FIRE – TECHNICAL CHARACTERISTICS OF CHOSEN COMBUSTIBLE FOOD DUSTS

Abstract: Combustible dusts in food industry are a significant risk, especially with regard to their explosion. Under certain specific circumstances it may occur in food companies very quickly and damage that can be caused by such explosions, mostly climb to huge amounts. Loss of life or injury of workers´ health are no exception. Therefore it is important to pay attention to fire-technical characteristics of combustible food dusts to protect against emergencies as a result of the explosion. The article deals with the characteristics of combustible dusts, especially the fire-technical characteristics, as well as with an explosion protection in food business.

Key words: combustible dust, flammable dust, food industry, fire – technical characteristics, dust explosions, explosion protection

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1. INTRODUCTION

Since time immemorial it has been used and worked with flammable dusts in food industry. The dust is mainly worked with in mills and different silos. Because of the flammability of the dusts a hazard of fires or explosions there has been always present in our society. The risk caused due to the manifestation of this danger has been increased in recent decades when these dusts began to be produced industrially. In this industrial area there is the risk of sedimented dust higher because of his big amounts, and there is also the frequency of equipments that may figure as ignition sources of fires and explosions higher. The consequences of such events may have strong influence on the used technology but also on the health of workers. In an environment where an explosion of combustible dust is present there must be met simultaneously several conditions for physico-chemical properties and fire-technical characteristics of the dust, which are necessary for determining formation of dust explosion. Therefore it is necessary to know all chemical and physical properties and also fire - technical characteristics of the dusts which is under construction. It is also necessary to use verified practices and to have also installed safety devices that can protect the technology against fires or explosions, or they can dispose of them very quickly in time.

2. SPECIFICS OF FLAMMABLE DUSTS PRESENT IN FOOD INDUSTRY AND AGRICULTURE

Food factories have some specifics that make the situation more favorable compared to other industries. They have a higher level of hygiene and cleanliness in the workplace, so there is usually not used to manipulate with higher amount of dust out of the technology and thus the risk of explosive atmospheres creation relates in the vast majority only to the interior of the devices (for example, in tanks and silos of flour, sugar, cocoa and other loose (powdery) materials and in transport systems or machines for mixing raw materials. But at that same time, however, this fact conceals a big danger of underestimating of situation. Operation, which for the first view looks clean and dust-free hides considerable risks at places which are not visible.

Agricultural operations are doing from this point of view considerably worse. Often the material is handled in an open area outside of the technology (such as income trashes, loose grain stores). It is raised a large amount of fine waste dusts during processing and cleaning of agricultural products (cereals, corn, to a less extent also canola and poppy). And also housekeeping in some areas, particularly in building silos and crop lines, is often problematic. [6]

2.1. Real industry accidents caused by explosion of combustible food and agricultural dusts

Historically, the explosion of food and agricultural dusts are known phenomenon for more than 200 years. The first explosion that was recorded was mill dust explosion in a warehouse in Turin in 1785. During following period there were many dust explosions in warehouses and food industries. E.g. in 1979 in Germany, an explosion destroyed almost the entire mill and caused 14 deaths. In 1982 there were also two major explosions in France in silo of the sugar factory "Boiry Sainte Rictrude" and malthouse "Metz". For example, there were killed 12 people. [3]

On February 7, 2008, a huge explosion and fire occurred at the Imperial Sugar refinery northwest of Savannah, Georgia, causing 14 deaths and injuring 38 others, including 14 with serious and life-threatening burns. The explosion was fueled by massive accumulations of combustible sugar dust throughout the packaging building. [4]

Figure 1 – Imperial Sugar Rafinery after explosion of sugar dust [4]

2.2. Fire – technical characteristics of food and agricultural dusts

To occur flammable dust explosions there are simultaneously present the following elements needed: combustible dust, initiating ignition source, oxygen (air), dispersion of combustible dust particles and their occurrence in a confined space (eg. in a container room in a manufacturing or processing facility) . Experimental tests can provide information about a number of basic fire - technical characteristics of dust, among which we include for example lower explosion limit, maximum explosion pressure, maximum rate of pressure rise, explosion constant K_{St}, minimum initiation energy, combustion temperature of sedimented dust, the combustion temperature of the swirled dust, the ignition temperature of sedimented and swirled dust, limit oxygen number.

For large number of combustible dusts it can be found these fire - technical characteristics in tables or specialized technical literature. However, it should be kept in mind that the values of these characteristics have the character of intervals, so they need to be understood just as approximate guide values. Safety parameters of combustible dust always depend on a specific technology and on conditions of

handling with the substance. [5] In following tables there could be seen the fire – technical characteristics of particular food flammable dusts stated in technical literature.

Table 1 Fire – technical characteristics of dried milk [2,8,9]

DRIED MILK	
Lower explosion limit [g/m^3]	60
The ignition temperature of the seated dust [°C]	330
The ignition temperature of the whirled dust [°C]	520
Maximum explosion pressure [MPa]	0,86
Explosion constant K_{St} [bar.m/s]	90
Minimum ignition energy [MJ]	35

Table 2 Fire – technical characteristics of cocoa [2,8,9]

COCOA	
Lower explosion limit [g/m^3]	65
The ignition temperature of the seated dust [°C]	200
The ignition temperature of the whirled dust [°C]	500
Maximum explosion pressure [MPa]	0,47
Minimum ignition energy [MJ]	100

Table 3 Fire – technical characteristics of dust sugar [2,8,9]

DUST SUGAR	
Lower explosion limit [g/m^3]	45
The ignition temperature of the seated dust [°C]	400
The ignition temperature of the whirled dust [°C]	370
Maximum explosion pressure [MPa]	0,75
Explosion constant K_{St} [bar.m/s]	126
Minimum ignition energy [MJ]	30

Table 4 Fire – technical characteristics of wheat flour [2,8,9]

WHEAT FLOUR	
Lower explosion limit [g/m^3]	125
The ignition temperature of the seated dust [°C]	360
The ignition temperature of the whirled dust [°C]	480
Maximum explosion pressure [MPa]	0,7
Explosion constant K_{St} [bar.m/s]	63
Minimum ignition energy [MJ]	40

3. EXPERIMENTS

There are two basic methods for measuring of ignition temperature of food dust, and those are measuring in sedimented state and measuring in whirled state of dust. Our experiments shown in this article are provided according to the second method. The measuring equipment is shown in the following figure 2.

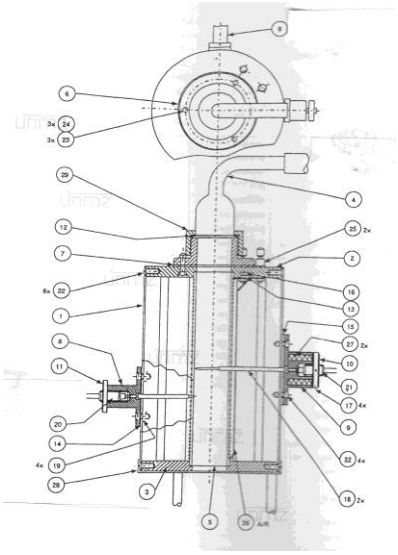

Figure 2 – Equipment for measuring of ignition temperature of whirled dust. Legend: 1 – furnace shell, 2 – top cover, 3 – lower cover, 4 – adapter, 5 – tube, 6 – sleeve, 7 – mat, 8,9 – flange for thermocouple, 10, 11 – locknut, 12, 13, 14, 15, 24 –mat, 16 – ring, 17 – pin, 18 – sleeve, 19 – nut, 20, 21 – thermocouple, 22 – countersunk bolt, 23 – convex nut, 25 – therminal, 26 – Kanthal wire, 27 – compression spring, 28 - rack ovens, 29 – hedgings ring, 30 – dust collector [7]

The values measured by the equipment for measuring of ignition temperature of whirled dusts are shown in the next table 5. As it can be observed in comparison with the values written in technical tables and literature there are some small variations in our laboratory measurements. They can be caused, as it is mentioned above, by the particular structure of the dust, by the size of its particles, by humidity of the dust, etc.

Table 5- Fire – technical characteristics of particular food dusts measured in our laboratory

Minimum ignition temperature of whirled dusts [°C]		
Dust	**Measured value**	**Tabled value**
Hladká múka	390	485
Hrubá múka	neg	-
Práškový cukor	380	360
Kakao	480	500
Sušené mlieko	510	520

4. CONCLUSION

Fire - technical characteristics of combustible dusts such as ignition temperature of dust in deposit state, ignition temperature in whirled state, minimum ignition energy, explosion constant K_{st}, etc. are not physical constants [1] and are depending on test conditions, on structure of the dusts, on size of dust particles, on humidity and many others circumstances and conditions. Using direct value of particular fire – technical characteristics without measuring for particular dust is not the right way and the safety in the food industries and agricultural companies could not be exact. That is why every food and agricultural plant need to have measured all fire – technical characteristics of the dusts that occur in the particular company. Such way of characterization of the sample could lead to higher safety of the food industry and to protecting many lives of workers and property.

5. REFERENCES

[1] Balog, K. and team: Flammability of materials and forensic approach in fire investigation. ExFoS – Expert Forensic Science, XXIIIrd international conference, Brno 2014, Czech republic

[2] Beck, G. and team : Požárně a bezpečnostně technické charakteristické hodnoty nebezpečných látek 1., 2., 976 p., 1990 Praha, ČSSR.

[3] Damec, J. a kol.: Protivýbuchová prevence v potravinářství a zemědělství. Edice SPBI Spektrum, 1999, p.2, ISBN: 80-86111-41-5

[4] Imperial Sugar Company Dust Explosion and Fire. [cit. August, 8th, 2016]. Available at http://www.csb.gov/imperial-sugar-company-dust-explosion-and-fire/

[5] Kořínek, K.: Požárně technické charakteristiky prachů a jejich význam v technické praxi. Výzkumný ústav bezpečnosti práce. Knihovna BOZP, čítárna [online], [December, 22nd, 2006], [cit. August, 2nd, 2016]. Available at http://www.bozpinfo.cz/win/knihovna/bozp/citarna/clanky/pozarni_ochrana/prach_vybuchy_pozary.html

[6] Nebezpečí výbuchu – potravinářske a zemědělské provozy. [Online] [September, 11th, 2014]. [cit. August, 8th, 2016]. Available at http://www.bezpecnostprace.info/item/nebezpeci-vybuchu-potravinarske-a-zemedelske-provozy

[7] STN EN 50281-2-1 Elektrické zariadenia do priestorov s horľavým prachom, Časť 2-1 : Skúšobné metódy, Metódy na stanovenie minimálnych teplôt vznietenia prachu. Slovenský ústav technickej normalizácie, Bratislava 2002, 32 p.

[8] Štroch, P.: Procesy hoření a výbuchů, EDIS ŽU, 2010 Žilina, 156 p. ISBN 978-80-554-0187-4.

[9] Štroch, P.: Riziko výbuchu prašných směsí a možnosti prevence, 80 p., ISBN 978-80-7362-515-3

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