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INFORMATION SUPPORT OF EXPERT EVALUATION OF ENGINEERING FACILITIES

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Abstract: This article explores the problem statement and models for making a decision about the feasibility of environmental measures during expert evaluation of engineering facilities.

Introduction

Environmental activities of industrial enterprises are regulated by the departments of state expert evaluation, regulation and licensing of local and regional Environment and Nature management administrations (committees) [1]. The result of an expert committee's work is a state environmental report which evaluates:

– validity of decisions about technology, placement options, scheduled ecological safety measures, environmental monitoring;

– sufficiency of scheduled arrangements, financial and technical means of remediation of potential accidents' consequences;

– sufficiency of ecological safety and natural reserves conservation measures;

– ecological feasibility and impact of facilities under state examination.

During expert evaluation examination a lot of responsibility is placed on experts.

This work shows an approach, which, on one the hand, enables to choose a schematic solution of such a system and, on the other hand, to evaluate the efficiency of scheduled ecological safety measures on the example of gas emissions treatment. It is based on research results described in [2–6].

Problem Statement

The choice of a technological scheme of gas emissions treatment system from a variety of options can be made with the most advanced method of expert systems. In order to make the best choice from a set of process structures, it is necessary to define evaluation criteria. Systems of gas emissions treatment possess many criteria that are grouped into three broad categories: 'costs', 'reliability', and 'safety'. We propose the following problem statement in order to form a set of technological scheme structures (**TSS**), which includes all required stages: it is necessary to determine a sequence of stages of air purification process to reach contaminants' concentration level of $\overline{C}_{\text{out}}$, such that for

$$\overline{C}_{\text{out}} + \overline{C}_{\text{back}} \le \overline{C}^{\lim} \tag{1}$$

the following is true

$$t_{\text{opt}} = \arg\min_{t \in T} F(t), \tag{2}$$

here T – set of available variants of treatment TSS; $\overline{C}_{\text{out}}, \overline{C}_{\text{back}}, \overline{C}^{\lim}$ – vector-functions of contaminant's output, background and limit concentration.

In this work F is a criterion of optimality, which is a sum of weighted relative losses of the following criteria: cost of all treatment stages; reliability of a treatment system; technological reliability and safety of treatment processes.

Economic criterion. When we form a knowledge base of treatment methods, reduced costs of each stage are evaluated aggregately. This criterion does not show the exact costs; at this stage of design we only have information about treatment stages, which allows estimating costs of treatment schemes with the help of expert judgment.

Reliability of treatment equipment. Reliability criterion is defined as the ability of equipment to perform specified functions keeping a set of performance indicators within prescribed limits, corresponding to specified modes and conditions of use, maintenance and repair. Reliability is a complex property, which may include reliability, technological effectiveness, and stability of one or a combination of properties for both equipment as a whole and its parts depending on equipment functions and operating conditions.

Technological effectiveness of treatment processes. Technological effectiveness of a process is its convenience and ease of its implementation, which allow executing a process aimed at desired results with minimal input of labor and resources.

Safety of gas emissions treatment processes. Here safety of treatment processes is measured by probability of a fire (an explosion). This criterion for newly designed systems is defined on the basis of safety values of object's elements, which allow estimating probability, control and management systems and other potentially inflammable or explosive elements.

Information-logical model

Based on previous experience of treatment processes design [7–9] in the form of a knowledge base, we set the target, for example air quality within acceptable norms, and using decision-making mechanism we get a combination of stages leading to our goal.

In a general form, an information-logical model (**ILM**) for decision-making support, enabling to choose a technological scheme of gas emissions treatment and relative equipment, represents a sum of data sets and sets of connections in the form of rules. Thus, ILM can be written as:

$$\mathrm{M} = \langle D,\ P \rangle,\ \ D = (d_1, \ldots, d_i, \ldots, d_N),\ \ P = \left(p_1, \ldots,\ p_j, \ldots, p_S\right),$$

here M – ILM operator; $d_1, \ldots, d_N$ – ILM data set; $p_1, \ldots, p_S$ – set of rules.

Set of rules are in the form of: if ... *(conditions fulfilled), then ... (consequences realized)* can be written as:

$$p^k : \left\{ \text{if} \left(\left(d_1^{k\,\prime}\ A_1\ z_1^{k\,\prime} \right) \Lambda_1 \left(d_2^{k\,\prime}\ A_2\ z_2^{k\,\prime} \right) \Lambda_2 \ldots \Lambda_{n-1} \left(d_n^{k\,\prime}\ A_n\ z_n^{k\,\prime} \right) \right) \right.$$
$$\left. \text{then} \left(d_{1m}^{k\,\prime\prime}\ A_1'\ z_{1M}^{k\,\prime\prime} \right) \right\},$$

here $A_1^{'}, A_i \in \{=, >, \geq, <, \leq\}$, $i = \overline{1,n}$ – arithmetic operator; $\Lambda_i \in \{\wedge, \vee\}$ – logical operator; $d_n^{''}, d_{1m}^{''}$ – input and output model parameters; $Z^{k'} = \left\{z_1^{k'}, \ldots, z_n^{k'}\right\}$ – input value of $d_n^{k'}$; $z_1^{k''} \in \left\{z_{11}^{k''}, \ldots, z_{1M}^{k''}\right\}$ – output value of $d_1^{k''}$; n – number of conditions; k – rule index.

The set of feasible treatment technological schemes is formed with the use of a heuristic algorithm. At first, connections between technological stages are written in the form of rules; these stages can provide the required characteristics of gas flow, relationship between input and output stages, connection between preceding and following stages and other similar dependences. Since the number of combinations does not exceed 10^4 and productivity of modern PCs is high, the solution can be obtained by sequential search among all possible combinations of schemes.

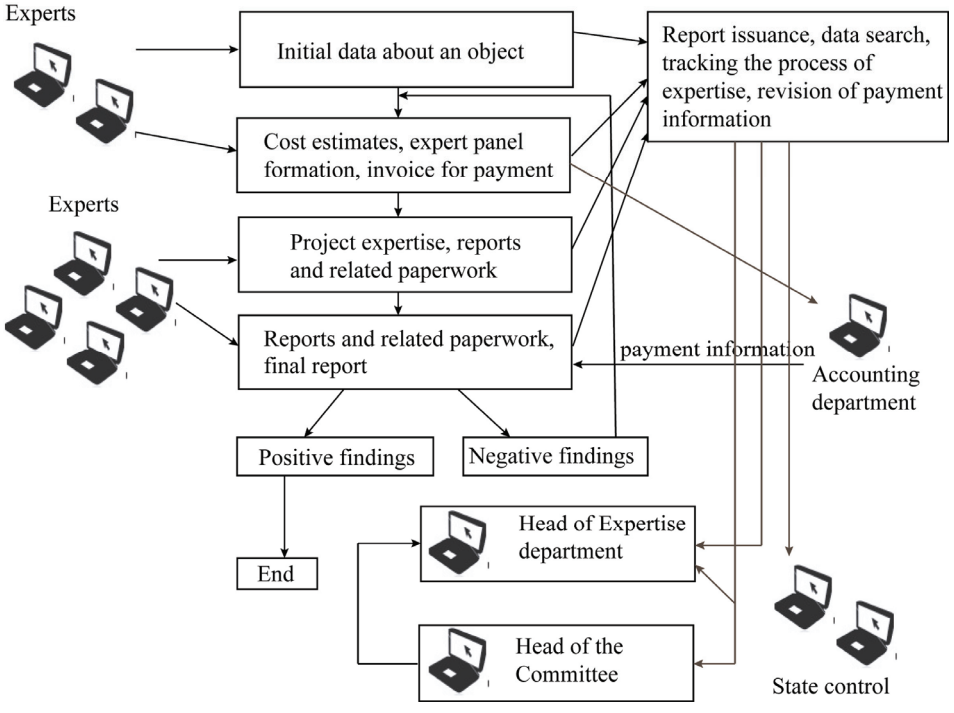
Software

An information system, which computerizes environmental activities of Ecological safety and environmental management departments, is designed. Such a system includes the following sub-systems:

– state expert evaluation data processing including sub-programs, which allow data output for various environments;

– water environment monitoring data processing including sub-program for analysis by various criteria.

Figure shows the scheme of interaction between services (committees) during expert evaluation with the use of the designed software. The calculation of external



Interaction scheme of various services during ecological expert evaluation

experts payment and all related paperwork are done according to the Federal Law "On Ecological Expert Evaluation". The sub-system allows automated tracking of objects through the entire chain of processing. It also enables to process documents as they become available, to analyze obtained results and to validate the need to conduct various activities, in order to avoid non-regulated impact on the environment.

Conclusion

As a result, the system generates a list of activities aimed on reduction of negative impact of industrial enterprises on the environment. Moreover, in most cases, we can estimate feasibility and approximate costs of environmental protection activities that are being evaluated.

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Информационная поддержка принятия решений при проведении экспертизы технических объектов

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Ключевые слова и фразы: виртуальная модель; информационная система; технический объект; экологическая экспертиза.

Аннотация: Рассмотрены постановка задачи и модели поддержки принятия решений о целесообразности утверждения природоохранных мероприятий при проведении экологической экспертизы промышленных объектов.

Informationsunterstützung der Entscheidungen bei der Durchführung der Expertise der technischen Objekte

Zusammenfassung: Es sind die Aufgabestellung und die Modelle der Unterstützung der Entscheidungen über die Zweckmäßigkeit der Bestätigung der Naturschutzmaßnahmen bei der Durchführung der ökologischen Expertise der Industrieobjekte betrachtet.

Soutien informatique de la prise des solutions lors de la réalisation de l'expertise des unités techniques

Résumé: Sont examinés la prise des solutions et les modèles du soutien de l'acceptation des décisions sur la rationnalité du sanctionnement des mesures de la protection de la nature lors de la réalisation de l'expertise écologique des unités industrielles.

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