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COMPARATIVE CONCENTRATION MEASUREMENTS OF DUST PRODUCED BY WOOD PROCESSING MACHINES

Abstract: *Industrrial activities have to comply with protective measures. For this reason, it is essential to know the maximum allowable concentration of chemical hazards (gas, steam and dust) which can occur in the workplace. In wood industry, a large amount of wood dust is produced during the mechanical wood processing. Unless adequate measures for its removal are undertaken, there may be potential hazards for the workers' health. The research has been carried out for purpose of determining the level of dust emission in different machines in wood processing workshops with no dedusting system included, by measuring concentrations of wood dust produced during the processing of wooden material.*

Key words: wood processing, wood dust, concentration measuring.

INTRODUCTION

During the technological process of mechanical treatment and wood processing, a large amount of wood waste is produced. The amount of waste, as well as its dimensions and shape, depend on the type of machine, procession degree, as well as the type of wood being processed. In certain wood processing operations, such as cutting and grinding, a large amount of fine wood dust is processed. This dust can be particularly hazardous for the health of workers, and there is also a risk from fires and explosions occurring, which can additionally threaten the workers and material goods [1].

As mentioned before, exposure to dust at workplace presents a potential hazard for the workers' health. Inhaling wood dust can cause allergic reactions of respiratory mucosa, that is, the respiratory system. If great amount of wood dust is present, it will have an irritating effect on eyes, nose and throat. Significant accumulation of fine dust particles may damage lung function, initiate asthma attack, and have carcinogenic effect as well [2].

In terms of occupational safety and health, dust can be classified by size into three categories, which are: respirable dust, inhalable dust, and total dust. Respirable dust is the type of dust which is small enough to get deep inside the lungs, therefore passing through the nose, throat and upper parts of the respiratory tract. The size of respirable dust particles is $\leq$ 5 μm (about 1/12 the width of an average human hair). Inhalable dust is the dust which usually can't get further from the nose, throat and upper respiratory tract, and whose average size is about 10 μm. Total dust includes all the particles, regardless of size and structure [3].

Testing of chemical hazards (gas, steam and dust) is performed at workplace, in the work environment, where chemical hazards occur in technological and working processes. The testing of chemical hazards is performed by taking at least one sample at workplace, closest to the hazard source [4].

There are many factors which can affect the noxiousness of substances in the work environment, the most important of which is the concentration of hazardous substances (in our case the wood dust concentration). Concentration, of course, refers to the amount of toxic matter, in a working environment, where the worker is exposed and where the measuring unit is usually mg/m^3 [5].

In order to protect the workers' health and safety, countries prescribe the limit values for concentration of chemical hazards.

Each country has its norms on maximum allowable concentrations (MAC), that is, on limit values, of chemical hazards at the workplace. The Serbian standard is SRPS Z.B0.001:1991 – maximum allowable concentrations of toxic gases vapours and aerosols in working premises atmosphere, and it includes over a 1000 different toxic matters. Testing of working atmosphere is performed according to the prescribed norms given in the standard. The SRPS Z.B0.001/1:2007 standard presents the alteration of the SRPS Z.B0.001:1991 Serbian standard and it is its integral part. The standards have been reviewed and confirmed in March 2012. According to it, the MAC for wood dust is 10 mg/m^3 [6].

For inhaling particles of hard wood types, the 1999/38/EC Directive of European Union prescribes the TWA limit value of 5 mg/m^3. TWA (Time Weighted Average) is measured or calculated as an average measured value for the period of eight hours [7].

OSHA (Occupational Safety and Health Administration) is the main federal agency in the USA, whose task is the enforcement of legislation in the area of occupational safety and health, and it prescribes the PELs (Permissible exposure limits) [8]:

- TWA 15 mg/m^3 for the total wood dust (soft and hard wood), and
- TWA 5 mg/m^3 for respirable wood dust (soft and hard wood).

According to the document published by HSE (Health and Safety Executive – a UK government body that deals with the management of health and safety at work) which contains a list of allowed exposure limits at workplace for soft and hard wood dust, the TWA for a working period of eight hours is 5 mg/m^3 [9].

Contemporary wood processing facilities use the systems for gathering wood waste, that is, wood dust. Special equipment, that is, system for dedusting is applied to the wood processing machines [10].

Due to the lack of funds, or more often due to the negligence or lack of awareness of dust wood, it may occur that some wood processing facilities may not have the equipment applied, and that the working conditions are therefore unfavorable.

This paper contains the analysis of wood dust concentration levels, measured in a wood processing facility where a dedusting system is not included, with the aim of determining the level of emission in different machines and defining the necessities of system installation.

WORKING METHOD AND MATERIALS

The research has been carried out in the workshops of factories producing furniture, mainly made of beech wood. In these workshops, various machines are used for wood cutting and processing. The machines used for processing, as well as types of wood processing during the measuring of wood dust concentration are given in the table below.

Table 1. *The font size and appearance for the styles*

Wood processing machine	Types of wood processing for a particular machine
Hand-held circular saw	Cutting
Table circular saw	Cutting
Dual circular saw	Cutting
Jointer (surface planer)	Shaping of wood elements
Wood shaper (spindle moulder)	Shaping of elements
Belt grinder	Grinding of elements
Spindle grinder	Grinding of elements
Drum grinder	Grinding of elements

Figure 1 shows the processing of beech tree elements in one of the processing machines listed.

Figure 1. *Processing of beech wood elements on belt grinder*

All of the listed machines for wood cutting and processing were not connected to a dedusting system.

For purpose of determining the pollution and air purity of the work atmosphere, special analytical methods have been developed. In the working atmosphere, it is important to constantly control concentrations of toxic gases, steams and particles, in order to determine whether they are within the allowed limits of MAC. For this reason, methods need to be adequate, sensitive enough, reliable and specific. Thereby, one of the most important factors upon determining the pollution of work atmosphere is the adequate way of sampling, with the aim of getting a precise result. Depending on the purpose of air sampling, there can be three sampling sites [11]:

1. Sampling is performed nearby the source of air pollution, with the aim of gaining information on the amount of pollutants released into the working environment. These samples are important for planning technical measures for suppressing air pollution.
2. Samples are taken from different parts of the work room, with the aim of getting spatial distribution of air pollution concentration.
3. Sampling is performed in workers' environment, with the aim of determining the level of exposure to pollutants. These samples should be taken in the workers' inhaling zone, and if they are changing their positions while working, the representative samples should be taken in all of their working positions. These samples are the most important in estimating the level of harm on health; therefore, sampling during the research is performed this way.

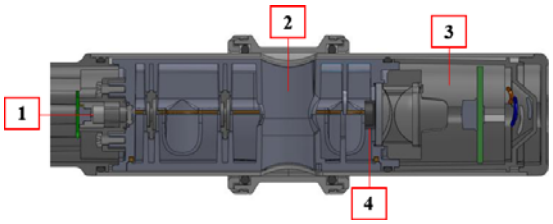
Using the CEL – 712 Microdust Pro instrument from Casella (figure 2), measuring is carried out in the period of three minutes per machine, by the Laboratory for air quality control at the Faculty of Occupational Safety in Niš, University of Niš.

CEL - 712 Microdust Pro is a portable instrument for measuring particle concentration (dust, smoke, fumes, pollen and other aerosols) in real time [12].

Figure 2. *CEL - 712 Microdust Pro*

Microdust Pro does not belong to instruments with traditional gravimetrical methods of dust measuring (which demand a certain sampling period and are not adequate for estimating the change of concentration degree in real time). It is an ideal instrument for estimating dust concentration in real time in mg/m³ in controlled areas. This instrument is portable and it has a separate probe which enables working in relatively inaccessible areas.

Microdust Pro uses a variable laser light source, which goes through the measurement chamber, that is, the measuring technique is light scattering with the help of visible, red laser light (wavelength of 635 nm <5 mW). The intersection of sampling probe is shown in figure 3.



1. Laser source
2. Measurement chamber (Sample volume)
3. Optical detector
4. Light stop

Figure 3. *Sampling probe*

In clean air conditions, no light gets to the receiver. When dust particles enter the chamber, a beam of laser light scatters at a narrow angle and one of its parts can be registered by the receiver.

So, Microdust Pro performs precise measures of dust concentration based on the principle of rectilinear light scattering. This instrument enables a graphical display of concentration changes, has internal data recording (which can later be displayed on computer), a simple user interface and the ability of measuring a wide range of concentrations. The measuring range of Microdust Pro instrument may be from 0.001mg/m^3 to 250 g/m^3 , covering six different measuring ranges: 0 - 2.5 mg/m^3, 0 - 25 mg/m^3, 0 - 250 mg/m^3, 0 - 2500 mg/m^3, 0 - 25 g/m^3 and 0 - 250 g/m^3.

The data generated by the CEL – 712 Microdust Pro instrument can be copied to a computer via USB cable. After copying, this data can be processed and analyzed using the Casella Insight Data Management software (figure 4). Casella Insight software enables instrument configuration, data downloading, data management and analysis, and has different reporting functions.

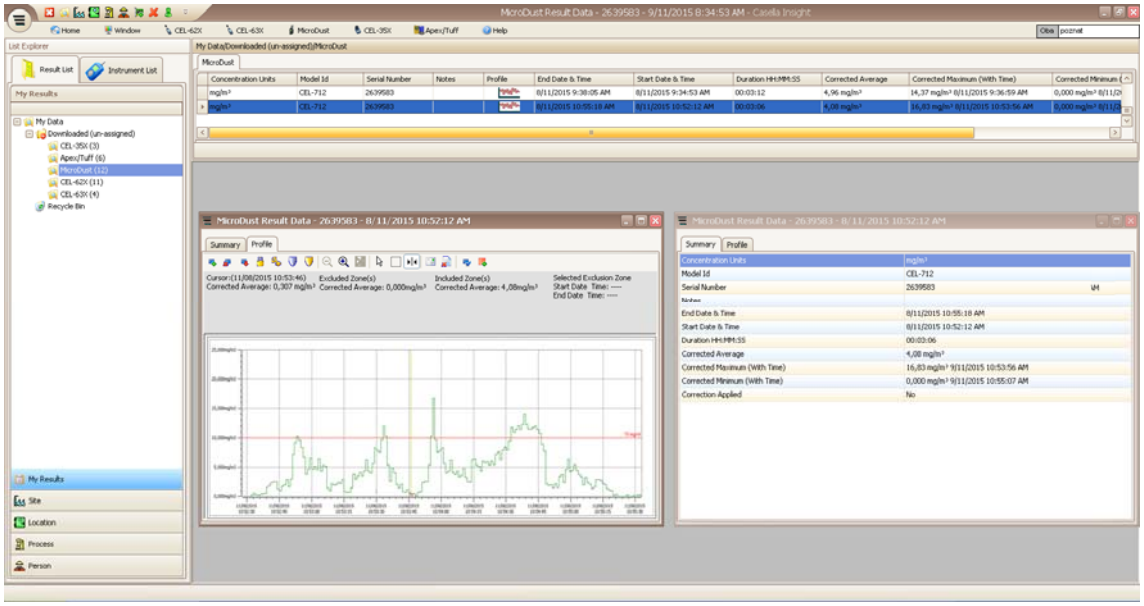


Figure 4. *Casella Insight Data Management software*

RESULTS AND DISCUSSION

The measured results of wood dust concentrations in air can be read directly from the screen of Microdust Pro instrument (figure 5), but the detailed information is received only after gaining data with the help of previously mentioned Insight Data Management software.

The results of wood dust concentrations in air, measured in Insight Data Management software can be displayed in the form of table (figure 6.) and graphs (figure 7.)

Measuring results (Table 2) show that there may be different wood dust concentrations, depending on the type of wood processing.

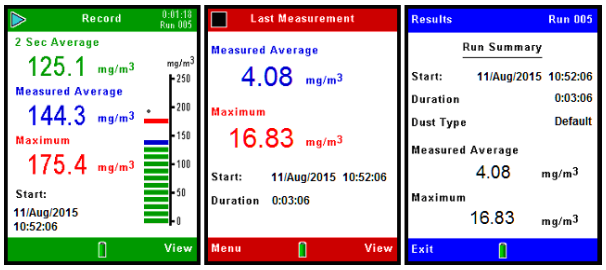


Figure 5. *Display of concentrations during (green) and after measuring (red and blue) [12]*

Sample Time	Corrected Concentration	Notes
8/11/2015 10:53:47 AM	0,547 mg/m³	
8/11/2015 10:53:48 AM	0,089 mg/m³	
8/11/2015 10:53:49 AM	0,742 mg/m³	
8/11/2015 10:53:50 AM	0,831 mg/m³	
8/11/2015 10:53:51 AM	2,367 mg/m³	
8/11/2015 10:53:52 AM	2,500 mg/m³	
8/11/2015 10:53:53 AM	2,500 mg/m³	
8/11/2015 10:53:54 AM	5,34 mg/m³	
8/11/2015 10:53:55 AM	10,28 mg/m³	
8/11/2015 10:53:56 AM	16,83 mg/m³	
8/11/2015 10:53:57 AM	9,68 mg/m³	

Figure 6. *Display of concentrations during (green) and after measuring (red and blue) [12]*

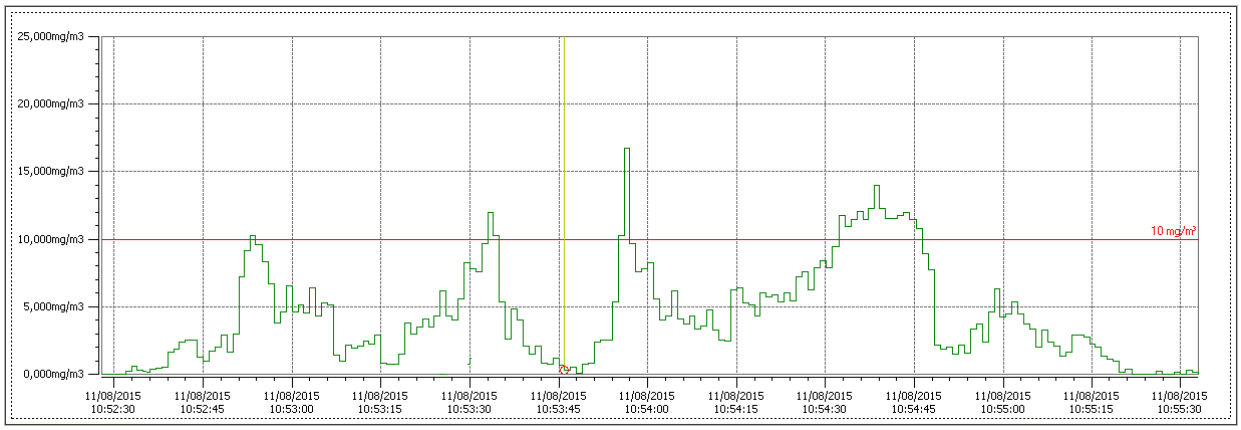


Figure 7. *Display of concentrations during (green) and after measuring (red and blue) [12]*

Table 2. *Average and maximum wood dust concentrations depending on types of wood processing machines and limit values of the standards and directives mentioned.*

Type of wood processing machine	**Average concentration [mg/m³]**	**Maximum concentration [mg/m³]**	**MAC** SRPS Z.B0.001:1991	**TWA** 1999/38/EC, 1910.1000 - T. Z1, EH 40/2005	**STEL** EH 40/2005
Hand-held circular saw	9,19	18,24	10 mg/m³	5 mg/m³	20 mg/m³
Table circular saw	8,59	15,52			
Dual circular saw	12,67	27,12			
Jointer (surface planer)	12,09	23,86			
Wood shaper (spindle moulder)	4,96	14,37			
Belt grinder	6,49	17,12			
Spindle grinder	4,08	16,83			
Drum grinder	3,91	12,75			

In working with hand-held circular saw and table circular saw, average wood dust concentrations have been recorded (9,19 mg/m^3 and 8,59 mg/m^3), which are similar to the MAC values of 10 mg/m^3 from the SRPS Z.B0.001:1991 standard.

The measurements recorded during the wood processing on dual circular saw and jointer, show high concentrations of up to 12,09 mg/m^3 and 12,67 mg/m^3, exceed the MAC of 10 mg/m^3 for wood dust, which is prescribed by the SRPS Z.B0.001:1991 Standard.

The average concentrations measured in other machines were lower, and did not exceed the MAC by the SRPS Z.B0.001:1991 Standard. However, they too exceed the allowed TWA values for respirable dust (5 mg/m^3) by the OSHA PEL, as well as the measures for maximum concentration given by the directives of EU and the British HSE.

Judging by the before stated, it can be noted that the value of 10,00 mg/m^3 for the MAC is double the size for dust wood, compared to other standards listed.

Contrary to the Serbian SRPS Z.B0.001:1991 Standard, the British EH 400/2005 also states STEL (Short-Term Exposure Limit) and represents the concentration of the hazardous chemical substance which the employee may be exposed to for a short time with no real health danger. The exposure to such hazardous chemical substance may last up to 15 minutes and may not be repeated more than four times during work time. The shortest time between the two periods of exposure needs to be at least 60 minutes. Maximum concentrations recorded during the wood processing on dual circular saw and jointer (27,12 mg/m^3 and 23,86 mg/m^3) exceed the STEL for cellulose inhalable dust which, according to the EH 40/2005 is 20 mg/m^3. The Serbian standard does not state the short-term exposure limits.

CONCLUSION

This paper is based on the research carried out in the carpenter workshops, in factories for producing furniture made of beech wood, with the aim of analyzing how the work conditions affect the very work process and the environment, that is, the workers' health.

Based on the conducted measurements and the analyzed data, it has been determined that during the wood processing with no protective measures, a large amount of wood dust may be generated, depending on the processing, that is, on the type of machine used.

It has also been determined that during the wood processing the amount of wood dust processed in this machine may be harmful for the safety of workplace, as well as the workers' health. Large concentrations have been measured during the processing by hand-held circular saw, table circular saw, dual circular saw, and jointer. The average dust wood concentrations, measured during the wood processing in these machines, were very close to or over the MAC prescribed by the standard SRPS Z.B0.001:1991 (10 mg/m^3), while in other machines, lower values have been recorded. However, all of the measured wood dust concentrations produced during tree processing in all of the machines tested, were above the allowed TWA values for respirable dust, which according to the OSHA is 5 mg/m^3, and above the TWA value which also amounts 5 mg/m^3, according to the directives of EU and British limits of work place exposure *EH 40/2005*. This data shows that the Serbian standard is not according to the global directives, that is, standards. Also, the Serbian standard does not state the short-term exposure limits of STEL, which is one of the disadvantages, as the workers' short-term exposure to concentrations larger than MAC, which may also harm the workers' health, is not taken into account.

Since the maximum allowable concentration for wood dust given in the Serbian standard is double the limit values given in the previously mentioned standards and directives, and since the standard does not take into account a short-term limit value of exposure, it is advised that they are reviewed and coordinated.

Considering the fact that large concentrations of dust wood are produced due to the lack of dedusting systems in the furniture producing factory, we can conclude that the work conditions in the workshops are unfavorable. In order to keep people healthy and the workplace safe, maintaining the workplace hygiene and cleaning off and removing wood dust is essential. Taking all of this into account, the conclusion is that a deducting system installation is necessary in all of the analyzed machines for wood processing.

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BIOGRAPHY

Aca Božilov was born in Niš, Serbia, in 1984. He received the Diploma in Fire protection from the Faculty of Occupational Safety in Niš, University of Niš, and is currently on Ph.D. studies in the area of Occupational Safety Engineering.
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UPOREDNA MERENJA KONCENTRACIJE PRAŠINE KOJA NASTAJE NA MAŠINAMA ZA OBRADU DRVETA

Aca Božilov, Nenad Živković, Dušica Pešić, Nikola Mišić, Bojan Bijelić

Apstrakt: *Industrijske aktivnosti je neophodno uskladiti sa merama zaštite. Zbog toga je potrebno poznavanje maksimalno dozvoljenih koncentracija hemijskih štetnosti (gasova, para i prašina) koje mogu da se jave na radnom mestu. U drvnoj industriji se prilikom mehaničke obrade drveta stvara velika količina drvene prašine. Ukoliko se ne preduzmu adekvatne mere za njeno uklanjanje stvara se potencijalna opasnost po zdravlje radnika. Istraživanje je sprovedeno u cilju određivanja stepena emisije prašine na različitim mašinama u radionicama za obradu drveta u kojima nije prisutan sistem za otprašivanje, merenjem koncentracija drvene prašine nastale prilikom obrade drvenog materijala.*

Ključne reči: Obrada drveta, drvena prašina, merenje koncentracije.