AUTOMATION AND MECHANIZATION IN MINING

RETRIEVAL AND TRANSMISSION OF INFORMATION
IN AUTOMATIC OPERATIONAL CONTROL SYSTEMS
FOR OPEN-CUT MINES

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INTRODUCTION

In automatic control systems in mining, the methods of information transmission (MIT) are particularly important, because the processes of mineral recovery are spread over wide areas and are very time-dependent. At present, information comes to the controller ("dispatcher") mainly over the telephone or radio link. These methods unavoidably produce subjectivism and incompleteness of the information and large delays and limitations in the transmission capacity (in other words on the possibilities) of the system controller-production. It is necessary to create means of retrieval and automatic transmission of digital information which can, in the complex conditions of a mine, ensure high-quality radio-channel transmission of several thousand messages from 100 or more sources spread over a large area.

According to their requirements and operating conditions, the methods of information transmission combine the characteristics of data transmission systems (high reliability indices, trustworthiness, efficiency, large total amounts of information, and connection with digital computers) and telemechanics systems (real time operation, a large number of scattered low-activity information sources, and lack of access to sources in central storage). Attempts to directly transfer the principles and equipment used in related fields of communications technology to the construction of methods of information transmission in open pits and quarries have so far been unsuccessful. In this article we will discuss the requirements and principles for the construction of methods of information transmission for automated control of open-cut mining operations.

Requirements for MIT in Open Pits and Quarries

Amount and Flow of Information. In Table 1 we give the information characteristics of automated systems of operational control for five quarries and open pits (limestone, asbestos, two ore quarries and one coal pit) with outputs of 12-100 million tons per year.

The data in Table 1 confirm that it is possible to satisfy the requirements of open-cut mines by means of information transmission methods with a small number of standard sizes of equipment. It is sufficient to transmit numerical statistical data on demand from a central control point (CCP); other types of information must be transmitted as the processes of production occur.

Rapidity of Action. Starting with the time characteristics of the loading-transportation processes, the mean time interval from the moment of origination of a message to the start of its transmission (mean delay time) should not exceed 5-10 sec. The rate of transmission is taken to conform to the recommendations of the International Telegraph and Telephone Consultative Committee (MKKTT) as 50, 100, or 200 baud. The mean duration of the interrogation period is up to 20 sec.

Reliability. The main requirements for accuracy and reliability of information transmission can be formulated on the basis of value criteria [2], regarding a method of information transmission as a subsystem of a system of higher rank, the ASOC of the mine [3]. We can impose the prerequisite that the accuracy index will correspond to the best radiotelephone ultrashort-wave channel [4]: the guaranteed probability of transmission of an error will not exceed $2.5 \times 10^{-6}$; the total probability of loss of information (due to faults in the equipment or system


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TABLE 1

<table>
<thead>
<tr>
<th>Designation of pit</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>Type series of MIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>characteristic</td>
</tr>
<tr>
<td>No. of peripheral</td>
<td>56</td>
<td>124</td>
<td>112</td>
<td>117</td>
<td>100</td>
<td>60, 125 (250)</td>
</tr>
<tr>
<td>points</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Amount of information (Hartley), bits:
- address: 6 7 7 7 6, 7, 8
- messages: 4 6 6 6 6, 8 (16)
- operational data: 6 8 8 6, 8 (16)
- accounting data: 6 8 8 8, 128 (256)
- instructions: 6 6 6 6 8 (16)

Rate of origination of information [11, bits/sec
- from all excavators and trains: 0.82 0.66
- from one excavator: 6.26 10^-3 5.96 10^-3
- from one train: 2.94 10^-2 2.87 10^-2

Rate of flow of information [11, sec^-1
- total from excavators and trains: 4.76 10^-2 6.15 10^-2 0.5
- from one excavator: 5.0 10^-3 5.2 10^-3 0.1; 1, 0
- from one train: 2.18 10^-3 2.03 10^-3

or suppression of interference) will not exceed 7.5 10^-6, and the time between faults will be at least 2500 h at a confidence level of 0.8 for each peripheral point and for each function.

Channels. For links to movable objects in quarries or open-pits it is desirable to use a radio channel. Until we can solve the problem of a reliable link along untreated electric power lines, radio channels in quarries and open pits are without competition.

General Requirements. To achieve high efficiency and continual improvement in the control of open-cut mines and quarries it is necessary advance the rate of development of techniques for retrieving, transmitting, and processing information in the automatic system for operational control. If we base the methods of information transmission on present requirements, then they will become hopelessly out of date by the time they are widely adopted in industry.

Fundamental Principles of Construction of MIT in Open Pits and Quarries so as to Achieve the Required System Characteristics

Retrieval of Information. This is regarded as discretization, with constant programmed or random interval \(\tau\), of discrete random processes \(\xi(t)\) representing the time-wise changes in the states of the sources of information [5]. The states of the processes \(\xi(t)\) do not change often [1]. For superposition of processes with infrequent changes of state (transitions), upper estimates of the mean relative entropy have been obtained [5, 6] in the form

\[
H(X(t)/X(t-\tau)) = \mu\tau \log \frac{\sum_{s=1}^{m} (n_s - 1)}{\mu\tau} - (m - \mu\tau) \log \left(1 - \frac{\mu\tau}{m}\right)
\]

as a function of the number of sources \(m\), the number of states of each source \(n_s\), and the rate of transmissions \(\mu\). From information theory it follows that messages formed by cyclic discretization with a constant interval for random processes \(\xi^{(s)}(t)\) (sources of information) have considerable redundancy [6, 7].

The efficiency of information retrieval in a given case can be considerably increased by coding the information source, not in states of the process \(\xi^{(s)}(t)\) \((s = 1, 2, \ldots, m)\), but in increments \(\xi^{(s)}(t) - \xi^{(s)}(t-\tau)\) [6].