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JUSTIFICATION OF THEORETICAL AND METHODOLOGICAL ASPECTS OF USING THE TOOLS OF SYSTEM ANALYSIS TO ENSURE THE PROTECTION OF ATMOSPHERIC AIR

The object of research is the degree of air pollution as a result of the work of enterprises of certain industries and the technology of their purification. One of the priority tasks is to ensure the country's environmental safety, but for its implementation it is necessary to minimize air pollution. For this, it is necessary to establish a full-fledged monitoring system, as well as modernize, maintain the functioning and control of air purification systems, polluted as a result of technological processes of enterprises of various industries. The work carried out the development of a methodology for control and selection of treatment equipment at the enterprise, using the tools of system analysis. Two scenarios of organizational and managerial actions have been identified using this technique. The first scenario – the purification degree of emissions of more than 90 % – provides that the equipment available at the enterprise ensures a satisfactory condition of the air entering the environment as a result of production processes. If this scenario is realized, the main task is to maintain a high purification level of the plant's emissions. For this purpose, it is advisable at the enterprise to carry out:

- constant monitoring of the operation and condition of air purification systems;
- proper maintenance of equipment (timely replacement and cleaning of filters, etc.);
- periodic training and advanced training of the personnel of the enterprise responsible for the operation of the equipment and the main technological processes of the enterprise.

The second scenario – purification degree of emissions up to 90 % – assumes that the equipment available at the enterprise is in an unsatisfactory condition and does not provide adequate air purification. If this scenario is realized, the algorithm of actions of the management and chief specialists of the enterprise should include such managerial and organizational actions:

- study and evaluation of scientific developments and modern treatment equipment available on the market;
- comparison of technological characteristics of alternative equipment models and selection of the best option, taking into account regulatory requirements and production and technological limitations;
- making a decision based on the results of a SWOT analysis.

The effectiveness of the developed methodology has been established on the example of the meat processing industry.

Keywords: atmospheric air, purification equipment, emissions of pollutants, purification degree of emissions.

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1. Introduction

One of the main factors in ensuring environmental safety in the world is clean atmospheric air that affects the health of the population. After all, studies prove that there is a direct link between the intensity of air pollution and people's well-being [1]. It is possible to achieve the state of minimal air pollution by combining active measures in the field of purification exhaust gases from mobile sources of pollution and preventing the ingress of pollutants from stationary sources [2]. The latter are mainly represented by enterprises of various industries and objects of the fuel and energy complex. Most of the enterprises engaged in the production of the main types of resources (electricity, water and gas) required to meet industry and household needs require significant moderni-

zation and re-equipment. And this task is presented as one of the priorities for ensuring state and environmental safety, will be considered on the example of Ukraine. As for other measures that are potentially capable of minimizing air pollution, they mainly relate to the establishment of a full-fledged monitoring system, modernization, support for the functioning and control of air purification systems, polluted as a result of technological processes of enterprises in other industries. It is to this question that this study is devoted.

2. The object of research and its technological audit

The object of research is the degree of air pollution as a result of the work of enterprises of certain industries

and the technology of their purification. Every year the operation of enterprises leads to the production of several hundred thousand tons of harmful substances, including specific substances. Only less than 50 % of these substances go through the purification system. The existing purification equipment at the enterprises does not provide the required purification degree, and the existing outdated equipment complicates the implementation of measures to prevent the formation of pollutants.

An increase in the scale of production leads to an increase in the level of air pollution, which in turn causes such phenomena: destruction of the ozone layer, climate change, an increase in the frequency of fogs, as well as a deterioration in the living conditions of the population.

3. The aim and objectives of research

The aim of research is to substantiate the theoretical and methodological aspects of control and selection of treatment equipment at an enterprise to ensure the efficiency of purification emissions of pollutants into the air.

To achieve the aim, the following objectives are set:

1. Develop a methodology for control and selection of treatment equipment at the enterprise.
2. Analyze the features of control over the installed treatment equipment.
3. Evaluate the effectiveness of the developed methodology on the example of a particular enterprise.

4. Research of existing solutions of the problem

Air pollution is a global environmental problem, which scientists began to actively investigate in the late 1950s. As a result, scientists have proven a close relationship between air pollution and mortality from lungs, cardiovascular and other diseases [3]. Moreover, recent scientific works prove the existence of a synergistic effect between the action of certain pollutants and manifestations of climate change, and enhance the negative impact of each other on the human body [4, 5]. All this determines the extreme importance of research related to reducing the impact of anthropogenic activities on the state of the air environment.

Emissions of pollutants resulting from the implementation of technological processes of industrial enterprises are one of the most intense sources of negative impact on the atmospheric air. The experience of the European Union (EU) shows that negative impacts can be mitigated by introducing cleaner industrial processes. Effective tools in this context:

- replacement of hazardous chemicals with safe analogues;
- use of filters and other technical solutions that can reduce emissions into the atmospheric air;
- improvement of technological processes in order to reduce the use of resources [6, 7]. Let's believe that such positive results in this area can be achieved through the implementation of fundamental government plans and relevant programs to ensure high quality of atmospheric air. At the same time, representatives of enterprises of various industries can be active participants and even initiators of such actions.

Researches of scientists in [8, 9] show that for effective management of atmospheric air quality, an integrated approach should be implemented, which includes an assessment of pollution sources and the level of man-made

hazard, study of the characteristics of enterprises in various industries and their technological processes, and the like.

Technologies and technological solutions used by enterprises to minimize the negative impacts of their activities on the environment often require significant financial costs and organizational efforts. And this statement is quite justified, even with the introduction of energy and resource saving technologies [10, 11]. With the increasing role of information in shaping public opinion and doing business, businesses can embrace environmentally responsible behavior as part of their reputation support. Therefore, fully agreeing with scientists in [12], let's argue that the dissemination of information about problems and the introduction of solutions by industry representatives are seen as one of the most effective ways to regulate the state of the environment.

Since at enterprises of various industries, equipment for purification emissions of varying degrees of accuracy and efficiency is used, therefore, it becomes necessary to develop a methodology that would simplify the process of modernization and control of such equipment.

5. Methods of research

The main aim of enterprise is the manufacture of a product and its marketing. However, during the implementation process, there is a significant impact on the environment. To reduce the negative impact of the operation of the enterprise on the state of atmospheric air, equipment is installed to clean up emissions from pollutants. At the same time, the choice of equipment, support and control of its functioning require organizational and management efforts. In this context, systems analysis tools can be effective for enterprises in any industry.

The value of system analysis in the context of this study is that it makes it possible to decompose complex problems into simpler elements, which, working together, form a production and ecological system. Considering that enterprises operating on the territory of the country are open by systems, and then actively interact with the environment, the developed algorithms for control and selection of treatment equipment are designed to reduce the negative effects. In addition, the system analysis allows making a reasonable choice of treatment equipment and reducing the risks of making erroneous management decisions. After all, this tool allows the use of quantitative assessment indicators together with qualitative indicators that can be obtained on the basis of expert assessments of experienced managers and specialists [13].

So, the proposed method of control and selection of treatment equipment at the enterprise is based on a systematic approach. It provides the construction of such a block diagram, a model that includes alternative scenarios for the development of events in the enterprise and possible ways of responding to them. Taking into account that in order to ensure compliance with environmental standards for the concentration of harmful substances in emissions, it is necessary to constantly monitor the operation of gas and dust purification equipment. With a decrease in the purification degree of pollutants in the emissions of an enterprise, an analysis of the purification system should be carried out or the market for analogues of purification equipment should be studied. Accordingly, using the tools of system analysis, a methodology for the control and selection of treatment equipment at the enterprise has been developed (Fig. 1).

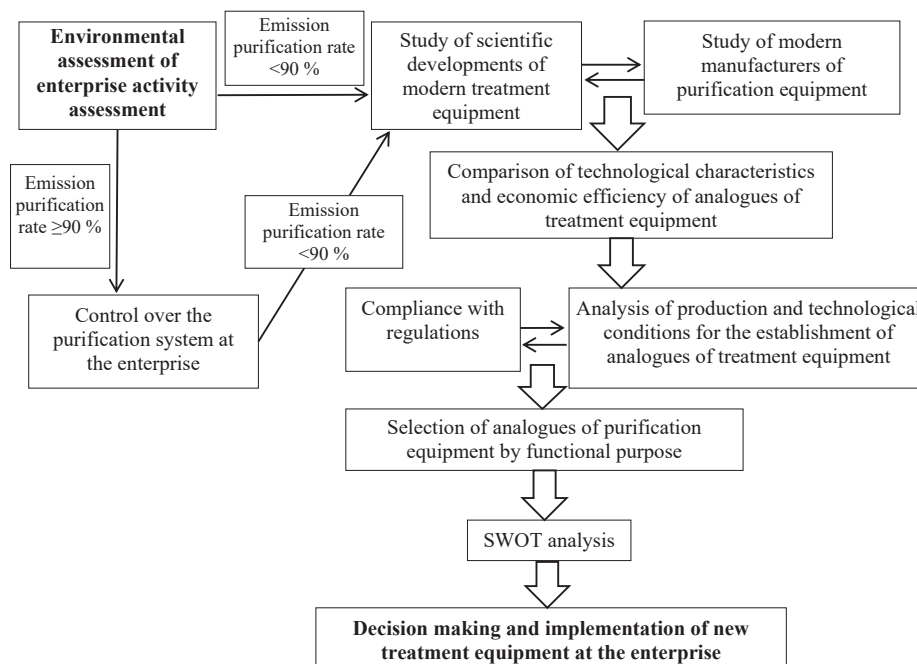


Fig. 1. Stages of control and selection of treatment equipment at the enterprise

In fact, the developed methodology provides for the introduction of active organizational and managerial actions under two scenarios:

1) the first – purification degree of emissions of more than 90 % – provides that the equipment available at the enterprise ensures a satisfactory condition of the air entering the environment as a result of production processes. If this scenario is realized, the main task is to maintain a high level of purification of the plant’s emissions. For this purpose, it is advisable at the enterprise to carry out:

- constant monitoring of the operation and condition of air purification systems;
- proper maintenance of equipment (timely replacement and cleaning of filters, etc.);
- periodic training and advanced training of the enterprise personnel responsible for the operation of the equipment and the main technological processes of the enterprise;

2) the second – purification degree of emissions up to 90 % – assumes that the equipment available at the enterprise is in an unsatisfactory condition and does not provide adequate air purification. If this scenario is realized, the algorithm of actions of the management and chief specialists of the enterprise should include such managerial and organizational actions:

- study and evaluation of scientific developments and modern treatment equipment available on the market;
- comparison of technological characteristics of alternative equipment models and selection of the best option, taking into account regulatory requirements and production and technological limitations;
- making a decision based on the results of a SWOT analysis.

6. Research results

The developed technique is universal and can become an effective tool for enterprises in various fields of activity. For example, consider the activities of a meat processing enterprise. At the first stage, let’s analyze the emissions of

pollutants into the air, carried out by the enterprise during the washing and disinfection of equipment and inventory, premises, the production of sausages, the operation of the boiler room, battery room, woodworking areas, welding station, metalworking machines. The main pollutants are given in Table 1.

Table 1
The power of emissions into the atmosphere by a meat processing enterprise

Name of substance	Hazard class	Threshold values (t/year)	Pollutant emission capacity (t/year)	
			2018 year	2019 year
Carbon (IV) oxide	2	500	647.559	648.644
Nitrogen (II) oxide	3	0.1	0.001	0.002
Mercury metal	1	0.0003	0.0000018	0.0000019
Nitrogen (IV) oxide	3	1.0	1.767	1.978
Ammonia	4	1.5	1.845	1.868
Sulfur (IV) oxide	3	1.5	0.004	0.008
Chlorine	2	0.1	0.028	0.033
Phenol	2	0.01	0.071	0.092
Wood dust	4	1.0	0.007	0.008
Suspended particles	3	0.5	0.515	0.534
Carbon (II) oxide	4	1.5	3.678	3.807
Total	–	–	655.475	656.974

It is found that the threshold values exceed the following substances: carbon (IV) oxide (1.3 times), suspended particles (1.1 times), nitrogen (IV) oxide (1.9 times), carbon (II) oxide (2.5 times), ammonia (1.2 times). The composition of pollutant emissions is 60 % of the most common pollutants, namely carbon dioxide, nitrogen dioxide, sulfur dioxide, carbon monoxide, dust. Hazardous pollutants account for 40 % and are represented by ammonia, chlorine, phenol, metallic mercury, etc.

The enterprise has a treatment facility in the form of an installation for collecting dust from the air, namely cyclone K-18 (Ukraine). It is found that during the operation of the treatment plant, the efficiency of the treatment is 76.13 %.

If the purification degree is less than 90 %, then it is necessary to study the possibilities of manufacturers of modern equipment on the market, as well as scientific developments. Odors around meat processing plants are caused by the release of ammonia, amines, fatty acids, and basic heterocyclic compounds. These odors cause great harm to the health of personnel and residents of the surrounding areas, worsen the health of farm animals and, as a result, the quality of agricultural products.

Quite important today are issues related to the development of measures aimed at reducing emissions into the atmosphere and eliminating unpleasant odors from meat processing complexes that have both environmental and sanitary and hygienic significance. Therefore, air purifying ion-exchange filters: contactor filter (CF), frame ion-exchange filter (FIF) and combined FIF-CF are successfully used for air purification at pig farms, poultry farms, meat processing plants and other similar enterprises in Germany, Poland, Sweden, the Republic of Belarus and other countries of the world. Ukraine also has an official representative of the leading manufacturer of these filters.

So, let's study the technological characteristics of these filters, the main advantages of which are a high purification degree (90–99 %); low operating costs are ensured by:

- low aerodynamic resistance;
- low water consumption;
- minimum electricity consumption;
- filter automation;
- small overall dimensions and weight of the filter;
- minimal noise load;
- minimal work on installation and commissioning.

After analyzing the information about the meat processing plant, filters, as well as finding data on the efficiency of air purification from pollutants using the FIF filter on the example of another enterprise (Table 2), it is possible to make a decision on the establishment of analogues of purification equipment.

Table 2

Efficiency of purification pollutants on the example of installing the FIF filter

Name of contaminants	Ejection power (t/year)	Purification efficiency (%)
Ammonia	9.987	95
Nitrogen (II) oxide	0.679	96
Chlorine	0.198	97
Phenol	0.876	95
Carbon (IV) oxide	4678.875	98
Sulfur (IV) oxide	0.345	95

According to the research results, it has been established that the efficiency of air purification from pollutants ranges from 95–98 %. And this indicates that the installation of the FIF filter is advisable to reduce the impact of the enterprise on the atmospheric air.

7. SWOT analysis of research results

Strengths. The purification equipment used at the enterprises removes dust from the emissions of pollutants, however, other gaseous pollutants continue to pollute the air in the future, contributing to climate change processes, as well as affecting the health of the population. Therefore, the use of the methodology developed in the work at the enterprise will make it possible to effectively select modern treatment equipment and its installation.

Weaknesses. In the developed methodology, it is indicated that if the purification degree of emissions is less than 90 %, it is necessary to introduce effective purification equipment. However, enterprises of various industries use purification equipment, mainly providing 70–90 % of the purification degree of emissions into the air. Accordingly, it is worth clarifying the organizational and managerial actions for the management of such enterprises where the treatment equipment provides a purification degree of 80–90 %.

Opportunities. There are modern purification systems on the world market that ensure the capture of many pollutants with a purification rate of more than 95 %. Developed filters and their technological characteristics meet the needs of enterprises in various industries.

Threats. Any purification system requires proper maintenance, so monitoring its efficiency will reduce both environmental production and financial risks for enterprises.

8. Conclusions

1. Using the tools of system analysis, a methodology for monitoring and selecting treatment equipment at the enterprise is developed. This technique contains sequential stages of organizational and management actions under the following conditions: if the purification degree of emissions is less than 90 %; if the purification degree is more than 90 %.

2. It is determined that in the conditions of the existing treatment equipment at the enterprise, which ensures the efficiency of the purification degree of emissions of more than 90 %, it is necessary to observe measures of constant monitoring of its condition. These measures include maintenance, monitoring of pollutant emissions before and after treatment systems, and training of personnel.

3. The effectiveness of the developed methodology is established on the example of the meat processing industry: from the environmental assessment of the enterprise and the analysis of the existing purification equipment, the study of manufacturers of purification systems and their technological characteristics to making a decision on their installation at the enterprise.

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