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ESTIMATION OF FACTORS INFLUENCING THE PRODUCTIVITY OF LHD MACHINES IN ESTONIAN OIL SHALE MINES

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Since the end of the 1980's LHD vehicles are the most widely used machines for loading and transportation in Estonian oil shale mines with room-and-pillar mining.

This paper presents a simple method based on the use of valuation points for the quick estimation of the job efficiency of LHDs in Estonian oil shale mines. Due to a more correct definition of the job conditions and their intensity we think that this system of assessment also enables to show more objectively and correctly the actual productivity of the machines. So the factors influencing the work of the LHDs in oil shale mines are given in points of assessment proceeding from relevant research and expertise.

Introduction

Presently about 20 LHD machines with tramming capacities of 3-10 t are operating in various Estonian oil shale mines. All these machines are powered by diesel engines. Use of LHD machines in oil shale room-and-pillar mining (see Fig. 1) is intensively widening in Estonia, because the production of stopes increases about 2-2.4 times in comparison with the conventional fleet of transport machines [1]. Whereas until the beginning of the 1990's most of the LHDs used in Estonia were manufactured by Russian and Ukrainian companies, today the majority of them are imported from Western countries, from such companies as *Toro* and *Wagner*. The first Ukrainian LHD machine PD-8B with a 4 m^3 bucket commenced operation in the *Ahtme* oil shale mine in 1988.

It is reasonable to use two groups of methods for selection of LHD machines. They are:

- Conventional methods, mainly used in Estonia until recently
- Modern methods of western companies, gradually being introduced at the present day

Conventional methods are well suited for selection of vehicles manufactured in East Europe (mainly in Russia) in accordance with their basic data, as presented in handbooks. In this case, calculations are based on various working parameters, using figures but not the performance curves. The only graph used in conventional methods is the gradeability-speed curve.

Modern methods of western companies presume first of all the availability of different performance curves and charts for LHD machines presented in manufacturers' handbooks. Using the above-mentioned

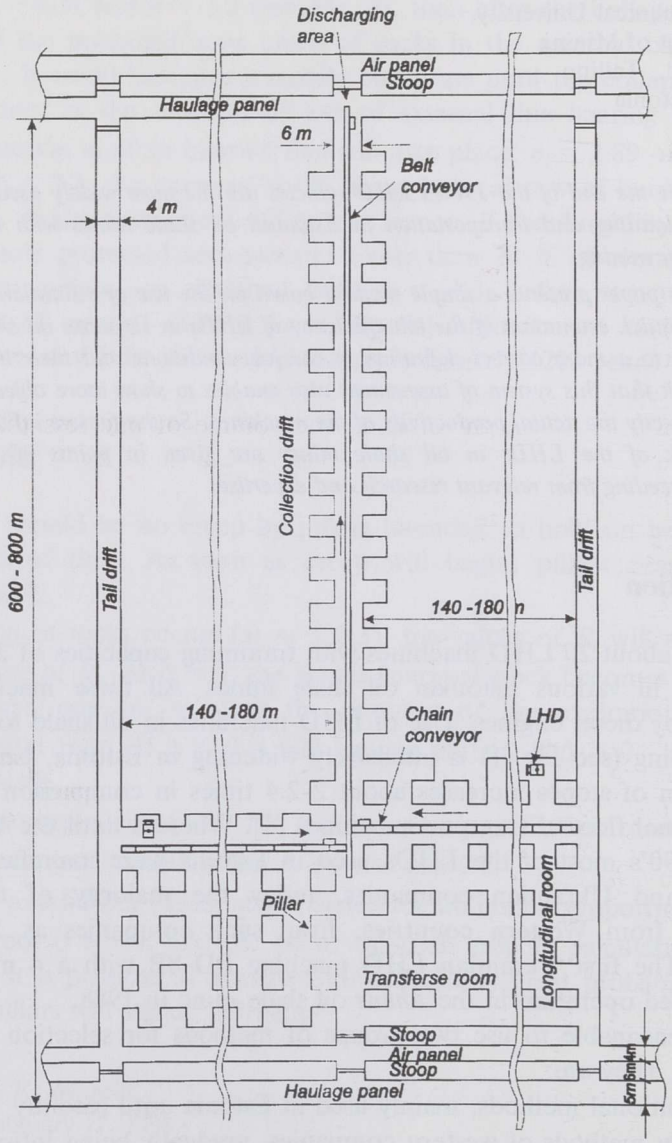


Fig. 1. Schematic layout of room-and-pillar mining

modern methods allows one to perform calculations in a short time and that is why they are of great interest.

In our interpretation, comparing these two groups of LHD selection methods gives the following principal differences:

- There are two different concepts of cycle time. In case of the conventional methods the concept of estimated total cycle time but in case of the modern methods the standard total cycle time is used
- There is a difference in estimation of downtime per shift. In using the conventional methods we consider only all work interruptions by machine utilization factor. However, using the modern methods, all downtimes but also job conditions of LHDs are considered in assessing job efficiency

Factors Influencing the Productivity of LHD Machines

Next only these job conditions as factors which increase the total cycle time and by that influence the productivity of LHDs [2] are discussed. The presented data are based entirely on field testing, experience and expertise [1, 3, 4]. Below the factors, which must be taken into consideration in Estonian oil shale mines, are presented in more detail.

They are:

1. The volume and height of pile. The volume of pile less than 50 m^3 and the height less than 3 m should be evaluated by 1 point. If the volume of pile is from 50 to 100 m^3 and the height less than 3 m then its value is assessed by 0.5 point
2. The existence of sharp turns (90 degrees) on main haulageways. This factor involves remarkable time loss and one turn should be assessed by one point
3. Mined bulk contains large lumps of the size over 400 mm. This factor ought to be assessed by 1 point if the bulk contains boulders from 10 to 20 % and by 0.5 point if the content of boulders is from 5 to 10 %
4. LHD machine carries out the sweeping of stope (bottom, roof, wall face). These operations are connected with the loss of productivity and should be evaluated by 0.5 point per one area (loading or dumping)
5. Small height of stope causes restriction of dumping. This factor should be assessed by 0.5 point

It might be of interest to know that in Estonian oil shale mines there is no need to deal with such factors influencing productivity, as

- deep standing water in the face of stopes
- rolling bottom of stopes
- bad illumination of face

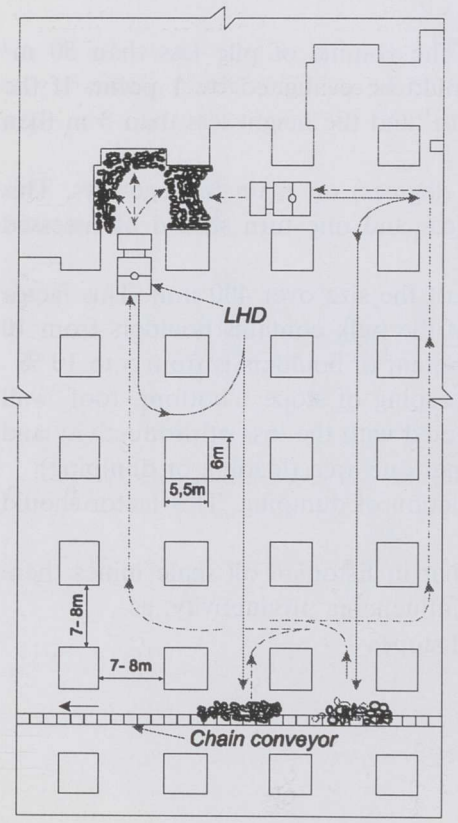
Levels of Job Conditions

Regarding the coexistence of various working conditions during the operation of LHD machines, it is reasonable to use a 5-level scale of job conditions. A definite situation indicates the sum of the valuation points which in its turn gives the value of the job efficiency. If the sum of the valuation points refers to a medium level then the job efficiency of the machine ought to be calculated by interpolation.

A 5-level Scale of Job Conditions for LHD Machines

Level of job conditions	Valuation points	Job efficiency
1. Excellent	2	0.92
2. Good	4	0.83
3. Average	6	0.75
4. Rather poor	8	0.67
5. Poor	10	0.58

Concluding Remarks



Below, as an example, a typical job situation in Estonian oil shale mines with room-and-pillar mining is presented (see Fig. 2) and one can see how the job efficiency is determined with the help of valuation points for the existing factors. The factors needed to consider are the following:

- Loading from a pile having the volume of 25-65 m^3 and the height - 3.3-2.7 m: 1 point
- The haulageway usually has 2 or 3 sharp turns: 2 (3) points
- Mined bulk contains the boulders in average from 5 to 10 %: 0.5 point

Fig. 2. Travel courses of LHD in the stope: – – – empty machine, —— loaded machine

- LHD machine sweeps at the loading area: 0.5 point
- Restriction to dumping: 0.5 point

Consequently, the number of points is from 5 to 6, which corresponds to the level of job conditions ranging from "good" to "average" and the job efficiency ranges from 0.83 to 0.75.

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