REDUCTION OF ECONOMIC RISK BY RE-PLANNING IN REAL-TIME

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Abstract. Risks in procurement of material resources and production at Ore Mining and Processing Enterprises (OMPE) are considered. It is established that economic risks can be reduced by re-planning in real-time. Methodological approaches to determining the economic effect of automated information systems (AIS) from re-planning of procurement taking into account probability of non-delivery are proposed. Set losses from risks of accidents and unplanned outages of machinery and equipment, risks of not identifying the performance of machines and equipment, risks of not identifying quality raw material, risks of fluctuations in the volume of production at previous stages, risks of unplanned urgent orders, etc. Management solutions to reduce these risks are developed. It is proved that in terms of capacity constraints any delay re-planning and determining backup machines and equipment leads to losses from the reduction in production volumes in subsequent stages.

Keywords: economic risks, re-planning, real-time, automated information systems, insurance reserves, probability of accident, buffer storage, quarry, stripping works.

Introduction

In conditions of market economy, domestic enterprises face different risks that require management in real-time. Re-planning in real-time, including use of automated information systems (AIS), can significantly reduce losses from many types of risks. Table 1 shows most common economic risks that can be reduced by re-planning in real-time.

AIS planning and control in real time allows to reduce losses from freezing current assets in insurance reserves, which are created in the process of procurement of material resources, in the production process. Also AIS planning and control in real time allow to stabilize the production and quality of ore in the quarry, to reduce insurance reserves in the buffer storage, to reduce transportation costs and so on (Kochura, 2011).

So, InGOK and UGOK use geographic information system (GIS) "K-MINE", developed by the company "Krivbassakademinvest" (Nazarenko, 2011). Module production preparation of GIS "K-MINE" allows you to perform time-consuming calculations on the formation of detailed production plans for each excavator fully automatically, which reduces probability of errors and lost time. System uses methods of linear programming with different optimization criteria.

But the main advantage of this system is that it is possible re-planning in real-time. GIS "K-MINE" contains detailed maps of the quarry, results of geological analysis field that allows you to create pre-production plans. Directly after stripping in real time in the system they are entering data samples from each face, updated performance data for each of the excavator taking into account changes in the scope of work and other data. Next it is performing re-planning of production and optimization in real time.

Method

The most common risk in procurement planning is a violation of material resources delivery terms by the provider. In article (Lobov, 2013) we are proposed to determine losses from this risk, take into account insurance reserves:

\[ \text{Lvio} = \frac{\Delta M_i - M \text{res}}{N \text{mat}_i} \times P \text{prod} \times \text{ROS}, \]

where \( \text{Lvio} \) – losses from violation of material resources delivery terms by the provider, UAH;
\( \Delta M_i \) – forgone amount of i-type of material resources delivery terms by the provider;
\( M \text{res}_i \) – specific natural norms of consumption of i-type of material resources;
Pprod – price of product unit, UAH;  
ROS – return on sales, share of unit;  
Mres\textsubscript{i} – insurance reserve of i-type of material resources in physical units.

Using of AIS planning and control in real-time we can significantly reduce time of decision-making and corresponding losses, because system automatically reports any deviations from the procurement plan at the time of their occurrence. Reduction of the period of decision-making allows a corresponding reduction of the insurance reserves.

<table>
<thead>
<tr>
<th>Type of plan</th>
<th>Risks that can be identified in the control process in real time</th>
<th>Management decisions on elimination of the negative influence of risks that require re-planning in real-time</th>
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</table>
| Procurement plan | Violation of material resources delivery terms by the provider.  
Change norms of material resources consumption due to changes in technology, changes in the quality of material resources | If you have appropriate capacity, deferral of production at the end of the period when the scheduled delivery.  
If you don't have appropriate capacity, increase purchases from other suppliers |
| Production plan | Risks of accidents machinery and equipment  
Risks of not identifying performance of machines and equipment.  
Risks of not identifying quality raw materials (iron content in raw ore)  
Risks of fluctuations in the volume of production at previous stages, which leads to incomplete loading of equipment and high energy consumption  
Risks of disease workers  
Risks of unplanned urgent orders | If you have a backup of machinery and equipment, decision on their use.  
If you don't have a backup, synchronization repairs on all subsequent stages  
Re-planning of production volumes between all machines to obtain the desired product quality (iron content in raw ore)  
Re-planning of production volumes between buffer storages and various units of equipment to ensure stable operation with full load  
Changing work schedules of workers  
Increase in production volumes, if you have free capacities to fulfill orders within the prescribed period or rejection of such orders |

In article (Lobov, 2013) in determining the economic effect from re-planning in real-time we are conventionally accepted that the company has the opportunity to reschedule purchasing from another supplier and receive all required amount of material resources. But it should be noted that the process of delivery of material resources in the domestic OMPE has a high degree of uncertainty. Therefore, we offer to determine an economic effect from re-planning in real time with taking into account probability of non-delivery of appropriate material resources by the first and the second provider.

If there is a probability of non-delivery by the second provider, in this part enterprise will loss from the violation of delivery terms (Lvio.pr):

\[ L_{\text{vio.pr}} = L_{\text{vio}} \times P_{\text{nd}}, \]  

where \( P_{\text{nd}} \) – probability of non-delivery of material resources by the second provider, UAH.

However, there is also probability of timely supply, equal to \((1 - P_{\text{nd}})\). In this part economic effect of the AIS can be taken into account. Therefore, economic effect of AIS from re-planning of purchases in real time, taking into account probability of non-delivery of appropriate material resources by the first and the second provider:

\[ E_{\text{pur.pr}} = \sum_{i=1}^{N} \Delta M_{\text{res}_i} \times P_{\text{mat}_i} \times \frac{q \times T_{\text{st}_i}}{365} \times (1 - P_{\text{nd}}) - L_{\text{vio}} \times P_{\text{nd}}, \]
where $\Delta M_{\text{res}}_i$ – amount of insurance reserves, which can replace reduction in the time of management decisions, UAH;

$P_{\text{mat}}_i$ – purchase price of i-type of material resources, UAH;

$q$ – annual discount rate, share of units;

$T_{\text{st}}_i$ – storage term of insurance reserves in the absence of AIS, days;

$N$ – total number of types of material resources.

For violation of norms of material resources consumption, and for violation of material resources delivery terms, there is loss of volume of i-type material resources ($\Delta M_i$). The economic effect of AIS planning in this case can be determined similarly by the formula (3).

**Results**

We are considering risks when planning production at the level of individual enterprises (table 1). One of most common risks is the risk of accidents and unplanned outages of machinery and equipment. This problem at OMPE is particularly relevant. The mining industry is very capital-intensive, and upgrade of machinery and equipment is significantly delayed, which leads to increased depreciation and unplanned accidents.

Particularly high risks of accidents take place when the mining and crushing of ore. These processes are operated heavy machinery and equipment, thus resulting in reduced unit costs, but also leads to their increased workload and rapid depreciation.

Traditional way to reducing depreciation is capital and current repairs of the equipment and its maintenance. But it should be noted that the depreciation is a stochastic process with a high degree of uncertainty and a large number of factors influencing it. When developing schedules of repairs it is impossible to consider all these factors and to fully restore the operability of the equipment. Therefore, for insurance against risks of accidents at OMPE backup machines and equipment often are used.

As noted above, excess capacity need high capital costs of enterprise, but unlike material resources, acquisition of unique and expensive mining equipment cannot be implemented quickly, even if appropriate management decisions are taking in time. Therefore, use of backup machines and equipment at OMPE is appropriate, because losses from long-term downtime much more.

As can be seen from the table 1, in the event of accidents it is desired efficiency in re-planning of using of machinery and equipment. At OMPE this task should be performed as quickly as possible, because almost all the processes are executed sequentially. So, stop at any previous production stage causes a stop in all subsequent stages. In terms of capacity constraints emergency stop automatically leads to losses from the reduction in production volumes. To reduce these risks on OMPE at every production stage buffer storages of unfinished goods are created.

But the greatest uncertainty is characterized ore mining process in a career that is connected with peculiarities of the technological process. It is almost impossible to accurately predict before carrying out stripping works production volumes and quality of ore in each face, volume of stripping, which also needs to be transported. Therefore, production of ore fluctuate is considerably and very irregular in time.

The creation of buffer storages solves this problem. Crushing equipment is run only at full load. It should be noted that the stop-start crushing equipment may be held at any time and without significant additional costs.

At the same time the stop-start section of concentrating factory is a very costly process. Feature of its work is that for a long time after starting section of the factory operates in a non-optimal mode with increased costs of electricity and losses. Therefore, the start of the section are planned only if there is a substantial stock of unfinished goods (ore) in the buffer storage that should compensate for any fluctuations in production in the crushing factory, quarry and provide stable operation for a long period of time.

The stop section of the concentrating factory is planned only for scheduled maintenance, in the case of a significant reduction in demand for products. It is planned to complete stop certain sections to provide continuous operation at full load other sections. The work for not full load is not allowed. Therefore, if the planned production volumes non multiple power section, it is planned or deferred residue production for the next planning period, or the formation of certain surplus production. This is due to low profitability of products that can not cover the increase in the proportion of losses at part load equipment.

Buffer storages solve another common problem is the imbalance of production capacity between stages. This problem, as the problem of depreciation, cannot be quickly solved due to the high capital intensive and
requires large-scale investment projects. Therefore, at domestic OMPE imbalances in production capacities are very common. So, at InGOK production capacity of crushing factory is significantly below the capacity of concentrating factories.

By the difference of production capacity stocks of unfinished goods in the buffer stock often are created. In this case, the concentrating factory started with a delay in the accumulation in the buffer storage (bunker) residues, sufficient for stable operation over the entire planning period.

Therefore, the buffer storages of unfinished goods and insurance reserves of material resources can significantly reduce risks associated with production. But similar to insurance reserves, creation of excessive stocks of unfinished goods leads to losses resulting from freezing of working capital in these stocks.

In terms of capacity constraints any delay re-planning and determine backup machines and equipment leads to losses from the reduction in production volumes in subsequent stages. Calculation of losses in the next production stage can be carried out according to the formula (1). In this case, specific natural norms of consumption (Nmat) are defined not for the material resource, but for unfinished goods that is the product of production stage where the accident it appeared. The forgone amount of material resources (∆M) is forgone volume of products on production stage, where the accident occurred. Assuming uniform in time production this indicator can be defined by the formula:

\[ ∆M = Qhou \times Tacc, \]  

where Tacc - time required to repair machines since it accident, hours; Qhou - hour emergency machine performance, t/hours.

In case of insurance reserves (Mres) presence on the buffer storage of the next production stage losses can be reduced and defined by the formula (1). The only difference is that the provider in this case is the previous production stage.

Due to using of AIS period of a decision on the replacement of machinery and equipment is significantly reduced as a result to the reduction of the period of collecting and processing the necessary information. The economic effect of AIS planning in this case can be determined by formula (3).

**Discussion**

It is established that the process of material resources delivery in the domestic OMPE has a high degree of uncertainty. Therefore, when determining the economic effect of re-planning in real time, it is advisable to take into account probability of non-delivery of appropriate material resources as the first and the second provider. In terms of capacity constraints any delay re-planning and determine backup machines and equipment leads to losses from the reduction in production volumes in subsequent stages.

**References**


