PREDICTING SPONTANEOUS COMBUSTION IN GRAIN PRODUCTION AND USE OF GAS ANALYZERS TO REDUCE THE RISKS OF EMERGENCY SITUATIONS

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Abstract. *Spontaneous combustion of grain products can occur due to improper storage or handling. This can occur due to the presence of high humidity, the presence of vegetable oils or vegetable oil residues on the grain, and also due to incorrect storage temperature. To detect and prevent possible spontaneous combustion in grain production, special equipment is used, such as thermometers to control temperature, humidity sensors, ventilation systems, oxygen meters and monitoring systems that help monitor storage conditions of grain products.*

The choice of specific measuring instruments depends on the specifics of grain production, the type of equipment used and the size of the production premises. This article discusses how to achieve the best results to prevent spontaneous combustion in grain production.

Keywords: *temperature sensor, spontaneous combustion, grain production, grain, temperature, temperature control.*

Introduction:

Explosions and fires in industry occur much more often than the general public realizes. As a result, production stops, equipment and buildings are damaged, and sometimes there are deaths. One of the most common causes of this type of incident is the mixing of flammable gases and vapors with air and various ignition sources. Solvents, chemicals and other flammable vapors and gases are present in a variety of harvesting, processing and manufacturing processes - they tend to activate and stimulate fires or explosions.

A gas analyzer, in general, is an instrument that has the ability to analyze samples for the presence of varieties of chemical gases. At the same time, its essential feature is the output of quantitative characteristics of this analysis with their display in numerical or graphical form. There are many types of gas analyzers, depending on the technology and method used, for example, chromatographic, infrared, flame ionization, thermocatalytic, etc.

At enterprises involved in the storage and processing of grain, infrared or flame ionization gas analyzers are most often used, which help prevent fires and spontaneous combustion of grain products.

As a rule, gas analyzers solve two problems: process control and/or leak detection (leak detection). Leak detection sensors are sometimes not affected by flammable gas at all, and if they are, the amounts are small. Leaks are relatively rare; in such cases, the sensors must report the presence of significant or unusual flammable gas concentrations. In this case, the priority is to reliably detect leaks rather than accurately determine the concentration of a hazardous substance.

In another case, when monitoring technological processes, the concentration of an explosive substance is determined, as a rule, in closed, heated spaces. In this case, the sensors must be equipped with an active sampling system. Technological processes use the constant release of hazardous substances - they often allow processes to be optimized and accelerated. Often the values of released substances are close to the safe permissible values. Therefore, when monitoring technological processes, gas analyzers must measure the concentration of hazardous substances with high accuracy, which is not needed for leak detectors.

Standard requirements for flame gas analyzers establish the minimum values permissible during their operation. For example, for methane, the accuracy should be approximately +/-10% of the actual gas concentration, and the reading settling time should be less than 10-12 seconds.

Based on their production and functional purpose, objects for storing, processing and using plant raw materials have a number of properties that contribute to the occurrence of emergency situations:

o There are developed connections between functional structures and equipment of objects.

o There is increased dust in production areas.

o There are finely dispersed products in highways and communications.

Statistical data on accidents and their development at facilities for the storage, processing and use of plant raw materials indicate that they are mainly localized within the territory of the facility and do not spread beyond its boundaries.

Accidents with severe consequences occur as a result of explosions of dust-air, gas-air or dust-gas-air mixtures inside equipment, containers and production premises, accompanied by the destruction of building structures and subsequent fire.

Grain is a living creature created by nature and endowed with the ability to reproduce its own kind. Like any other living creature, it breathes, i.e. absorbs oxygen, which enters into oxidative reactions with hydrocarbons in the grain composition, resulting in the release of carbon dioxide and water. The oxidation reaction occurs with the release of heat.

Those. Each kilogram of dry matter in the process of complete oxidation gives a thermal effect of 2870 KJ, while 0.58 kg of water and 1.54 kg of CO2 are released into the grain mass. The higher the temperature of the grain mass, the more intense the grain oxidation processes. Everything would be fine, only microorganisms always live on the grain, and their vital activity depends on the conditions in which the grain is located! If temperature and moisture are in a favorable ratio for the life and reproduction of microorganisms, then this is what happens. The essence of the life activity of microorganisms is the same - the absorption of nutrients from the grain and the release of CO_2, water and heat. It should be noted that microorganisms are able to consume nutrients exclusively in liquid form, i.e. in fact, they drink them. Microorganisms spend more than 90% of their energy on respiration and the rest is spent on maintaining life and reproduction. This suggests that water vapor condensate is necessary for the life of microorganisms. During the process of self-warming of grain, the respiration of microorganisms combines with the respiration of the grain itself, which speeds up the process.

The process of heating grain to a certain temperature value is reversible (point B in Fig. 1), i.e. you can return to a lower temperature without changing the quality of the grain, but starting from a certain temperature value, the process becomes irreversible (point C in Fig. 1), and self-heating progresses very quickly. If you do not intervene in this process, the grain will become completely unusable. The ambient temperature has practically no effect on the process. There are known cases of complete destruction of grain during self-heating, when the air temperature outside the storage facility was -40°C.

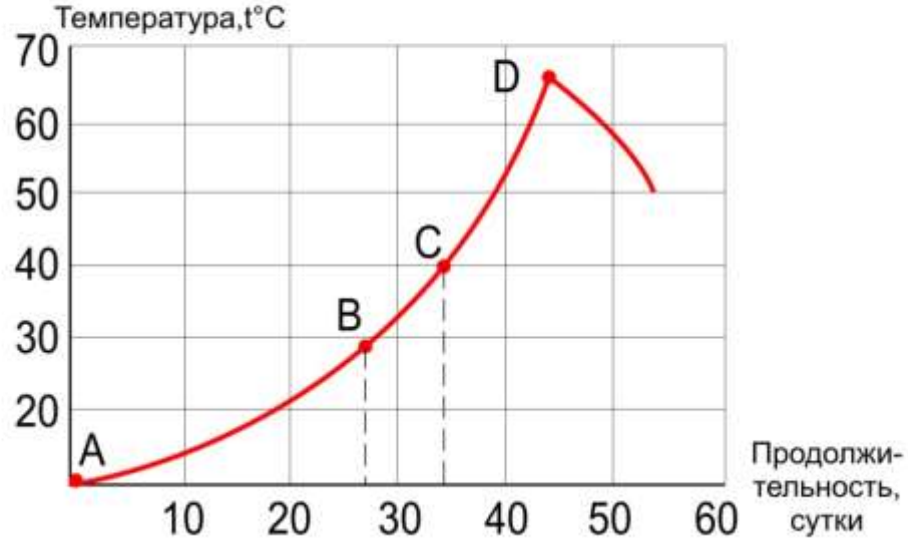

Fig 1. Spontaneous combustion process

In this case, an avalanche of microorganisms multiplies. The resistance of microorganisms to temperatures varies. Less heat-resistant grains stop functioning as temperatures rise and pass the baton to more heat-resistant grains, which render the grain completely unusable. Many researchers monitor this process by the intensity of CO_2 release.

Research shows that physiological activity increases sharply with an increase in grain moisture content of more than 14% and at an initial temperature of 25°C (Fig. 2).

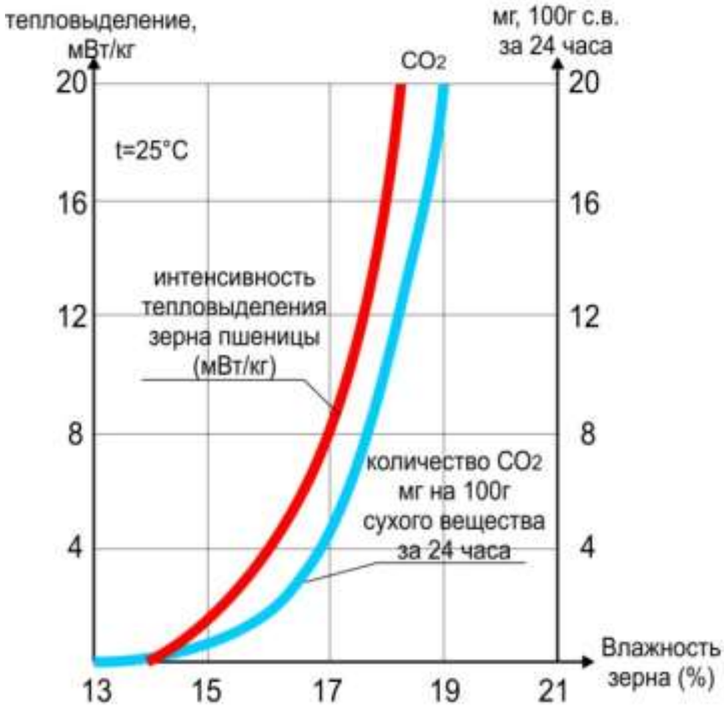

Fig 2. Heat release of grain

It can be seen that the intensity of grain respiration and heat release are closely interrelated. But free moisture plays a much greater role in the process of starting self-heating in the grain mass, as a carrier of nutrition for microorganisms constantly present on the grain. If the process of vital activity of the grain itself strongly depends on its humidity and temperature, then the process of vital activity of microorganisms depends even more on these parameters. Naturally, this results in a sharp increase in the number of colonies of mold fungi (Fig. 3).

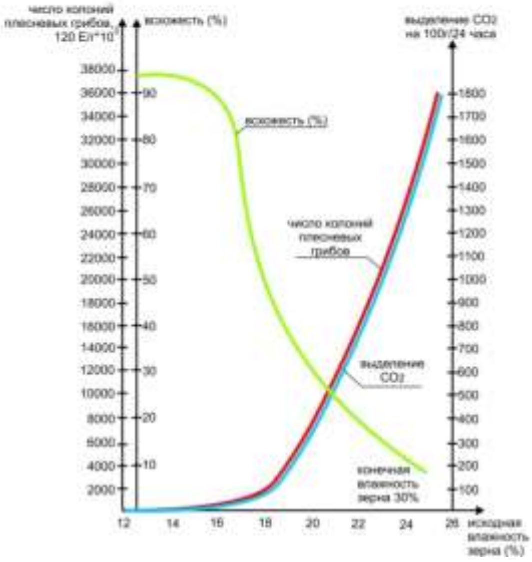

Fig 3. The ratio of colonies of moldy fungi to grain moisture content

Microscopic fungi, during their growth, penetrate the embryo and endosperm and poison the tissues of the embryo. The loss of germination during the development of self-warming indicates the cessation of the vital activity of grain and a decrease in the share of its participation in the further development of self-warming. Only microorganisms take the process to the limit. A sharp drop in germination occurs when the temperature rises above 35°C. Experts attribute this to the beginning of denaturation of the embryo protein.

The almost coincidence of the curves for the increase in the number of colonies of microscopic fungi in the grain mass and the intensity of their respiration (based on the release of CO2) allows us to confidently connect these processes quantitatively.

From Figure 3 it can be seen that up to an initial humidity of 16-17% at an initial temperature of 25°C, the reproduction of microorganisms practically does not increase, but it is worth adding only 2% humidity, and the process takes on an avalanche acceleration. It is no coincidence that before the word humidity there is the word initial, because it is clear that the moisture content of the grain during the process of self-heating increases and in the example given, with an initial moisture content of 25%, the final moisture content was already 30%.

Fig 4. Spontaneous combustion of grain dust.

The main threat is grain dust, the source of which is the friction of grains against each other during any movement. At a minimum concentration in the air, dust has more destructive power than dynamite. A dust explosion inside a confined space creates excess static pressure that is 12.5 times higher than the failure point of a reinforced concrete slab.

As a rule, pockets of self-heating occur when established rules and technological processes are violated - exceeding the established storage periods, high humidity, dirtiness, oil content, poor cleaning of silos and bins from products from the previous storage period, and when dissimilar products are stored together.

Long-term storage of self-heating products leads to their spontaneous combustion, during which flammable gaseous products of thermal-oxidative destruction: hydrogen, methane, carbon monoxide in concentrations exceeding the value of the lower concentration limits of flame propagation (LCFL) of these gases (LCFL values, % vol.: H2 - 4.08; CH4 - 5.24; CO - 12.50).

When designing a fire protection system for facilities storing, processing and using plant raw materials, it is necessary to provide for the following possibilities:

fire detection by technical means (fire detectors) and alarm systems in elevator bunkers and elevators, as well as other technological premises;

receiving signals from manual call points installed on the territory and premises of the facility;

supplying control signals for fire extinguishing systems;

supplying control signals to the warning and evacuation system (WES) of people in case of fire;

sending signals to shut down technological equipment for loading and transporting grain in case of fire;

prompt display of the system status on the display of the operator’s automated workstation (AWS).

In many industries there is a need to coat products with solvent-based materials. This is followed by the use of ovens or drying chambers to remove solvents from the final product. Often, solvent vapors accumulate in them, which can lead to an explosive situation. Such accumulation may be the result of a malfunction: sudden excess of coating, change in ventilation level. In any of these cases, the concentration of flammable vapors has the potential to rise above safe levels, creating an explosive mixture in the air. Requirements for the safe operation of solvent drying ovens are given in the safety and fire safety documents. Typically, they limit the maximum solvent concentration allowed to 25% LEL in the worst case. However, when installing a gas analyzer for flammable gases and vapors, the maximum permissible concentration is already 50% of the LEL. Analyzers also improve process efficiency and significantly reduce energy consumption.

The fight against grain losses due to warming is the most important task and is considered throughout the world as one of the reserves for reducing the shortage of food supplies to the population. In this regard, reducing grain injury is part of the solution to the problem, because injured grain (mechanically damaged) increases the likelihood of self-heating with all the ensuing consequences.

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