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Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

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ИЗВЕСТИЯ

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ГЕОЛОГИЯ ЖӘНЕ ТЕХНИКАЛЫҚ ҒЫЛЫМДАР СЕРИЯСЫ

♦

СЕРИЯ ГЕОЛОГИИ И ТЕХНИЧЕСКИХ НАУК

♦

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THE ANALYSIS OF HEAT AND MASS PROPERTIES OF THE FIRE EXTINGUISHING POWDER IN EFFECTIVENESS CRITERIA

Abstract. The given research presents the classification of fire extinguishing and explosion suppression compositions. The effect on the combustion reaction is possible with the help of physical and chemical methods of gas mixture components concentration reducing, cooling the combustion zone and slowing down of chain reactions with the help of a phlegmatizing or inhibiting substances, of which the most universal and perspective are powder materials. In view of the high toxicity and environmental hazard of inhibitors (halides), the most promising search and development of effective powder compositions based on chlorides and substances with pronounced endothermic properties (easy-boiling, easy-decomposing, easy-melting) causing a sharp cooling of the combustion zone. The general laws of the effectiveness of extinguishing powders from their composition was considered in the scope of literature. There are proposed only some unsystematic series of dependence of the studied mineral compounds. Therefore, a necessary condition for solving the problems of developing effective flame arresters is to find common indicators and properties of substances that can become criteria for their phlegmatizing ability.

Keywords: fire extinguishing powders, explosion suppression composition, spread materials, burning reagents, efficiency of powder, heat and mass properties.

Classification of fire extinguishing and explosion suppression compositions. One of the modern means of fires fighting and explosions are fire extinguishing and explosion suppression powders, which are finely powdered mineral salts with various additives preventing caking and balling. Powders are differed with universal actions, providing the extinguishing of even such materials that cannot be put out by water and other means.

Powders used to extinguish most of the fires classes [1, 2]. Class A - burning solids, accompanied by decay (wood, paper, textiles, coal etc.) and not followed by decay (plastic, rubber); B - burning liquids (gasoline, petroleum products, alcohols, solvents, etc.); C - combustion of gas- and vaporous substances (ammonia, methane, propane, and others.); D - burning metals and metal-containing compounds (magnesium, aluminum, potassium, sodium, etc.); E - combustion of materials in electric installations under voltage.

Therefore, the powder can be used to extinguish of any substances and materials. Powder compositions depending on the class of fire that they can extinguish, divide:

- powders of ABCE type - active main component - phosphorus-ammonium salts;

powders of BCE - the main component of these powders can be sodium and potassium bicarbonate; potassium sulfate; potassium chloride; alloy urea with salts of carbonic acid, etc.;

- powders of D type - main component - potassium chloride; graphite, etc.

There are distinguished powders of general and special purpose. Powders of common purpose (ABCE, BCE types) is used to extinguish fires of ordinary (organic) easy-flammable combustible materials (EF) and combustible liquids (CL), for example various liquefied gases, solid material - wood, rubber, plastics, etc. The extinguishing of these materials is reached by creating a powder cloud that envelops the hearth burning.

The powders of special purpose are produced for the particular class of fire, for example for B. C and D classes. Cessation of combustion in this case is achieved by isolating the burning surface from the ambient air.

The advantages of powder include the possibility of their application for the deterrent and explosion suppression. In this regard, by applying powders fall into two groups: fire-extinguishing and explosion suppression. The largest group consists of extinguishing powders used for charging, manual and mobile fire extinguishers, fixed installations and special fire vehicles.

Fire extinguishing of powders ability of the general purpose is increased with rising of their dispersion (size reduction of particles), powders of a special purpose - almost does not depend on the degree of their dispersion. From literature data [3, 4] it is known that some mineral powders are active inhibitors of the chain gas-phase combustion reactions and can be used as explosion suppression agents.

So, in the USA, Germany, England, France developed and uses automatic systems of protection of curb, as a rule, commercially available fire-extinguishing powder or finely divided salts of phosphoric salts and carbonic acid.

Fire extinguishing powders properties and compositions characteristics. There are widely used various substances to prevent ignition and explosion of methane - air mixtures at mining industry at the present time. Beginning from simple deterrents (inert dust and water with the addition of 5-7% surfactants), the restraining effect of which is to reduce the temperature to a level at which terminates combustion. And finishing with the highly efficient flame retardants based on easy-decaying salts are treated with a special water-repellent additives and disintegrating, can extinguish the flame of the flash (explosion) at relatively low unit costs, about 0.01 to 0.10 kg/m^3 of protected volume [5].

The extinguishing with powder method can be used to explain the physical-chemical properties of the powder (table 1) and the effect of the following factors:

- dilution of the combustible environment with gaseous products of powder decomposition or directly by a powder cloud;
- cooling of the combustion zone as a result of the heat cost for powder particles heating its partial evaporation and decomposition in flame;
- effect of fire-resistance achieved by passing the flame through the narrow channels, as if created by a powder cloud;
- inhibition of chemical reactions that lead to the development burning, gaseous products of evaporation and powders decomposition or heterogeneous open circuits on the powders surface or solid products of their decomposition.

The working life of agents is limited to 5-10 years and depends largely on the conditions of fire extinguishing compositions service.

So, powders, working in the conditions of transport are subject to additional vibration, which leads to the seal structure, the so-called effect of “pepper”.

Standard GCST 26952-97 is spread to fire-extinguishing powders for general purposes, and establishes requirements for the indicators of technical level and quality as well their test methods.

Universal fire-extinguishing powders, such as P-2AP and P-4AP are checked on quality indicators according to the TC 113-08-597-86 [6].

Powder P-2A1T is used for filling powder fire extinguishers and installations and P-4AP for volume distant extinguishing of underground fires in coal mine workings and can be used for equipment of explosion-protection automatic machines.

Extinguishing powders are complex heterogeneous systems, so they have specific properties and characteristics which depend on their fire-extinguishing ability. Chemical composition of powders also determines their fire extinguishing action and performance properties.

There is presented information about the applied powder flame retardant compositions in the reviews [7-10].

The basis for fire extinguishing powder is phosphorus- salt (mono- and di-ammonium phosphates) such as: $(NH_4)_2HPO_4$, $NH_4H_2PO_4$; potassium chlorides KCl and others. In the composition of the powders also enter special additives that prevent the balling and caking.

Table 1 – Basic physical-chemical data of fire extinguishing powders

Class of fires	The combustible material	The required physical-chemical properties of powder	Spread components
A	Carbon-containing (wood, coal, rubber-technical products, plastic and other)	Viscous polymer film formation at the temperature 200-250°.	Phosphorus-ammonium salt; a sodium salt of boric acid
B	Flammable liquids (gasoline, alcohol, paints, solvents and others)	The ability of the surface particles and products of its evaporation (decomposition) sharp slowdown the chain reaction of combustion; the ability of the powder substances quickly decompose at T >200°C	Phosphorus-ammonium salts; bicarbonates and chlorides of potassium (sodium)
C	Combustible gases and vapors (hydrogen, methane, ammonia, propane - butane mixture, vapours of acetone, and others)	Same	Same
D	Light metals and their alloys (magnesium, aluminium, potassium, sodium)	The formation of melting film which stable at the temperatures of 2000-3000 °C	Potassium chloride (sodium); Melamine; graphite; cryolite
E	Electrical equipment and cables up to 1000-1200 V (at the latest international standards this class is absent)	The absence of electric-conductivity of powder layer and powder-air stream	From foresaid components-of all, besides graphite, but good dried (till humidity no more than 0,5%)

The powders based on bicarbonate and carbonates of alkaline materials ($KHCO_3$, $NaHCO_3$) are widespread. To improve the yield and sustainability of the structure the additives of silicon organic compounds are entered. These powders are resistant to caking and have good performance properties.

One of the directions in solving the problem of phlegmatizing of explosive atmospheres is the use of special chemical compounds, relatively small additions of which greatly reduce the possibility of ignition from heat source. For this purpose, the authors of [11] were investigated substances: sodium bromide, sodium chloride and sodium bicarbonate with a particle size, a predominant fraction (87%) 0,2-0,5 mm.

Thus, the PSB powder made from bicarbonate of sodium has good performance properties, low-cost, and the main component of it available. Powder PSB is designed to extinguish fires of B, C and E classes. It is widely used for extinguishing liquefied gases large quantities of petroleum products (for example during an emergency landing of the aircraft), alcohols and other polar GL.

Currently available powder brand PSB-3 (TU 6-18-139-93) characterized by a higher dispersion and, consequently, increased fire-extinguishing ability.

Sodium bicarbonate and aerosol enters into powder PSB-3 as well nepheline concentrate is used to improve the fluidity.

Powder brand of PSB-3M is designed for extinguishing fires of B, C and E classes. It represents by itself a mechanical mixture of 87-90% of sodium bicarbonate (bicarbonate); 7-10% of nepheline concentrate; 3-5% flowing additives. The rate of fire extinguishing ability when extinguishing fire of B class is no more than 0,8 kg/m^2 (TU - 2149-017-19968286-95).

In addition, there are copyright certificates and patents for a number of fire extinguishing powder formulations, although not exploited commercially, but is of interest. In particular, to enhance fire-extinguishing efficiency of the composition added salts of organic acids - sodium carbonate [A. S. 1142128 (USSR)], trilon B [us Pat. 2118834 (UK)] and other salts.

There is a tendency to apply active fire-extinguishing salts (solution) in porous media. As inorganic salts - vermiculite, aerosil, zeolite, or organic - polystyrene (patent 4226727 USA; patent 77537 NDP). Along with effective powder type "Monex" is underway on the preparation of ternary alloys of the type urea (melamine) phosphate - bicarbonate.

485742 A. S. (USSR) invited the inhibitor of ignition of combustible gases consisting of inorganic salts of potassium stearate and talc for suppression of ignition improvement and the flame of a mixture of acetylene with air extinguishing. Components: 93-96% sulfide; 3-5% of potassium stearate and talc 1-2%.

In a.s. 563503 (USSR) to improve the efficiency of preventing dust explosions, and the prevention of caking as the ammonium salts, the composition contains ammonium bromide (97-98%) and calcium stearate. The mixture is ground until full passage through a sieve of 0.075.

The authors of [12] were investigated the combustion of explosive substances under conditions similar to the conditions in the mine, and also the effect of various reagents added to explosives to prevent them from burning. It was established experimentally that the most effective action have inorganic compounds with a high content of water of crystallization such as: $Al_2(NO_3)_3 \cdot 9H_2O; Al_2(SO_4)_3 \cdot 18H_2O$.

The authors of [13, 14] were experimentally investigated the inhibitors following the explosion of a coal - air mixture: rock dust, crushed limestone (both calcium carbonate), a conventional composition for fire extinguisher (sodium bicarbonate), "Monex".Sevrikov and others [15] suggest to use as fire-extinguishing powder industrial dust cement plants, especially dust Bakhchisaray cement plant the extinguishing capability of which is equal to 0,7-0,8 kg/m^2 (i.e. as at PSB).

To obtain fusible powders it is advisable to search among complex multi-component compositions that form a eutectic [16]. The eutectic is a thin mixture of solids, is simultaneously crystallized from the melt at a temperature lower than the melting components or other mixtures thereof. For example, in the ternary diagram of fusibility of the system CaO - SiO_2 - Al_2O_3 used for finding low-melting compositions metallurgical slag, the melting point of pure oxide is 2570, 2040, and 1728°C, respectively, and a eutectic mixture consisting of: 24% CaO + 62% SiO_2+ 14% $A1_2O_3$ starts to melt already at 1170 °C.

Considering the economic aspect of the problem, effective fire extinguishing powder compositions are supposed to look for on the basis of cheap natural materials and industrial wastes, among which the perspective can be slag, the chloride technology of nonferrous metallurgy. Examples of this are the reference data that the double eutectic mixture of 35% KCl + 65% $CuCl_2$ is melted at 150 °C, while pure KCl and $CuCl_2$ - at 770°C and 630 °C, respectively, and the triple eutectic melting separate $ZnCl_2$, NaCl and KCl are respectively 320 °C, 800 °C and 770 °C.

The perspective direction from an economic point of view is obtaining fire extinguishing powder based on mixtures of chlorine-containing effluents, rolling mills and iron mill scale rolling mills with the aim of iron chlorides crystal-hydrates obtaining, the effectiveness of which is conditioned by low temperature flowing of endothermic reactions decomposition and melting.

So according to I. T. Granovsky [17], $FeC1_2 \cdot 4H_2O$ is decomposed at a temperature of 76 °C, $FeC1_3 \cdot 6H_2O$ melts at 37°C and boils at 285°C. Anhydrous iron (II) chloride melts at 677°C, the iron chloride (III) at 309°C and sodium chloride, which melts only at 800°C is considered as a good enough antipirogen.

Thus, the chlorides of alkali metals are one of the most effective flame arresters. They are considered most promising for the development of new powder formulations because they are low-toxic and widely available. At the same time, Baratov noted that on the basis of these salts, fire-extinguishing powders, such as PGS-M (mixture NaCl and KCl) is recommended for metals extinguishing by the method of isolation from the air, and the possibility of their application as flame retardants has not been reported.

Thus, the research [18] revealed that the most efficient inert for lignite dust is the powder of NaCl, phlegmatizing ability of which is 3,5 times is higher than in dust $CaCO_3$.

The authors of [19] are proposed already as an inhibitor composition based on NaCl additives as a promoter of 0,1-5% $FeC1_2$.

There are claimed the ways of coal dust suppression in the mine atmosphere by blowing fine $CaC1_2$ and prevent its explosion of composite powders on the basis of chlorides ($CaC1_2$, $MgCl_2$, NaCl) with the addition of 0,1-3% hydrophilic organic wetting agent and 0,1-2% anti-corrosion agent (chromium, silicate, phosphorus and aluminate).

In several works of [19-23] are noted effectiveness of the suppression with fine powders of chlorides, including AlC1, NaCl, KCl - explosions of methane and KCl - the hybrid mixtures of methane with coal dust.

A review of the scientific-technical and patent literature allowing to conclude that the most promising components for the manufacture of powders are phosphor-ammonium salt, sulfide- ammonium and aluminium- ammonium crystal-hydrates of alum type, chlorine and fluorine-containing compounds such as "Monex", salts of alkali metals, salts of carbonic acid, bicarbonate and sodium or potassium carbonate.

Fire-extinguishing capacity and efficiency of powders. Nowadays more and more preference is given to powder products due to their high fire extinguishing efficiency. They are also the most cost-effective means of extinguishing based on the indicator as "the ratio of the cost of extinguishing to the area of extinguishing".

Comparing the technical data of domestic and foreign fire extinguishing powders, which are presented in table 2, it can be seen that they have approximately the same fire extinguishing capacity and close in performance properties are. As the main component in fire extinguishing powders are used:

- bicarbonate and sodium and potassium carbonate;
- ammophos (ammonium phosphate);
- sodium and potassium chlorides;
- carbamide (urea);
- ammonium, potassium and sodium sulfates.

Table 2 – The characteristic of fire-explosion-danger dispersion wastes

Appellation of test-tube	Compound, % weight	Group of combustibility	Temperature, °C		
			Tn	Tk	Ignition of air suspension
Blast furnace slag	SiO_2 - 36,72; CaO - 39,13; MgO - 7,51; $A1_2O_3$ - 13,64	NG	no	No	
Open-hearth slag	SiO_2 - 18,72; CaO - 45,25; MgO - 9,84; P_2O_5 - 1,65; $A1_2O_3$ - 4,15; FeO - 12,26; MnO - 6,98	NG	No	No	No
Dust of open-hearth gas-cleaning	Fe_2O_3 - 54,5; Ca - 3,14; SiO_2 - 1,9; MgO - 2,28; S - 2,75	NG	No	No	No
Convertor slag	SiO_2 - 8,45; CaO - 44,03; $A1_2O_3$ - 2,14; MgO - 5,24; MnO - 4,35; FeO - 15,34; P_2O_5 - 6,34	NG	No	No	No
Dolomite slag	CaO - 44,50; SiO_2 - 3,71; MgO - 26,36; MnO - 0,25; Fe_2O_3 - 0,22; $A1_2O_3$ - 1,74	NG	No Endo-effect 420-640 750-	Notill 1000	No
Limestone dust	CaO - 81,75; SiO_2 - l,20; MgO - 0,77; $A1_2O_3$ - 0,61; S - 0,02	NG	Noendo-effect 430-580 720-830	Notill 1000	sparks
Graphite-containing dust of ventilation system	C - 97	TG	420	760	900 sparks

The general dependence of explosion-suppressing and fire-extinguishing powders efficiency on their chemical composition (at their identical dispersion) in the scientific and technical literature is not revealed by us. There are disclosed fragmentary according to the different composition of groups of substances. Some regularity of the effectiveness of powders with the composition of compounds present only in the last fourth and fifth cases:

1) $J \rangle Br \rangle\rangle Cl \rangle F$ (halogens, halons)
2) $NaHCO_3 \langle NaF \langle Na_2C_2O_4 \langle Na_2Cl_3 \langle K_2CO_3 \langle KCl \langle K_2Cr_2O_7 \langle NaCl \langle K_2C_2O_4 \cdot H_2O$
3) $SiO_2 \langle NaCl \langle meltingKCl : NaCl : FeCl_2 - 55 : 44{,}8 : 0{,}2 \langle NaCl : KOH - 99 : 1 \langle$
$\langle meltingNaCl : MgF_2 - 98 : 2$
4) Hydrates of Salts > Hydroxides >Anhydrous Salts > Oxides
5) Salts: Chlorides > Carbonated >Sulphates and moreover: FeR>MgR>CaR, where R- acid residue - $SO_4^{-2}, CO_3^{-2}, Cl^{-1} or OH^{-1}$

The aim of our study is to find fire-extinguishing powders, in which the main part would be non-combustible (table 2) dusty metallurgical wastes of JSC "Arcelor Mittal Temirtau". The emphasis is powder flame-suppressing compositions development for the effective suppression of ignition and explosion, which would have been made from abundant raw materials by simple technology.

Therefore, the physical-chemical evaluation of metallurgical wastes by JSC “Arcelor Mittal Temirtau” is relevant both for the development of technological options for their use and for the search for new materials for the production of fire-extinguishing compositions [24, 25]. The large-tonnage dispersed waste of metallurgical plant, which have a phlegmatizing or inhibitory properties are:

- calcareous, limestone and dolomite dust of products of limestone burning shops which contains carbonates, hydroxides and calcium and magnesium oxides;
- blast furnace and steelmaking slags consisting of calcium, magnesium, aluminum, silicon and iron oxides in free state and bound in various compositions;
- neutralized acid runoff of rolling mills;
- iron oxide formed during regeneration of spent etching solution.

There is performed a review of scientific-technical and patent literature on the endothermic properties of powder materials and compositions, similar in composition to waste, as explosion suppression substances.

The efficiency of powder phlegmatizers can be combined into three groups [26].

The first group is substances that act as inert when heated. These include dispersed wastes consisting mainly of oxides:

- SiO_2-spent foundry molding mixtures;
- Fe_2O_3-dust generated during the regeneration of spent pickling solutions of rolling mills;
- CaO, MgO, SiO_2, Al_2O_3 - oxides, contained in very stable silicates of CaO-SiO_2, MgO-SiO_2, Al_2O_3-SiO_2 in metallurgical slag. These substances do not undergo structural, mineralogical or chemical transformations when heated even above 1000°C. Fire-extinguishing properties of oxides are the weakest. The effect of phlegmatization by inertia increases with the use of substances with endothermic melting processes.

To them are related commonly magnesium, potassium, calcium and sodium chlorides, which have a melting point of 700-800°C.

The effect of oxides is due only to the physical absorption of the heat of the combustion reaction, which leads to a decrease in its thermal effect, a slowdown in the rate of combustion and an increase in the ignition temperature.

The second group is substances in which the heating occurs endothermic decomposition reaction with the transition to a substance of a different composition. These include:

- carbonates ($CaCO_3$>$MgCO_3$) contained in the limestone and dolomite dust, as well as calcined lime and dolomite dusts and bulk materials steel mills;
- hydroxides Ca $(OH)_2$ and Mg $(OH)_2$ formed upon contact with water during granulation of blast furnace slag and absorption of moisture from the air by lime and dolomite dust;
- iron hydroxides $Fe(OH)_2$, Fe $(OH)_3$ contained in the neutralized acid runoff of steel rolling mills;
- hydrates of iron and calcium salts, containing in its composition crystal-hydrates, i.e. chemically bound water, which are formed in acidic and neutralized effluents of steel-making shops, and are in the form of a solution or suspension, and after drying - in a dispersed state.

The third group is substances that have chemical effect on the reaction of oxidation and ignition in a combustible environment (chlorides).

Considering both efficiency, and ecological safety, search and development of compositions among substances with pronounced endothermic properties is the most perspective, i.e. preference, it is necessary to give to the materials causing sharp cooling of a zone of burning or capable to create the environment which is not supporting burning.

To these materials are related carbonates, crystal hydrates and other fusible salts. For example, as anti-pirogen are recommended the following: urea (CH_4ON_2), which melts at 132°C; dolomite ($CaCO_3 \cdot MgCO_3$) decomposes at 350°C with the release of carbon dioxide; alum $KAl(SO_4)_3 \cdot 12H_2O$-above 100°C decomposes with the release of water vapor.

Recent studies have established [27] that one of the main factors determining the fire extinguishing capacity of powder wastes is the temperature of endothermic processes occurring in them during heating. The explosive action of powders with equal dispersion increases in a number of:

Oxides < Salt Anhydrous < Hydroxides < Hydrates Of Salts, Including Sulfates < Carbonates < Chlorides, And CaR<MgR<FeR (R - acid residue - $SO_4^{-2}, CO_3^{-2}, Cl^{-1} or OH^{-1}$).

The authors of somescientific papers [28} noted that the efficiency of powder inhibitors is significantly influenced by the way of their spraying and delivery to the flame front. There are three ways to feed powders into a fire or explosion zone: pneumatic, explosive and combined.

Pneumatic method is carried out in several ways:

- the charge and case of the fire extinguisher are constantly under pressure of the displacing inert gas (air, nitrogen, carbon dioxide) or steam of the extinguishing agent;
- presence in the fire extinguisher with powder of the spray can with the compressed or liquefied gas located in the case of the fire extinguisher or outside;
- presence in the powder container of excess pressure created by the release of gas in the course of a chemical reaction between the components of the charge of a special pyrotechnic gas-generating element of the fire extinguisher;
- supply of extinguishing agent is carried out as a result of the thermal effect on electric current or chemical reaction products of components of a special element;
- ejection supply of fine powder in the air satellite stream (volumetric remote extinguishing powder in the mine, cable channels).

Explosive (pulse) method is implemented by placing before or in the mass of the explosive charge a detonator, the mass is selected experimentally. Explosive method has a number of advantages compared to the pneumatic method: instantaneous response, fast powder cloud formation, activation and dispersion of fire extinguishing powder by explosion energy, small inertia of the method. However, there are drawbacks: there are restrictions in the use of explosives require special accounting and storage. Burning explosives during blasting in coal mines can cause gas or coal dust explosion.

The combined (pneumatic impulse) method of feeding the powder into the fire or explosion is carried out by the energy of the gas compressed in the cylinder, the unlocking of which occurs with the help of an instantaneous micro-explosion.

The widespread use of powder-filled fire extinguishers and with an integrated pressure source, with regard to pulsed fire extinguishers and explosives is a new generation of firefighting equipment.

The successful and timely suppression of ignition and explosion of a gas-air mixture depends on the speed of introduction of an effective inhibitor into the ignition zone or flame front. For this purpose, high-speed automatic systems of active suppression [29] are used, the designs of which have recently been intensively developed. Typically, such systems include: explosion detection sensors that react to light, UV-radiation, static pressure, thermal radiation, smoke; control and amplifying device of the signal coming from the sensor and sending a command to the fuse; explosive devices, triggered by the charge of explosives and powder inhibitors, sprayed into the combustion zone or explosion.

Generators of volumetric aerosol fire extinguishing or volumetric extinguishing system (VES) are the most modern means of fire extinguishing.

They are designed to extinguish fires of flammable liquids and combustible liquids (gasoline and other oil products, organic solvents, etc.) and solid materials (wood, insulated materials, plastics, etc.) and electrical equipments (power and high voltage installations, consumer and industrial electronics, etc.)

Volumetric quenching systems (VES) are suitable for extinguishing alkaline and alkaline earth materials, as well as substances whose combustion takes place without the presence of air.

The VES generators are divided into: manual (VES-5M) and stationary (VES-1). The protected volume in case of fire by VES-5M generator up to 40m^3 and VES-1 generator is up to 60 m^3.

To actuate the VES-5 generator it is necessary: remove the cap from the start node, then sharply pull the cord and throw it into the burning room.

To start the VES-1 generator, special thermo-chemical or electrical start-up units are used.

The use of thermo-chemical start-up units, triggered when the temperature reaches 90°C in the protected volume, allows each generator, if there are several, to work completely autonomously. Generators with thermal nodes run, installed under the ceiling of the room in the area of the most likely ignition.

The use of electric start-up units allows the use of VES-1 generators at sites with fire alarms. Installation of the VES-1 generator in the protected area is performed using a special bracket. The operating position of the generator is horizontal or vertical by the injector downwards. Generators with electric start node are placed at random.

VES-1 generators operate in a temperature range from minus 55°C to plus 55° and 100% humidity.

In case of fire and tripping of generators, persons in this moment in a secure room need to quickly leave it firmly closed doors and not to take any action to extinguish the fire and calling the fire brigade.

Generators VES it is recommended to equip the following objects: industrial enterprises, power installations, household enterprises, public buildings, educational institutions, research institutes and establishments, banks and offices, shopping bases and warehouses, entertainment enterprises, administrative and residential buildings and vehicles.

In particularly hazardous conditions using automatic systems, as in the former Soviet Union developed the system explosion-suppression "Rainbow" and "Underbar", German firm "Total" designed "ACHEMA", a relatively new (2003), the Russian development of ASVP-LV explosion-suppression [30].

ASVP-LV includes:

a) explosion localization device (ELD) is a device, spraying the flame retardant powder and explosion creating a barrier in the form of clouds of flame retardant powder in suspension in underground mines;

b) autonomous command device (ACD) is a device that provides actuation of ELD.

The explosion localization device consists of a cone-shaped hopper and an intermediate chamber filled with flame retardant powder, inside of which is the working cavity of the device filled with compressed high-pressure air. Autonomous command device is docked with the device triggering of ELD and consists of extension rods, couplings, receiving shield and mounting nuts.

To protect the conveyor workings must be installed automatic systems ASVP-LV throughout the mine workings, at a distance apart of not more than 300 m. In the workings of the conveyor that transports only one kind, such systems are not installed.

For isolation of fire sites automatic systems of ASVP-LV are placed on all adjacent to them developments.

The systems are placed on the incoming and outgoing air streams in the production of monorail-equipped. The system by means of suspension and supports is attached to the elements of the fortress under the roof of the mining reception of acceptance board to the direction of expected spread of the shock wave front and the flame front formed as a result of the explosion of methane-air mixture and (or) coal dust. Unfortunately, this device has not been widely used.

Nowadays as we do here, and abroad, sufficient experience of creation of automatic system of explosion suppression. To develop, numerous variants of the basic elements and nodes of such systems were created, and their improvement continues.

So in Germany serially produced various modifications of the complex explosion suppression BVS complex [31], this is an automatic explosion device, developed by an experienced drift Westphalia mining partnership (BVS) especially for protection from explosions in the mine degasification systems. It is already for several years is an integral part of the means of explosion-protection mine degasification systems, and has justified itself in practice. According to the results of the experiments the most effective means for suppression of explosions is a powder based on ammonium phosphate sold under the brand name of tropolar.

In the [32] the powder efficiency of inhibitors was estimated by the lowest extinguishing concentration of powder in the detonation chamber g/l. Spraying device (suppressor) consisted of a polyethylene shell of spherical shape of the powdery inhibitor and an explosive charge. The authors noted that the effectiveness of powder inhibitors significantly affected by the method of atomization and delivery to the flame front. Testing of the restraining devices was successful.

Combustion, as is known, is a set of complex chemical and physical processes, such as chemical reactions, combustible oxidizer, diffusion, heat transfer and others. Due to the process of flame propagation in the combustible gas mixture heat transfer and the diffusion of the active centers of flame (ACF). If the flame propagation velocity is significantly less than the velocity of sound propagation in a given medium, it is deflagration combustion, if is more this is detonation combustion or explosion. However, between deflagration combustion, when the shock wave is absent and detonation combustion, when the flame front and the shock wave front are combined, there is an area of "double non-stationary discontinuities". This is when the shock wave front propagates with a speed greater than the speed of propagation of the flame front and between them there is the explosion.

At suppression of deflagration burning powder fire equipment with pneumatic powder supply - manual and mobile fire extinguishers, stationary installations, cars can be used. In the case of explosive processes in the field of "double non - stationary explosions" - needed explosives with a spraying charge BB. In the case of the transition of the explosive process in detonation, when the flame front is combined with the shock wave front, - all available to date powder technology is unsuitable.

Application and long-term of the use of fire extinguishing powder. According to TC 113-08-597-86 on acceptance and standard tests the parameters of powders on points are checked to the following scheme: 7 (index of fire extinguishing ability), 9 (index of caking capacity), 10 (resistance to thermal influence), 11 (resistance to vibration and shaking), 12(term of persistence) and parameter on 8 point (fluidity) on acceptance, standard, periodic and certification tests.

The application of powders (their durability) is taken to be equal to the number of years during which the values of fire extinguishing ability and fluidity correspond to the values of GCST.

Long-term of powders also depends on additives. To reduce the traceability and moisture absorption, as well as to increase vibration resistance are the next additives to powders: modified aerosils, amines of fatty acids, stearates of metals, various organic-silicon liquids [68], as well as inert powdering additives such as phlogopite, talc, fireclay - kaolin dust and vermiculite. It is noted that in each case it is necessary to find the optimal ratio of powdery additives in the powder, since their insufficient share will lead to deterioration in the performance properties of the powder (moisture absorption, flow traceability, vibration-stability) and to reduction in the guaranteed period of storage. Their excess will lead to the deterioration of its fire-extinguishing efficiency (especially on class - A, so aerosils, and inert additives impede the melting film formation on the smoldering surface). The excess in the powder of liquid hydro-phobizing additives can also lead to deterioration its fluidity and fire extinguishing efficiency on the following classes: B and C - too dense coating of powder particles with the film leads to increased adhesion, and to a decrease in inhibitory efficiency.

In addition, overly expensive aerosol increases the cost of the powder. A literature search yielded no information on the possibility of extending the operating period of overdue (non-conforming) fire extinguishing powder.

Conclusions:

1. The effect on the combustion reaction is possible with the help of physical and chemical methods of gas mixture components concentration reducing, cooling the combustion zone and slowing down of chain reactions with the help of a phlegmatizing or inhibiting substances, of which the most universal and perspective are powder materials.

2. There have been tested a wide range of inorganic and organic compounds in laboratory conditions in different countries as powder phlegmatizers and inhibitors of ignition and explosion of gas-air mixtures. However, a number of formulations are unacceptable because of the release of toxic products (freons), scarcity, and high cost of raw materials and complexity of technology.

3. In view of the high toxicity and environmental hazard of inhibitors (halides), the most promising search and development of effective powder compositions based on chlorides and substances with pronounced endothermic properties (easy-boiling, easy-decomposing, easy-melting) causing a sharp cooling of the combustion zone.

4. The analysis of scientific and technical literature did not reveal the general laws of the effectiveness of extinguishing powders from their composition. There are proposed only some unsystematic series of dependence of the studied mineral compounds. Therefore, a necessary condition for solving the problems of developing effective flame arresters is to find common indicators and properties of substances that can become criteria for their phlegmatizing ability.

5. The following conditions are taken into account in the development of new flame retardants:

- not deficiency and cheapness of the raw materials (at first it is industrial waste);
- low toxicity and environmental safety;
- simplemanu facturing technology.

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ТИІМДІЛІК ӨЛШІМІ БОЙЫНША ӨРТСӨНДІРГІШ УНТАҚТАРДЫҢ ЖЫЛУЛЫҚ ЖӘНЕ САЛМАҚТЫҚ КАСИЕТТЕРІН ТАЛДАУ

Аннотация. Берілген зерттеу жұмысында өрт сөндіру мен жарылыс қауіпсіздігі құрамының классификациясы көрсетілген. Жану реакциясына ықпалды физикалық және химиялық газдардың қоспалар компоненттерінің концентрациясын төмендету әдістері, флегматикалық және ингибитикалық заттар көмегімен жану аумағын азайту және тізбекті реакцияны баяулату арқылы жасауға болады. Флегматикалық және ингибитикалық заттардың ішінде ең тиімді және перспективтісі болып ұнтақ тәріздем материалдар болып табылады. Уыттылығы мен экологиялық қауіпсіздігі жағынан жоғары болып келетін ингибиторлардың (галогенидтердің) ішінде тиімді ұнтақ тәріздес композицияларды дайындау үшін жану аумағын лезде мұздатуды тудыратын эндотермиялық қаситтері айқын (оңай қайнайтын, оңай ыдырайтын, оңай балқитын) хродиттер негізінде ұнтақтар болып табылады. Әдебиет щолуында өртсөндіруші ұнтақтардың құрамына байланысты олардың тиімділігінің жалпы заңдылықтары қарастырылды. Зерттелген минералды қосылыстыр тәуелділігінің кейбір жүйесіздік қатарлары ұсынылды. Тиімді өртсөндіргіштерді жасап шығару үшін қажетті шарттар ретінде флекматикалық қаситтерінің критериясы бола алатын заттардың жалпы көрсеткіштері мен қаситтерін іздеу болып табылады.

Түйін сөздер: өрт сөндіргіш ұнтақтар, жарылысты төмендеткіш қабілеті, спрейлер, жаңғыш реагенттер, ұнтақ тиімділігі, жылу және массалық қасиеттері.

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АНАЛИЗ ТЕПЛОВЫХ И МАССОВЫХ СВОЙСТВ ОГНЕТУШАЩИХ ПОРОШКОВ В КРИТЕРИЯХ ЭФФЕКТИВНОСТИ

Аннотация. В данном исследовании представлена классификация составов пожаротушения и взрывобезопасности. Воздействие на реакцию горения возможно с помощью физических и химических методов снижения концентрации компонентов газовой смеси, охлаждения зоны горения и замедления цепных реакций с помощью флегматизирующих или ингибирующих веществ, из которых наиболее универсальными и перспективными являются порошкообразные материалы. Ввиду высокой токсичности и экологической опасности ингибиторов (галогенидов) наиболее перспективными для разработки эффективных порошковых композиций являются порошки на основе хлоридов и веществ с выраженными эндотермическими свойствами (легкокипящие, легкоразлагающиеся, легкоплавкие), вызывающие резкое охлаждение зоны горения. Общие закономерности эффективности огнетушащих порошков в зависимости от их состава были рассмотрены в обзоре литературы. Предложены некоторые несистематические ряды зависимости изученных минеральных соединений. Необходимым условием для разработки эффективных пламегасителей является поиск общих показателей и свойств веществ, которые могут стать критериями их флегматизирующей способности.

Ключевые слова: огнетушащие порошки, взрывоподавляющая способность, спрей, горючие реагенты, эффективность порошка, тепловые и массовые свойства.

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