Monitoring of production processes in the waste processing industry and their impact on the environment

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Abstract. Methods and practical implementations of monitoring production processes in industrial processing of solid household waste and their impact on the environment are considered. This makes it possible to increase the efficiency of the interaction of the automated enterprise management system with the objects of the enterprise in the implementation of their modeling, as well as to raise the level of controllability of the production system. With the implementation of continuous analysis, the problem of optimizing the links between processing facilities is solved in order to ultimately increase the output of high-quality products, the company's response to external changes and the requirements of environmental standards. The presently actual production facilities providing processing of solid household waste are considered. Within the framework of the IDEF0 functional modeling method, the characteristic properties of enterprises are determined and their representation is built in the form of an IDEF0-model.

1. Introduction

With the development of monitoring systems in modern automated enterprise management systems (ACS), it becomes necessary to design and implement effective systems and tracking methods that allow both to build complex analytical reports and to develop integrated approaches to maintaining complex production systems in their original state while stabilizing the necessary parameters [1-3]. Typically, monitoring systems are not limited to hardware, such as an extensive network of additional sensors and wired and wireless networks. An important point is the use of optimal, high-speed and low-cost software implementations that provide data collection and analysis. Modern approaches should provide a degree of independence, objectivity and efficiency in assessing production processes, create the necessary foundations for further improving the tools of strategic enterprise management, in particular, when modernizing production assets.
To improve the efficiency of processing enterprises, it is necessary to create model-algorithmic support for monitoring systems [4], which is essential for substantiating and making decisions, as well as for adjusting control actions on the structural components of the ACS.

For distributed organizational and technological complexes of enterprises, it becomes necessary to create a subsystem for monitoring their effectiveness for planning and optimizing the debugging of ACS activities. This subsystem should effectively support the monitoring systems in the unified information space of corporate united enterprises, providing general access to the databases of the operation of the control and measuring information of ACS [5].

Monitoring and control over the efficient operation of a complex of enterprises will allow not only to monitor the stable operation of each production, but also to effectively manage the quality, finances and personnel of the entire set of related industries, which ultimately requires the introduction of appropriate methodological and mathematical support [6]. Thus, the creation of a model-algorithmic support for an automated monitoring subsystem of ACS is an important scientific, technical and practical task.

2. Environmental features of industries in the waste processing industry

With the development of technical and economic progress and an increase in the population of the world, an ecological crisis of the growth of industrial and household waste began to be observed [7, 8], a large proportion of which falls on industrial waste, which gives rise to the problem of energy efficiency and economic feasibility of their processing [9]. The issues of environmental safety of the population fall on the share of solid household and municipal waste (MSW and solid waste, respectively).

These issues affect the comfortable life and health of the population now. A more complete overview of the state of the waste problem can be found in [10-14]. The problem of waste is closely related to the ecological situation in the world and requires a deep systematic approach, both within the framework of solving organizational and technological problems of industrial facilities, and within the framework of a modern synergistic approach to an ecologically developing system of relationships between man and nature [7].

When considering waste in terms of its impact on humans in a psychological and comfortable sense, the closest will be municipal waste (MW) municipal solid waste (MSW), figure 1. The sizes of the circles indicate the degree of impact on human health and well-being.
Therefore, the work considers approbation on the industry and its production components for MSW reprocessing, does not take into account the MW reprocessing industry, production and nuclear waste.

3. Method and initial data

Methods of theoretical and experimental research, methods of system analysis of industries, methods of functional and instrumental modeling are used as research methods. The use of the DEA method and its modifications is promising [1]. The software implementation of models and algorithms uses the method of object-oriented analysis and programming.

For a visual representation of the subject of approbation, we describe the MSW recycling industry. For recycling (reuse) [15] of the entire mass of the city's waste generated, a system of industrial enterprises and complexes is used, which are classified as follows [9]:

- Enterprises dealing only with processing:
  - recycle waste into raw materials and materials;
  - processed into finished products for sale and consumption.
- Enterprises using processed raw materials together with natural or separately (engaged in processing, but having a separate economic function):
  - use recycled waste as fertilizer;
  - use recycled waste as fuel.
- Complexes for storage of non-recyclable waste:
  - for subsequent processing (temporary storage);
  - for the purpose of safe storage (for timeless storage).
- Enterprises utilizing and neutralizing hazardous waste.
- Industrial complexes for waste collection.
- Industrial complexes for the commercial sale of products and materials from recyclable materials.
- Sorting complexes.

One production facility can accommodate the functions of various industries in the processing industry described in [16].

Optimization of the processing industry can be carried out by combining several types of functions in one production. This is important for those enterprises of the industry that are in each city (region) and in which they are engaged in complex processing. For example, in order to reduce the cost of fuels and lubricants, a sorting plant is installed at the buffer landfill, where special vehicles store city MSWs [16]. At the same time, already separated and pressed material is taken away for processing using large-sized vehicles.

Let's highlight the main similarities and differences in the organizational and technological plan of MSW processing plants. Thus, MSW recycling plants have a number of features.

- At the input of the model, you can consider such parameters as the cost of raw materials, energy, personnel (labor input).
- The output of the model is a processed useful product, tailings, environmental impact on the external environment.
- Enterprises interact through foreign economic, organizational and technological, resource exchange channels in one industry and with related industries.
- It is necessary to achieve management at all levels of production (enterprise management with economic ties, production management as the development of a high-quality product, shop management as an organizational and technological unit, process line management - several lines, process control - a unit, local process control).
- There is a need for algorithmic control objects.
• Systematic financial investments are required to modernize the enterprise.

MSW processing plants are characterized by the following features.

• Mixed multicomponent mass is often used as raw material.
• Raw materials for processing consist of dissimilar products, with different chemical and physical compositions, little deterministic at the input.
• Due to poorly developed economic and legal mechanisms, there is a small contingent of sales of processed products.
• A small but significant percentage of the preparation of raw materials for processing, depending on the technology, falls on the pre-production process.

4. Research results

Based on the characteristics of MSW processing plants, we will present a functional model as an object coordinating flows with the environment (figure 2). Let's depict the enterprise model for interaction with material and non-material flows in the form of a block according to the rules of functional modeling IDEF0.

![Figure 2. Scheme in IDEF0 format of MSW recycling plant.](image)

The figure 2 introduces the following notation:

\( V_1, V_2, V_3 \ldots V_N \) – recycled components;

\( V^*_1, V^*_2, V^*_3 \ldots V^*_M \) – unprocessed residues of substances that go to landfills (special storage places);

\( V_{\text{nom}} \) – consumed nominal amount of recyclable waste (plant capacity);

\( R_{\text{add}} \) – resources required by the enterprise for processing (purchased additional materials, packaging, electricity);

\( E_{\text{n}} \) – regulations and requirements for recycling;

\( L_{\text{n}} \) – legal regulations and requirements governing processing;

\( R_{\text{f}} \) – support required for the implementation of processing;

\( E_{\text{mpc}} \) – harmful concentrations of substances released into the external environment during the activities of the enterprise.

The circuit shown in figure 2 is a block of the IDEF0 diagram [17], which, according to the methodology, performs a certain function and has connections in the form of input and output arrows. The enlarged model in the form of a block is a "black box", which, when detailed, contains similar
blocks of the structure of the designated block, with informational and material links between each other. Internal blocks reflect the structure and principles of functioning of the block that contains them, and their links are assigned to the links of the main block.

So, when considering the scheme in figure 2, it can be seen that $V_{nom}$ is the total volume of waste for processing, arriving at the enterprise, goes first to the sorting conveyor located "inside" the main block - the "MSW processing enterprise". Then the recycled waste components from the indoor unit, such as the aluminum can press complex, exit as $V_1$ of the main unit. We regard this as a recycled component for the shipment of manufactured products.

According to the same principle, each block is detailed within the framework of the IDEF0 functional modeling methodology. As a rule, the researcher reaches a level where detailing will not be of value to him.

5. Conclusion
The study of functional models using the example of waste processing industries served as the basis for constructing methods for analyzing enterprise structures in ACS. Periodic analysis of the structure of the enterprise in ACS allows you to quickly monitor the state of the production system, focus on the features of their main blocks in order to increase the integrated efficiency of the enterprise.

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