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INVESTIGATION OF AIR POLLUTANTS DISPERSION AT WORKSTANDS

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SUMMARY: This paper presents results of research on air pollutants dispersion within a working room. The tests were performed in a woodworking shop room, posing the hazard of exposure to hard wood (oak or beech) dust.

The characteristic parameters for evaluation of pollutants dispersion from a machine equipped with a local exhaust ventilation were specified for the room. Three measurement methods (flow visualisation, anemometric, and tracer gases methods) were applied for the tests, enabling determination of air flow directions, air velocity distribution, and variation in concentration of a tracer gas, simulating the real pollution in characteristic points of the working room.

The research indicates that air velocity values achieved their maximum within the breathing zone of the employees present at the circular saw and local exhaust ventilation operation area, and amounted from 0.35 m/s up to 0.45 m/s. Moreover, the air flow resulting from the circular saw and the local exhaust ventilation system operation was causing a quicker tracer gas dispersion within the employees' breathing zone. Tracer gas concentration in the employees' breathing zone amounted from 1.56 ppm up to 1.81 ppm.

Key words: *pollutants, tracer gases, air velocity, local exhaust ventilation*

INTRODUCTION

One of the most basic working conditions that conform to occupational safety requirements is a prevention of employees against exposure to pollutants within their working rooms *(Council Directive..., 1989).*

For relationship with European Union directives, machinery causing pollutant emission hazard must be equipped with proper means of collection protective equipment against aerosols, i.e. housings or local exhaust ventilation *(Council Directive..., 1989, Council Directive 89/654/EEC, 1989, Council Directive 98/391/EC,* 1998, *Council Directive 2001/45/EC, 2001).*

From the point of view of pollution emission prevention, the most advantageous and recommended solution is air-tight sealing, i.e. placing hermetic housings around the pollution emission sources. Air-tight sealing is recommended in particular for equipment emitting the most harmful pollutions – those of pneumoconiosis-causing or carcinogenic character *(Szymanski, Wasiluk, 2000).*

A total isolation of a machine within a housing is sometimes impossible; in such situations partial housings with working openings, or local exhaust ventilation systems equipped with suction nozzles and hoods (stationary or movable) are applied *(Jankowska, Wiecek, 1999).*

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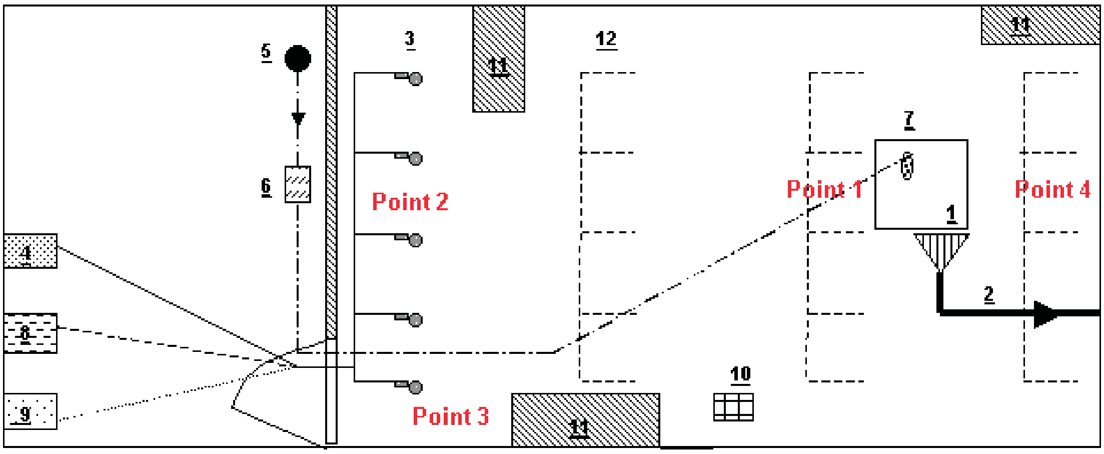
Placing of a complete or partial housing on emission sources eliminates or significantly reduces the dispersion of pollutants within the working environment, while – for economic or technical reasons – the machines remain equipped with local exhaust ventilation systems. In such cases, the pollution which the local exhaust ventilation failed to intercept may disperse in the entire working room.

Therefore, results of research on parameters related to the area of pollution dispersion from a machine equipped with a local exhaust ventilation system in a selected working room have been presented in this paper.

MATERIALS

The tests were performed in a woodworking shop room during operation of a circular saw equipped with a local exhaust ventilation system. Testing of parameters related to the pollutant dispersion area in the room was made in the conditions created by the equipment being in operation, simulating the real pollution with a tracer gas.

The testing was realised with local exhaust ventilation switched on, in the measuring points which location has been presented in figure 1.



Notes:
1 – machine with local exhaust ventilation system,
2 – pollution exhausting duct,
3 – anemometer probe,
4 – portable gas analyser
5 – tracer gas tank,
6 – flow meter,
7 – tracer gas emitting probe,
8 – anemometer,
9 – smoke generating set,
10 – digital still camera,
11 – other working room equipment,
12 – measurement dimensions, points 1, 2, 3, and 4 – measurement points within the employees' breathing zone (gas analyser and smoke generating probes)

Oznake:
1 – stroj s lokalnim sustavom za ispušnu ventilaciju,
2 – odvod zagađenja,
3 – sonda anemometra,
4 – prenosivi plinski analizator,
5 – spremnik za ispitni plin,
6 – mjerač gibanja,
7 – sonda za emitiranje ispitnog plina,
8 – anemometar,
9 – sprava za generiranje dima,
10 – digitalna kamera,
11 – druga oprema,
12 – mjerne dimenzije točke 1, 2, 3 i 4 – mjerne točke u zoni disanja (plinski analizator i sonde za stvaranje dima)

Figure 1. Location diagram of the working stands, the testing stand, and the measurement points within the woodwork shop room

Slika 1. Dijagram rasporeda radnih mjesta, ispitno mjesto i mjerne točke u drvnoj radionici

METHODS

The following measurement methods were applied to determine pollution dispersion from a circular saw equipped with local exhaust ventilation *(Jankowski, Jankowska, 2004):*

- Flow visualisation, based on observation of the flow of smoke released in the pollution emission place and determining directions of pollution dispersion in the points placed within the employees' breathing zone in the room (measurement points 1 to 4);
- Anemometric method, based on determining air flow velocity distribution in a room by measurements made in different points located on horizontal and vertical dimensions within the room (fig. 1);
- Tracer gas, the method based on a tracer gas being released with a constant rate in an actual place of pollution emission, and later on determining its concentration in points located within the employees' breathing zone in the room (measurement points 1 to 4).

Measurement point No. 1 was located in the circular saw operator's breathing zone, while measurement points No. 2, 3, and 4 were placed in the respective breathing zones of the other employees within the room.

The research into the tracer gas concentrations were preceded by testing of air flow directions (by visualisation) and of air velocity (with anemometric method).

RESULTS

The first test conducted was based on smoke visualisation method to show air flow directions in the selected measurement points. Observation of smoke flow direction was realised in four measurement points of pollution dispersion in the room, as presented in figure 1. This allowed to determine air movement within the room in terms of pollution emission hazard, i.e. at 1.5 m above the room floor, which reflects the employees' breathing zone.

The smoke was generated in the measurement points with a specialised equipment (Dragër Safety AG & Co. KGaA, Germany), and then its dispersion was fixed with a digital still camera.

The observation results of smoke flow direction in the entire room have been presented in figure 2. The red arrows mark the flow direction of the air streams generated by the circular saw disc rotary movement.

The smoke flow visualisation presented in figure 2 indicates that an incoming air stream resulted from the circular saw disc rotary movement. The stream was directed towards measurement points No. 1, 2, and 3. No smoke flow was observed in point No. 4. The smoke flow visualisation indicated an impact of air volume stream from the local exhaust ventilation on the air flow around the circular saw (fig. 2).

Air velocity was measured with anemometers VelociCalc Plus, type 8360 (TSI Inc., USA).

Measurements of air velocity variation in the pollution dispersion area were made in the measurement points within the working room. These were situated 1.5 m above the floor, which reflects the employees' breathing zone. The locations of the measurement points in the room in question have been presented in figure 3.

Air velocity variation at the dimension of 1.5 m above the floor of the working room has been presented in figure 4.

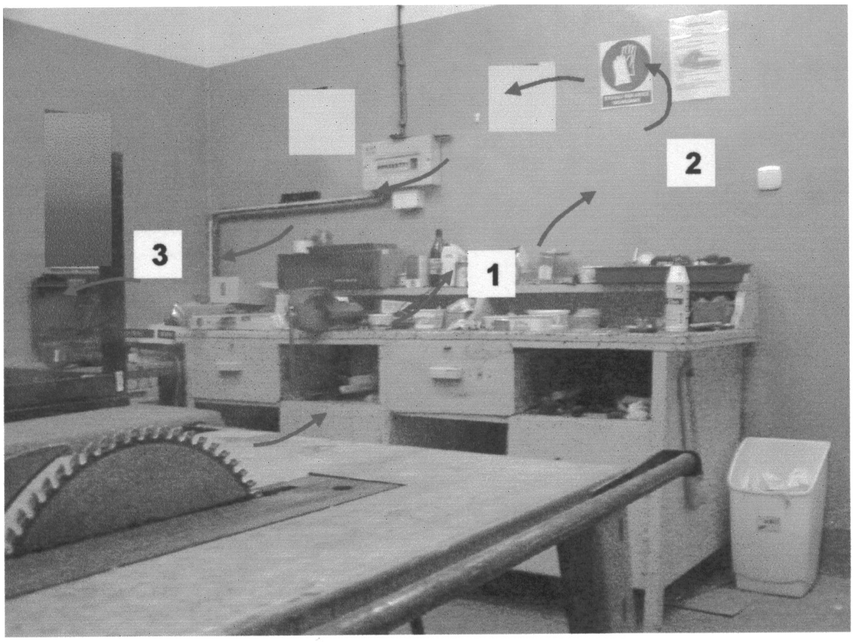
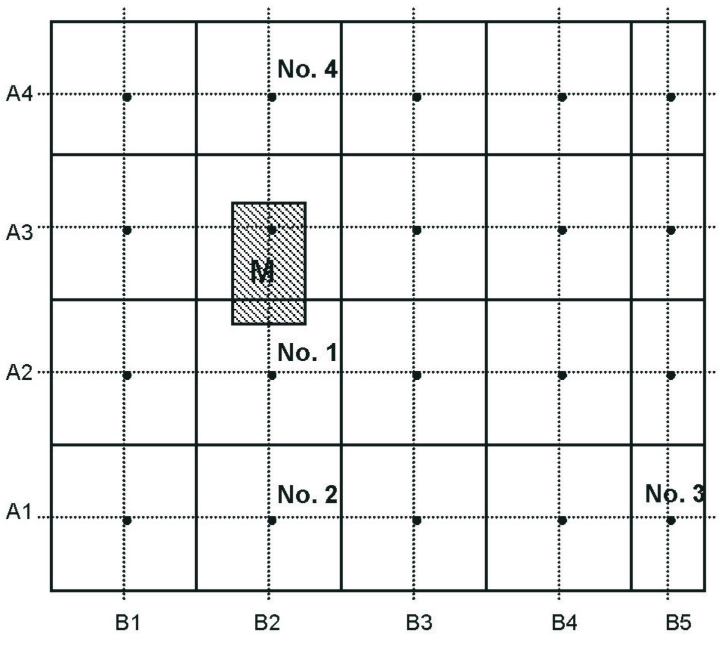


Figure 2. Visualisation of smoke flow in the pollution dispersion area in the working room
Slika 2. Vizualizacija gibanja dima u području širenja zagađenja u radnoj prostoriji



M – circular saw, 1, 2, 3, and 4 –points of tracer gas concentration measurement and of smoke flow observation

M – kružna pila, 1, 2, 3 i 4 – točke mjerenja koncentracije ispitnog plina i promatranja gibanja dima

Figure 3. Measurement points distribution in the working room
Slika 3. Razmještaj mjernih točaka u radnoj prostoriji

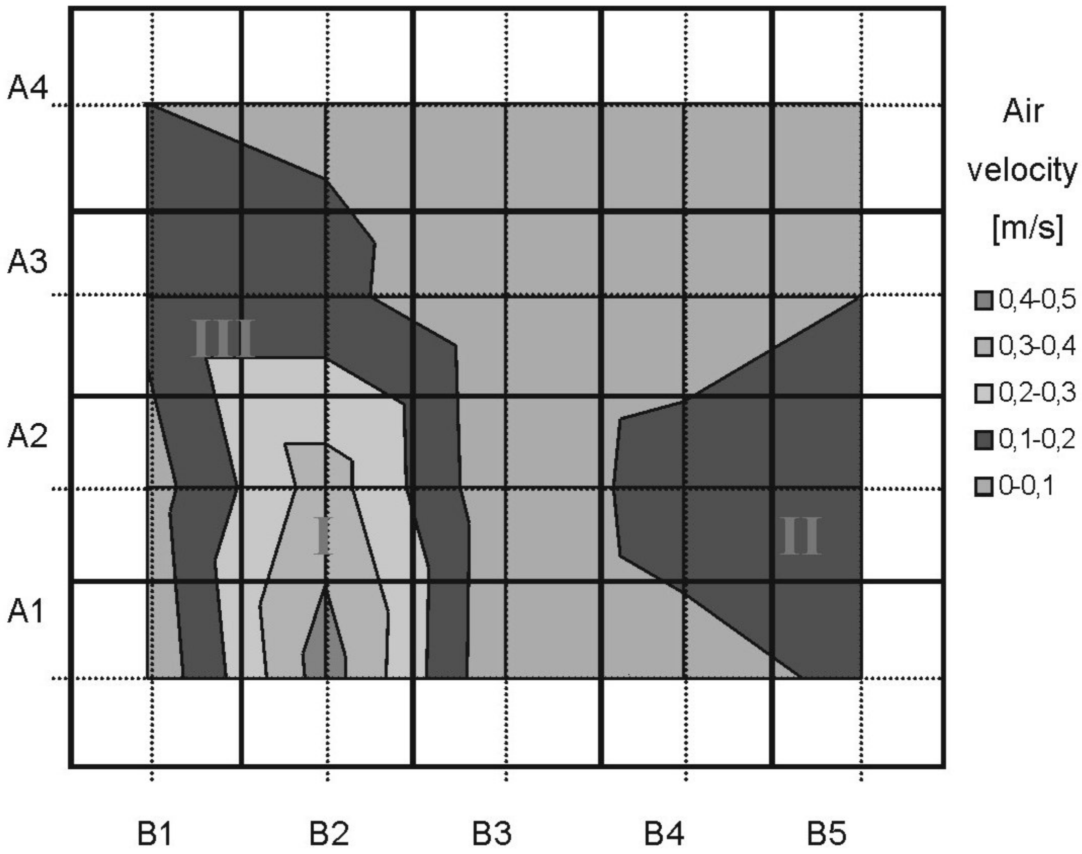


Figure 4. Air velocity distribution at the dimension of 1.5 m above the working room floor
Slika 4. Distribucija brzine zraka na 1,5 m iznad poda radne prostorije

Measurement results, presented in figure 4, indicated increase of air velocity in three areas of the room. Area I embraced the respective breathing zones of the circular saw operator and of the employee working near measurement point No. 2 (fields: A1B2, A2B2, and A3B2). In Area I, air velocity values remained within the range from 0.35 m/s to 0.45 m/s. The air stream caused by the circular saw disc rotary movement was directed towards measurement point No. 2 (fig. 2). The air stream velocity was found to decrease with the distance from the circular saw, while its direction was increasingly upward. In measurement point No. 1, within the breathing zone of the saw operator (field A2B2), air velocity amounted to 0.35 m/s, while in the breathing zone of the employee working near measurement point No. 2 (field A1B2), air velocity amounted as much as 0.45 m/s. An increase in the air velocity was also observed in Area II, which reflected the breathing zone of the employee working near measurement point No. 3 (fields A1B5 and A2B5). Values of air velocity did not exceed 0.17 m/s. In Area III (field A3B1), the air stream from the local exhaust ventilation system influenced the increase in velocity of the air stream from the circular saw. Air velocity measured in this area amounted to 0.16 m/s. In the measurement points not embraced by the influence of these streams, measurement point No. 4 included, values of air velocity were close to zero.

Concentration measurements of the tracer gas were made in four measurement points within the pollution dispersion area in the room, as presented in figure 1. The gas tracer (sulphur hexafluoride – SF_6) was released in the point of emission by the circular saw with a probe. The direction of the tracer flow from the probe complied with the direction of emission of the actual pollutant. Tracer concentration in the room was measured with portable gas analyser type MIRAN SappIRe 100E (Foxboro, USA).

The indicator for the pollutant dispersion within the working room is the tracer gas concentration in the breathing zone of the employees at the working stand being the pollutant emission source (bench circular saw) and at the working stands situated around.

Distribution of the tracer gas concentrations in the employees' breathing zone (measurement points 1 to 4) has been presented in figure 5.

the increased air flow in these points, which can be seen in figure 4. Higher tracer values than in measurement point No. 3 (the area embraced by the air streams originating from the circular saw and the local exhaust ventilation system) were in turn observed in measurement point No. 4 (the area not embraced by these streams).

CONCLUSIONS

Research on pollution dispersion in a selected working room of a woodworking shop led to the following conclusions:

1. Values and directions of air streams resulting from the circular saw disc rotary movement and the operation of the local exhaust ventilation system influence the air velocity distribution in the employees' breathing zone in the room.

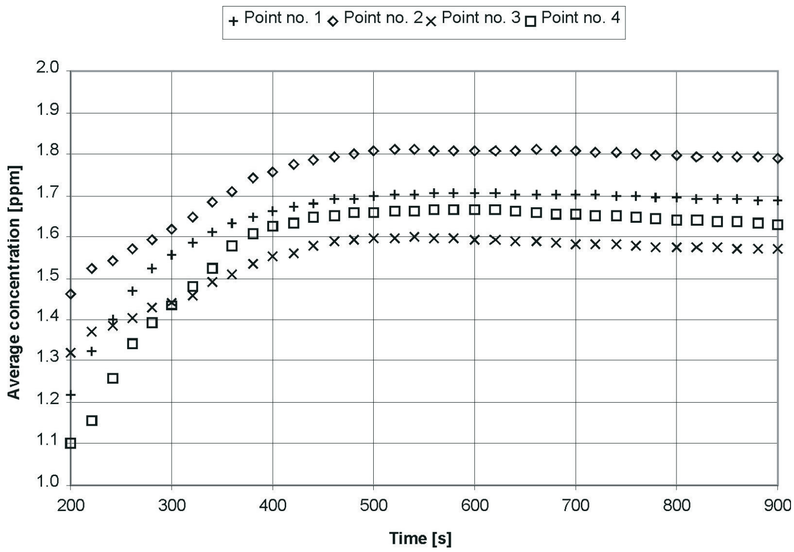


Figure 5. Tracer gas distribution within the employees' breathing zone

Slika 5. Distribucija ispitnog plina u zoni disanja

Analysis of the date presented in figure 5 indicates that about 500 s after gas tracer releasing, its concentration stabilised in all the measurement points observed. Tracer concentration in the employees' breathing zone reminded in the range from 1.56 ppm to 1.81 ppm. Higher tracer concentrations, observed in measurement points No. 1 and 2, may have been caused by a quicker tracer movement due to

2. Air movement in the room caused quicker tracer gas movement towards the employees' breathing zone.

3. The circular saw disc rotary movement and the operation of the local exhaust ventilation influence on air circulation in the employees' breathing zone may cause pollution dispersion within the working room under observation.

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ISPITIVANJE ŠIRENJA ZAGAĐIVAČA ZRAKA NA RADNOM MJESTU

SAŽETAK: Članak opisuje rezultate ispitivanja širenja zagađivača zraka u radnoj prostoriji. Ispitivanje je provedeno u drvnoj radionici s ciljem istraživanja opasnosti od izlaganja hrastovoj ili bukovoj drvnoj prašini.
Navedeni su tipični parametri za izračun širenja zagađivača iz stroja s ugrađenom ispušnom ventilacijom za određenu prostoriju. Primijenjene su tri metode mjerenja (vizualizacija protoka, anemometrijska metoda i metoda ispitnih plinova) kako bi se ustanovili smjerovi gibanja zraka, distribucija brzine zraka i varijacije u koncentraciji ispitnog plina i to simuliranjem stvarnog zagađenja u karakterističnim točkama radne prostorije.
Ispitivanje pokazuje da su vrijednosti za brzinu zraka bile najveće unutar zone disanja radnika na kružnoj pili i u zoni lokalne ispušne ventilacije, a kretale su se od 0,35 m/s do 0,45 m/s. Nadalje, protok zraka proizveden radom pile i lokalnog ispušnog sustava uzrokovao je brže širenje ispitnog plina u zoni disanja. Koncentracija ispitnog plina u zoni disanja bila je od 1,56 ppm do 1,81 ppm.

Ključne riječi: *zagađivači, ispitni plinovi, brzina zraka, lokalna ispušna ventilacija*

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