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SIMULATION TESTS OF MINE TRANSPORT SYSTEMS

Summary. In the paper a method of simulation tests for mine transport systems used in coal mines is presented. The simulation model can be applied to testing the properties and the behaviour of a certain class of transport systems containing surge bins in their structure. The simulation test results are presented relating to the effect of the surge bin capacity and its location on the efficiency of transport systems for some exemplary input data.

The results obtained have proved the usefulness of the simulation test technique for solving the problems of analysis and synthesis of the operational processes of mine transport systems.

1. INTRODUCTION

An effective way of increasing the capacity of the mining transport systems is the application of surge bins between some of the system elements or subsystems, whose factors of reliability differ considerably from one another.

There is however a problem of determining the rational capacity of the surge bins and the influence of definite capacities on the effective output of the transport system [1, 2].

Many publications were made on this subject. The methods proposed at first, which based on deterministic models, of searching for solutions by means of probabilistic models, or the attempts of using the mass service theory model for solving the problems of mine transport systems with surge bins have not yet given any positive results. There are still no effective solutions which could be used in practice.

The experience gained hitherto in this field make us look for solution of that problem in the simulation test methods.

In this paper is presented the method of determining the influence of the capacity and location of the surge bins on the output of the shaft transport machinery systems which compose very important subsystems of the mine machinery systems operating in coal mines.

To solve that problem the method of simulation tests is used. In the analysed shaft transport machinery systems (STMS) there are the following subsystems:

1. subsystem no 1 accomplishing the delivery of coal to the shaft bottom,
2. subsystem no 2 containing all the elements of the shaft bottom,
3. subsystem no 3 consisting of the winding gear with the headgear and the movable and immovable shaft elements,
4. subsystem no 4 containing all the elements of the shaft top,
5. subsystem no 5 accomplishing the receipt of coal from the shaft top.

Under the notion of the shaft transport machinery system (STMS) we understand a system comprising the five subsystems quoted above together with the relations between them. The particular interest of these systems can be interpreted by the fact, that the transport capacities of those systems often decide upon the current production capacities of mines.

2 2. SIMULATION TESTS

The results obtained from the wide operational investigations of the STMS (3), point to the usefulness of an analysis of the STMS structure comprising two surge bins. One surge bin Z1, should be placed between the two subsystems no 1 and no 2, and the other one (Z2) between the subsystems no 4 and 5 (fig. 1). The main purpose of the simulation tests was the determination of the relation between the capacity of the surge bins Z1 and Z2 and the effective output of the STMS. For the tests a typical STMS was assumed, which was divided into five subsystems, for which previously the factors characterising their operational processes were funnd [2].

The factors of failure formation rate λ and of failure decline rate β were the basis for the generation of time intervals of the proper operation and the times of failure duration of the individual subsystems.

In the generation process of the time intervals mentioned above some limitations were assumed regarding the generated values, resulting from accuracy of the input data, the assumed accuracy of the simulation teste and from the principles of the operational preces organisation of the systems analysed.

A block diagram of the STMS for which the simulation tests were carried out are presented in fig. 1.

The input parameters for the simulations tests were:

a) failure formation rate $\lambda_1 - \lambda_5$
b) failure decline rate $\beta_1 - \beta_5$
c) nominal outputs of subsystems E_1 to E_5
d) surge bin capacities Z1 and Z2
e) overall simulation time TK,
f) daily disposable time of operation of subsystems 1 to 5.

The recorded output quantities of the coal transport simulation process were as follows:

a) sum of coal delivered by subsystem no 1, W (1) counted in front of the surge bin at the shaft bottom,
b) sum of coal transported by the subsystems 1 to 4, W(4) counted in front of the surge bin at the shaft top,
c) sum of coal transported by the system analysed, W (5) counted as the amount of coal collected by the preparation plant,
d) sum of coal accumulated in the surge bin Z1 at the shaft bottom, S1,
e) sum of coal accumulated in the Z2 surge bin at the shaft top, S2,
f) sum of untransported coal by the system analysed (losses in output by break-downs of STMS subsystems, at certain capacities of surge bins), S.

Having in mind the aim of investigation and the required accuracy a mathematical model of the simulator was worked out. When setting up the model all the characteristic cases of the STMS structure were analysed, i.e. the system could habe one surge bin, two bins, or it may have no surge bins at all in its structure. According to the case analysed, the simulated coal transport was accomplished by all the subsystems simultaneously, or by some of them. The simulator realising the mathematical model on the digital computer consists of seven segments. The operation of each segment was described in the form which corresponded to their programs in the FORTRAN source language. In fig. 2 are shown the diagrams of connections and callings of each of the simulator segments. The "main" segment is used to introduce the input data, to call the segment which directly controls the simulation process and to lead the simulation output. The segment "SYMU" operates with the random number generator and controls directly the run of the simulation process.

The segments "subsystem no 1", "surge bin D", subsystems 2, 3, 4", "surge bin G", "subsystem 5" accomplish the simulation process of coal transport by the STMS.

By the STMS model, worked out for the digital computer, the influence can be determined of all the input parameters on the STMS efficiency, by means of the superposition method.

A detailed instruction explaining the denominations taken during working out and programming the model for the digital computer is given in paper (2).

During working out and programming, the correctness of the simulator model was checked many times. The checking was done of the full printout of the simulation process for the given system structure.

The actual planning of experiments was preceded by the primary simulation runs, which led to some limitation of numbers of the necessary experiments for solving the formulated problem.

It was assumed, that the nominal outpats of the individual subsystems were equal, and that the disposable times of operation of all the subsystems were equal and coincident. Consequently for the definite values of λ and β factors the simulation of the coal transport in the STMS was running in dependence on the structure assumed.

The tests were carried out for different sites and capacities of the surge bins and for several nominal outputs E_1 to E_5 of the systems analysed.

The factors of failure formation and decline rates of the STMS subsystems were taken on the level of the mean values obtained during operational tests [2] ;

$$\lambda_1 = 0{,}90 \frac{1}{h} ; \qquad \beta_1 = 4{,}0 \frac{1}{h} ;$$

$$\lambda_2 = 0{,}14 \frac{1}{h} ; \qquad \beta_2 = 5{,}0 \frac{1}{h} ;$$

$$\lambda_3 = 0{,}035 \frac{1}{h} ; \qquad \beta_3 = 3{,}0 \frac{1}{h} ;$$

$$\lambda_4 = 0{,}11 \frac{1}{h} ; \qquad \beta_4 = 2{,}7 \frac{1}{h} ;$$

$$\lambda_5 = 0{,}37 \frac{1}{h} ; \qquad \beta_5 = 4{,}5 \frac{1}{h} ;$$

The capacity of the Z1 surge bin at the shaft bottom was taken in the range of 0 to 2000 Mg with a step of 200 Mg and the capacity of the shaft top surge bin Z2 in the range of 0 to 600 Mg with the 100 Mg step.

The assumption was made, that the system operates for six days per week and that the disposable time of the individual subsystems is 18 hours during the working day, i.e. TD = 18 h.

It was also assumed, that the failures of the individual STMS subsystems are currently eliminated during the disposable operating time and also during the time assigned for repairs, overhauls and preventive renewals. The overall simulation time TK = 108 h was taken, which is equivalent to the working week of the system analysed. This time period was accepted as sufficient after the results had been compared, (for some selected simulation runs) which were printed after the single and the double simulation time i.e. 108 and 216 h. The deviations were some tens of hundredths of one percent.

By the simulation tests the k_v factor was determined, which represents an increase of the STMS output in dependence on the capacity and siting of the surge bins. In fig. 3 and 4 are presented the exemplary values of the k_v factor depending on the surge bin capacity Z1, for various nominal capacities E keeping the rest of the input parameters constant, namely Z2 = 0 and Z2 = 200 (fig. 4). Similar examples of k_v are shown in fig. 5 and 6 depending on the surge bin capacity Z2, for warious nominal capacities E, and the constant rest input parameters and Z1 = 0 and Z1 = 200 (fig. 6).

3. CONCLUSION

The STMS simulation model gives the possibility for studying the properties and behaviour of transport systems of a certain class with the surge bins. It is possible to follow dynamically the coal transport process of a system with assumed parameters and structure. Also the influence of all the input parameters on the capacity of the system can be studied, i.e. the factors of the operational reliability, nominal outputs E, surge bin capacities. The results give the practical possibility to choose properly the capacity of the surge bins for a transport system characterized by certain factors of operational reliability.

REFERENCES

[1] Hansel J., Kuleczka J.: Propozycja sposobu wyznaczania efektywnej wydajności godzinowej skipowych urządzeń wyciągowych. "Calculation method for the hourly effective winding capacity of the skip winding installations". III Konferencja Naukowo-Techniczna "Kierunki rozwoju górniczych urządzeń wyciągowych", Kraków 1984.

[2] Kuleczka J.: Wyznaczenie wpływu niezawodności eksploatacyjnej na wydajność systemów maszynowych transportu pionowego. "Determination of the exploitational reliability on the capacity fo the shaft transport machinery systems". Praca doktorska, AGH, Kraków 1983.

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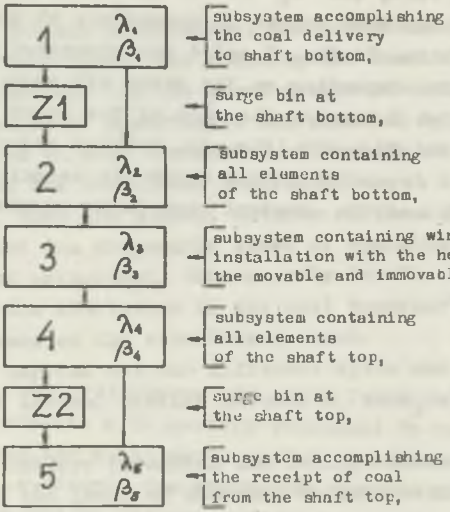

Fig. 1. Block diagram of the STMS for which simulation tests were made

Legend: 1 - subsystem accomplishing the coal delivery to shaft bottom, 2 - subsystem containing all elements of the shaft bottom, 3 - subsystem containing winding installation with the headgear and the movable and immovable equipment, 4 - subsystem containing all the elements of the shaft top, 5 - subsystem accomplishing the receipt of coal from the shaft top, Z1 - surge bin at the shaft bottom, Z2 - surge bin at the shaft top

Rys. 1. Schemat blokowy system maszynowego transportu szybowego, dla którego przeprowadzono badania symulacyjne

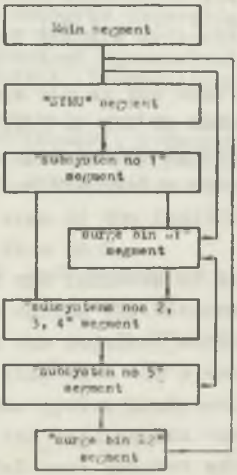

Fig. 2. Circuit and call diagram of the simulator segments

Rys. 2 Schemat połączeń segmentu symulatora

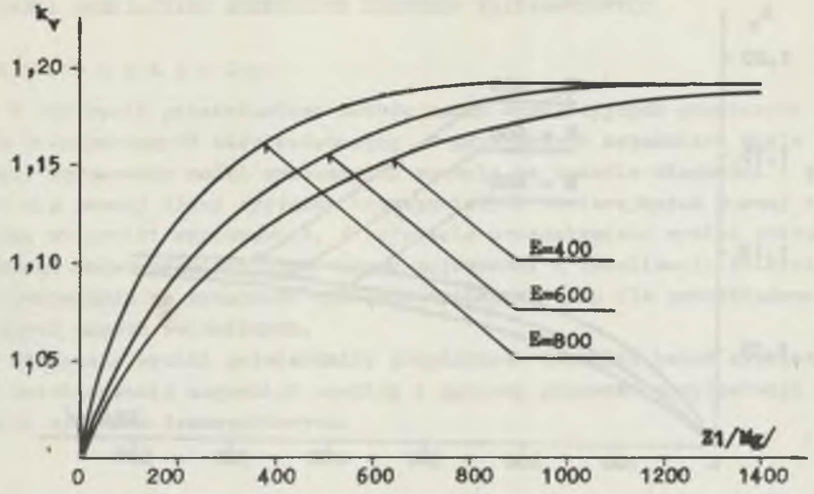

Fig. 3. k_v factor versus surge bin capacity Z1 for various nominal outputs E, the rest of input parameters kept constant and Z2 = 0

Rys. 3. Wykres współczynnika k_v w funkcji pojemności zbiornika wyrównawczego dla różnych wydajności E, pozostałe parametry systemu byży stałe a Z2 = 0

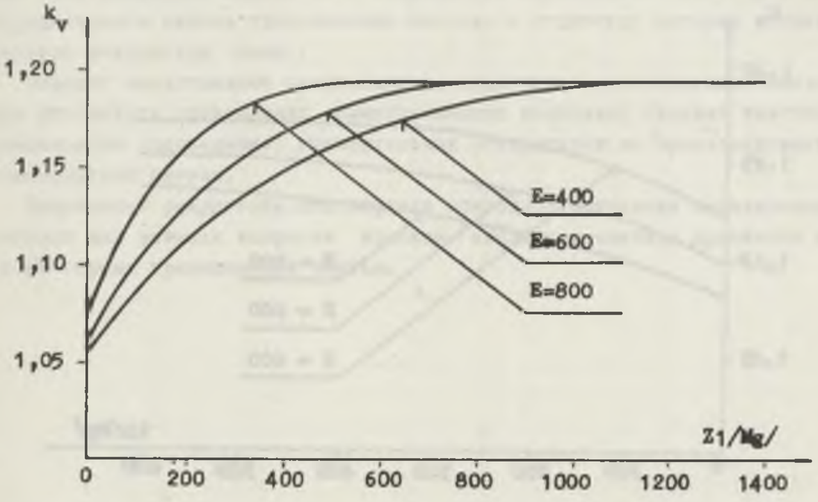

Fig. 4. k_v factor versus Z1 surge bin capacity for various nominal outputs E, the rest of input parameters being constant and Z2 = 200

Rys. 4. Wykres współczynnika k_v w funkcji pojemności zbiornika wyrównawczego dla różnych wydajności E, pozostałe parametry systemu były stałe a Z2 = 200

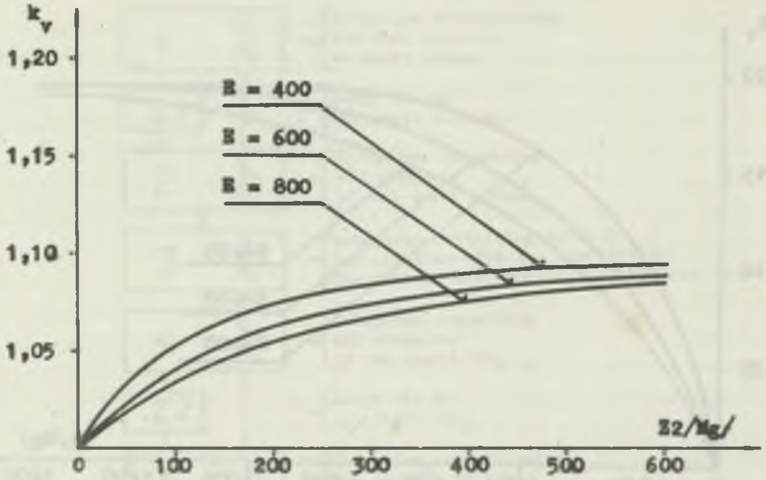

Fig. 5. k_v factor versus Z2 surge bin capacity for various nominal outpust E, the rest of input parameters being constant and Z1 = 0

Rys. 5. Wykres współczynnika k_v w funkcji Z2 pojemności zbiornika wyrównawczego dla różnych wydajności E, pozostałe parametry systemu były stałe a Z1 = 0

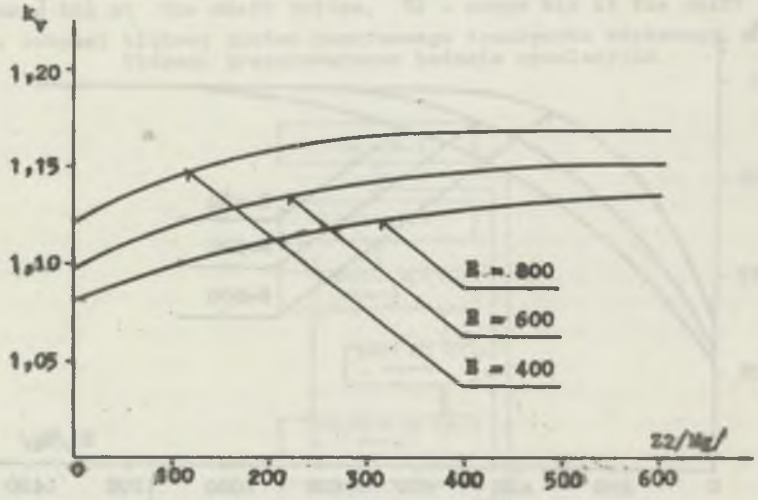

Fig. 6. k_v factor versus Z2 surge bin capacity for various nominal outputs E, the rest of input parameters being constant and Z1 = 200

Rys. 6. Wykres współczynnika k_v w funkcji Z2 pojemności zbiornika wyrównawczego dla różnych wydajności E, pozostałe parametry systemu były stałe a Z1 = 200

BADANIA SYMULACYJNE GÓRNICZYCH SYSTEMÓW TRANSPORTOWYCH

Streszczenie

W referacie przedstawiono metodę badań symulacyjnych górniczych systemów transportowych eksploatowanych w głębinowych kopalniach węgla kamiennego. Opracowany model symulacyjny pozwala na badanie własności i zachowanie się pewnej klasy systemów transportowych zawierających w swej strukturze zbiorniki wyrównawcze. W referacie przedstawiono wyniki przeprowadzonych badań symulacyjnych wpływu pojemności i lokalizacji zbiorników wyrównawczych na wydajność systemów transportowych dla przeykładowo dobranych danych wejściowych.

Otrzymane wyniki potwierdziły przydatność techniki badań symulacyjnych do rozwiązywania zagadnień analizy i syntezy procesów eksploatacji górniczych systemów transportowych.

СЫМИТИРОВАННЫЕ ИСПЫТАНИЯ ГОРНЫХ ТРАНСПОРТНЫХ СИСТЕМ

Резюме

В реферате представлен метод сымитированных испытаний горных транспортных систем, эксплуатируемых на подземных каменноугольных шахтах. Разработанная сымитированная модель дает возможность исследовать свойства и поведение определенного класса транспортных систем, в структуру которых входят уравнительные резурвуары (баки).

Реферат представляет основанные на примерах соответствующих выходных данных результаты проведённых сымитированных испытаний влияния вместимости и локализации (размещения) уравнительных резервуаров на производительность транспортных систем.

Полученные результаты подтвердили пригодность техники сымитированных испытаний для решения вопросов проблем анализа и синтеза процессов эксплуатации горных транспортных систем.