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DEVELOPMENT OF GAS-GENERATOR CHEMICAL CARTRIDGES WORKING IN THE MODE OF NON-EXPLOSIVE DESTRUCTIVE MIXTURE

M. I. Tulepov[1], Sh. E. Gabdrashova[1], N. M. Rakhova[1], L. R. Sassykova[1*], D. A. Baiseitov[1], Zh. Elemesova[1], M. A. Korchagin[2], S. Sendilvelan[3], I. O. Pustovalov[1] and Z.A. Mansurov[1]

[1] Faculty of Chemistry and Chemical Technology, al-Farabi Kazakh National University, 050040, Almaty, Kazakhstan

[2]Institute of Solid State Chemistry and Mechanochemistry, Siberian Branch of the Russian Academy of Sciences, 630128, Novosibirsk, Russia

[3]Department of Mechanical Engineering, Dr. M.G.R Educational and Research Institute, University, 600 095, Chennai, India

*E-mail : larissa.rav@mail.ru

ABSTRACT

The work aim was the choice of technology that provides the possibility of destruction of various construction objects without the creation of shock, seismic waves, fragmentation, dust formation, concomitant detonation crushing with minimal emission of harmful substances. Preparation of the gas-chemical cartridges containing carbon nanomaterials was the result of researches. The composition of the non-explosive destructive mixture based on materials of Kazakhstan origin developing expansion force in a closed volume up to 30 MPa is developed. A composition of a fast-hardening mixture having a hardening rate of 8 MPa/h is created. The maximum level of strength of cement stone non-explosive breaking mixture for 30 min. hardening reaches 23 MPa. The hardening time of fast-hardening mixtures with a non-explosive breaking mixture was 15-20 min. In the case of using gas-chemical cartridges of the developed composition, the role of the carbon nanomaterial in it was determined by the low combustion rates of the composition and, very importantly, by slow ignition (the combustion of a single cartridge lasts up to 0.3 s under blasthole conditions). As a result of the carried out researches, it was found out that the range of scattering of splinters of concrete will depend on the amount of gas-generator composition, of its chemical composition and the burning rate. The developed technologies allow carrying out sparing blasting during the destruction of concrete brick structures in conditions of the dense building.

Keywords: combustion, gas-generator chemical cartridge, non-explosive destructive mixture, carbon-containing nanostructured material

INTRODUCTION

One of the most laborious and long-term stages of carrying out construction work in conditions of dense construction is the dismantling of reinforced concrete structures which are subject to dismantling. At the most productive, drilling and explosive method of conducting such operations, it is required to completely exclude the negative impact on the environment of shock air and seismic waves, toxic detonation products, as well as scattering of fragments of the dismantled object.[1-4] The continuous increase in the use of high-energy explosives (mixtures) in various spheres, for example, mining, construction, metalworking, construction materials industry, necessitates the use of increased security measures.[5-7] The power of explosions carried out in recent years at mining enterprises in Kazakhstan has increased significantly. According to the results of instrumental observations and sensations of residents of the cities of the republic, in some quarries explosions are comparable in their effect to an earthquake. The consequences of such explosions are manifested in the fall of chimneys, beams of ceilings of buildings

and structures, exfoliation of plaster, layering of foundations, appearance of cracks.[8-11] Underground mass explosions can have a seismic effect on underground excavations with a long service life located outside of seismic sources and locate on the surface of an industrial and cultural purpose building[12-15]. One of the promising ways to ensure the absence of seismic fluctuations, the improvement of the ecology of the environment from the harmful effects of explosive gases and the protection of natural resources, the reduction in the cost of mining ore and the energy intensity of mining operations, and the increase in the safety of their maintenance, is the use of a non-explosive disintegrating mixture based on gas-generator chemical cartridges[16-22]. Non-explosive disrupting substance (NEDS) is a non-flammable powder, hermetically packaged, which can be stored for a long time. NEDS is based on carbonate rock and various additives added during firing, or by grinding.[3,7,22-28]

The purpose of the work was the choice of technology that provides the possibility of destroying various building objects without creating shock, seismic waves, a scattering of fragments, the formation of dust accompanying detonation crushing with a minimum emission of harmful substances. The task of the work was the preparation of gas generators, which could be directly used in the field for splitting a block of stone or destruction of solid mineral species with a composition, allowing the desired speed of combustion and combustion power without adding of additional components.

EXPERIMENTAL

As a non-explosive destructive substance of NEDS, a carbon-containing nanostructured material (CNM) based on mineral and plant raw materials included in the compositions of gas-generator chemical compositions was used in this work. The CNM was synthesized in a propane-butane gas medium on the surface of the "Shubarkul" coal (Kazakhstan). Surface images of carbon black are shown in Fig.-1.

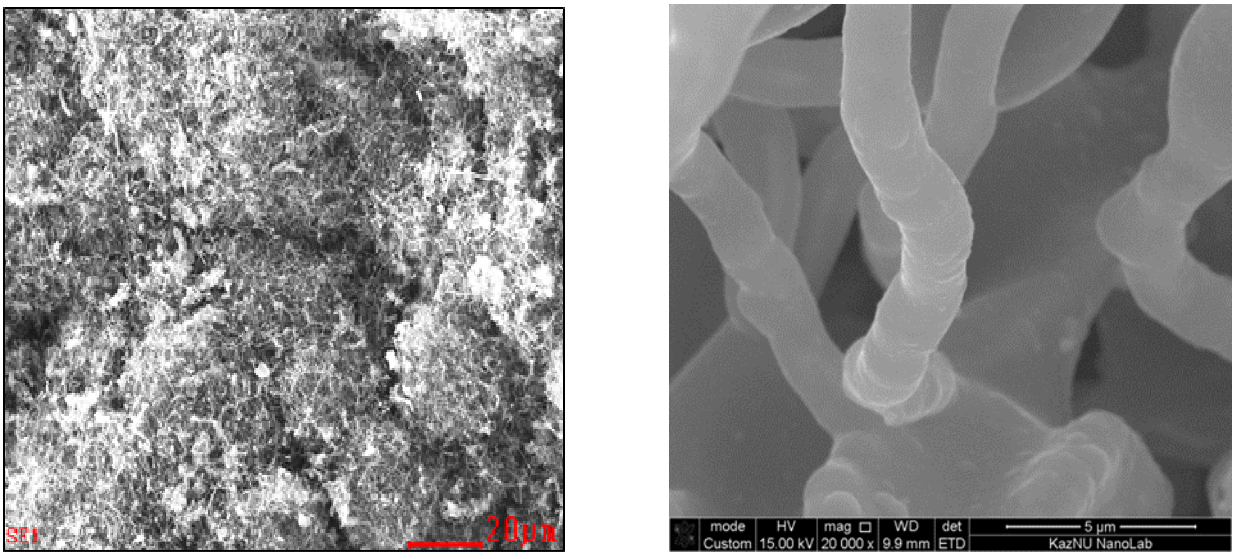


Fig.-1: A carbon-containing nanostructured material (CNM)

A composition with the following components: ammonium nitrate -70%, magnesium-10%, technical carbon (TC)-10%, smokeless powder (nitrocellulose) - 10% was developed.[8] The sulfur was completely replaced with magnesium, since magnesium is an active fuel, easily oxidized, shows a high temperature during combustion, this contributes to an increase in the value of the working capacity of combustion products (WC). As can be seen from the table, the replacement of sulfur by magnesium in a ternary mixture significantly increases WC.

At 10% magnesium content, the introduction of a smokeless powder (SP) into the ternary mixture leads to an increase in the RT to 961 kJ/kg and a specific gas capacity of up to 961 L/kg. Smokeless powder (SP)

is one of the types of powders based on cellulose nitrate, without a polymer base. The table shows the calculated energy characteristics of some gas-generator compositions.

Table-1: Calculated energy characteristics of gas-generator compositions

No	Gas Generating Composition	Working capacity of combustion products (WC), kJ/kg	Specific gas production, $W_{spesific}$, L/kg
1	NH_4NO_3-80 %, S-10 %, TC-10 %	615	910
2	NH_4NO_3-80 %, Mg-10 %, TC -10 %	946	956
3	NH_4NO_3-80 %, Mg-10 %, TC -10 %, SP -10 %	961	961

For carrying out pilot tests of composition the gas generator chemical cartridge (GGCB) in the mode of the non-explosive disrupting mixture (NEDM) the reinforced concrete column with two hols for input (Fig.-2) was made.

Fig.-2: Reinforced concrete column with 2 holes for the input of the gas generator operating in the low-speed detonation mode and the non-explosive expanding mixture

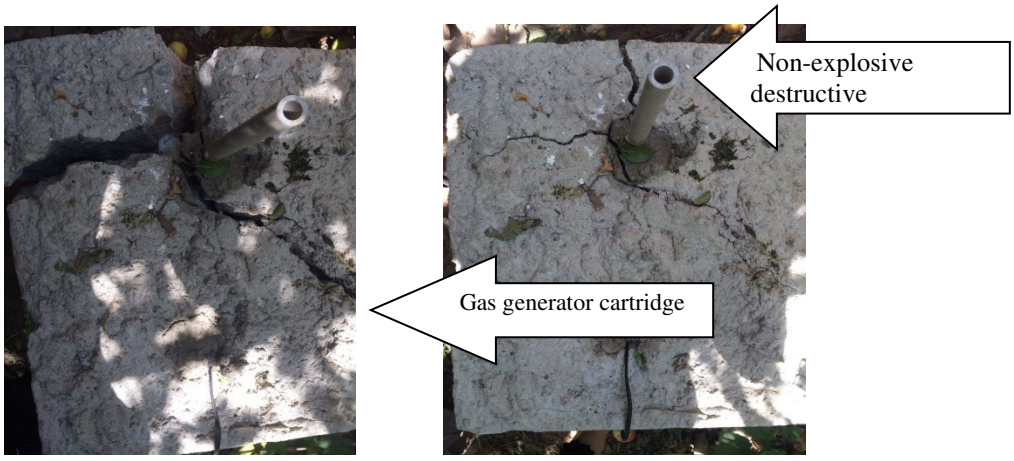
The first hole was intended for the introduction of NEDM (quicklime + water)[15,19], a second hole for the introduction of a gas-chemical cartridge. After the introduction of the non-explosive expanding mixture, the core was sealed with a fast hardening shear, which is a mixture of calcium chloride $CaCl_2$ + cement + water. After that, water is fed into the hole through the cartridge, mixing with the water the powder of NEDM increases its volume and creates static stresses in the hole, which destroys it. The process of hydration occurs according to the following reaction: $CaO + H_2O \rightarrow Ca(OH)_2$. After NEDM was fed into the hole, cracks formed in the block (Fig.-3a).

RESULTS AND DISCUSSION

The use of GGCC has certain limitations: it is necessary to tightly pierce the hole with sand (granite screening) and a sufficient depth of the hole. The first is due to the fact that the pressure developed during the burning of the gas generator composition can develop only in a closed volume.[29] The second condition is connected both with the magnitude of the pressure developed during combustion and with the rate of its growth and is determined by the friction force of the block against the wall of the hole.[30] Therefore, before starting the basic work, it is necessary to carry out tuning tests to determine these conditions, especially when the objects with the unknown structure of the reinforcement are destroyed.

To determine the effectiveness of the action of NEDM, consisting mainly of fast-hardening cement, its physicochemical characteristics, in particular, its composition, setting time, chemical additives, etc., play

an important role[2,8,9,15]. All these parameters vary with the construction of different facilities and should be taken into account in the selective efficiency of the gas-chemical cartridge.



a b

Fig.-3: Destruction of a reinforced concrete column of a non-explosive destructive mixture
(a) the appearance of a crack on the column during the operation of NEDM; (b) destruction of the column by gas-generator composition

A constructive possibility of improving the locking and sealing of the bore space and sealing the walls of the bore hole with different compositions was investigated. As the bottom material, the best materials were the screening of the granite fraction 0-5 mm and the quarry sand large. Improved sealing can be achieved by crushing at the beginning of tamping clay wad, and then tamping of the stemming of dropout or sand. When using GGCC for the disintegration of concrete or reinforced concrete structures of small transverse dimensions, the question arises of reliable locking of gases in short holes. In this case, the adhesion of the block with the walls of the hole in a short section may not be sufficient, and as a result, lumbago occurs. To solve this problem, we tested NEDM and anchor locking the mouth of the hole.
For this purpose, experiments were conducted to determine the setting time of NEDM, from the ratio of water to cement (W:C). As a result of the experiments, it is established (fig.-4), the setting time has a directly proportional dependence on the water-cement ratio, which indicates the homogeneity of the chemical reactions of the interaction of cement components with water, while the solidification time was only 25-30 min.

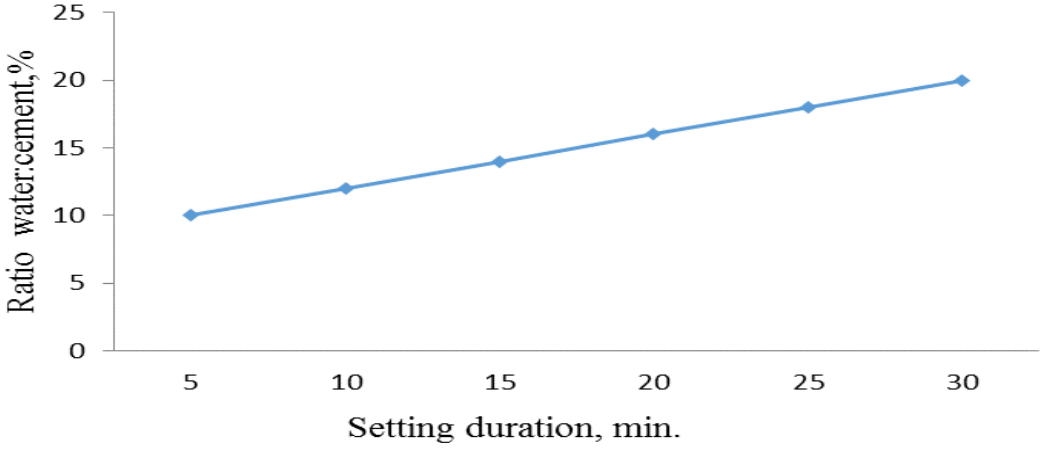


Fig.-4: Dependence of setting time of cement stone on the ratio of W:C

Experiments by determination of durability (the strength) of NEDM from an accelerating agent dosage, in particular, from $CaCl_2$ were made. Apparently from Fig.-5 additive of an accelerating agent has a directly proportional dependence on durability (the strength) of materials NEDM. From what it is possible to state efficient manifestation of properties of an accelerating agent at introduction it in the form of a chemical solution in ready cement mixture.

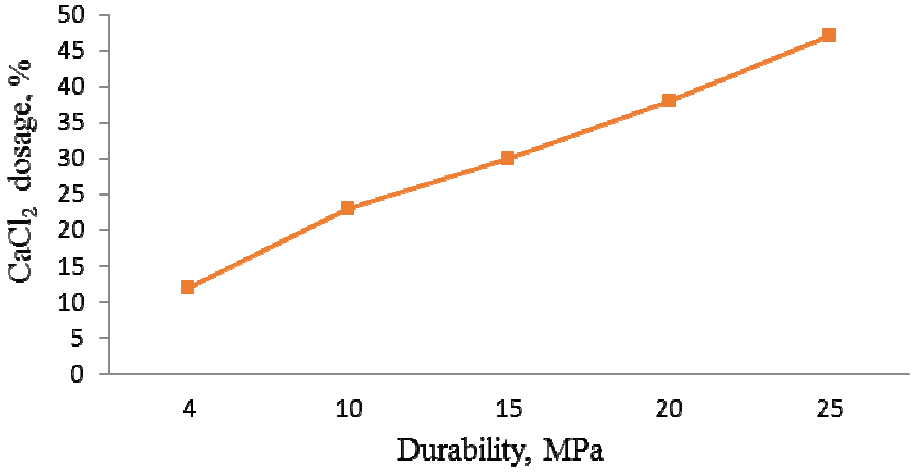


Fig.-5: Dependence of strength (durability) on the dosage of the hardening accelerator

Next, a gas generator operating in the low-velocity detonation mode was developed, having the following components in the composition: oxidizer (NH_4NO_3) - 60%; carbon nanomaterial - 20%; magnesium - 10%; SP - 10%. Subsequent tests have shown that the gas generator chemical cartridge (GGCC) has a great destructive power, which allows to destroy reinforced concrete structures (Fig.-6).

Fig.-6: Destruction of concrete gas generator chemical cartridge composition: oxidizer (NH_4NO_3) - 60%; CNM - 20%; magnesium - 10%; smokeless powder - 10%

CONCLUSION

The result of the studies was the preparation of gas-chemical cartridges containing carbon nanomaterials. The composition of the non-explosive destructive mixture based on materials of Kazakhstan content is developed, which develops the expansion force in a closed volume up to 30 MPa. NEDM fast-hardening mixtures have been developed, the hardening time of which was 15 - 20 minutes. Cement stone NEDM at

the ratio of water:cement of the initial solution equal to 0.4 and the addition of the modifier of the chemical component (CC), $CaCl_2$ in the first 15 min. has a curing speed of 8 MPa/h. The maximum level of strength of cement stone NEDM for 30 min. when hardened, reaches 23 MPa. To develop the technology of preparation of a fast-hardening mixture, the character of the hardening accelerator was studied depending on its feeding into the process of preparation of cement mortar. At the same time, the crushing strength was from 15 to 20 MPa. As a result of the investigations carried out, it was found out that the range of expansion of concrete fragments will depend on the amount of gas-generator composition of its chemical composition and the burning rate.

In the case of using GGCC of the above composition, the role of the carbon nanomaterial in it was determined by the low combustion rates of the composition and, most importantly, by slow ignition (the combustion of a single cartridge lasts up to 0.3 s under conditions of a hole).

The developed technologies will allow to conduct sparing blasting at the destruction of concrete brick structures in dense building conditions.

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