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1. Katarína LUKÁČOVÁ, 2. Marek MORAVEC

EXPOSURE ASSESSMENT OF SOLID AEROSOLS DURING PRODUCTION OF BLOCKS TO BALANCE WEIGHT FOR WASHING MACHINE

1-2. Technical University of Košice, Faculty of Mechanical Engineering, Department of Processing and Environmental Engineering, Park Komenského 5, 042 00 Košice, SLOVAKIA

ABSTACT: People in working environment are exposed to a variety of potentially harmful agents in the air they breathe. Depending on type of production site people can be exposed to several kinds of solid aerosols and some of these aerosols are active simultaneously. It increases their risk. In production site for producing concrete blocks for washing machine there are people exposed to solid aerosols containing iron cement, iron and its alloys. Both of these aerosols are dangerous for people, if their concentration is too high or exposure time is too long. In the article we presented the results from measurement from this kind of production site and show that on the basis of the results, it is important to monitor the concentration of solid aerosols in the working environment. On the base of our results the employer must eliminate this negative environmental factor.
Keywords: exposure assessment, solid aerosol, concrete block, production site

1. INTRODUCTION

The production site consists of two production halls – concrete hall and plastic hall. In the concrete hall there is preparing mixture for blocks for washing machine balance weight, pouring and picking final products (blocks). The plastic hall is used for pressing components of polypropylene and polymer materials. The measurements were realized in concrete hall.
The measurement was realized in concrete hall. There are produced concrete blocks for washing machines. Because of the variety of balancing mechanisms, the shape of concrete blocks is different (Figure 1) and depends on type of washing machine. The concrete blocks are used to washing machine balance weight – balance the load properly. The concrete blocks are composed from mixture of concrete, iron and its alloys.

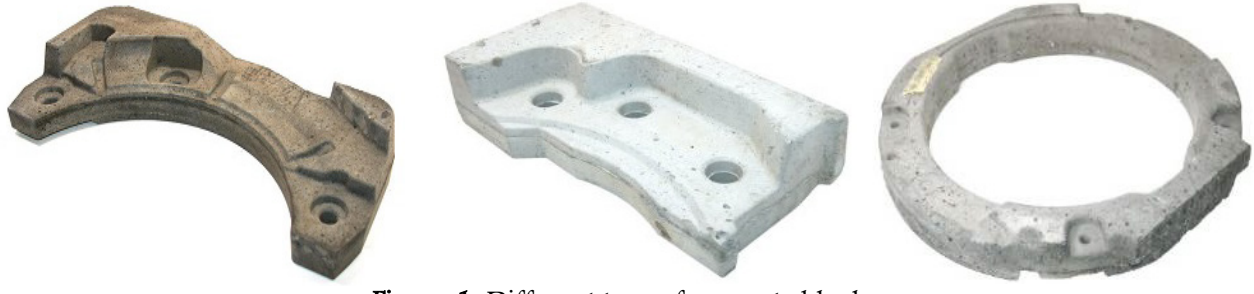

Figure 1. Different type of concrete blocks

The concrete blocks are then mounted inside washing machines (Figure 2).
The main sources of solid aerosols are:

- grinding scaling,
- dosing of cement and crushed scaling,
- picking components from the forms,
- maintenance forms.

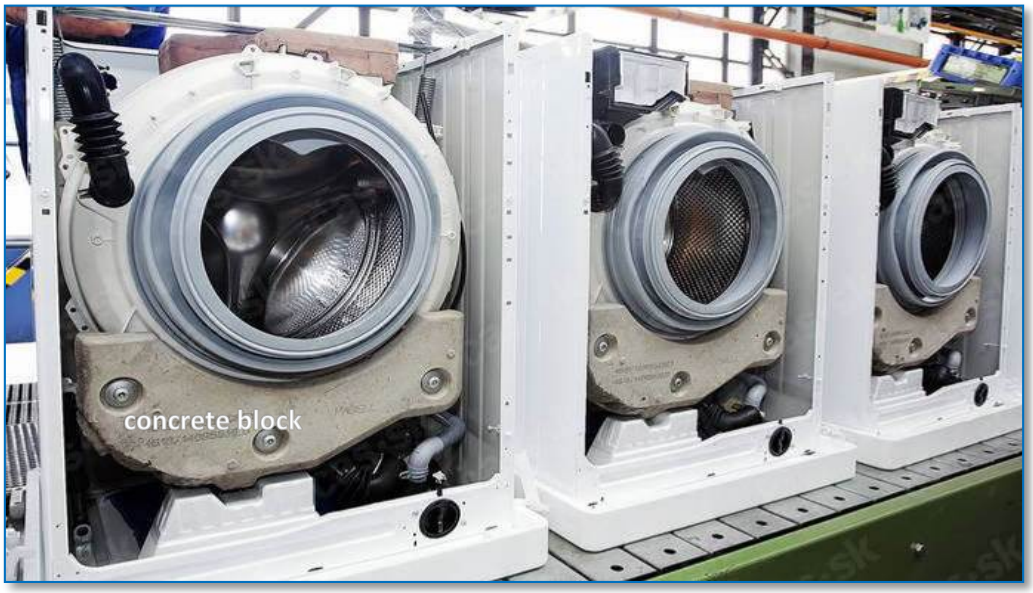

Figure 2. Concrete block inside washing machine (Whirlpool Slovakia)

Concrete hall can be considered as an open space with the free spread of solid aerosols. Individual departments are affected reviewed solid aerosols from other sites, not related to a specific activity worker at the specific workplace.

Ventilation in different parts of the hall is natural (doors and windows) and those parts where it is not possible, are ventilated by fans located in the perimeter walls of the hall.

All workplaces are free exhaust.

2. EXPERIMENTAL MEASUREMENT

During measurement were used only personal samplings (no stationary samplings). In personal sampling, the sampler is attached to the wearer within his or her breathing zone, and the pump is connected to it by a length of flexible tubing and worn in a pocket on a belt. The breathing zone is the space around the worker's face from where the breath is taken, and is generally accepted to extend no more than 30 cm from the mouth. Personal sampling instruments are normally mounted therefore on the upper chest, close to the collar-bone. There were realized eight personal samplings. In assessed site was collected inhalable fraction of solid aerosols. Personal samples were collected in the workers' breathing zone using IOM sampling heads with glass fiber filters. The IOM sampler is the preferred method of sampling the inhalable aerosol. Glass fiber filters (from SKC Inc.), made of binder-free borosilicate glass fiber, provide a torturous path of openings that allow air to pass through but trap particles throughout the depth of the filter. Glass fiber filters are autoclavable and provide high particle retention and wet strength.

IOM samplers require a pump unit capable of maintaining a smooth flow rate of 2.0 ± 0.1 $l.min^{-1}$ throughout the sampling period. During the measurements were used personal pump Airchek2000 (from SKC Inc.). The flow rate was calibrated to 2 $l.min^{-1}$. [6, 7]

Concentrations of solid aerosols were determined using gravimetric analysis. After drawing a measured volume of air through the reweighed collection medium (filter) mounted in a suitable particle size selective sampler, the mass concentration can then be determined from the mass of the aerosol collected and the sampled air volume. The weight of dust collected is determined by weighing the substrates (in cassettes) both before and after sampling. [1, 2, 5]

The measured aerosol concentration, c, in $mg.m^{-3}$, can be calculated according to the following equation:

$$c = \frac{m_2 - m_1 - b}{V} \quad (1)$$

where: m_1 - mass of filter (plus cassette) before sampling [mg], m_2 - mass of filter (plus cassette) after sampling [mg], b - average mass change of blanks [mg], V_S - volume of air sampled [m^3]. [5]

Time-weighted average, *TWA*, is a regulatory value defining the concentration of dust to which a person is exposed in ambient air in the working environment, averaged over a period, usually 8 hours. Time-weighted average is calculated as:

$$TWA = \frac{\sum c_i t_i}{\sum_{i=1}^{n} t_i} = \frac{c_1 t_1 + c_2 t_2 + ... + c_n t_n}{t_1 + t_2 + ... + t_n} \quad (1)$$

where: c_i - concentration [mg.m^{-3}], t_i - exposure time [min]. [1]
Exposure duration for all profession was 440 minutes. In the table 1 there are performed the results of measurement – measured value, time-weighted average (TWA) and assessed value. Assessed value includes uncertainty.

Table 1. Results of inhalable dust exposure

P	Personal sampling	Sample	Measured value	TWA	Assessed value
-	Profession	-	[mg.m^{-3}]	[mg.m^{-3}]	[mg.m^{-3}]
1	Discharger	06	23.3	21.4	26.49
2	Operator stripping machine	07	21.5	19.7	24.44
3	Fork lift driver	08	3.7	3.4	4.24
4	CAT driver	09	2.7	2.5	3.04
5	Shredder operator	10	9.4	8.6	10.64
6	Maintainer	18	3.4	3.2	3.91
7	Operator of blender	19	6.3	5.7	7.11
8	Forms maintainer	20	4.5	4.2	5.16

The highest concentrations were found for profession discharger and operator stripping machine who are exposed to cement dust. The lowest concentrations were found for profession CAT driver and maintainer who are exposed to iron and its alloys dust.

3. RESULTS

Table 2 shows comparison assessed values to limit values (WELs). The limit values are based on Government Ordinance of the Slovak Republic no. 471/2011.
The workplace exposure limits (WELs) for kinds of dust in monitoring production site are:

- cement dust - 10 mg.m^{-3} (8 hour time-weighted average, TWA),
- iron and its alloys dust - 6 mg.m^{-3} (8 hour time-weighted average, TWA). [4]

Table 2. Comparison to limits

P	Personal sampling	WELs	Comparison
-	Profession	[mg.m^{-3}]	exceeded / satisfies
1	Discharger	10	exceeded
2	Operator stripping machine	10	exceeded
3	Fork lift driver	6	satisfies
4	CAT driver	6	satisfies
5	Shredder operator	6	exceeded
6	Maintainer	6	satisfies
7	Operator of blender	6	exceeded
8	Forms maintainer	6	satisfies

In four professions there are exceeded the limit values – discharger, operator stripping machine, shredder operator, operator of blender. The employer has to take measures. The employer has again performed measurement after application the measures and to assess if results exceeded or satisfies limits values. The other professions with exposure to solid aerosol are under the limit values. In these professions is not necessary to apply the measures.

4. CONCLUSION

For measurement were chosen eight professions and the results show that in four cases (discharger, operator stripping machine, shredder operator and operator of blender) is exposure concentration exceeded. For profession discharger and operator stripping machine workplace exposure limit is exceeded twice. The measurements show that measures are necessary and employer must adopt corrective measures.

Acknowledgement

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