Comprehensive assessment of the dust environment at the construction industry enterprises

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Abstract. Most technological lines for the production of building materials, products and structures are accompanied by dust emission at almost all stages of their production. In the absence or imperfection of aspiration systems, the concentration of dust in the working area air can be many times higher than the standard values. In this case, unfavorable working conditions are most often caused by an increased concentration of dust in the air of industrial premises. Assessment of the dust environment at industrial enterprises, as a rule, is understood as the study of air in working areas, the power of dust emissions into the atmosphere, as well as the efficiency of dust cleaning devices [1].

1 Introduction

The objective of this study is to describe an algorithm for a comprehensive assessment of the dust environment in the working area air, which includes the dust concentration measurements, study of dust properties (physicochemical, dispersed composition), compilation of a dust balance for isolated rooms in general and an assessment of such an important component as power dust emissions from technological equipment into the working area, as well as an assessment of dedusting effectiveness, dust removal, dust suppression, etc.

2 Theoretical part

To solve the problem, we will consider a general approach to assessing the dust environment at enterprises and the components of this assessment.

1. Estimation of the total dust content of air in the working areas as a random variable.

A comprehensive assessment of the dust environment involves a point estimate of the average daily, average shift and maximum one-time dust concentrations in the working area air. It also gives an opportunity to obtain the probabilistic characteristics of these quantities, including the distribution density function of the total concentration. Based on

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the probabilistic characteristics, it can be concluded that the risk (probability) of exceeding the total concentration value of the standard values [1].

2. Estimation of PM_{2.5} and PM₁₀ concentration in the air of working areas based on the consideration of the dispersed composition of dust as a random function and the total concentration of dust as a random variable [2 - 4].

Particles with a size of 2.5 μm and 10 μm are considered as "small" fractions in the air of working zones. Then, as a result of measurements, the probabilistic characteristics will be for the concentrations in the air of the working zones of particles with a size of, respectively, no more than 2.5 μm (PM_{2.5} or C_{f2.5}) and no more than 10 microns (PM₁₀ or C_{f10}). Plotting the distribution density P_D for the pass function D (d_p) will allow you to calculate the risk of exceeding the fractional concentration of possible standards by the formula:

$$P_D(C > AAS) = \int_0^\infty P_c(C) \left(\int_{AAS}^\infty f_D(d_{norm}) dD \right) dC, \quad (1)$$

where f_D is the differential distribution functions of a random variable function D(f) the passage of the dust particles mass along the diameters.

Comparison of the fractional concentration in the working area air with the dispersed composition of the dust escaping from the process equipment will make it possible to assess the contribution of each equipment piece to the dustiness of the air in the working area [5, 6].

3. Assessment of the overall and fractional efficiency of dust cleaning systems and dust collection apparatus separately.

At the same time, the fractional efficiency of hatching devices, as a rule, depends little on jumps in the work of the technological process and is described by deterministic functions. However, the overall collection efficiency as a value depending on the dispersed composition of dust in the aerosol supplied for cleaning will be a random value. A comprehensive assessment of the dust environment involves not only determining accurate estimates of the overall efficiency of each dust collection equipment unit (i.e., the average values), but also obtaining probabilistic characteristics (distribution density functions, etc.) [7-10].

4. Assessment of the dust emissions power into the atmosphere from organized sources and the proportion of dust coming from them to work areas located at industrial sites [11].

The basis for determining this characteristic is the results of the dust dispersed composition total concentration and determination measurements in the emissions from organized emission sources or calculated data obtained from the results of assessing the total and fractional efficiency of dust collection, as well as the concentration of dust in the streams entering dust collection systems from technological equipment. In both cases, the total emission power should be considered as a random variable, and the dispersed composition of the emitted dust - as a random function. Existing techniques allow to estimate with a sufficient degree of accuracy the patterns of dispersion of dust emissions, including at industrial sites. In this case, the amount of dust entering the working areas in open areas should also be considered as a random variable.

5. Assessment of the power of dust emissions from unorganized sources and assessment of their impact on dust content in working areas located on the territory of the enterprise [6, 11, 12, 14].

Particular attention should be paid to the possibility of reducing the emissions power from fugitive sources and reducing their concentration. A comprehensive assessment of the dust environment at the construction industry enterprises should also include an assessment of the possibility of using waste and reducing the burden on the environment by reducing unauthorized dumps of dusty waste.

6. The technique for evaluating technological equipment as a source of dust emissions makes it possible to assess the degree of equipment tightness.

Moreover, a point estimate for the emission power is sufficient here, since the main thing in it is qualitative indicators, such as determining the dustiest equipment, comparison with previous measurements of dust emissions and with industry indicators. Based on the dust emissions values (or changes in these values), a conclusion on the equipment tightness degree adequacy or on the effectiveness (inefficiency) of dust removal means (primarily, aspiration systems) is made. To assess the dedusting effectiveness means, it is possible to use the technique of a complete survey of dedusting systems [10].

7. An important characteristic included in the assessment of the dusty environment at the enterprise should be the assessment of the risk of illness of workers (or the risk of deterioration in their health) when working in dusty conditions. At the same time, simultaneous examinations of the state of the air environment at workplaces and the health of workers make it possible to find the relationship between the risk of exceeding the dust concentration (including fractional dust) in the air [5, 12, 13].

Figure 1 shows a diagram of a dust environment comprehensive assessment at the construction industry enterprises. The algorithm of the scheme is based on theoretical and experimental studies, methodological approaches and field studies.

Fig. 1. Scheme of a comprehensive assessment of the dust environment at the construction industry enterprises

3 Conclusion

To carry out a comprehensive assessment of the dusty environment at the construction industry enterprises, a whole range of theoretical, experimental and field studies is required. The methodological approaches to the comprehensive assessment are based on theoretical studies and make it possible to derive the methods for measuring the dispersed composition of dust in the air, assessing technological equipment as a source of dust emissions,

determining the aerodynamic characteristics in a cloud, and developing specific standards for dust emissions from technological equipment. The result of theoretical, experimental, field studies and methodological approaches will be a comprehensive assessment of the dust environment, which makes it possible to assess the risk (probability) of exceeding the fractional concentration of standards PM10, PM2,5 etc., an assessment of the total concentration of dust in the air of the working area and the risk of exceeding the existing standards, an assessment of the power of emissions into the atmosphere from organized sources and an assessment of the total and fractional slip in dust collection systems, an assessment of the technological equipment tightness, an assessment of the efficiency and reliability of dedusting means, an assessment of the capacity emissions from fugitive sources and determine the proportion of organized and fugitive emissions entering the working area.

References

1. V.N. Azarov, S.A. Koshkarev, Bulletin of the Volgograd State. architectural and construction university. Series: Construction and architecture **43**, 161-174 (2016).
2. A.I. Evtushenko, A.A. Sakharova, V.O. Kharlamov, V.N. Azarov, *The study of the silica clay dust elemental composition in building materials' production*, IOP Conference Series: Materials Science and Engineering. **913** (2020). International Scientific Conference «Construction and Architecture: Theory and Practice of Innovative Development» (CATPID-2020). URL: <https://iopscience.iop.org/article/10.1088/1757-899X/913/3/032047/pdf>.
3. V.N. Azarov, N.A. Marinin, R.A. Burkhanova, A.V. Azarov, Bulletin of the Volgograd State University of Architecture and Civil Engineering. Series: Construction and architecture **30(49)**, 256-260 (2013).
4. V.N. Azarov, N.V. Menzelintseva, N.Yu. Karapuzova, E.O. Fomina, N.A. Pshenichkina, Bulletin of the Volgograd State architectural and construction university. Series: Construction and architecture **44 (63), Part 2**, 134-144 (2016).
5. V.N. Azarov, O.S. Vlasova, N. Yu. Klime, Bulletin of the Volgograd State Architectural and Construction University. Series. Construction and architecture **32 (51)**, 172-177 (2013).
6. V.N. Azarov, N.V. Menzelintseva, N.Yu. Karapuzova, E.O. Fomina, N.A. Pshenichkina, Bulletin of the Volgograd State. architectural and construction university. Series. Construction and architecture **44 (63), Part 2**, 145-156 (2016).
7. V.N. Azarov, V.P. Batmanov, A.B. Strelyaeva, V.V. Lupinogin, A.I. Evtushenko, International Review of Civil Engineering **7 (5)**, 132-136 (2016).
8. A.A. Sakharova, V.N. Azarov, Construction and reconstruction **2(82)**, 106-115 (2019).
9. V.N. Azarov, A.A. Sakharova, *Aerodynamic Characteristics and Fractional Composition of the Flask Dust*, All-Russian research-to-practice conference "Ecology and safety in the technosphere: current problems and solutions" (EST 2018, 22–24 November 2018, Yurga, Russian Federation). - Conference Series: Earth and Environmental Science. - Publishing Ltd IOP. **224 (1)**, 8 (2019). URL: <https://iopscience.iop.org/article/10.1088/1755-1315/224/1/012027/pdf>.
10. A. Vasiliev, I. V. Stefanenko, V. N. Azarov, D. V. Nikolenko, *The study of the aerodynamic characteristics of dust particles in the air of roadside areas*, E3S Web of Conferences **126** (2019). International Conference on Modern Trends in Manufacturing Technologies and Equipment (ICMTMTE 2019) (Sevastopol, Russia, September 9-13,

- 2019). Sevastopol State University. [Publisher: EDP Sciences].URL: <https://doi.org/10.1051/e3sconf/201912600071>.
11. V.N. Azarov, S.A. Koshkarev, M.A. Nikolenko, R.A. Burkhanova, Engineering Journal of Don **3** (2014).
 12. V.N. Azarov, E. Yu. Kozlovtsseva, Bulletin of the Volgograd State University of Architecture and Civil Engineering. Series: Construction and architecture **51 (70)**, 170-177 (2018).
 13. N.V. Menzelintseva, V.N. Azarov, N.U. Karapuzova, A.M. Redhwan, International Review of Civil Engineering **6 (6)**, 145-150 (2015).
 14. I.V. Stefanenko, V.N. Azarov, N.M. Sergina, Applied Mechanics and Materials: Proceedings of the International Conference Civil, Architectural, Structural and Constructional Engineering II, South Korea, 2017 [Trans Tech Publications, Switzerland] **878**, 269-272 (2017). doi:10.4028/www.scientific.net/AMM.878.269.