Mon-21-043

Risk management in the method of calculating the economic effect of a closed air purification system

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SUMMARY

The mechanism of operation of a closed filtration and ventilation system with devices for cleaning the air from pollutants in metallurgical production, including during the repair of worn-out metallurgical equipment by surfacing, is proposed. The system determines the concentration of the main pollutants (solid particles (dust / aerosol undifferentiated in composition), sulfur dioxide, carbon monoxide, nitrogen dioxide). The concentration of priority specific pollutants is measured: formaldehyde, ammonia, phenol, hydrogen sulfide, carbon disulfide. When choosing a priority list of specific substances, the emissions of each substance were taken into account. At the end of the hazard identification stage for each of the selected substances from the surfacing zone, the most harmful substances (manganese, silicon, carbon, nickel and oxide compounds of manganese, iron, silicon) were identified; potentially sensitive groups of welders. The influence of risk management in calculating the economic effect from the introduction of a closed air purification system has been investigated. The factors are presented in a form of formulas. New methods, that allow taking into account risk management when calculating the economic effect of the influence of harmful substances during surfacing, are proposed. A system of grading the severity of effects, used in establishing a class for assessing the impact of harmful substances, is proposed. The algorithm, that simulates the consideration of the risk management criterion in monitoring and in operational analysis when making management decisions in a closed air purification system, has been formed.

Introduction

The mechanism of sustainable development of countries aimed at reducing greenhouse gas emissions was proposed by the Kyoto Protocol and the Paris Agreement. The United Nations has adopted a plan to reverse natural resource degradation and a national and regional development strategy for the protection of ecosystems and the implementation of integrated management of land, air, water and biological resources. The development of an algorithm and methods for calculating the economic effect, taking into account the achievements in the theory of risk management, is necessary. The authors presented a closed filtering and ventilation system for purification from pollutants. The system was tested in practice in three districts of the city of Mariupol – the Ukrainian city of the ferrous metallurgy with a poor environmental situation.

Risk is the likelihood of events with negative consequences. There is no methodology for accounting for risk management when calculating the economic effect. There is a need to form an algorithm for determining risk management when calculating the economic effect of using the proposed system for cleaning from the content of harmful emissions into the airspace. The proposed calculation method is shown using the example of surfacing processes. The theoretical part of six risk management factors R is presented, absorption characteristics and relevance assessment (compliance of available data for welders, including potentially sensitive population groups) are given.The proposed method sets the task of taking into account risk management when calculating the economic effect of harmful substances impact on humans, equipment and the environment.

Materials and research methods

The concentrations of the main pollutants (solid particles (dust / aerosol undifferentiated in composition), sulfur dioxide, carbon monoxide, nitrogen dioxide) are determined. Concentrations of priority specific pollutants are also measured: formaldehyde, ammonia, phenol, hydrogen sulfide, carbon disulfide. When choosing a priority list of specific substances, the emissions of each substance were taken into account, first of all. Six risk factors R were identified:

$$\mathbf{R\ \{HI, EA, DRR, RC, RA, DMO\},} \qquad (1)$$

where: HI - hazard identification taking into account all aspects. EA - exposure assessment (characteristics of pollution sources, routes of movement of pollutants from the source to the surfactant, paths and points of impact, exposure levels, and others). This is an assessment of carcinogenic risk, as well as health risks from exposure to certain harmful substances, including welding aerosols (WA). The magnitude of the slope of the dependence is depicted by the increase in the likelihood of the development of harmful reactions with an increase in the concentration of harmful substances, using the example of WA. DRR - establishment of the "dose - response" relationship. Dose-response analysis provides for the establishment of the causality of the development of harmful effects. RC - characteristic of risk. The main goal of this stage is to summarize all available data (weighted assessment, determination of priorities in levels of impact, assessment of the applicability of measures, the creation of modern technologies for solving problems, taking into account the psychological aspects and management of the risks posed in the work). RA - risk assessment (application of scientific research, in particular, the determination of environmental impact, consequences and forecast in accordance with the requirements of the Kyoto Agreement and the Paris Protocol to reduce emissions of harmful substances into the atmosphere). The risk assessment is very specific and assesses the risk of developing specific harmful effects on the human body. DMO - determination of the management object of purely management risks (weighing according to certain indicators, constructing a matrix of factors, analyzing various options by priorities and changes in weight units for correct and objective decision-making, taking into account risk management and making an informed decision), that used in establishing the hazard class for assessing the impact of harmful substances. Hazard class 1 - optimal working conditions. In this class permissible working conditions are observed, which can cause functional deviations, but after a regulated rest, the human body returns to its normal condition. Hazard class 2 - harmful working conditions, characterized by the presence of harmful production factors that exceed hygienic standards. They have an adverse effect on the worker and can negatively affect the offspring. Hazard class 3 is divided into four degrees: - working conditions characterized by such deviations from hygienic standards that cause reversible functional changes and lead to the risk of developing a disease; - working conditions with such levels of hazardous and harmful factors can cause persistent functional disorders, leading in most cases of an increase in morbidity with temporary disability, an increase in the incidence of general morbidity, the appearance of initial signs of occupational pathology; - working conditions characterized by such levels of harmful factors that lead to the development of occupational pathology in mild forms during the period of labor activity, the growth of chronic general somatic pathology, including increased levels of morbidity with temporary disability; - working conditions under which severe forms of occupational diseases can occur, there is a significant increase in chronic pathology and high levels of morbidity with temporary disability. Hazard class 4 - hazardous (extreme) working conditions, characterized by such levels of production factors, the impact of which during a work shift (or part of it) poses a threat to life, a high risk of severe forms of acute occupational injuries.

The economic effect is calculated according to the methodology (*Guidelines for the determination…, 1999; Logvinov, 2016; Sutokskaya, Avkhimenko, 1993*) for the period of operation (1 year) of a new environmentally friendly technology for a year. It consists of the difference in costs before implementation and after implementation, multiplied by the number of products.

$$\mathbf{E_1 = (C_1 - C_2) \times N_2,} \tag{2}$$

where: E_1 - is the annual economic effect; C_1 - reduced costs per unit of production before implementation; C_2 - adjusted costs per unit of production after implementation; N_2 - the number of products, manufactured during the year.

When calculating the economic effect of invisible factors in the creation of new technologies, it is necessary to take into account the following indicators:

A) Prevention of losses of net production ($\mathbf{E_{NP}}$), during the illness of workers and employees employed in material production.

$$\mathbf{E_{NP} = NP \times N_{PI} \times (P_2 - P_1),} \tag{3}$$

where: NP - is the average value of net production per one worked person-day; Initial data for calculating loss prevention with existing technologies, during the illness of workers and employees before and after implementation; N_{PI} - the number of workers who have suffered illness or are distracted from the production of caring for sick family members for reasons caused by environmental pollution (during the year) ; P_2 - average annual number of person-days after the introduction of environmental protection measures; P_1 - average annual number of person-days before the introduction of environmental protection measures; C_2 - reduced costs per unit of output after implementation.

B) Reduction of the amount (E_{PR}) payments to workers and employees from social insurance funds for the period of temporary and permanent disability to workers and employees who fell ill due to reasons related to environmental pollution.

$$\mathbf{E_{PR} = N_{PB} \times TDB \times (P_2 - P_1),} \tag{4}$$

where: N_{PB} - is the number of people receiving benefits due to diseases with temporary and permanent disability due to deterioration of the environment (within a year). In some enterprises, health-improving means are included in the social package. TDB - the average amount of temporary disability benefits per day of illness; P2 - P1 - average annual number of lost person-days.

C) Reducing health care costs ($\mathbf{E_{HR}}$) for treating workers for illnesses caused by pollution

$$E_{HR} = (C_{HC1} \times P_{I1} \times D_{I1}) - (C_{HC2} \times P_{I2} \times D_{I2}), \quad (5)$$

where: C_{HC1}, C_{HC2} - the average costs in health care per day of treatment in outpatients conditions and in the hospital, respectively, before and after introduction; P_{I1}, P_{I2} - the number of patients treated for diseases associated with environmental pollution, before and after introduction; D_{I1}, D_{I2} - the average number of days of illness per patient before and after introduction.

D) The effect of preventing premature wear of fixed assets when using a natural resource of lower quality or operating equipment in a contaminated environment is calculated as:

- cost savings (**E_{CR}**) on current capital repairs due to environmental protection measures, a reduced number of repairs caused by a decrease in the level of environmental pollution;

- an increase in profit from an increase in the service life of equipment.

$$E_{CR} = EC \times ROA \times (T_2 - T_1), \quad (6)$$

where: EC - is the cost of equipment; ROA - coefficient of profitability of fixed assets; T_1 , T_2 - duration of equipment operation, respectively, before and after the introduction.

In the course of the work, an algorithm was formed that simulates the work of the proposed methodology for calculating the economic effect from the introduction of a closed air purification system. The mechanism of operation of a closed air purification system is shown in Fig. 1.

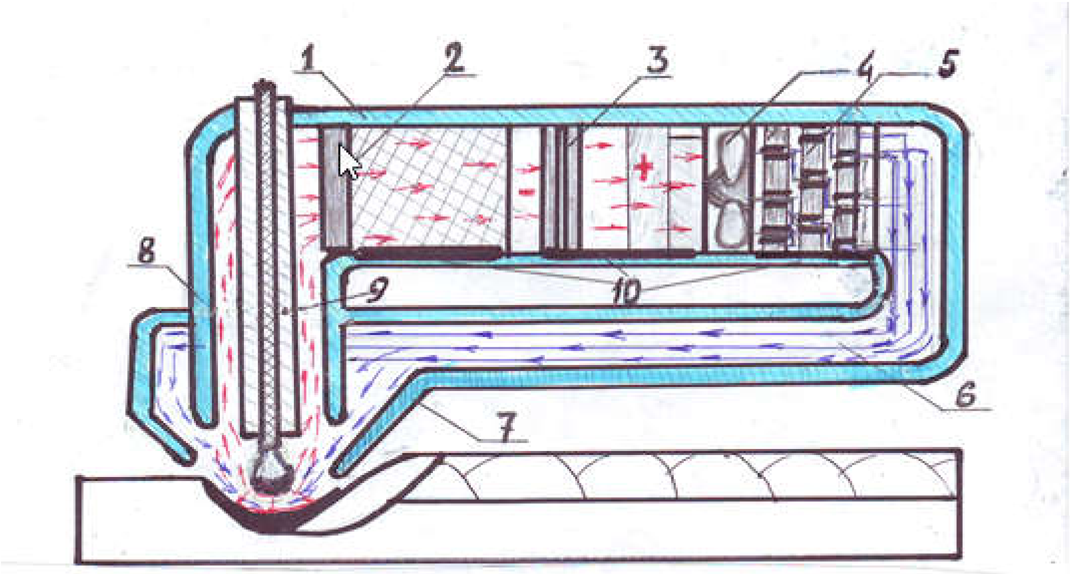

***Figure 1** The mechanism of operation of a closed air purification system. 1-framework, 2-mechanical filter in the form of a mesh; 3-electrostatic filter formed from rods and plates; 4-pump in the form of a fan; 5-sorption (chemical) in the form of pressed platinum with displaced channels from various sorbents; 6-duct is connected from the housings; 7 conical tips; 8-cylindrical suction is located coaxially with the electrode; 9-electrode holder is located coaxially with the electrode: 10- container formed by three sections of filters.* First Break Guidelines for authors.

Conclusions and suggestions

1. The influence of risk management in calculating the economic effect from the introduction of a closed air system has been studied. The factors are presented in a formalized form of formulas (1-6).
2. New methods have been proposed that allow taking into account risk management when calculating

the economic effect of the influence of harmful substances during surfacing. 3. The gradation of the effects of working conditions is presented. 4. An algorithm has been formed that simulates the consideration of the criterion of risk management in monitoring and in operational analysis when making managerial decisions in a closed air purification system.

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