

Dust explosion hazard in wood processing

GRZEGORZ DUDARSKI, MARIA KOWAL, CZESŁAW CZĘSTOCHOWSKI
University of Zielona Góra, Faculty of Mechanical Engineering

Abstract: *Dust explosion hazard in wood processing. Explosion hazard is one of threats resulting from wood dust presence in the location of machines and also inside pneumatic dedusting installations. This article presents assessment problem for dust explosion hazard in wood machining processes. Explosion hazard zones ranges were determined in particular dedusting installation elements and also the probability for their occurrence. Effective sources for explosive dust atmosphere ignition were identified. Recommendations were formulated relating to minimization of explosion hazard in wood industry.*

Keywords: occupational safety, wood dust, explosion hazard.

INTRODUCTION

Explosion hazard is understood as the ability of combustible gasses, combustible vapors of fluids, dust or fibers of combustible solids, to mix with air, which, under the influence of an ignition initiating factor, explode. They undergo instantaneous combustion along with pressure increase.

Explosion hazards may occur on working stands in all manufactories which are related to easily combustible substances. Explosion hazard is present in chemical industry, food and feed industries, pharmaceutical industry, on landfills, in heating power plants and in wood industry.

Aspiration exposure to wood dust and exposure to noise are fundamental problems on stands for wood mechanical processing. The highest concentration of inhalable dust are recorded on working stands for grinders, circular saws and milling machines. Dust which is produced during wood mechanical processing is carried away by de-dusting systems, inside which explosion hazard occurs of dust explosive atmosphere.

Only dust consisting of nominal grain diameter below 500 μm can give rise to a dust cloud and explosion hazard. Wood residues have diversified fractional composition depending on the type of machining, applied tools and cutting parameters. Fractional composition analysis for wood residues produced from oak wood and spruce sawing showed that explosive fraction content exceeds approximately 90% of inhalable dust mass for oak wood and 70-90% for spruce depending on the method of processing (*Očkajová, Banski A. 2009*).

FACTORS AFFECTING WOOD DUST EXPLOSION HAZARD IN RELATION TO CURRENT REGULATIONS

Employers need to assess the risk related to occurrence of explosive atmosphere, by taking into account in particular: probability of occurrence of explosive atmosphere and its stability; probability of occurrence of ignition sources, including atmospheric discharges and the probability for this source to be active in potential ignition initiation; installation character and type, applied substances, technological processes and their possible mutual interaction along with scale of anticipated consequences.

On working stands where explosive atmosphere may occur, there take place regular hazard assessments (not less frequently than once a year), and particularly they are (*R.M.G 2010*):

- probability and frequency of occurrence of explosive atmosphere,

- probability of occurrence and activation of ignition sources, including electrostatic discharges,
- identification and assessment of explosion hazards caused by technical devices and work processes, but also applied raw materials and semi-finished products,
- unwelcome consequences scale assessment.

One duty resulting from risk assessment for employers is to file „Explosion countermeasures documentation“, which according to the Regulation needs to include:

- information on explosive atmosphere identification, and assessment of explosion hazard occurrence,
- information on applied adequate countermeasures, avoiding explosion hazard occurrence, which is filed in the form of a brochure,
- list of work stands affected by explosion hazards including their classification,
- declaration informing about working stands and tools, but also about alarming devices which are designed, used and maintained in accordance to the principles of safety.

Explosion countermeasures documentation should be filed before a particular work stand is approved for use. Information included in it should be passed on to workers during work safety trainings. It should also be verified in case of, both, technological and organizational changes.

Physico-chemical properties of wood dust

Wood dust produced during machining process is combustive dust with grains which can be of nominal size smaller than 500 μm , and it can remain, suspended in the air, for a sufficiently long period of time in order to create air mixed cloud of dust, in which concentration exceeds the lower explosive limit. Basic physico-chemical parameters for combustive dust are mainly dependent on grain size. Dusts of finer fraction are characterized by higher susceptibility to explosion occurrence. Explosiveness parameters are also dependent on: related humidity of dust, wood species and air humidity. Physico-chemical properties of selected wood dusts are presented in Table 1. They have been compared with other combustive and explosive dusts parameters.

Tab. 1 Physico-chemical properties of wood dust

	Particles size (average)	Lower explosive limit	Max. explosion pressure	Explosiveness index	Min. ignition energy	Spontaneous Ignition Temperature	Minimum Ignition Temperature for dust cloud
<i>Dust type</i>	D50	LEL	Pmax	Kst	MIE	SIT	MIT
	μm	g/m^3	bar	bar.m/s	mJ	$^{\circ}\text{C}$	$^{\circ}\text{C}$
Scots pine wood dust	550	50	9,3	65	9	250	360
White sugar	730	60	9,5	138	30	460	370
Wheat flour Type 150	250	60	8,8	87	100	450	430

Wood dust fractional composition

Due to diversified fractional composition of residues produced during wood machining on corresponding lathes, sieve analysis of fractional composition was carried out.

Taking into account the influence of dust particle size on basic explosive parameters, processes were selected in which the highest percentage share is taken by dust fractions below 500 μm (*Aksentowicz., Użdżicki 2009*).

The analysis revealed that wood machining on circular saw produces the highest amount of dusts and fine particles. Similar fractional distribution is also observed in a chips sample, which were produced during wood processing on a lowerspindle moulder and a thicknesser planner. It is worth to emphasize that in all analyzed machining processes there is a fraction of chips produced with sizes below 500 μm , namely the fraction which creates explosion hazard (*Aksentowicz., Użdżicki 2009*).

ANALYSIS RESULTS

Individual installation elements, during its standard usage, contain wood combustible dust clouds which are produced during machining processes. Table 2 identifies explosion hazard zones in a room and in individual elements of fumes extraction system.

Tab. 2 Explosion hazard zones

<i>No</i>	<i>Area</i>	<i>Ex. Zone</i>
1	Space around loathes	zone 21
2	Internal hull space of loathes	zone 20
3	Internal space of extraction pipes	zone 20
4	Internal space of extraction fan	zone 20
5	Internal space of dust collector (cyclone)	zone 20
6	Internal space of refuse receptacle	zone 20
7	Space in the installation collector additional pipe	zone 22
8	External space around dust collector	zone 22
9	Space in the machining room	zone 22

Potential ignition sources are precisely enumerated and explained in the Polish Norm PN-EN 1127-1:2011. Among them are: 1) hot surfaces; 2) flames and hot gasses (including hot particles); 3) mechanically produced sparks; 4) electric devices; 5) stray currents and cathodic protection against corrosion; 6) static electricity (brush discharges, tapered discharges and discharges from dust cloud); 7) lightning strikes; 8) electromagnetic waves of radio frequencies (from 104 Hz to 3x10¹² Hz); 9) electromagnetic waves of frequencies from 3x10¹¹ Hz to 3x10¹⁵ Hz; 10) ionizing radiation; 11) ultrasounds; 12) adiabatic compression and shock waves; 13) exothermic reactions, including dust spontaneous combustions (*PN-EN 1127-1:2001*).

Probability identification and assessment results for effective ignition sources occurrence in the analyzed room and dedusting installation are presented in table 3.

Tab. 3 Probability assessment for ignition sources occurrence

No	Technological process	Ignition sources according to PN-EN 60079-10												
		Hot surfaces	Flames and hot	Mechanically generated sparks	Electric devices	Electric equalizing currents	Static electricity	Atmospheric discharges	High frequency electromagnetic waves	Electromagnetic	Ionizing radiation	Ultrasound waves	Adiabatic compression and	Chemical reactions (exothermic)
		1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Wood machining process	A	C	A	B	D	C	C	D	D	D	D	D	D
<i>Legend</i>														
A		- ignition sources which may occur permanently or often;												
B		- ignition sources which may occur rarely;												
C		- ignition sources which may hardly ever occur												
D		- Source occurrence not recorded												

Effective ignition sources are classified according to probability of their occurrence. They may occur permanently or often, rarely or almost never. If such probability can not be estimated, one should assume that such ignition source occurs permanently.

Among all effective ignition sources in the examined process only those ones should be taken into account which may occur often or permanently. Some of these are: hot surfaces of casings of electric motors inside bodies of machines; mechanically generated sparks resulting from foreign bodies which may enter the inside part of dedusting installation and cause sparking by hitting against internal surfaces of dedusting pipes, fans, cyclone filters and silos. Electric devices such as: electric motors, controlling panels may become effective ignition sources at the moment of dust cloud occurrence with concentration exceeding LEL in the outer space e.g. resulting from dedusting installation malfunction.

SUMMARY

The performed analyses in the wood basic machining process indicated significant explosion hazard, which can not be ignored. Wood and wood-base materials residues apart from high combustion hazard, may also mix with air and create explosive atmosphere.

Statistical records show that 30% of registered explosions are related to wood industry branch, and the most common places for explosions to take place are: silos and vessels, dedusting installations, pneumatic transportation pipelines and mechanical conveyors. Fine wood dust fractions, the most dangerous as far as explosion hazard is concerned, occur during machining on all examined lathes. It is then necessary to state that in every business running this type of machining, according to Ministry of Industry Regulation from June 8th 2010 concerning minimum requirements relating to work safety in respect to probability of occurrence of explosive atmosphere at work stands (Journal [...] of Laws No 138 item 931), it is essential to carry out explosion hazard assessment and file documentation on protecting work stands preventing explosions. Working staff should apply technical and organizational means, which should follow the above mentioned documents – the most important of them are:

- preventing forming explosive atmospheres – elimination of dust emission sources,
- elimination of ignition sources in places in which it is impossible (due to technological process type) to avoid dust emission,

- minimization of potential consequences of explosions, primarily in order to improve work safety at working stands but also to protect property.

REFERENCES

1. AKSENTOWICZ R., UŹDZICKI W. 2009: *Wstępne badania charakterystyki wiórów powstających przy mechanicznej obróbce drewna*. Przemysł Drzewny, 2009, nr 2.
2. OČKAJOVÁ A., BANSKI A. 2009: *Characteristic of dust from wood sanding process*. In: *Wood machining and processing– produkt quality and waste characteristics*. Monography. Warsaw: WULS – SGGW Press, 2009, ISBN 978-83-7583-107-8.
3. PN-EN 1127-1:2001; Atmosfery wybuchowe. Zapobieganie wybuchowi i ochrona przed wybuchem. Pojęcia podstawowe i metodologia.
4. Rozporządzenie Ministra Gospodarki z dnia 8 lipca 2010 r. w sprawie minimalnych wymagań dotyczących bezpieczeństwa i higieny pracy, związanych z możliwością wystąpienia w miejscu pracy atmosfery wybuchowej (Dz.U. Nr 138, poz. 931) §4.4.

Streszczenie: *Ryzyko wybuchu pyłu w procesie obróbki drewna.* Ryzyko wybuchu jest jednym z zagrożeń wynikających z obecności pyłu drzewnego w obszarze maszyn oraz wewnątrz pneumatycznych instalacji odciągowych. W artykule przedstawiono problem oceny ryzyka wybuchu pyłu w procesach obróbki drewna. Określono zasięgi stref zagrożenia wybuchem w poszczególnych elementach instalacji odciągowej i prawdopodobieństwo ich wystąpienia. Dokonano identyfikacji efektywnych źródeł zapłonu pyłowej atmosfery wybuchowej. Sformułowano zalecenia dotyczące ograniczania zagrożenia wybuchem w przemyśle drzewnym.

Corresponding authors:

Maria Kowal, Grzegorz Dudarski, Czesław Częstochowski
University of Zielona Góra,
Faculty of Mechanical Engineering,
Division of Engineering of Work Environmental,
65-264 Zielona Góra,
ul. Szafrana 4,
Poland