Aspects of transport system management within mining complex using information and telecommunication systems

A S Semykina, N A Zagorodniy, A A Konev, E V Duganova

Belgorod State Technological University named after V.G. Shukhov, 46 Kostyukov St., Belgorod, 308012, Russia

E-mail: fantarock@mail.ru

Abstract: The paper considers aspects of transport system management within the mining complex. It indicates information and telecommunication systems that are used to increase transportation efficiency. It also describes key advantages and disadvantages. It is found that software products of the Modular Company used in pits allow increasing transport performance, minimizing losses and ensuring efficient transportation of minerals.

1. Introduction
At present, every mining company strives to reduce time and cost for production and transportation of iron ore raw materials. The global positioning system (GPS) is no more sufficient for efficient management and control over production. Many producers develop software products, which, when combined with GPS, allow receiving information on the entire production, including transportation stages, detecting downtime and eliminating all issues immediately. Therefore, the analysis of computer-assisted systems to control production through open and deep pit mining of minerals remains an urgent task.

The transportation of minerals from a pit to a processing plant or an external dump represents one of the major technological processes covering mining and production of iron ore and overburden rocks.

Thus, for instance, the Lebedinsky GOK pit generally applies high-performance loading machines as KrAZ, dump trucks as BELAZ-75131, BELAZ-75309, CAT-785C, CAT-789C, etc. [1]. A dump truck with high loading capacity is able to transport up to 220 t of iron ore per one trip.

GLONASS-GPS system is used to control and optimize work of a transport complex in pits. This system makes it possible to control all production stages in real time that allows making all necessary changes and adjustments in due time. The disadvantage of this system is its weak satellite signal or its absence at the pit bottom, which may suspend work of production control systems and fail to monitor potential operation failures in due time.

Currently, mining enterprises use software products of the leading foreign manufacturers: Modular (USA), Wenco (Canada), Micromine (Australia) and domestic ones: Soyuztekhnokom, Promtech, Karier, etc. to manage and control their mining transport [2].

Peculiar features of foreign automatic control systems used in mining transportation include the fact that they were developed with a wide use of computer aids, and computer-based solutions of tasks bound to the theory of linear and dynamic programming were used as an algorithm of optimal control
of cargo transportation. A radio communication system is widely used to ensure prompt link of a dispatcher with dump truck drivers [9].

2. Mining transport control via Modular

The work of heavy-load dump trucks, using the example of Lebedinsky GOK, is arranged through the automated control system produced by Modular Mining System.

Modular Mining System is the corporation engaged in development of computer systems for mining control in open and deep pit production [6].

The Modular software system ensures control over the entire transportation process and technical condition of machines in real time. The Modular model studies allow controlling shift turnaround and implementing the strategy of dump trucks distribution along all pit sites, modeling trips to loading terminals with changing the transportation route [1, 3].

The Modular automated control system used for mining transportation gives an opportunity for mining enterprises to control the entire process of minerals transportation, namely:

1. to control transported volumes;
2. to select a rational transportation route;
3. to control fuel consumption;
4. to control transportation time;
5. to choose the most suitable and efficient arrangement of access road stations;
6. to ensure strategic placement of repair, filling stations and sediment tanks;
7. to control technical condition of the equipment;
8. to control road conditions, etc.

Dispatch, ModularReady, AssetAlert, PTX-B, MineCare and ProVision are the most widely spread and utilized systems produced by the Modular Mining System.

One of the most critical and widely applied Modular systems is the Dispatch integrated software package, which main functions are specified in Figure 1.

The Dispatch software allows controlling and managing work of dump trucks, controlling fuel consumption and quantity of transported goods, planning maintenance of transport machines. Due to its use the enterprises are able to enhance their performance, production efficiency, level of safety and cost management.

The GPS system, which operating mode is combined with an operating mode of the Dispatch software, makes it possible to define and trace the location of transport and equipment within a pit, as well as to monitor road conditions. The transfer of images on the location of dump trucks and excavators from a pit ensures online control over the transportation process.

The Dispatch system ensures sound control of all vehicles. Information from on-board computers installed in dump trucks and excavators is transferred to the central computer of the single center. Thus, it captures transport delay and downtime, which allows the dispatcher taking immediate measures.

| Dispatch function                  |
|-----------------------------------|
| Remote control                    |
| Transport loading analysis        |
| Materials mixing control          |
| Traffic flow optimization         |
| Fuel consumption control          |
| On-line reporting                 |

*Figure 1. Dispatch function*

Loading and unloading of dump truck with iron ore and overburden rocks is also controlled by the Dispatch system. Infrared sensors, installed on an excavator and a dump truck, ensure loading and unloading and control the cargo volume using the load cell.
Technical conditions of machinery and equipment are controlled in real time via the ModularReady interface. The information obtained from this program makes it possible to define technical failures and to take urgent measures for their elimination, which, in turn, will positively impact the productivity and safety of transportation.

The AssetAlert system of the Modular company allows defining location, movement and speed, as well as technical conditions of any transport (fuel level, tire pressure, temperature, etc.). Being directly installed on a vehicle, the system reads various parameters. The AssetAlert allows optimizing machine operation, controlling their movement, preventing downtime, detecting failures and defects of transport in due time.

The mobile PTX-B platform of the Modular company is mounted on dump trucks, excavators and other equipment, thus making it possible for an operator to interact with the system. Using the screen and the portable computer a user-friendly system-based interface of the operator is installed. This interface allows receiving the necessary information on transportation details, road and transport conditions, loading and unloading, etc. without interrupting the production.

The MineCare system is used to organize transport maintenance works. It allows obtaining information on technical condition of dump trucks and excavators. Remote monitoring of technical conditions, tracing of downtime and delays, reasons for failures make it possible to define the exact date when vehicle maintenance or repair shall be made. The MineCare allows reducing costs of maintenance or repair and increases performance, service life and productivity of machinery.

When detecting failures of mining vehicles or equipment, malfunctions during transportation of raw materials, the Modular system notifies the corresponding division on emerging issues. The MineCare maintenance control system allows displaying an actual event with audio signal. Thus, the system tracks unplanned shutdowns of dump trucks, malfunctions of machine knots and units. This maintenance control system is also able to forecast failures and define the terms of regular maintenance.

The ProVision system provides for real-time optimization of the mining process. On the example of the excavator, the ProVision defines the direction of raw materials extraction, which ensures higher quality production, defines boundaries of ore occurrence, controls direction, movement and inclination angle of a bucket, controls bench bottom limits, etc.

Each system of the Modular Mining System company presented above interacts with each other. The joint use of software systems and the GPS makes it possible to integrate the obtained data, to control the transportation, to define the most complicated sites, to keep track of technical condition and work of vehicles, and to ensure their best performance.

3. Main factors reducing the efficiency of transportation
The transportation of iron ore raw materials among all processes related to mining is the most complicated and energy-intensive. The transportation control requires special techniques and methods, as well as the use of modern means of telecommunication and software alongside with the implementation of the dispatch system.

Disturbance of process conditions, failures in operation and, consequently, time losses and cost resulted in the need to increase the transportation efficiency of iron ore raw materials in a pit via dispatch tools. Among others, the system triggered the following improvements:

1. Downtime of dump trucks and excavators.

   During mining dump trucks and heavy-load vehicles operate in pits for quite a long time. This leads to excessive fuel consumption and various failures of machinery. Suspense-in-maintenance leads to time and financial losses. The Dispatch software helps to reduce the downtime of dump trucks and other machinery to a minimum.

   The Dispatch applies linear programming algorithm thus defining the maximum possible flow rate between sources of rocks and their recipients. It considers operational parameters of vehicles: equipment size, compliance of an excavator and a dump truck and assigning the excavator to a particular site. The optimal flow rate of materials is thus calculated. In order to make sure that
available vehicles comply with the optimal flow of materials, the dynamic programming algorithm is used [8].

The Dispatch system helps to define the shortest route to loading stations, a treatment facility or an external dump. The Dispatch allows creating the most rational route of transportation.

2. Lack of fuel and shift turnaround.

Lack of fuel in a tank can lead to operating failures and shutdown, which will definitely lead to certain losses. The Dispatch system controls fuel consumption. At the minimum fuel level, the system notifies the dispatcher and sends the dump truck for refueling. In this case, the Dispatch minimizes run and downtime at gas stations.

The Dispatch module of shift turnaround control allows increasing equipment performance at the beginning and the end of a shift. The system automatically forecasts whether, for instance, a dump truck will manage to make another trip before the shift end, and thereby distributes work of employees and transport throughout a shift.

3. Transport delays.

Transport delays may happen for many reasons. They may happen due to malfunction of a dump truck or an excavator, increase in loading time, choice of irrational route or failure to access the loading area, etc. Wrong trip or choice of irrational route lead to excessive fuel consumption and time losses. The Dispatch system allows selecting the corresponding route with minimum losses, managing employees and equipment, creating work schedules and ensuring efficient management of all production stages.

4. Incorrect weight distribution.

Incorrect distribution of iron ore to the destination point may happen during transportation of raw materials. Transporting ores to a dump or sending barren rocks to a factory leads to considerable losses. The ProVision system checks ore condition in terms of its compliance with the discharge place.

5. Roughness of pit banks.

The ProVision system reduces time of a dump truck for loading. The ProVision system defines flatter loading platforms, which reduces time of loading and fuel consumption.

6. Transport failures.

Various machinery failures and malfunctions may occur during operation in a pit [5]. The MineCare system allows controlling technical condition of equipment, detecting failures in due time and setting time for maintenance.

Besides, the above reasons for failures in transportation, there is another complicated aspect, i.e. insufficient control of equipment condition, overspeed, malfunctions of service equipment, failure of tracking and control, improper operation of equipment, reduction of service life, insufficient control over maintenance, failure in pit navigation, etc. [4].

The Modular product package may serve the solution to potential operating failures. The systems and their modules ensure obtaining information online and taking measures to eliminate reasons of transportation failure. The Modular systems also make it possible to optimize all stages of the mining process.

4. Conclusions

The use of software products and radio communication tools of the Modular Mining System alongside with GPS in many respects simplifies the management of the entire transportation in a pit. The improvement of vehicle control of mining enterprises is mainly achieved through the Modular systems. Systems and modules of the Modular Mining System allow creating rational routes, controlling loading time, cargo volumes, working platform zones, technical condition of vehicles, their maintenance and repair, employees work schedule, etc. Continuous online control over all transportation stages will balance the transportation process with regard to other processes related to ore mining, save time for transportation, reduce vehicle downtime, exclude potential failures in operation, ensure efficiency of the transportation, increase transport performance, and reduce transportation costs.
The example of Lebedinsky GOK demonstrated that the Modular products allowed improving productivity of dump trucks and excavators, increasing the cargo volume, reducing time of ore delivery to a factory or a dump. Currently, all efforts of the Lebedinsky GOK are aimed to increase the operating performance of its transport infrastructure and transport complex [7].

The main disadvantages of the Modular system include limited speed and carrying capacity of a transmission channel, potential losses of information on trips. Besides, the information may get into the so-called shadow zone, equipment may be overloaded especially in pits with a large vehicle park, and large number of repeaters may be required.

Despite all disadvantages, the Modular software complex provides an opportunity to increase the performance of mining enterprises, improve labor productivity, ensure production of high-quality raw materials in hard-to-reach areas, and reduce losses.

Various problems occur during transportation thus causing its underperformance. In order to solve the above tasks, every mining and processing enterprise shall ensure the following:

1. to optimize traffic flows. To take full advantage of time and resources. To minimize downtime of dump trucks and excavators;
2. to increase technical availability of machinery by ensuring regular monitoring of its technical conditions, as well as maintenance and repair works;
3. to ensure safe mining operations;
4. to carry out routine analysis of operating performance by collecting the necessary data, adopting the obtained information to ensure prompt and correct decisions on further actions;
5. to ensure continuous monitoring of events.

Methods and techniques of transport management serve efficient tools of managing any mining-transport complex of an enterprise and achieving the maximum performance indicators.

If embedded into mining enterprises, such systems allow eliminating losses of transportation and reaching the marginal productivity.

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