Time cycle calculation procedure for the special crew during the mining mobile machine complex operation

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Abstract. The relevance of the research is specified by the necessity to optimize the delft mobile tunneling equipment operation. Target of the research is tunneling time cycle justification for the special crew during the mining mobile machine complex operation. Methods of the research included the consideration of operation organization schemes in the drifting face and effective use of the mobile equipment during mine exploratory working operations. Time cycle calculation procedures for major processes have been considered. This has been done for the special crew during the mobile machine complex operations for several working faces and various organization schemes.

1. Introduction
Underground mine exploratory workings in the mineral deposits are often driven with the lateral derivation (the adit shaft or entry with the crosscuts and insets) including, as a rule, more or less, extensive main opening and one or several drifts which are usually shortwall driven (the insets or crosscuts).

Mine exploratory working operation is a complex technological process that includes the series of production processes (PP): drilling, charging and blasting, ventilation, shaft mucking and dirt haul, timbering, rail laying and many other operations interconnected and logically performed. So, to implement all these above mentioned processes there should be necessary machinery and equipment.

2. Cycle calculation
Workings drive operation is planned to have such distribution of work in the drifting cycle when tunneling machinery and equipment make maximum use.

Mine exploratory workings operation may be organized by one (out of three) scheme depending on mining and geological conditions and technological level. These are the following:
1 – sequential implementation of the main production processes in the drifting cycle for one working face without synchronism;
2 – concurrent execution of the main production processes in the drifting cycle for one working face with synchronism;
3 – combined execution of the main production processes in the drifting cycle for several working faces.

Let’s consider the sequential scheme of the operations in the working face. Stall equipment of the complex (a loading machine and rail-mounted jumbo) is always in the working face (or at the face...
spur track) before the drivage completion of the relevant working, i.e. the equipment is operated by the special drift crew who sequentially implements all cycle stages. The cycle time is the following:

\[
T_\text{n} = T_{1\text{bo}} - K_{\text{zm}} \cdot \frac{T_{\text{cm}}}{n} \quad (1)
\]

\[
T_{1\text{bo}} = T_{\gamma} + T_{\delta} + T_{\text{zm}} \quad (2)
\]

\[
T_{\text{zm}} = T_{\text{za}} + T_{\text{np}} + K_{\text{zm}} = \Delta T_{1\text{bo}} / T_{\text{cm}}
\]

where \( T_{1\text{bo}} \) – the cycle duration during the sequential implementation of the main production processes by the special drift crew (when the loading and drilling machines are always in the working face), h; \( T_{\gamma} \), \( T_{\delta} \), \( T_{\text{za}} \), \( T_{\text{np}} \) – the time for shaft mucking, blast-holes drilling, charging and blasting, ventilation of the working face, h; \( K_{\text{zm}} \) – coefficient showing the possibility of synchronism between the charging\blasting \ventilation process and a shift break.

In particular case, when the cycle begins with the underground shaft mucking, the average time for the cycle time reduction is the following [1]

\[
\Delta T_{1\text{bo}} = \frac{T_{1\text{bo}} - T_{\text{cm}}}{n}, \quad \text{if } n \cdot T_{1\text{bo}} - \min \{T_{\text{za}}, T_{MCI} \} \leq T_{\text{cm}} \quad (3)
\]

\[
\Delta T_{1\text{bo}} = T_{1\text{bo}} - n' \frac{T_{\text{cm}}}{n}, \quad \text{if } T_{1\text{bo}} - \min \{T_{\text{za}}, T_{MCI} \} \leq n' \frac{T_{\text{cm}}}{n} \quad (4)
\]

\[
0 \quad \text{if not, } \quad n' = \left\lfloor \frac{T_{\text{cm}}}{T_{1\text{bo}}} \right\rfloor + 1, \quad \text{if } T_{1\text{bo}} \leq T_{\text{cm}}
\]

where \( T_{\text{cm}}, T_{MCI} \) – the shift duration and the shift break duration, respectively, h; \( \Delta T_{1\text{bo}} \) – the average time for the cycle reduction (the cycle begins with the underground water mucking), h; \( n \) – the number of the cycles during the shift; \( n_{\text{za}} \) – the number of the shifts during the working face operation per day. Bracketed expression \( \lfloor \rfloor \) means the integer part.

A failure of the inequality (3) or (4) indicates that we can neglect the cycle reduction time at the expense of charging\blasting \ventilation process partially synchronized to the shift break. So, \( T_{\text{n}} = T_{1\text{bo}} \). The equipment relocation is unreasonable when the maximum distance exceeds the value. So, the maximum distance \( L_{\text{max}} \) between the working faces should not exceed the smallest value.

\[
L_{\text{max}} \leq \min \{V_{\text{nep}} (0,5 \Delta T_{1\text{bo}} - T_{\delta})\},
\]

where \( T_{\delta} \) – the process duration, h; \( V_{\text{nep}} \) – the average transportation velocity of the equipment along the workings, m/h.

If \( L_{\gamma} \leq L_{\text{max}} \), then \( T_{\text{n}} = T_{1\text{bo}} \), if \( L_{\gamma} > L_{\text{max}} \), then \( T_{\text{n}} > T_{1\text{bo}} \).

If according to the equation (5) we have

\[
L_{\text{max}} \leq 0, \quad \text{i.e., } \quad 0,5 T_{1\text{bo}} \leq T_{\text{pm}} \left( T_{\text{UI}} > T_{1\text{bo}} \right),
\]

where \( T_{\text{pm}} \) – time for the longest cycle process, h;

\( L_{\text{max}} \) – the maximum distance between the working faces of the built workings, m; \( L_{\gamma} \) – the average distance between the working faces of the built workings during their drivage process, m.

In this case the complex should better be used in one working face. Figure 1 shows the work flow chart for the special drift crew during the simultaneous drivage of two workings by the mobile machine complex of the wheeled and rail-mounted equipment which was used in “Sevvostgeologiya” organizations. Let’s substitute the appropriate initial data for the equation (5) related to the drivage pattern in figure 1 (\( T_{\gamma} = 2,3 \text{ h}; T_{\delta} = 2,4 \text{ h}; T_{\text{za}} = 1,3 \text{ h}; T_{1\text{bo}} = 6,0 \text{ h} \)). Thus, the maximum distance between the working faces of the built workings by this complex should not exceed the following:

- for the rail-mounted jumbo (with the average travelling velocity along the workings)

\[
V_{\text{nep}} = (2,27 / 6,5)^{1/4} \cdot 3,6 \text{ km/h} = 2,5 \text{ km/h} \Rightarrow 1500 \text{ m};
\]

- for the loading machine (with the average travelling velocity)

\[
V_{\text{nep}} = 1 \cdot 3,6 \text{ km/h} = 2500 \text{ m}. 
\]
Finally, the maximum distance between the attended working faces for this machine complex is equivalent to the minimum value – 1500 m.

One tunnelling equipment set for two working faces.

3. Conclusion
To identify the average travelling velocity along all the workings, the equations for determining the longest tunneling cycle time (shaft mucking, blast-hole drilling) for each machine have been provided. The maximum distance between the attended working faces has been identified.

References

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