Models of MZV Production Logistics in Research and Education

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KEYWORDS: *modeling, optimization, material flows, management, mine transport system*

ABSTRACT: *Supplying of mine working places with material and mine outfit, belongs among the most demanding tasks of an automated control system of technological process of the underground coal mine. This part of logistics ensures the correct run of material flows in the framework of the whole underground mine complex, and namely both on its surface and in its underground part, in coalfields as well. The general goal of the operative management is the fact so that the materials and mine outfit would be on given working place in given time period, in assortment required and necessary quantity. The management of the whole process has to ensure the optimization of the delivery in such a way so that the non-technological idle times would not arise which would be the cause of delay of the mining working places preparation and so the fall-outs in mining and in the final consequence the cause of lower profitability of the mining process.*

It is generally known that the quality of the control and management of whatever process depends on the knowledge of the given process and the possibility of its prediction. Implementation of simulation models on a computer and testing various possibilities are the basic components of the system control. Computer models enable determine, checked respectively, the critical points in colliery transport system, influence of different variants on the control strategy. This all make possible to control such a complex problems.

The problems of operative management of material flows on working places of the underground mine are characteristic by their complexity, and namely due to the fact that from the viewpoint of the organizational structure with the managing of which various departments deal which, in the time being, fall both under the competence of chief engineer and under the competence of deputy-director for production but also the deputy-director for economics. The flow of materials both new and the re-used one and respective also the materials determined for renovation is not managed and controlled from one centre, and, that's why, the whole series of discrepancies arises, especially under the extraordinary situations.

So that it could be possible to manage the whole process in all its connections it is necessary to have the simulation models for disposal realized on the basis of mathematical models with the help of simulation programs. The mathematical models of processes must be based upon the analyses on concrete operation situations including the transport technology, information subsystem and last but not least the organizational structure already mentioned. The computer aid is necessary, too, and namely in the form of specially developed application software. For the purpose of operative control of the above mentioned problems we developed, in the framework of project GAČR (Grant Agency of the Czech Republic), No.: 105/01/0009, the simulation program ASMAT on our working place.(Faculty of mining and geology, Institute of economics a control systems, Department of Automated control systems).This paper analyzes both the development computer models and simulation for controlling the whole problems.

1 INTRODUCTION

Nowadays, in a situation when coal companies are under a pressure of competition and difficulties with coal sales, is very important to increase their productivity and efficiency. This can be made by harmonizing mining and transport due to automated control systems in deep mines.

One of the most important problems, in deep mines, is supplying working places with materials. Everything has to be done in the right time. Working places need material in the right assortment and necessary quantity. If the needed materials are not in the required quantity and assortment at the working places in time, this may cause significant economic wastes. But this is complicated problems and has to be controlled. The aim of the material flows control is to create optimum conditions to the nines continuity. This aim has to be ensured under permanently changing conditions of the dynamics of time-spatial mining process and with the interaction among other underground coal mine subsystems. This required simulation models produced by computer. Then the models enable to optimize and predict the given process.

2 PROBLEM STATEMENTS

The purpose of simulation models of the material and mine outfit transport on working places of underground coal mines is to help the operating control of the working place material supply by material (WMS). The goal of operating control is so that the material required would be transported on working place in time, and namely in quantity and assortment required. If it is not so then the undesired idle times in preparation works arise and due to it also the economic losses. The complex solution of these problems requires such control system which would ensure the trouble-free and rational material flow to single mine working places, robbing, clearance, sorting and renewal of the material used, at optimum concentration of labor force taking share in transport and handling means.

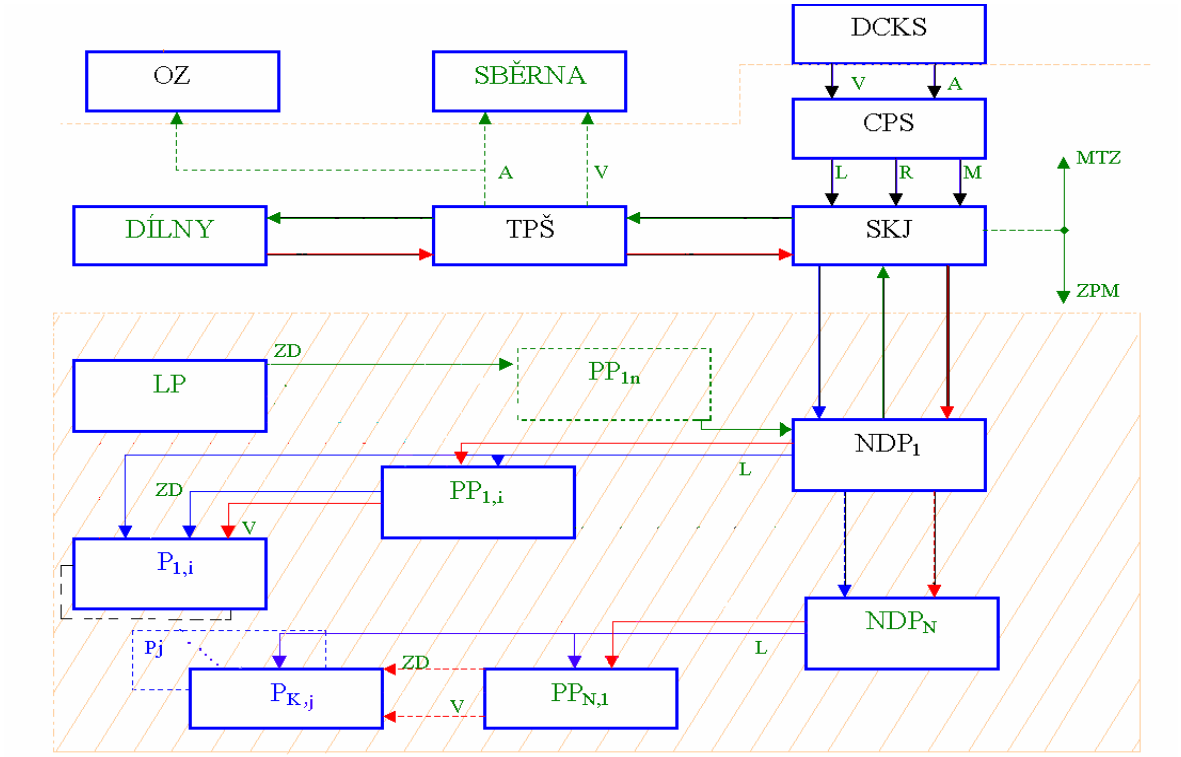

Figure 1 – MZV subsystem chart

The situation in supplying the mine working places with material and mine outfit is illustrated as a system in figure 1. The figure is divided into the surface and underground part of the mine. The system of material and technical supplying concerns the problems of suppliers' -customers' relations, materials flow from the suppliers (DCKS) by the railway siding (V) or car transport (A), material storage on stockyards and in the stores on the mine surface (CPS). The shunting trackage at the shaft (SKJ) creates the border, as a system, between the area of material and technical supplying and the area of mine working places supplying. The area of the mine working places supplying with material includes the transport of material and mine outfit from the mine surface to the mine levels and, from there, then on single mine working places by the system of the controlled delivery of material according to the actual consumption. The transport of material and mine outfit on preparation working places (P1,i ,…… ,PK,j), up to the yielding

from the mine surface on the mine level NDP1 (N) is ensured in three ways: on rails (L), on suspended travel (ZD) and in the combined way. The combined way, mostly used, is created by the transport on rails up to the place of transship point (PP1,i) and after transloading of material on suspended travel, then by the transport on suspended travel. In the interest of the greatest continuity of material and mine outfit transport as possible it is desirable to shunt the trains with material on shunting trackage at the material shaft according to the levels and places of consumption.

The material flows from the mine working places liquidated have the opposite direction of transport (LP). After their classification according to the wear degree (TPŠ) they are either directed into the workshops on the mine surface or into the repairs plants or collection plant. After renewal in the workshops the material is used again. In some underground coal mines there exists also the possibility of the material and outfit renewal in workshops located directly in the underground. After renewal, this material is added to the transport of new, non-used material.

3 SIMULATION MODELS

It is generally known that the quality of the control and management of whatever process depends on the knowledge of the given process and the possibility of its prediction. Implementation of simulation models on a computer and testing various possibilities are the basic components of the system control. Computer models enable determine, checked respectively, the critical points in colliery transport system, influence of different variants on the control strategy. This all make possible to control such a complex problems.

3.1 Analyses

To create the model of the material transport process, it is necessary to find out the particular transport structure, the Transport structure analysis, which is used in a specific colliery. According to (Strakoš,V. 1994) the whole transport process consists of the following sequence:

Delay (1) – loading (2) – delay (3) – transport (4) – delay (5) – unloading (6)

As we can see there are many different activities (machine, manual, etc.) depending on the used up transport system, see chapter above.

Management structure analysis is also used in the creation of computer models. A process of controlling delivery materials to the road heads and coalfaces is nearly different in any colliery. Many different managing centre and working groups, in deep mines in OKR, share in this problem.

The multi-aspect nature of these problems requires the system approach based upon the methodology of automated control systems which is based on the analysis of the control system and organization. The whole procedure of the control system analysis and organization is characterized by transformation of the following structures: (Burý, A. 1995)

Organizational structure(1) – functional structure(2) – information structure(3)

Organizational structure determines the composition and mutual relations of all organizational centers taking share in the organization and control of given process. It can be illustrated by oriented graph, in which are the elements of organizational structure - control centers, and the graph edges represent the hierarchy of relations between the control centers in mutual relations.

Functional structure describes all kinds of activities, which are performed by organizational centers in respect to the given process control. It is also determined by the graph, where the elements of structure are representing the single functions executed, and the edges of the net graph which express the mutual relations between the functions and sequences of their realization.

Information structure expresses the directions and characteristics of information flows. It can be defined either for the entity of the system functions or for the entity of organizational control centers. It can be illustrated by the oriented graph, where graph nodes are the elements of information structure, representing either the entity of functions or the entity of control centers, and edges express the information flows between them with corresponding relations.

3.2 Mathematical - Methodological Phase of Modeling

The organizationally control activities and activities of working technological character at ensuring the delivery of material on mine working place can be modeled and formulated mathematically by edge oriented network graph. On figure 2 is an example of modeled problems in deep mine. (Part of Lazy mine MZV subsystem).

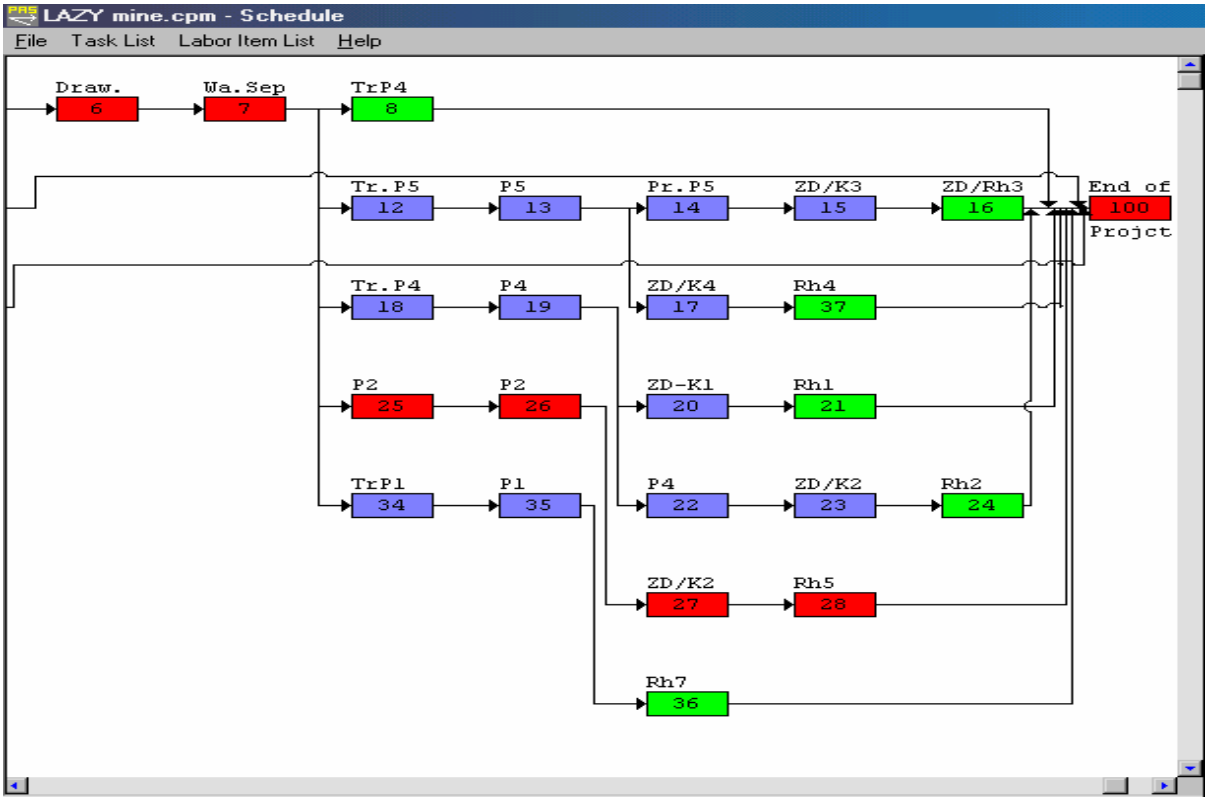

Figure 2 – An example of MZV net graph.

In the net diagram are connected tasks as: wagon separation (Wa.Sep.),locomotive transport of wagons with materials to the transloafing point (Tr.P1 – Tr.P5), transloading of material in transloading point on suspended travel (P1-P5), transport of materials on suspended travel from the transloading point up to the roadheads (Rh1-Rh7), etc. In the time order of their realization.

The control and organization of complicated systems, which are the technological processes and logistic processes, require the methods and simulation models for disposal which will enable:

- providing of exhaustive knowledge of relations and dependencies between all partial activities so that the clear and full overview of working procedure with the respect of given hierarchic control stage with all connections and conditions would be given;
- providing of effective term plan enabling:
  a) evaluation of importance of partial activities from the viewpoint of timely fulfilling of the whole action controlled,
  b) control of the works time progress,
  c) prediction of the work progress fulfilling in the future in such a way so that it is possible to realize the measures for elimination of the deviations arisen in time;
- he possibility of effective coordination of all activities taking part in given action;
- economic utilization of working machines and transport equipment which take share in given action, and namely from the viewpoint of further actions realized;
- the possibility of execution, to the end and timely, of all necessary changes in the framework of the terms set;
- the elimination of redundant information for certain stage of control;
- the setting of the whole time of the controlled action realization not only with the respect of direct costs connected with its realization but also with the respect of losses and additional

costs which would arise by extraordinary time period necessary for realization or by its extension;
- creation of presuppositions for smooth information flow as well as presuppositions for their processing on digital computer;
- optimization of the action from the viewpoint of the duration and resources.

3.3 Simulation Program

The more complex control of transport logistic process requires the solution of greater number of optimization tasks. And the application of operating analysis of such extensive tasks requires the processing of given algorithms with the application of simulation program.

The simulation program ASMAT we realized (Burý, A., Čech, R. 2002) in the framework of the project GAČR 105/01/0009 as the application software for creation of computer models and simulation of problems of control of supplying the mine working places with material and mine outfit. The conception of the program is based on the presupposition that the logistic process modeled can be formulated mathematically by oriented network graph (by the entity of nodes and corresponding oriented edges). Therefore the simulation program is based on the network oriented graphic environment for model creation (editing of network graph) with subsequent simulation. The offer menu of the ASMAT program enables the following functions:

- Work with a file – it serves for saving, reading, res. deleting of the model database from the computer disk.
- Editing of graphic network – it is the graphic mean for data input, entering the structure of computer model with the help of the network graph.
- Entering of input data – the experts estimations of the activities time duration, descriptions of activities and nodes of the graph, loaded and transported material etc.
- Time updating – entering of time of the controlled action commencement and time of updating of positions changes, graphical animation of movement of material batches in the network graph – model.
- Graphical illustration – drawing of network graph of the model and illustration of animation of the position change of the sets with material, with the possibility of detailed information concerning the assortment and quantity of material being transported.
- Gantt's diagram – illustration of time periods of the activities duration with identification of the critical activities. It enables also the illustration of time updating.
- Table illustration - of experts estimations, values of time reserves of the operations, terms of realization of the network graph nodes, probability of controlled points – milestones realization, probability of the nodes changes into the critical nodes.
- Probability of the controlled action completion in term – it enables the verification of correctness of the selected term of the controlled action completion and also to propose a new term for the realization probability set.
- Critical path – it illustrates the sequence of critical activities both graphically in the form of the Gantt's diagram and in the form of table extract with giving the nodes defining the critical activities, time period of given critical activity duration, its name, res. description.

On the figure 3, as an example of graphic outputs, is given the required simulation of the position of wagon sets with material including detailed information.

On the figure 3 is displayed the net diagram with the model of MZV subsystem of ČSA mine. It is displayed the position of the wagon sets with materials in the given time. (black) At the same time was asked the detailed information about assortment and quantity in the wagon set, which is in the position of the modeled action (19 – 21). This asked information is illustrated in the graphic output by the detailed table (dark green), which contains column of materials (MATERIÁL) and column of their quantity (MNOŽSTVÍ).

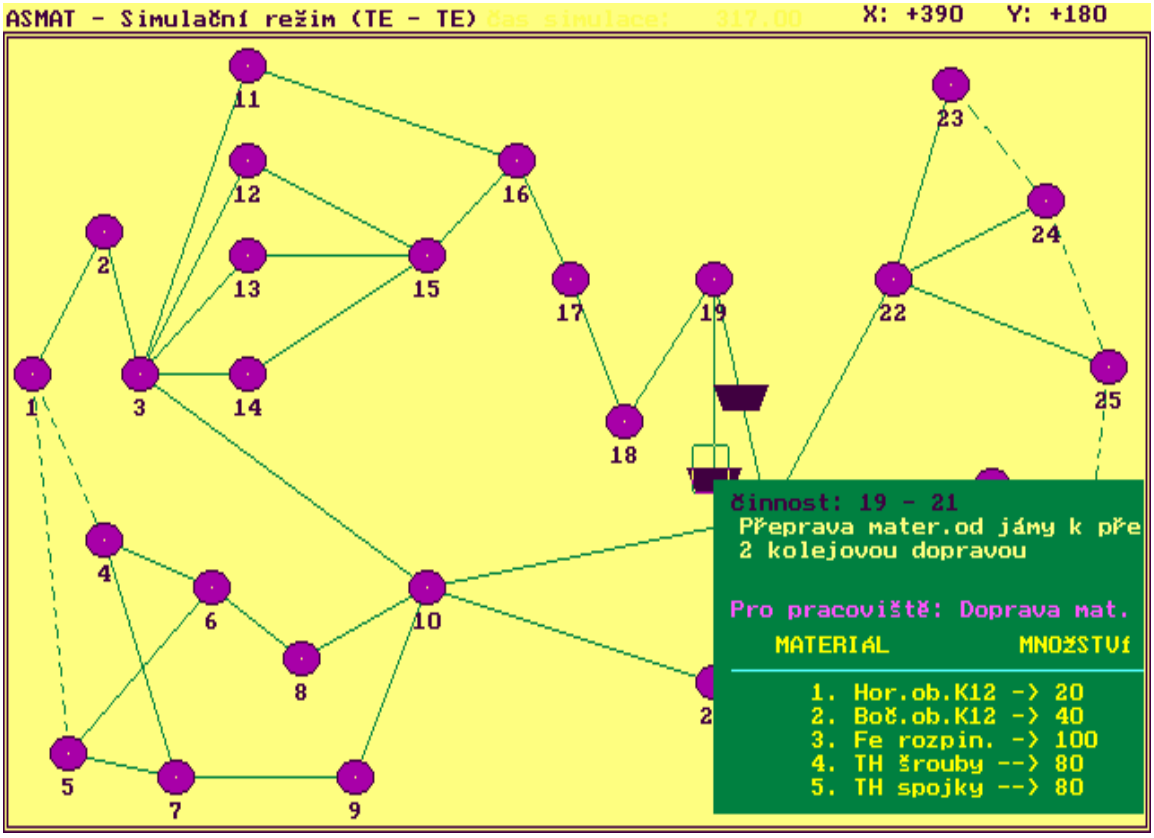

Figure 3 – An example of one ASMAT graphic outputs.

4 CONCLUSION

The problems of controlled material flows to the working places in a deep coal mine is most important and complex. To solve it, this requires an automated control system based on information technology and simulation models produced by a computer with simulation program. The importance of simulation models of controlled material flows consists in the fact that there is the " tool " for the both operational and tactical material flows control.

The control of the work processes and keeping of the terms set in the framework of the logistic process by methods of network analysis leads to the optimisation of time and costs. Simulation models implementing by simulation program ASMAT, which was developed at our department, are then very good tools for that.

All methodology of creating simulation models, including simulation program, can be served for both research and education. At present, in our department, we also used them for trainning in the subjects: Automation of transport, Automation of mining process.

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