 10^5 Pa,

γ = 0.003 66 K^{-1}.

From the introduced expression can be deduced, that the normal dry air density is 1.276 kg m^{-3}. As it is apparent from the volumetric air concentration, the greatest percentage share in air has right nitrogen and oxygen. The nitrogen density amounts to 1.234 kg m^{-3} and oxygen 1.409 kg m^{-3}.

By simple calculation from the percentage share of oxygen in the air and its density we are able to determine, that 1 m^3 of air contains 295.749 g of oxygen. That means, that the blast of mass of 1000 g TNT (Tritol) depletes by its negative oxygen balance 740g of oxygen (O_2), which is contained in 2.502 m^3 of air.

Understanding the importance of negative oxygen balance

As follows out of the introduced example, the army explosives (TNT) with negative oxygen balance do remove considerably big amount of oxygen by the blast from the surrounding air atmosphere; that feature can be advantageously utilized in protection against the wildfire spreading.

Composition of the blast products

Composition of the products at explosives with negative oxygen balance, where the oxygen content falls short for oxidation of all carbon to carbon monoxide CO (in blast products remains free carbon).

The equation of the reaction breakdown can be generally recorded as follows:

$$C_aH_bN_cO_d = n_{co}CO + n_{co2}CO_2 + n_{H2O}H_2O + n_{H2}H_2 + n_{N2}N_2 + n_CC \qquad (4)$$

In that case, besides the reaction of water gas can be in progress even so called reaction of producer gas

$$2CO \leftrightarrows CO_2 + C \qquad (5)$$

By the explosion carbon monoxide ***(CO)*** is released together with carbon dioxide ***(CO_2)***.

By ***CO_2*** no further risk is threatening, however ***CO*** can react with oxygen under formation of next ***CO_2***. Such reaction is however exothermic and releases further energy in a form of fire. So in closed premises the risk of ignition rises markedly than in the free area. ***CO*** is lighter than air therefore the risk is greater under the roofed-over surfaces. In other cases, for instance in free stage, ***CO*** runs out and the probability of ignition is imperceptible.

3 Blast products

Carbon monoxide

Carbon monoxide is colourless gas without taste or odour, lighter than air, non-irritating. It is only poorly resolvable in water. It is contained in coal gas, in producer gas, and in water gas; it has strongly reducing properties. In the nature, it is present in inconsiderable amount in the atmosphere, where it is formed firstly by photolysis of carbon dioxide by virtue of ultraviolet rays, as a product of imperfect burn of fossil fuels and biomass. It is also contained in the volcanic gasses.

In the overwhelming amount, it is also present in the interstellar space. It has been bound also in the Mars atmosphere (0.08 %) and proven in spectroscopy in comma of comets.

It is created by burning of carbon with a small amount of oxygen:

K[2C] (O2 + 2CO + K[]

eventually by reaction of water vapours with carbon at high temperatures (preparation of water gas):

K[H2O] (H2 + + K[]

In imperceptible amounts, it is created at metabolic processes in live organisms and therefore it is contained in trace amounts of the exhaled air from lungs. It rashly merges with oxygen (blazes with bluish flame) to carbon dioxide:

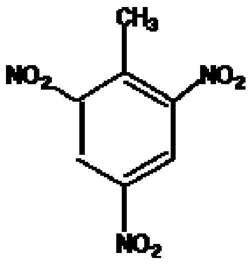
K[2CO] (O2 + 2CO2 + K[]

under release of considerably big amount of heat. It blasts in a mixture with air, containing from 12.5 until 74.2 % of carbon monoxide.

Carbon monoxide is substantially poisonous; its toxicity is incurred with a strong affinity to blood haemoglobin (the blood colouring matter), with which it creates carboxyhaemoglobin, by which the oxygen transfer in a form of oxyhaemoglobin from lungs to tissues is blocked. The bond of carbon monoxide to haemoglobin is roughly two hundred times stronger than that of oxygen and that is why its removal from blood takes many hours up even days. The poisoning symptoms occur already by conversion of 10 % haemoglobin to carboxyhaemoglobin. That fact is also an essence of one of harmful influences of smoking.

Composition of the TNT blast products

Chemical term 2,4,6-trinitrotoluene, summary formula $C_6H_2(NO_2)_3CH_3$, or also $C_7H_5N_3O_6$.



Provided we consider the outbreak of TNT charge of certain mass, it is easy to deduct after assignment of number of individual elements (N, C, H and O) into equation (4 and 5), that in the free surface past the explosion there shall be in the surroundings great amount of carbon dioxide and carbon monoxide, and they will mutually react. [4],[10],[11]

4 Practical utilisation of oxygen balance and the impact of a shock wave

The negative oxygen balance and shock wave impact can be utilised by stoppage of the earthbound wildfire spreading. Practically the centred blasts shall be appositionally distributed (of the weight of approx. 6 kg), or anti-tank bombs (of the explosive weight of approx. 10-12 kg) in-line at the distance of 1 m from each other, they shall be interconnected with detonating fuse and launched at the same time tight before arrival of the fire forehead (see Fig. No. 2).

Fig. 2:
Utilisation of the shock wave and negative oxygen balance by stoppage of the earthbound wildfire spreading

Conclusion:

We cannot consider the energy released at the explosion as only a negative activity with subsequent destructive consequences. By the means of the explosives techniques it is possible to cut down the time needed for the work fulfilment by other means, take advantage in the possibility of the on-time utilization of the stopping blast with sufficient effect.

There is a difference between particular kinds of explosives. While the industrial explosives are for price more available, by employment of the army blasts it is possible to reach greater efficiency and accuracy, so better potential to aims fulfilment, they are designated for. It is by virtue of a whole set of features, the army explosives dispose of. The great distinction of the army explosives is their chemical and physical stability, rather high brisance and working capability.

If we speak about advantages of army explosives, we shall take into account mainly engineer troops charges (respectively as normal one, so the special), which is under all conditions produced for destructions and tested in work.

The authorities above all of the Czech Republic Army, but also firemen and technical chiefs of shot-firing, who are skilled to work with explosives, have according to directives (for example Zen-2-6 Explosives and demolition, Explosive technique etc.)[17], [18] for destruction on individual objects defined patterns according to individual kinds of charge. By this, the calculation of explosives amount and its positioning simplifies and security upon its usage increases. The negative oxygen balance of the army high explosives has its advantages, above all by utilization of blasts against wildfire spreading.

The stockpile of army and industrial explosives and charges are rather big and generally evenly distributed in particular regions all over the region of the Czech Republic, which simplifies take-off, manipulation, effect in explosives and igniters refilling to specialists up to the very place of their utilization.

In the paper there is shown the subject, that by the means of the shock wave it is possible to extinguish any fire respectively to places where we are unable to use classic fire fighting techniques, thus especially there where is inaccessible terrain, huge altitude above the terrain etc. From my scheduled hypothesis, thus calculation of oxygen balance and basic explosive TNT blast products composition results the fact, what we know that 1 kg of that high explosive shall consume oxygen from the imminent surroundings after the blast, which is contained in 2,502 m^3 of the air. Each no specialist can imagine how the wildfire surroundings shall look like, if we use in the total sum i.e. 12 kg of mentioned high explosive. At practice it goes in such way, that the shock wave quenches the fire flames regardless of it is the industrial or army blast. In case of usage, the high explosives with negative oxygen balance the seat of fire behaves in the same way as in case of back burn fire, or usage of chemical substances for air attenuation (air depletion off the oxygen component). Practical tests approved this hypothesis. Since in the first phase of fire extinguishing by the means of blast no difference can be seen, the seat of fire quenched by the means of explosive with positive or balanced oxygen balance very soon after the detonation exhibits marks of flaming up, sometimes as swift as the technique (as a rule a helicopter with water bag) have to quench an over again blazed ground surface. At the army high explosives (TNT) thanks to the air very depleted from the oxygen component, it is hardly possible to burn up again. Thereafter it depends on circumstances and first of all on wildfire extent. As in practice by fire of a small range the solders were able to quench by the means of hand hammers, in case of larger wildfire the scene of a fire was casted over with water from the helicopter bag.

For the completeness, I shall add, that labelling TNT as an army explosive is not perfect, however this allocation matches to all publications, I conveyed from. After 1989, when happen to disarmament in Europe, TNT was pyrogenated on delaborative lines from the military ammunition and at present, this blasting explosive is used in the civic sector. It domesticated during last 15 years by utilization in the industry in such a degree, that at present qualification „military“ is very sporadic.

NOTE:

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