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PERTURBATION PROBLEMS IN A CONVEYANCE MOTION IN THE INTEGRATED TRANSPORT SYSTEM OF CONTINUOUS OPERATION

Summary. One out of many propositions for replacement of hoisting installations is the Integrated Transport System of Continuous Operation. The system is briefly described in the paper and a peculiar problem of perturbation in conveyance motion in the system is considered. Basic reasons of conveyance stoppage are listed with the reference to the points where they come into being. Moreover, the system "looseness" is defined and considered, its essential measure presented and the influence for the probability of conveyance stopage tackled. At the end of the paper, an example of the system division with regard to its looseness is shown which is the first, basic step in the calculation of system capacity procedure.

1. INTRODUCTION

Nowadays, there is a clearly visible tendency to find an alternative method of hoisting for undergroud mines. Several methods and techniques are developed to such an extend that they offer the replacement for classic hoisting installations in some areas. The Kiruna Electric Truck System, Flexowell Technology, Continental Sandwich Type High Angle Conveyors are - among the others - good examples of such the effer.

There are also some new ideas of vertical transportation like pneumatic hoisting for instance. A brand new proposition is the Multi-conveyance Continuous Hoisting considered in the Republic of South Africa where the research work and some stand tests have been carried out since 1987. In Poland a similar idea is being tackled since more than a year and investigation is carried out on the theoretical ground.

There are many very interesting problems waiting for their solution associated with this latter new system of transportation. In Poland the Multi-conveyance Continuous Hoisting has been termed as the Integrated Transport System of Continuous Operation.

The purpose of this paper is to consider some basic problems connected with the analysis of perturbation in a conveyance motion in the Intergated

Transport System of Continuous Operation.

2. SYSTEM DESCRIPTION

It is assumed that the haulage of mineral won from underground is accomplished by a system of many conveyances running on both vertical and horizontal special tracks, creating a closed loop. Each conveyance has its own electrical drive propelling two double toothed wheels rotating and running on two parallel track lanes. Conveyances move continuously with a low speed, say 2 m/s one after another servicing all undergroud levels and hauling mineral won onto a bank to the unloading point where they are released from the load (Fig.1). Dumping is accomplished without stoppage of conveyance. However, if the full ore box has to be removef from the conveyance due to some reason, its motion is stopped to do this and another empty box is fixed to the conveyance. Then the motion is resumed again. But this is an exception rather than the rule.

Instead of a pretty assumption on continuous transportation some interruptions and breaks in this process are inevitable. Let us disscus some basic problems connected with this phenomenon.

3. PERTURBATION ANALYSIS IN A CONVEYANCE MOTION

There is no doubt that each unforeseen conveyance stoppage lower the system effectivness. All interruptions and breaks disturb hauling and they make this in a twofold manner:

- halted conveyance either does not haul ore if it is full or it does not run towards loading point if it is empty,
- halted conveyance makes "jam" which can result in perturbation of further conveyances motion.

Basic reasons of conveyance stoppage are the following:

a) unreliability of conveyance,
b) failure of track,
c) ore lack in loading point,
d) lack of the system driving power,
e) obstruction in dumping point,
f) track blockade by junction,
g) track blockade by obstacle (halted conveyance or another reason),
h) aimed conveyance stoppage (for replacement of ore box, directing conveyance onto another track line etc).

Notice, that the above reasons can grouped in five sets depending on object which caused this. Here we have:

- conveyance (a), (g),
- track,
- another piece of equipment (c) - (f),
-something unexpected (g),
- control system centre (h).

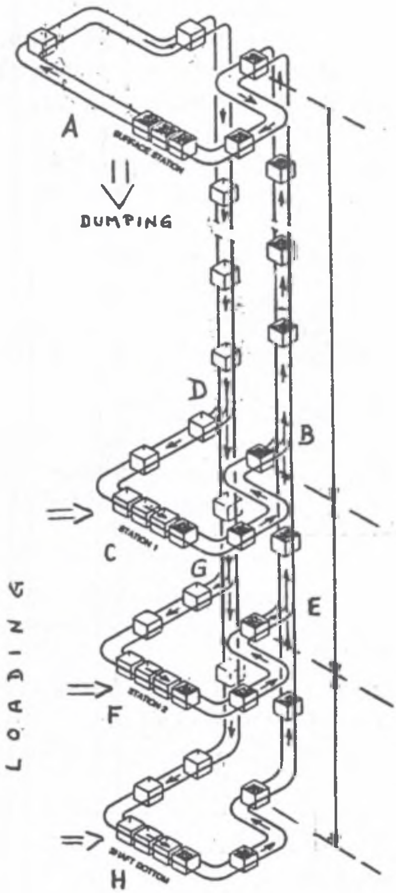

Fig.1. Sketch of the Integrated Transport System of Continuous Operation and its division on points significant for the system looseness

Let us perceive that due to causes listed recently in points a, b, d, g and h conveyance can be halted at any track point stoppage because of reasons named in points c, e, f refer to particular track segments only.

Reasons of perturbation are associated with:

- reliability properties of equipment (a) - (e),
- organisation of conveyance movement (f),
- occurance of unexpected blockade (g),
- deterministic action in the framework of the system control (h).

For perturbation of conveyahce motion has influence a special characteristic feature of the system - its "looseness" (rev. package). This is a property of the system consisting in its resistance against blocking, congestion.

Under the term congestion we mean here conveyance (or conveyances) stoppage without any respect on reason,in a certain point of track which can cause:

- halting necessity of other conveyances motion,
- stoppage of ore delivery to the system,
- stoppage of ore receiving in the dumping point,
- necessity to direct other conveyances onto the reserve track to pass round the congestion,
- to send the failed conveyance to the workshop for repair.

For a system with one loading and one dumping points the basic measure of system looseness is the ratio between the mean number of conveyances being on track of a hauling loop to the total track loop length for given:

- conveyance reliability,
- track reliability,
- reliability of other pieces of equipment co-operating with the loop.

Thus the ratio is the average conveyance number per unit of track loop length.

The term "the mean number of conveyances being on track" means that we assume the dynamic dispatching following increment or decrement in ore production for instance which causes variation in the number of conveyances running on track loop.

If the number of loading points is two or more or the number of dumping points is two or more the term "looseness" should refer to the track loop intervals only where this ratio is constant. Thus we can consider the system looseness on its j-th interval as the ratio between the mean number of conveyances being on this interval to the total track length of this j-th interval for given:

- conveyance reliability,
- track reliability,
- reliability of pieces of equipment co-operating with this interval.

As an essential measure of reliability of equipment the long-run availability should be assumed.

Notice that the system interval looseness is always positive in sign because there is no sense to consider system or subsystem without any conveyance. Furthermore, if the minimum distance between two neighbouring conveyances is l_m (its determination ia a separate interesting problem) then the system interval looseness is alwyas not less than l_m^{-1} due to obvious reasons.

Mathematically taking we can write:

$$\alpha_j = \bar{n}_j/h_j \Big|_{A_c, A_t, A_o} \quad ; \quad l_m^{-1} > \alpha_j > 0, \tag{1}$$

where: α_j - system looseness on j-th loop interval,
$\bar{n}_j$ - mean conveyance number moving on j-th track loop interval,
h_j - length of j-th track loop interval,
A_c - long-run availability of conveyance,
A_t - long-run availability of track,
A_o - total long-run availability of pieces of equipment co-operating with j-th track loop interval.

Taking into account the definition of system looseness, the following relationship holds:

$$\alpha_j = \bar{n}_j/h_j \Big|_{A_c, A_t, A_o} \;\prec\; \alpha_j = \bar{n}_j/h_j \Big|_{A_c, A_t, A_{o1}} \tag{2}$$

for $A_{o1} > A_o$.

Symbol $\prec$ is taken from the theory of sets from the chapter considering ordered sets. It is also being used in the prediction theory considering properties of prediction goodness measures.

Symbol $\prec$ means that the system looseness described by the right side of relationship (2) is more advantageous than the left one.

It is obvious that if the long-run availability of co-operating pieces of equipment (or track or conveyance) increases the system looseness increases also for the rest of parameters remaining constant. This is because resistance against blocking is greater for more reliable machinery.

Notice that the system looseness has influence on the probability of conveyance stoppage. This probability is one of the key parameters in the system hauling capacity calculation.

If the length of a given track interval is significant and the mean number of conveyances running on it is low, we say that this subsystem is loose.

Let us perceive that assuming constant availability of all pieces of equipment and for fixed organisation of system, increment in number of conveyances on a given track interval for loose subystem makes small increment of the probability of conveyance stoppage. Making further increment in the mean number of running conveyances on this track interval we can notice that the probability of conveyance stoppage increases slowly, later more intensively and for values near l_m^{-1} rapidly runs to unity.

There is no room here to present similar cosideration for relationships between availability of equipment involved in operation of the system and perturbation of conveyance motion.

For now we can state that the probability of conveyance stoppage is a function of the following basic parameters:

$$\bar{p}_{sj} = f(A_c, A_t, \bar{n}_t, A_o, \alpha_j) \qquad (3)$$

where $\bar{n}_j$ is the mean number of conveyances being in the motion on j-th track interval.

At the end of this short consideration one term needs more attention: "track loop interval of constant looseness". Let us look at the Fig.1. It is easy to notice that the whole system should be splitted onto six intervals:

- DAB, -BE, -DG, -EHG, -BCD, -EFG

taking into account looseness of the system. Obviously DG = BE, so totally the system has five track intervals of different looseness. Such a system division is the first step in the calculation procedure of its capacity for design purposes.

Recenzent: Doc.dr inż. Tadeusz Zmysłowski

Wpłynęło do Redakcji w listopadzie 1991 r.

PROBLEMY ZAKŁÓCEŃ RUCHU NACZYNIA W ZINTEGROWANYM SYSTEMIE TRANSPORTU CIĄGŁEGO

S t r e s z c z e n i e

Jedną z wielu propozycji zastąpienia urządzeń wyciągowych jest Zintegrowany System Transportu Ciągłego. System ten został skrótowo opisany w niniejszym artykule, a jego szczególny problem zakłóceń w ruchu naczynia, przeanalizowany. Wyliczone zostały podstawowe przyczyny zatrzymywania naczyń z uwzględnieniem miejsc ich powstawania. Ponadto zostało zdefiniowane pojęcie "luźności" systemu, podano podstawowy miernik tej właściwości oraz jej wpływ na prawdopodobieństwo zatrzymania naczynia. Artykuł kończy przykład podziału systemu biorąc pod uwagę jego odcinki o jednakowej luźności, co jest pierwszym, podstawowym krokiem w obliczaniu przepustowości transportowej systemu.

ПРОБЛЕМЫ ПОМЕХ В ДВИЖЕНИИ СОСУДА В ОБЪЕДИНЕНОЙ СИСТЕМЕ НЕПРЕРЫВНОГО ТРАНСПОРТА

Р е з ю м е

Одним из многих предложений замены подьемного оборудования является Объединенная Система Непрерывного транспорта . Эта система была кратко описана в статье , а также проанализированы спепифические проблемы нарушения движения подъемных сосудов. Определены основные причины задержки подьемных сосудов с учетом мест их возникновения . Определено понятие "зазорность" системы , представлен базовый измеритель этой особенности , а также ее влияние на вероятность задержки подъемного сосуда . Дан пример классификации системы , где рассматриваются ее части одинаковой "зазорности" , что является первым , основным шагом в определении пропускной способности транспортной системы.