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New Fire Extinguishing Powder Compositions Based on Powder Waste of Production Enterprises

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Abstract: *The article presents research data on the fire extinguishing ability of powder combustion inhibitors obtained on the basis of waste from the production of mineral fertilizers.*

The factors influencing the extinguishing process with powder compositions are investigated, such as dilution of the combustible medium with gaseous decomposition products of the powder or the powder cloud itself, cooling of the combustion zone as a result of heat expenditure on heating the powder particles, the effect of fire blocking achieved when the flame passes through narrow channels and inhibition of the combustion process with gaseous products of evaporation of decomposition.

It was determined that when tested in the process of extinguishing the resulting dispersed composition of a fire extinguishing agent based on phosphogypsum in a mixture with sols, its friability increases, which in turn facilitates its use in the extinguishing process.

It has been established that with a sol content of 30%, the heat of combustion is effectively carried away from the combustion zone and, as a result, leads to a decrease in the fire extinguishing time.

Key words: *safety, fire, combustion, emulsion, suspension, flash, flames, explosion, spontaneous combustion, toxicity, oxygen index, carbon monoxide, oxidation, flame front, methane, cold wall effect, sublimation, recombination, flame torch, gas fountains, fire-extinguishing cloud, phosphates, phosphogypsum, soil.*

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The main direction of activities to ensure fire safety of national economy facilities, including industrial facilities, fixed in the standard on fire safety requirements is a systematic approach associated with the analysis of real fire hazard, engineering calculations of the main characteristics of fires and fire protection, including calculations of the reliability and economic efficiency of these systems.

Methods for preventing fires. In this work, the processes of inhibition of combustion of combustible materials - gases, organic materials and then - are considered.

The effect of fire extinguishing agents on the combustion process is usually considered as a result of replacing active carriers of the flail with low-active ones.

In the study of the effect of inhibitors on flames and on the limiting phenomena in gases, in this regard, it seems to be a priority to study the mechanism of fuel transformation in the flame front.

The heat-generating (cold) flame zone detects carbon dioxide, carbon monoxide, methane, hydrogen, formaldehyde, ethylene, propylene, acetaldehyde, propionic aldehyde, hydro peroxides.

The nature of peroxide radicals is replaced with increasing fuel burn up. Molecules of hydrogen, carbon monoxide, carbon dioxide, water vapor, and about 10% of the initial amount of oxygen enter the hot zone of the stoichiometric mixture [1].

It has been determined that, in the flame zone, the mechanism of fuel oxidation under the conditions of the flame front is qualitatively different from the mechanisms of slow oxidation. The reason for this phenomenon is that a rather intense diffusion flux of active particles rushes from the hot zone into the fresh mixture, among which the flux of hydrogen atoms is intense.

But if the diffusion fluxes of oxygen atoms, methyl, hydroxyl methyl radicals is small due to their high reactivity, and then the main source of chain nucleation in the cold layers of the combustion front should be considered the flux of hydrogen atoms.

The study showed that the most probable channel of fuel loss at the initial stage of oxidation under these conditions is the sum of the reactions [2]:

$H + O_2 + M \rightarrow HO_2 + M$; $HO_2 + H \rightarrow 2OH$; $HO_2 + H \rightarrow H_2O + O$;

$RH + OH \rightarrow R + H_2O$; $RH + O \rightarrow R + OH$; $RH + H \rightarrow R + H_2$

The following chemical reactions can occur in the cold layers of the combustion front:

$R + H \rightarrow$ unsaturated hydrocarbon+ H_2

$R + OH \rightarrow$ unsaturated hydrocarbon+ H_2O

$R + H \rightarrow RH$

$RO_2 + RO_2 \rightarrow 2RO + O_2$.

At high concentrations of hydrogen and hydroxide radicals in the pre-flame zone, peroxide radicals can be attacked with the formation of free valence in the hydrocarbon chain:

$C_3H_7O_2\text{-} + H \rightarrow \text{-}CH_2CH_2CH_2O_2\text{-} + H_2$;

$C_3H_7O_2\text{-} + OH \rightarrow \text{-}CH_2CH_2CH_2O_2\text{-} + H_2O$;

Or according to the general reaction:

$RO_2 + O_2 \rightarrow RO_4$ or $RO + O_2 \rightarrow RO_3$

Based on the presented model of the flame front of the combustion of mixed combustible materials, it can be seen that suppression or inhibition of combustion processes should be carried out by selecting the physicochemical features of known inhibitors.

The likelihood of an explosion of combustible mixtures can be reduced by powdered substances of various classes of compounds, which represent another class of inhibitors [3].

The study of the effectiveness of heterogeneous inhibitors using the example of the combustion of a mixture of methane with air showed that halides of alkali metals, especially iodides, at a concentration of 1-10 mg /L of the mixture, change the combustion rate by a factor of 2.

During the oxidation of n-butane in a vessel coated with a suspension of lead oxides: PbO, Pb_2O_3. PbO_2observedasimilareffect.

A more probable explanation for the efficiency of powders seems to us to be the presence of in homogeneities in the crystals, as well as unfinished crystals that form free valences on the surface. Such active centers have a structure.

The death of the active centers of the combustion chain is not equally probable at a given active center of the surface. The surface as a whole is a catalyst if, in its presence, another channel for the transformation of fuel arises. It is clear that the same powders have different effects on different flames [4].

The study of the fire extinguishing efficiency of various PFEC - powder fire extinguishing compositions allows you to formulate certain ideas about the mechanisms of their action, and the effectiveness of PFEC increases with an increase in their dispersion.

PFEC acts by the mechanism of conventional physical dilution of reagents in the combustion reaction zone. These particles are small in mass; their total heat capacity and heat-absorbing surface are very large.

Therefore, they warm up faster and take with them a large amount of heat from the chemical reaction zone.

Passing through this flame front, the powder particles take away part of the heat transferred from it by the fresh gas-air mixture (the extinguishing efficiency increases the smaller the average diameter of the given powder).

These particles of fire extinguishing powder, when they enter the chemical reaction zone, taking away heat from the flame front, acts according to the cold wall mechanism.

The distance between individual particles of highly dispersed powders in the combustion zone is very small and the formation of channels between them having a size much smaller than the critical one, because when the powder is introduced in bulk, the effect of a cold wall is manifested.

It is also accompanied by reactions with the mechanism of heterogeneous recombination of active centers of a chemical reaction on the surface of a solid PFEC particle.

When PFEC particles enter the zone of chemical reaction of combustion, a decomposition process occurs, sublimation with the release of gas components, but it is obvious that these endothermic processes lead to additional removal of heat from the zone of chemical reaction and its dilution with vapors and gases, if the evaporated products are chemically active inhibitors, then the mechanism of chemical inhibition of the decomposition products of PFEC is also added to this.

The mechanisms for the termination of powder fire extinguishing agents POS can be different, but the dominant mechanism of the process depends on the type of fuel, the combustion mode, the type of POS used, as well as on the way it is supplied to the combustion zone.

The advantage of powders, in addition to their high fire extinguishing efficiency, includes versatility, i.e. the ability to suppress the combustion of various, including pyrophoric, compounds and substances not extinguished by water and foams (metals and organ metallic compounds, etc.); the possibility of using energized equipment to extinguish fires; no damage to materials; the ability to extinguish fires at low temperatures, etc.

All fire extinguishing powders can be divided into two main groups: general-purpose powders intended for extinguishing fires with hydrocarbon fuels, conventional carbonaceous materials (wood, etc.), electrical equipment, etc., and special powders, intended for extinguishing metals, organ metallic compounds, etc.

At the same time, fire-extinguishing powders also have known drawbacks, the main of which is their tendency to caking and clumping.

At the same time, the ability to transport powders through pipelines and form a fire extinguishing cloud is lost. In this regard, powders did not find wide application for a long time, and only after the creation of a modern technology for their manufacture, which ensures good fluidity of powders, resistance to caking, etc., their industrial production began.

Currently, the most widely used are powder compositions based on bicarbonates and carbonates of alkali metals and ammonium salts of phosphoric acid. To improve the fluidity and stability during storage of powder formulations, various additives are introduced into them.

Fire extinguishing powders are not produced in the Republic of Uzbekistan; they are imported from other countries. Therefore, we have chosen the waste of the chemical production of phosphogypsum as a fire extinguishing powder.

Phosphogypsum is a dihydrate gypsum with admixtures of soluble (sulfuric acid, phosphoric acid, mono- and dicalcium phosphate) and insoluble (silica, phosphates, fluorides) substances. Its main substance ($CaS0_4 \cdot 2H_20$) is at least 80%.In the agricultural industry, it is used for gypsum plastering of soils. This process is called chemical reclamation and is carried out in order to reduce the alkalinity of the soil and increase fertility [2].

The composition of phosphogypsum contains calcium, which displaces sodium from the soil and helps to normalize water permeability.

Phosphogypsum tends to set and cake. For the convenience of its use as a fire extinguishing powder, sols were introduced into the composition of phosphogypsum in various quantities (table 1).

Table 1. Influence on the fire extinguishing properties of the powder composition of phosphogypsum.

№	Ash to phosphogypsum ratio, %	Specific surface ash,%	Specific surface of phosphogypsum, %	Bulk density of the mixture, kg / m^3	Model fire extinguishing hotbed for wood: + extinguishes; – does not extinguish.	Model hotbed for extinguishing gas: + extinguishes; – does not extinguish.
1	10 : 90	4200	3500	720	+	–
2	30 : 70	4200	3500	710	+	+
3	35 : 65	4200	3500	700	+	–
4	40 : 60	4200	4000	630	+	–
5	50 : 50	4200	4500	600	–	+

Phosphogypsum is dried at a temperature of 20-70^{0}C, ground to a specific surface area of 3500-4500 cm^2 / g. Crushed phosphogypsum is mixed with ash in the percentage shown in table 1.

The result of this method is the creation of a powder suitable for extinguishing fires of all classes.

Mixtures of phosphogypsum powder with modified ash were prepared in different ratios, and quenching characteristics were determined (Table 1).

It follows from the data that samples 4 to 6 do not meet the requirements for bulk density (not <700 kg/m^3). This decrease is due to the higher specific surface area (5000 cm^2/g). All positive results were obtained for a mixture of phosphogypsum and ash only in a ratio of 70:30.

The extinguishing process with powder compositions can be explained by the following factors:

- dilution of the combustible medium with gaseous decomposition products of the powder or directly of the powder cloud;
- cooling of the combustion zone as a result of the consumption of heat for heating the powder particles, their partial evaporation and decomposition in the flame;

- the effect of fire barriers, achieved when the flame passes through narrow channels, by analogy with mesh, gravel, etc. fire barriers;
- Inhibition of the combustion process, carried out homogeneously by gaseous products of evaporation and decomposition of powders or heterogeneously on the surface of particles or solid decomposition products.

It was shown in reviews [3] that in the case of extinguishing the flame with the most effective powders, their action can be explained only by the last factor inhibition of the combustion process.

The addition of ash in various amounts to phosphogypsum gives the mixture flow ability and ease of use of a fire extinguishing powder. Thermal analysis was carried out to study the properties of the mixture at high temperatures. Thermal analysis was carried out on a Paulik-Paulik-Erdey system derivatograph [5] at a speed of 9 deg / min and a sample of -0.1 g at the sensitivity of galvanometers T-900, TG-200, DTA-1/10, and DTT-1/10. The recording was carried out under atmospheric conditions with constant removal of gas from among the water using a water jet pump. A platinum crucible 7 mm in diameter without a lid served as a holder. $A1_20_3$ was used as a reference.

The heating curve of the phosphogypsum sample shows six endothermic effects at 147, 160, 178, 652, 810, 828°C and two exothermic effects at 328, 709°C. The first three effects are accompanied by a weight reduction of four percent. Subsequent effects are mild weight loss. The total weight loss in the temperature range 60-900°C according to the thermogravimetry curve is 11%.

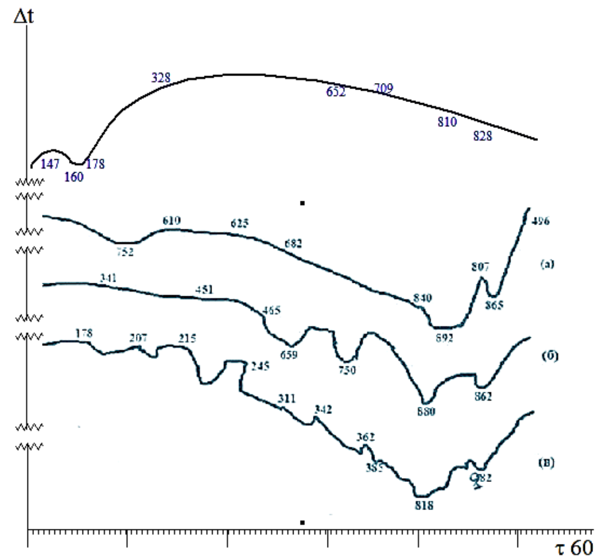

Fig.1. Differential heating curves of powder compositions based on phosphogypsum with ash additives: a) -10% b) - 30% c) - 50%.

The DTA curve of the 10% sample showed nine endothermic effects at 156, 170, 610, 622, 628, 647, 682, 752, 892°C and six exothermic effects at 140, 428, 496, 514, 678, 865°C. The total weight loss in the temperature range 60-900°C according to the thermogravimetry curve is 12.03%.

The heating curve of the 30% sample is characterized by twelve endothermic effects at 110, 148, 160, 194, 273, 423, 659, 695, 736, 750, 862, 880°C and eighteen exothermic effects at 123, 220, 236, 281, 311, 341, 372, 391, 400, 451, 465, 528, 557, 566, 582, 622, 635, and 807°C. The total weight loss in the range of 60-900 ° C according to the thermogravimetry curve is 12.96%.

The heating curve of the 50% sample shows two endothermic effects at 154.362 and three exothermic effects at 385, 482, and 818°C. The total weight loss in the temperature range 60-900°C according to the thermogravimetry curve is 18.85%.

Summarizing the above review, it can be noted that at present there is a fairly extensive assortment of fire extinguishing agents. Moreover, many of them have a very high fire extinguishing efficiency and with their help, it seems possible to provide a sufficiently reliable fire protection for many industrial facilities. A successful solution to this problem is possible only on the basis of a detailed knowledge of the capabilities of various fire extinguishing agents and the ability to determine the optimal conditions and methods of their application. At the same time, the relevance in the search for new fire extinguishing agents does not diminish.

Thus, it follows that the thermal behavior of the samples depends on the composition, preparation methods, and the nature of the added starting components.

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