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Do not underestimate danger of explosion; Even dust can destroy equipment and kill☆

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Summary Explosions never happen at random, they have their exact laws. And sometimes they need very little — high dust concentration, turbulence and ignition source, often spontaneous combustion. If these conditions are met, explosions always follow. It needs to be mentioned that all organic substances are explosive, for example starch, flour, dried milk, sugar, cocoa, pharmaceuticals, textiles, wood and coal dust and others. The highest risk of explosion primarily threatens factories, where they work with dust in any way. Explosions occur directly in pieces of technological equipment during milling, drying, pneumatic or mechanical transport, storage and filtration, and they usually have fatal consequences. Unfortunately organic substance explosion do not only destroy the equipment, they also often kill.

Introduction

The year is 1987. Destructive explosion of flax dust in a linen factory in Harbin, China kills 47 people and injures another 179 (Los Angeles Times, 2015). On the second of August 2014 in early hours of the morning an explosion can be heard in a factory producing automobile parts in the Kchun-shan city in Eastern China (Fox News, 2015). The massive explosion kills almost 70 people and tens of others are injured. Explosion of whirled up aluminum dust is indicated as one of possible causes (The Guardian, 2015). The year 2015 is not an exception. World agencies informed that explosion of colored dust based on starch that was used at the festival Color Play Asia in June killed 10 people and injured another 485 (CNN, 2015), and that in August explosion in a warehouse of dangerous material in the Chinese port of Tianjin at least 44 people were killed and over 700 injured (CNN, Massive Blasts . . ., 2015). This information, that by far do not include every accident of this kind, shows one thing: Literary any dust can explode under ideal conditions, be it grain, flour, starch, sugar, dried milk, cocoa, coffee, coal or aluminum dust.

The highest risk of explosion primarily threatens in production processes, where dust is handled in any way. These

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Figure 1 Accident caused by dust explosion in the Chinese city of Kchun-shan (Woodworking Industry News, 2015).

processes are used, for example, in food, pharmaceutical or chemical industries. Technologies that companies use for milling, drying, pneumatic or mechanical transport, storage and filtration are highly susceptible to self-ignition, occurrence of fire and explosion. A series of accidents, fires and explosions, which happened in the past, turned attention of experts to development of systems and devices that could protect industrial technologies against these events (Fig. 1).

Methodology

Explosion can be in many cases prevented by active explosion protection, namely by exclusion of at least one of the three components needed for explosion of organic substances — initiation ignition source, concentration of explosive substance above lower explosion limit and oxidation agent. However, in about 40% of processing industry it is not possible to exclude even one of these initiation components, therefore quite safe conditions cannot be provided without passive explosion protection. Primarily technological processes during milling, drying, pneumatic or mechanical transport, storage and filtration are highly susceptible to self-ignition, occurrence of fire and explosion. In these cases the risk of explosion is high without the use of anti-explosion elements designed for a given technology on the basis of careful analysis by a professional company that works in the area of explosion prevention.

Design of explosion protection

When we consider equipment with potential explosion danger, we need to make sure that the equipment is suitably located, with regard to danger zones and layout of the construction project, already in the project phase of proposed technology. At the same time we need to make sure that the technology is resistant to all conditions occurring during explosion.

Not only operational conditions need to be expertly evaluated, but also each specific technological process and its equipment in such way that helps an operator or a project engineer to exactly determine a measure of explosion risk, and possibly propose a way to eliminate it or completely exclude the possibility of explosion. If experts, who are technically capable of determining that a substance is explosive, and who know its speed of explosion pressure increase, can actively participate in preparation of project documentation, then the best possible protection against explosion without technological limitations can be achieved. Unprofessional proposals of protective explosion elements in a technology can in many cases lead even to increase in explosion effects instead of their suppression. The result of complex explosive protection is a document called the Document on Protection Against Explosion that, based on fire technical and explosive parameters, specifies in detail environment classifications, types and numbers of safety elements, safety regulations for the technological process, defines possible ignition sources, safety zones, required measures in the area of electricity and electrostatic electricity, solutions for signalization and blocking and starting of operations after possible explosion. This document takes into account current state of technical equipment, as well as technological solutions in the area of machines and equipment.

Self-ignition risks

Possible causes of explosions of powder substances include self-ignition. At the same time reaching of critical temperature depends on substance properties, especially on kinetics of heat release, layer thickness, conditions of heat exchange with surroundings, and also on the length of time, for which the critical temperature conditions last. Fire or explosion can be caused also by mechanical impurities in insufficiently filtered air brought to technological equipment; friction areas of individual equipment parts are also risky (especially on various sprayers, fans and tourniquets), and danger is also represented by electrical sparks caused by static electricity or, for example, by friction of blades of dirty fan against its cover. These risks are present during processing of bulk materials in mills, crushers, exhaust equipment, during the process of drying or pneumatic transport of material, etc.

As an example I present fire technical and explosive parameters of selected types of dust during the process of drying. Table 1 shows common bulk materials that can be encountered in the food and pharmaceutical industries. Each substance has their lower and upper explosivity limits. They depend on dust grain sizes, their concentrations and spread in the environment and oxygen content and temperature of the environment. The finer and drier the dust is and the higher is the environment temperature, the more ignition-prone the substance is, and its explosion is stronger. Not only layers of deposited dust, that can be swirled up by different ways, especially in pipes, separation cyclones or filters, are dangerous, but also decreases in flow speed and increases in environment temperature, for example due to power outages, insufficient air filtration or imperfect cleaning of technological pieces of equipment.

Table 1 shows that dried milk, for example, that falls under the st1 explosive class, and that has tendency to self-ignite, has the lower explosive limit of 40 g m^{-3}. There would be no explosion in case that its concentration falls under this limit. On the contrary, in case that it would get into contact with an ignition source, an explosion would certainly occur,