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Analysis of explosive parameters of eucalyptus dust in wood and furniture industry

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Abstract: *Analysis of explosive parameters of eucalyptus dust in wood and furniture industry.* In the article are presented research results of the maximum explosion pressure, maximum rate of explosion pressure rise, low explosion limit for eucalyptus wood dust. Wood particle size was below 200μm. This research was carried out in 20 dm^3 spherical vessel according to PN-EN 14034:2011 standard.

Keywords: dust explosion, industrial dust, industrial safety

INTRODUCTION

Within the forestry industry, the wood based panel industry is of utmost significance. It is only thanks to the mechanical transformation of the grown wood into wood based panels with defined properties that the requirements of modern wooden and furniture constructions can be optimally complied with. However, the production processes, such as the processing of the wood into chips, fibres or veneer as well as the drying and pressing of the combustible materials to structural elements, hold various risks of fire. Sparks, glowing embers or particles, generated in different plant areas, can easily cause serious fire and explosions. The susceptibility of wood dust to explosion poses a serious hazard, as it may take place in numerous different technological processes. The exothermal nature of the oxidation reaction, and subsequently the combustion of wood dust, allows additionally easy progress as this dust has a developed proper surface of the material, which increases the contact of the flammable material (dust) with an oxidizer (air) [1-5].

This paper presents the susceptibility of dust to the initiation of explosion by setting out and analysing values of the maximum explosion pressure (p_{max}) and the maximal rate of explosion pressure rise $(dp/dt)_{max}$ and low explosion limit (LEL) of cloud dust of wood exotic species dust in accordance with the standard PN-EN 14034:2011. The conducted experimental tests were used to preventing and/or minimising the consequences of explosions.

MATERIALS AND METHODS

The study involved dust of exotic wood namely eucalyptus (Eucalyptus grandis). The particle size of dust up to 200μm and moisture content 6,12%. The experimental chamber (spherical shaped) with a 20 dm^3 capacity is the most crucial laboratory device that is used for testing explosive properties for the determination of an explosion threat connected with a given dust or a mixture of several dusts based on their parameters, i.e.

- determination of maximum explosion pressure P_{max} of dust clouds in accordance with EN 14034-1:2004+A1:2011 [7],
- determination of the maximum rate of explosion pressure rise $(dp/dt)_{max}$ of dust clouds in accordance with EN 14034-2:2006+A1:2011 [8],
- determination of the lower explosion limit LEL of dust clouds in accordance with EN 14034-3:2006+A1:2011 [9],

The spherical experimental chamber is an effect of the implementation of a global research standard and has been allowed for both in European standards: EN 14034, and in American ones: ASTM E1226.

RESULTS OF MEASUREMENTS

Maximum explosion pressure (p_{max}) is maximum pressure occurring in a closed vessel during the explosion of an explosive atmosphere determined under specified test conditions. The highest value obtained for a given concentration is seen in figure 1.

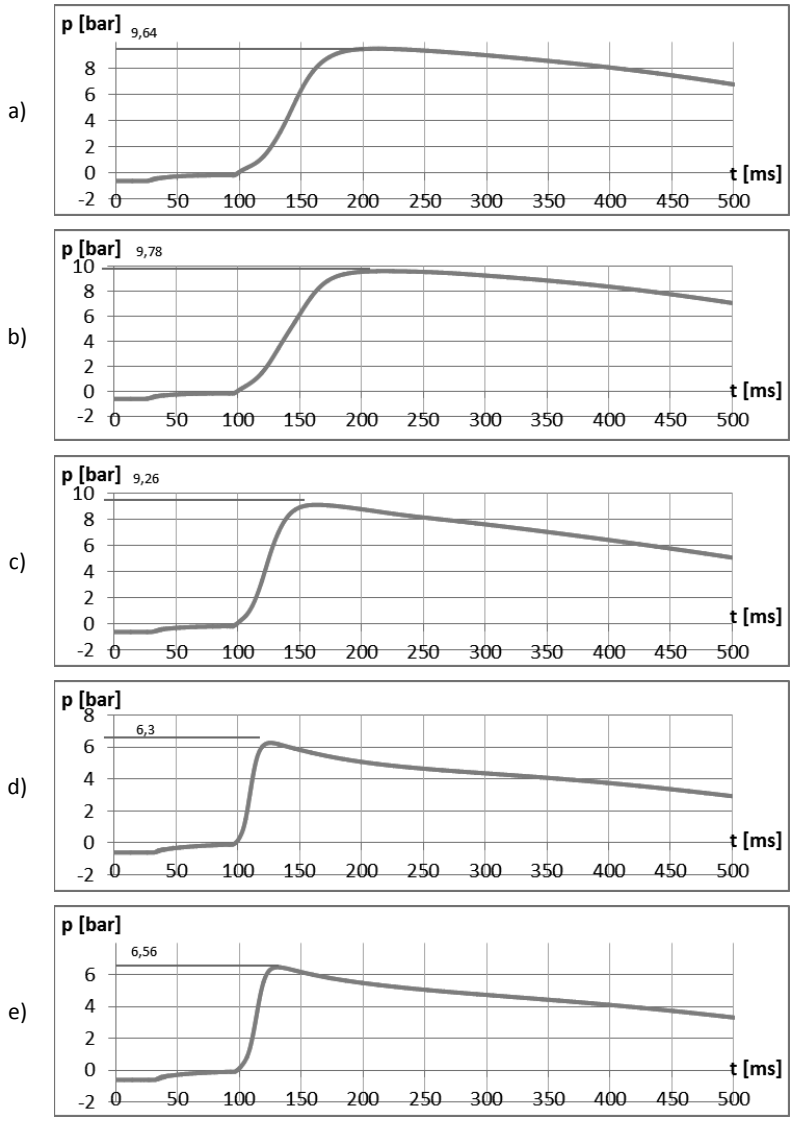

Figure 1. Dependence of the maximum explosion pressure for a eucalyptus dust explosion in a closed vessel a) 5g, b) 10g, c) 15g, d) 20g, e) 25g.

Maximum explosion pressure for eucalyptus came to 9,78 bar and was observed for concentration 500 g/m^3.

Maximum rate of explosion pressure rise $(dp/dt)_{max}$ is maximum value of the pressure rise per unit time during explosions of all explosive atmospheres in the explosion range of a combustible substance in a closed vessel under specified test conditions. Maximum rate of explosion pressure rise for eucalyptus came to 314,72 bar/s and was observed for concentration 1000 g/m^3. All measurements values is seen in table 1.

Table 1. Values of maximum rate of explosion pressure rise for eucalyptus dust for a given concentration

Dust concentration [g]	250	500	750	1000	1250
Maximum rate of explosion pressure rise $(dp/dt)_{max}$ [bar/s]	187,36	159,76	270,21	314,72	302,69

Lower explosion limit is the minimum fuel concentration which is capable of supperting flame propagation in a uniform dust cloud. In the case of dusts, only the lower explosion limit is measurable. An ignition of the dust explosion shall be considered to have take place, when the measured overpressure (influence of two chemical igniters summary for 2kJ included) relative to the initial pressure is lower than 0,5 bar. The highest concentration of eucalyptus dust at which no ignition occurs in three consecutive tests shall be taken as the lower explosion limit and are presented in figure 2. Lower explosion limit for eucalyptus dust is measured for concentration 30 g/m^3.

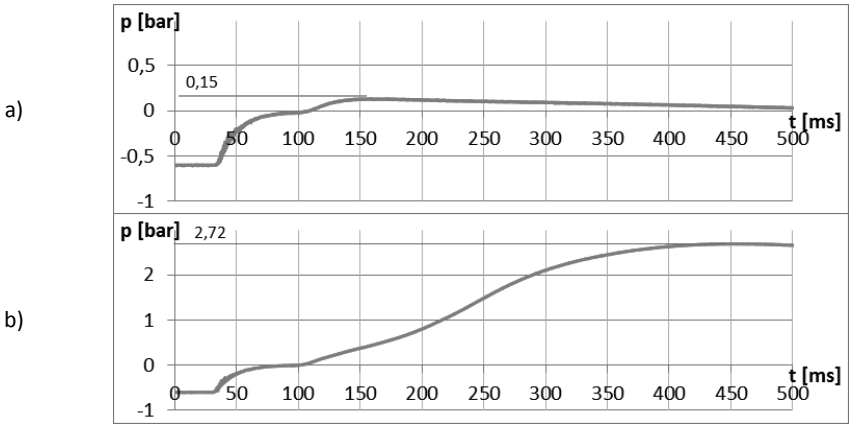

Figure 2. Pressure evolution with time during a dust explosion in a closed vessel for eucalyptus dust for: a) mass 0,6g –without ignition, b) mass 1,2g –ignition observed.

ANALYSIS OF RESULTS

Maximum explosion pressure is determined in a spherical chamber with the volume 20dm^3 by recording the curve „pressure – time". From the curve the values of maximum explosion pressure and maximum rate of pressure rise are calculated. Maximum explosion pressure for eucalyptus dust is the range 9,78 bar and for pine dust 7,49 bar. The maximum rate of pressure rise is the range 314,72 bar/s for eucalyptus dust (exotic wood) to 318,77 bar/s for pine dust (native wood) [6]. The maximum rate of pressure rise in considered to be the

best characteristic of explosion severity of dusts because of the so-called ‘cubic law”. The mathematical formulation of the cubic law is:

$$(dp/dt)_{max} * V^{1/3} = K_{st} = cont.$$

The K_{st} value is considered as a measure of dust explosibility and permits us to calculate the explosion effects in a given volume. This value is the basis of classification of dust explosibility to the classes St1, St2 and St3. According to the general rules, dusts with K_{st} <200 bar/s belong to the class St1of lowest hazard. The dusts with K_{st} in the range 201-300 bar/s belong to the class St2 and are more dangerous. The dusts with K_{st} >300 bar/s are the most dangerous (class St3). Dust specific characteristic value (K_{st}) for eucalyptus dust is 85,43 m*bar/s and for pine dust 106,7 m*bar/s. Wood dusts generally belong to the class St1.

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REFERENCES

1) PÓŁKA. M., PIECHOCKA E., KUKFISZ B,. *Susceptibility of inflammable industrial dust to ignition from heated surface,* Przemysł Chemiczny, 2012, nr 6, s. 1000-1003.
2) B. KUKFISZ, M. PÓŁKA, Z. SALAMONOWICZ, M. WOLIŃSKI, *The use of selected extinguishing powder for reducing industrial dust explosion impact*, Przemysł Chemiczny, 92/10, (2013), 1000-1003.
3) M. PÓŁKA, Z. SALAMONOWICZ, M. WOLIŃSKI, B. KUKFISZ, *Experimental analysis of minimal ignition temperatures of a dust layer and cloud on a heated surface of selected flammable dust*, Elsevier *Procedia Engineering* 45 (2012) 414-423.
4) M. PÓŁKA, *Fire and explosion hazards of wooden dust – selected problems*, „Ann. Warsaw Agricult. Univ.-SGGW, For and Wood Technol.” 2007, nr 62, p. 163−166.
5) M. PÓŁKA, *Comparative analysis of minimal ignition temperatures clouds of wooden dusts*„„Annals of Warsaw University of Life Sciences – SGGW, Forestry and Wood Technology” 2008, nr 63, p. 201−204.
6) PÓŁKA M., KUKFISZ B., WOLIŃSKI M., SALAMONOWICZ Z., *Experimental Investigation of Inertization Parameters,* Annals of 8th World Conference on Experimental Heat Transfer Fluid Mechanics, and Thermodynamics, Lisbona 16-20.06.2013.
7) PN-EN 14034-1+A1:2011 – Determination of explosion characteristic of dust clouds- Part 1: Determination of the maximum explosion pressure p_{max} of the dust clouds. 2011.
8) PN-EN 14034-2+A1:2011 - Determination of explosion characteristic of dust clouds- Part 2: Determination of the maximum rate of explosion pressure rise $(dp/dt)_{max}$ of the dust clouds 2011.
9) PN-EN 14034-3+A1:2011 - Determination of explosion characteristic of dust clouds- Part 3: Determination of the lower explosion limit (LEL) of the dust clouds 2011.

Streszczenie: *Analiza parametrów wybuchowych pyłu eukaliptusa w przemyśle drzewnym i meblowym*. W artykule przedstawiono wyniki badań maksymalnego ciśnienia wybuchu, maksymalnej szybkości przyrostu ciśnienia wybuchu i dolnej granicy wybuchowości pyłu drzewnego eukaliptusowego. Rozmiar ziarna pyłu był poniżej 200 μm. Badania przeprowadzono w komorze sferycznej o objętości 20 dm^3 zgodnie z normą PN-EN 4034:2011.

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