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A competitive mechanism for selecting a supplier by a coal mining company based on the use of a system for monitoring the exploitation of material and technical resources

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Abstract. The feedforward and feedback of production departments and supply service of a large enterprise and the existing order and criterion for selecting a supplier of material and technical resources are described. It is shown that the minimum cost of material and technical resources is used as the dominant criterion for choosing a supplier, which, as a rule, leads to manipulation by the supplier and entails various risks for the enterprise. In the article to eliminate these shortcomings it is proposed to use a mechanism for selecting a supplier of material and technical resources using the monitoring system of material resource during its operations. The system for monitoring a material resource is a system collecting information about the total cost of a resource for an enterprise, which is formed both at the expense of the resource purchase price and at the costs of its use in the production process. For the implementation of a material resource monitoring system, standard format of a template was developed for entering the resource usage data into the system, also principles of its creation and effects from its use are also provided.

1. Introduction

The functioning of coal mining enterprises is characterized by a variety of technological processes, different for open and underground mining methods.

For enterprises that extract coal by underground method, among the main technological processes can be distinguished: mining, separation of coal from the massif, transportation of coal on conveyors or in self-propelled railcars in the workings, delivery of coal and rock to the surface, ventilation, degassing and water drainage. For enterprises mining coal by an open method, technological processes are mining and transportation of overburden and coal, drilling wells for blasting works, formation of temporary roads, storing rock mass.

Among the main features of the underground method of coal mining are the following: the need to build capital mine workings to open up a mine field and carry out development workings to prepare coal reserves for extraction, retimbering and maintaining of mine workings; the need for measures combating methane, dust, providing ventilation of mine workings, controlling of rock pressure; the presence of harsh and harmful working conditions, a great danger of underground mining; the significant length of the capital and development workings affects the costs of both the delivery of coal to the surface and the delivery of resources; the use of high-performance combines, cleaning systems, conveyors, pumps and other expensive equipment requires a large amount of spare parts.

The open features of coal mining are characterized by the following: the need to remove and move large volumes of host rocks (as a rule, the volume of overburden rocks is several times greater than the



volume of coal mined, therefore, most of the costs for coal mining in the open pit accounts for works with overburden); the need to use powerful and productive equipment, the production of blasting operations due to the significant size of open-pit workings; the need to follow a clear sequence of mining coal seams.

The listed features of the coal production cause high costs for the purchase and use of various material and technical resources (MTR). The activity of the enterprise, carried out during the procurement of materials and equipment, is one of the main elements, through which the costs of resource purchase, the quantitative and qualitative characteristics of MTR used by the enterprise are formed; not only the enterprise operation but also its industrial safety depend on the rhythm and timeliness of MTR supplies to the enterprise [1].

Therefore, this paper deals with the supply issues of coal mining enterprises.

2. Results and discussion

The MTR enterprise supply activity is an interaction of a multitude of active elements in accordance with the regulations and the organizational structure of the enterprise.

The mechanisms of internal interaction are the rules, procedures, norms of interaction between the center and agents within the enterprise that determine the need for materials and equipment, according to their choice, and so on. Mechanisms of supplier selection are the rules, procedures, standards for the selection by the center of external agents (MTR suppliers). The mechanisms of operational management are the rules, procedures, norms of interaction between the center and agents within the enterprise in order to manage the MTR supply, their storage, use in the production.

Let us consider the procedure for the provision of enterprises with MTR in terms of internal interaction. At this level, it is conditionally possible to single out the center (controlling subsystem), which sets the rules, norms, regulations, structure and at least two elements of the controlled subsystem – the production department (hereinafter – department) and the supply service, which are interconnected, exchange information between themselves and the center. The interests of the center in this case will be to ensure the most transparent exchange of information between the department and the supply service, and to establish their stable interaction in the supply of materials and equipment.

The interaction of the production department and supply service occurs in two main areas:

- Feedforward. Statement by the supply service of their requirements for materials and equipment and the need in them;
- Feedback. Assessment of the department satisfaction with the MTR, complaint management.

These two types of communication are rarely observed in pure form, often mixing in the process of interaction. They are separated for the convenience of the study.

Let us consider how direct communication of the department and supply services occur. The department declares the need for MTR in the following ways:

- in the case when the MTR and its supplier are known (there are concluded contracts, there is a practice of application, etc.), the department, using an automated accounting system, enters data on item numbers and the amount of MTR. The document thus formed is called the application. The order of registration, the timing of the application are governed by the center. The prepared application of the department is transferred to the supply service, where there is a consolidation of applications and the final formation of the need for materials and equipment.
- when there is a need to change the MTR or its supplier (development of new production, unsatisfactory characteristics, search for MTR-analogues), the department creates terms of reference (TOR) – a list of MTR for procurement, which establishes the basic requirements for the purchased MTR, technical characteristics, quality indicators, feasibility and special requirements. In the TOR, the departments indicate a number of essential characteristics for defining clear requirements for the procured MTR. TOR will later be used when choosing a supplier.

Feedback is also carried out when creating a TOR, as it takes into account the experience of previous deliveries. Complaints management, as part of the feedback, is a collection of conclusions, acts, on the basis of which the fact of delivery of low-quality MTR is confirmed and measures are taken regarding the unfair supplier in the future.

Thus, the internal interaction mechanisms determine how the center manages the interaction between the supply service and the department. However, the management of this interaction is not enough for the functioning of MTR supply. Therefore, we will consider in more detail the mechanisms for selecting an MTR supplier.

The supply service, acting on behalf and in the interests of the center, interacts with a variety of agents – potential MTR suppliers. In this case, it is also possible to distinguish two directions of interaction:

- Feedforward. Statements from the supply service to external agents of requirements for materials and equipment, conditions of supply, etc.
- Feedback. Consideration of technical and commercial proposal submitted by agents (TCP), complaints management.

TCP is a package of documents characterizing both the supplier and the MTR offered by it. The collected TCPs are considered by the supply service. In the course of the work, conclusions are drawn about the acceptability of TCPs and the possibility of their improvement due to changes in one or several characteristics. As a rule, the main characteristic is the cost of the proposed MTR. The result of the supply service with potential suppliers is a decision made by the center regarding the agent with whom it is necessary to enter into a supply contract.

Supplier selection is carried out in accordance with certain criteria defined in the “Procurement Regulations ...”, according to which the received proposals from potential suppliers are evaluated. As a rule, the following criteria are used: cost of materials and equipment, terms of payment, quality characteristics of resources, status of a potential supplier (manufacturer, manufacturer’s trading house, intermediate party), deadline, MTR delivery period, delivery terms, availability of an MTR warehouse in the region, certificates, licenses and other documents.

The winner (winners) of the procurement procedure is one or several supplying agents who have offered the best conditions for the execution of the contract, while, as a rule, the main criterion is the cost of materials and equipment, which is one of the drawbacks of the existing supplier selection mechanism.

The result of the functioning of the internal interaction mechanisms (the interaction of the department and the supply service) and the selection of the supplier (the interaction of the supply service and agents) is a contract for delivery with one of the MTR supplying agents, taking into account the needs and requirements of the department. A discrete competition or tender with a competitive mechanism is the most widely applied instrument when choosing an MTR supplier agent, when the competition object is indivisible and the winner receives everything.

The competitive mechanisms are widespread in the management of organizational systems, the mechanisms have a number of strengths: they stimulate agents to increase their efficiency, reduce the subjectivity of decisions made by the center. The main role of the center in this case is to determine the winner on the basis of the constraint in the resource, and the agents – the message of their application for the resource and/or the efficiency of resource use.

An analysis of existing methods of supplier selection shows that, currently, the method of dominant characteristics is used to increase the speed of decision making and minimize the time for procurement procedures as the main method of supplier selection. As the dominant characteristic of the TCP evaluation, the cost of MTR is mainly used. In other words, it is in the interests of the center to purchase such MTR, which is simultaneously characterized by a set of certain characteristics and entails minimal costs.

Let us consider in more detail the situation that occurs when choosing an agent in the existing supply mechanism. The center, represented by the procurement service, launches a competitive mechanism for an MTR. In this situation, the interest of the agent is the provision of such information

about his proposal, which allows it to win the competition. Namely, the confirmation of the expected MTR characteristics by the center and the achievement of minimum costs for the MTR purchase. The agent, when formulating its TCP, relies on two main limitations: the cost of its own production (or the cost of acquiring and selling materials and equipment when fulfilling the role of an intermediary party) and the profit margin implied in the price offered.

This often leads to the manifestation in the selection mechanism of a MTR supplier of the negative trait of any competitive mechanism – manipulability, which is described in [2]. In the case of the use of competitive mechanisms in the supply, manipulation is carried out by distorting the information provided by agents-suppliers. Knowing that the center focuses primarily on the minimum cost of MTR, agents can offer an MTR formally compliant with the requirements, but in practice this MTR can seriously yield in its performance characteristics to the offers of other agents. Consequently, the cost of such MTR will be lower than that of other agents, so it becomes preferable for the center. It can be said that the agent detects and exploits the vulnerability in existing competitive mechanisms: focusing on the minimum cost of MTR.

Thus, the possibility of manipulation due to the orientation to the minimum cost of MTR entails the following risks:

- fair agents with proposals of high-quality, but more expensive MTR, are “screened out” as a result of the implementation of the tender mechanism;
- the choice of agents that exploit vulnerability in a competitive mechanism may ultimately lead to an increase in the costs of the enterprise. The agent, offering low-quality MTR, but at a minimal cost, makes the transfer of costs from its own production system to the production system of the enterprise. A low-quality MTR for the center may have a higher total cost of ownership, that is, require large maintenance costs, and have a shorter service life.

According to the results of the procurement procedure with the application of MTR minimum value criterion, the winner is revealed and a contract is concluded with it. Further, after the delivery of the MTR by the winning agent to the enterprise-consumer and during technological processes the unsatisfactory quality or inconsistency of the MTR to the TOR is revealed.

Then, the supply service, within the framework of its authority, performs the claim work procedures: the relevant documentation is drawn up, and proposals are prepared for the replacement or repair of the MTR by the supplier. Note the negative consequences of these actions:

- assessment of the MTR actual quality occurs only when materials and equipment are delivered to the company’s warehouse, and often only after its use in production. Therefore, the work on the acceptance of MTR, warehousing, transfer to production, the subsequent examination, paperwork increase the costs of the enterprise;
- there are costs not only in monetary terms, but it is also a loss of time for the claim work, organization of a new procurement procedure.

It can be said that a sequence of interrelated actions is formed, which cause the company to receive substandard MTRs: “criterion of minimum cost of materials and equipment” – “winning of an unscrupulous agent in a competitive mechanism” – “poor quality of materials and equipment” – “assignment of an agent to the list of unfair suppliers” – “use criteria for the minimum cost of MTR in the new procedure.

Let us refer to the works of the authors for the objective assessment of the impact of the delivery of low-quality MTR on production processes. In publication [3] it is noted: “The analysis of the values of the failure rate and the downtime rate due to failures shows that the least reliable excavator units are the mechanisms of lifting, turning, pressure and movement. In dragline excavators, working equipment, traction and bucket lifting mechanisms are most often break down. In [4] it is indicated that with a single influence of operating factors, the cost of excavating the rock mass with EKG-18R/20K excavator can vary from 3.8 rubles/tonne using original spare parts to 30.6 rubles/tonne using non-original spare parts.

Therefore, in order to improve the supplier selection mechanism, it is necessary to propose a method that would combine the possibility of taking into account a larger number of criteria

(characteristics) of supplier selection along with ease of use. The significance of some MTR for a sustainable production process requires that the supply mechanism must be flexible not only in terms of the amount of the procurement, but also in terms of the place and role of the specific MTR in the production process.

An alternative could be the organizational and economic mechanism developed by the authors and based on the use of a resource exploitation monitoring system (REMS).

The REMS in its context is a type of decision support system (DSS) that allows the user to process and analyze data arrays using a set of objective models.

The basis of the information support of the REMS is a database on the MTR supply, which is updated in the process of identifying low-quality MTR. The main values entered into the database are the individual identifier of the supplier, the individual identifier of the MTR (item number), the cost and the number of poor-quality MTR. This database can be built using specialized software with the assistance of analysts.

The purpose of using the REMS in the mechanism for determining the choice of supplier is to identify all cases of supply of poor quality MTR, their frequency, localization by departments. It is also important to take into account the effect of these deliveries on the production process (loss of profit), the most common types of defects or non-conformities with the MTR technical task.

At present, the preparation of claims, administrative notes, acts of internal control services consumes a lot of working time of various specialists. Since a number of agents are involved in the supply mechanism, the absence of a standard template often leads to data loss and their repeated duplication. A significant role in this situation is played by the human factor. The description of MTR defects, the content of complaints to suppliers may also vary depending on the department. As a result, universality is lost, and the time spent on data processing is growing. Therefore, one of the functions

performed by REMS will be the function of processing and storing data regarding each fact of defect detection: the data will be contained in one database, which reduces the risk of loss and allows all specialists to use the same available information source.

It is proposed to fill the database on the supply of low-quality MTR using a standard template with fields for entering values. The use of the standard REMS is intended primarily to present data on the supply of poor quality MTR in a comparable form and exclude the introduction of incorrect data.

Figure 1 shows one of the possible formats of a standard template for entering data on the used MTR into the REMS.

The field “Type of Defect” is filled in the form on the basis of expert opinion (opinion) of representatives of technical services, or on the basis of records by specialists of the company’s departments. When specified in the form, the wording of this reason will be included in the TOR or used in the negotiation process with suppliers.

The screenshot shows a web-based form titled "Resources". It contains the following fields and controls:

- Structural department**: A dropdown menu.
- Supplier**: A dropdown menu.
- MTR nomenclature number**: A dropdown menu.
- MTR group**: A text input field.
- Cost of improper MTR, rub.**: A text input field.
- Date of the detected MTR defect**: A text input field.
- Stage of a defect detection**: A text input field.
- Type of a defect**: A text input field.
- Downtime due to the use of impMTR, h.**: A text input field.
- The need for unscheduled repairs**: Radio buttons for "Yes" and "No".
- Documents of MTR defect recording**: A text input field.
- MTR replacement dates**: A text input field.
- Save and exit**: A button at the bottom.

Figure 1. An example use of the REMS form.

filled in the form on the basis of expert opinion (opinion) of representatives of technical services, or on the basis of records by specialists of the company’s departments. When specified in the form, the wording of this reason will be included in the TOR or used in the negotiation process with suppliers.

This type of defect should be paid the most attention when receiving TKR from agents in order to minimize repeated deliveries of goods and equipment with similar types of defects in MTR. Using the codification system for the most common defects will allow accounting to be formalized and simplified.

Principles of the REMS design:

- Principle of transparency. All information on poor-quality MTR through the report system of the REMS comes to the center and can be used both in its raw form (for example, describing types of defects) and using calculations to make adjustments to the supplier selection mechanism. Also, such information reports can be stored and used at any time, regardless of the level of competence and experience of individual employees;
- Principle of standardization and unification. The template that is filled in when working with REMS is universal for all departments of enterprises, and, therefore, can be used without any difficulty. Thanks to the standard template of the REMS, information on the supply of poor-quality MTR is also unified: a description of the type of defect can be limited or expanded, the ability to attach photographic materials to record the facts of poor quality MTR, etc.;
- Principle of simplicity. Entering data into the REMS does not require a significant investment of time and labor, since the input is carried out in a simple tabular form on the basis of a single directory of nomenclature, which is implemented in all modern accounting systems. Defects information can also be borrowed from standard documents drawn up during claim work.

From the organization point of view, it is proposed to distinguish two levels of the REMS at the center level and at the service level.

At the center level, the REMS serves as a decision support tool for decision makers. The center has access to summary analytical reports on departments for various reporting periods, statistics, and so on. At the supply service level, first of all, the standard REMS of templates and the data on the supply of low-quality MTR are filled in.

The enlarged algorithm of functioning of the REMS is shown in figure 2:

- in the supply service, data on low-quality MTR is entered into the template form, and the relevant fields for each case of poor-quality MTR delivery are filled in;
- by means of built-in control panels of the REMS, the correctness of the entered data is checked: whether the MTR group, the supplier complies with the nomenclature, the limitation on the length of the text description of the defect type, etc.
- after passing through all the checks, a document-report of the enterprise's REMS is formed that contains all the entered data. This report is available at the center level;
- a summary report of the REMS is prepared for a certain period and includes the departments and MTR which the decision maker is interested in.
- As it can be seen, the communication process of the departments and the supply service is simplified in terms of the purchase of low-quality MTR: the movement of information occurs without the direct influence of the human factor. Therefore, a series of data that could be lost or deliberately ignored, mistakenly taken as insignificant, can no longer be ignored. In this regard, when introducing REMS, it is possible to obtain data that previously simply did not enter the supply service or were part of the professional knowledge and experience of specific employees, but were not available to other employees.
- Thus, the use of REMS will reveal:
- MTR groups (for example, spare parts) the purchases of which require a more scrupulous choice of suppliers to minimize the risk of delivery of low-quality MTR;
- areas of procurement (in terms of departments, which often receive poor quality MTR), which are given insufficient attention;
- departments and production processes, in which the use of low-quality MTR should be completely excluded. This can be identified by the frequency and duration of production process shutdowns due to the poor quality MTR.

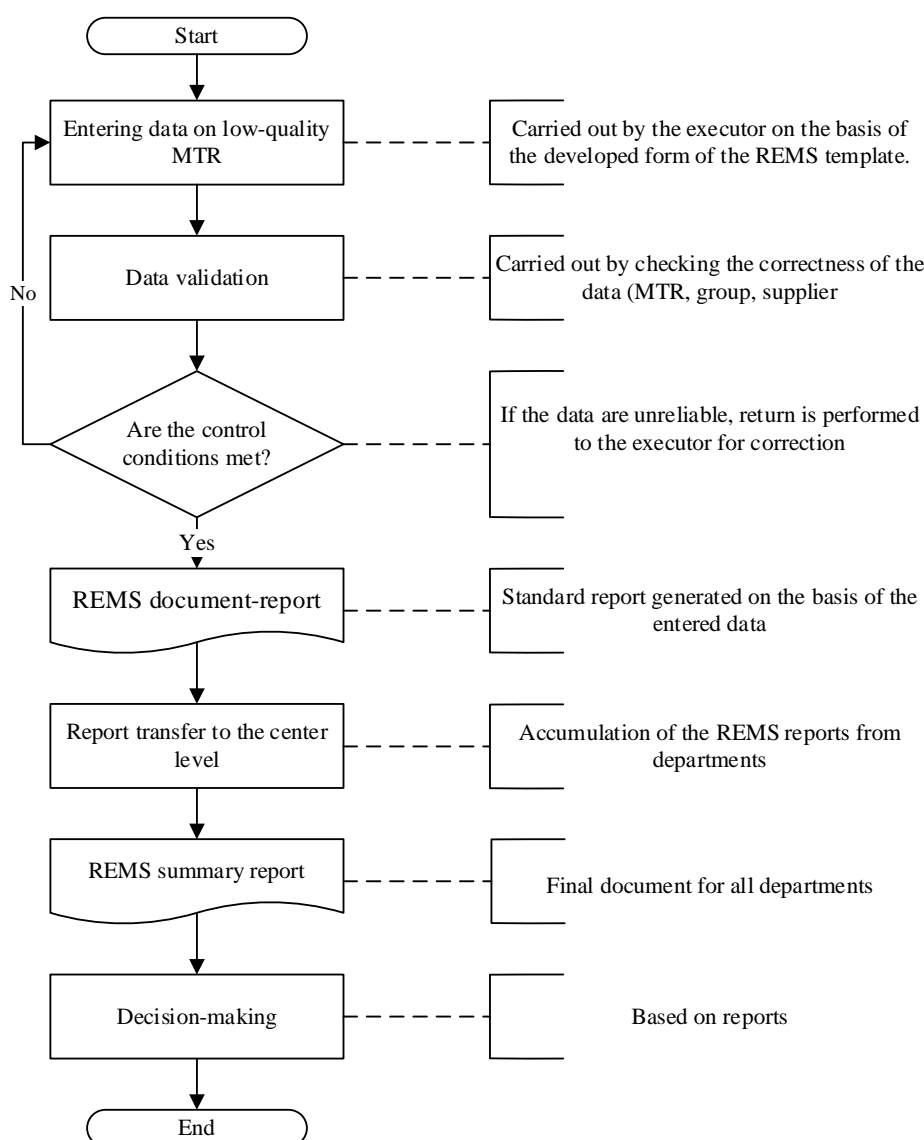


Figure 2. Algorithm of the REMS operation.

As a criterion for selecting a supplier using data from the REMS, it is proposed to use the MTR total cost of ownership (TCO).

The essence of the application of TCO is the study and evaluation of not only the direct cost of MTR, but also the costs arising from purchasing, use, disposal of purchased MTR. In addition to the cost of delivery, it is necessary at least to take into account the cost of operation, maintenance of the purchased MTR, its service life, costs associated with its disposal. Detailed substantiation of the use of TCO in procurement at coal mining enterprises is given in other works of the authors [5, 6].

3. Conclusion

In order to optimize the competitive mechanism for selecting an MTR supplier by a coal-mining enterprise, an algorithm for the REMS operation was developed, during the implementation of which at the level of the production department a document-report REMS is created that contains all previously entered data. Further, the report is forwarded to the REMS of the supply service, where all

similar reports from other departments are processed. The result of the REMS functioning will be a variety of information not only about suppliers and MTR, but also the entire MTR groups, which are often characterized by low quality, departments that most often face low quality of MTR, time and costs for establishing the causes of failure, nature of the most frequent defects, information on stops of production process (allows the most vulnerable to the production process to be identified, which are most affected by low quality resources).

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