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METHODOLOGY FOR ANALYSIS AND CALCULATION THE DISCONTINUOUS LOADING AND TRANSPORT SYSTEMS IN PREPARATION THE TECHNICAL DOCUMENTATION USING THE RPMGLOBAL - TALPAC SOFTWARE[**]

Abstract

This paper presents the software methodology of modeling load and haulage systems in open pit mining, necessary data required for modeling and analysis, methods of simulation for the purpose of optimisation and some of the final optimisation results. Although there are more than one software programs that are in use for this purpose, this paper is focused exclusively on software RPMGlobal Talpac. The paper's goal is to show the importance of accuracy of input parameters for realistic modeling and simulation of load and haulage systems for the purpose of correct results from the analysis.

Keywords: *mine planning software, modeling of open pit transport systems, load and haul optimisation and analysis*

INTRODUCTION

For the purpose of calculation and analysis the technological phase of truck transport, several software programs are applied in the preparation of technical documentation in the surface exploitation. This paper describes the methodology for implementation the Talpac software of the RPMGlobal Company. The Talpac software is used worldwide to analyze the productivity of surface transportation and loading systems. The software, by modeling the real operating conditions, determines the necessary parameters for the technological and economic evaluation of discontinuous loading and transport systems [1, 2, 3]. The aim of these efforts is to determine the most profitable excavation plan and the highest rate of return of invested funds [4, 5, 6, 7].

DESCRIPTION OF THE INPUT PARAMETERS FOR THE SIMULATION PROCESS OF DISCONTINUOUS LOADING AND TRANSPORT SYSTEMS

Modeling of the real operating process is achieved by simulating the same, with the input parameters varying within the real operating limits. Depending on the need, i.e. whether studies, technical projects or operational plans are made, the various capabilities of the Talpac software are used. The basic Talpac software window is shown in Figure 1.

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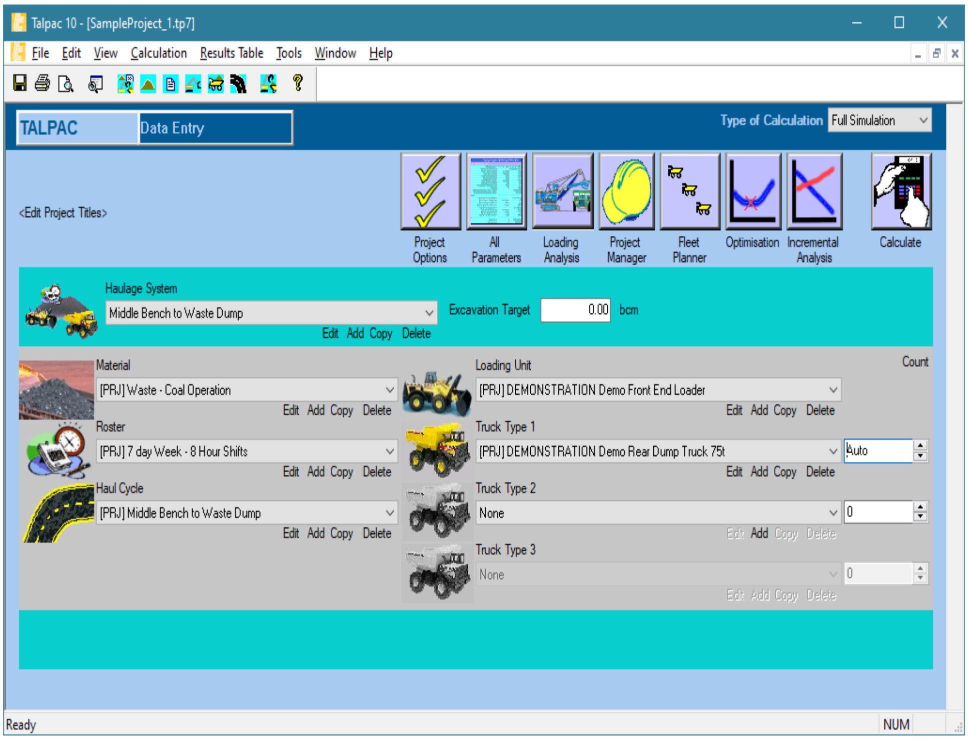


Figure 1 *The basic Talpac software window*

The loading and transport system is defined in the Talpac software by the following software components [8, 9]:

- type of material (physical mechanical characteristics, technological parameters such as coefficient of loosening and loading of a bucket),
- production “roster” (number of operational days in a year, operational and non-operational time losses in a year and shift and organization of work),
- selected loading equipment (type and technological parameters of loading equipment),
- selected transport equipment (type and technological parameters of a truck),
- transport cycle (transport relation characteristics).

The following Figures 2 and 3 provide an overview of a window for adjustment the basic components of loading and transport systems.

SIMULATION METHODS OF THE DISCONTINUOUS LOADING AND TRANSPORT SYSTEMS

Production analysis of the loading and transport system in the Talpac software is achieved through two types of simulation or type of calculation, as follows [8, 9]:

- “Quick Estimate“, and
- “Full Simulation“

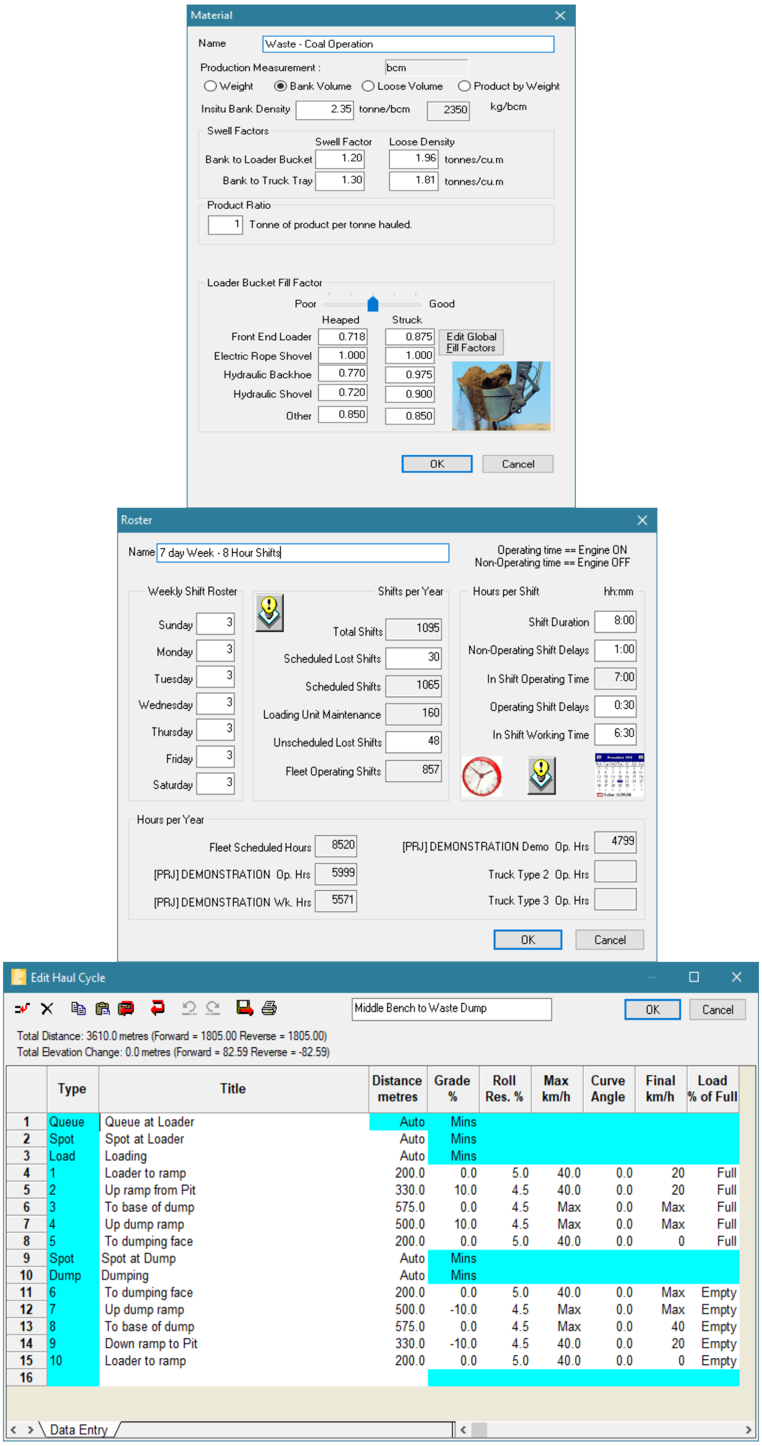


Figure 2 *Windows for adjustment the Material, "Roster" and Transport Cycle components*

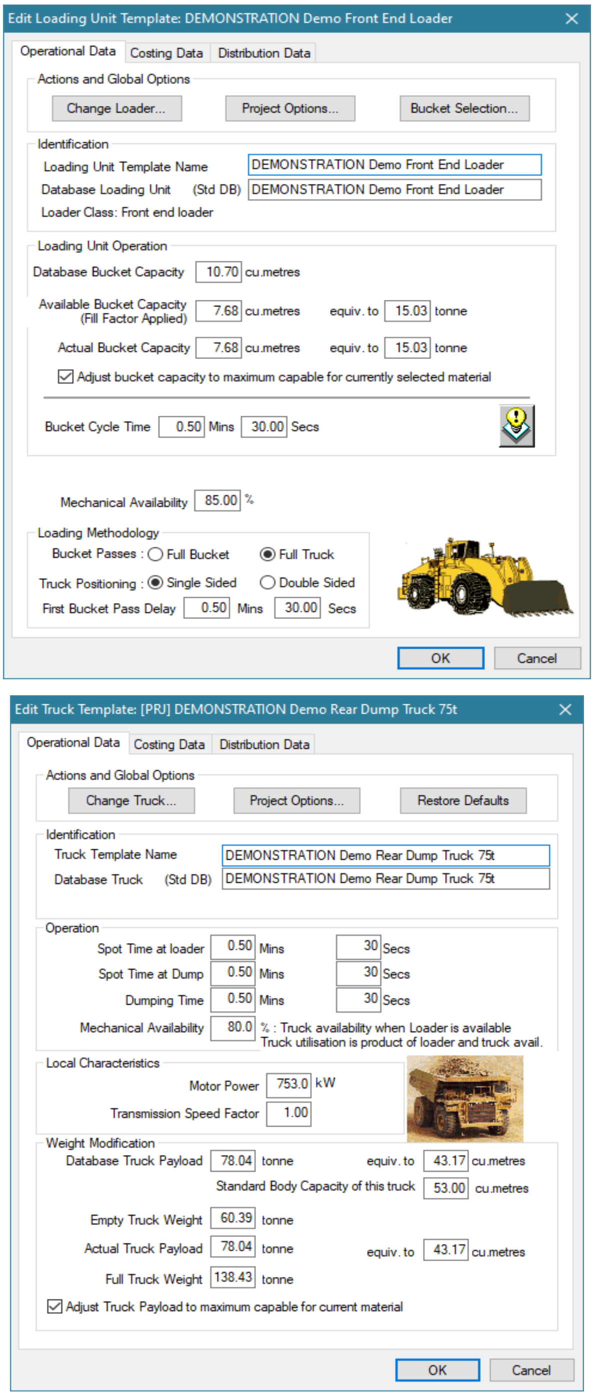


Figure 3 *Windows for adjustment the selected loading and transport equipment*

The “Quick Estimate” calculation implies that there is no variability in the technological parameters of loading and transport equipment and is a deterministic type of analysis.

The "Full Simulation" calculation is a stochastic type of analysis that takes into account a variability of operational loading and transport parameters such as the loading cycle time, amount of material in a loading bucket, and the transport cycle time due to the variability of time losses (truck waiting for loading). Due to the simulation of real-life conditions in production, the "Full Simulation" results are more credible and this type of simulation is a fundamental for calculation the technological phase of transport. The following figure (Figure 4) shows the graphs of the distribution of parameters that vary with loading and transport.

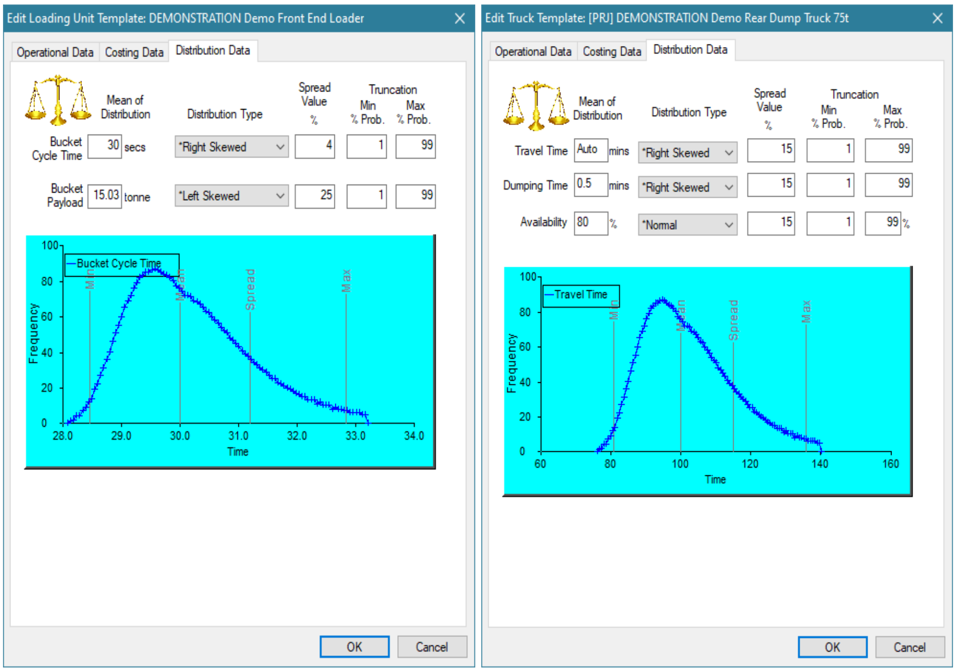


Figure 4 *Window for distribution the loading and transport parameters whose variability is simulated in the “Full Simulation” analysis*

Since that the Talpac analyzes in detail one specific transport route, the result is an analysis of the truck operating (exploitation) capacity and fuel standard for that specific route, for example the route of ore transport from a particular bench to the primary crusher. The number of trucks required to achieve the planned production in a given period is obtained by the weighted average the truck operating capacity for all active benches during that period. In the same way, the weighted average of fuel standard is calculated on the basis of the individual values of fuel standards for specific routes that are active in a given period.

SOFTWARE CALCULATION OF A TRUCK CAPACITY

The software calculation of the exploitation capacity of a truck in the Talpac can be represented by the following formula:

$$Q_h = \frac{N_k}{T_c} \cdot k_{vi},\ t/h$$

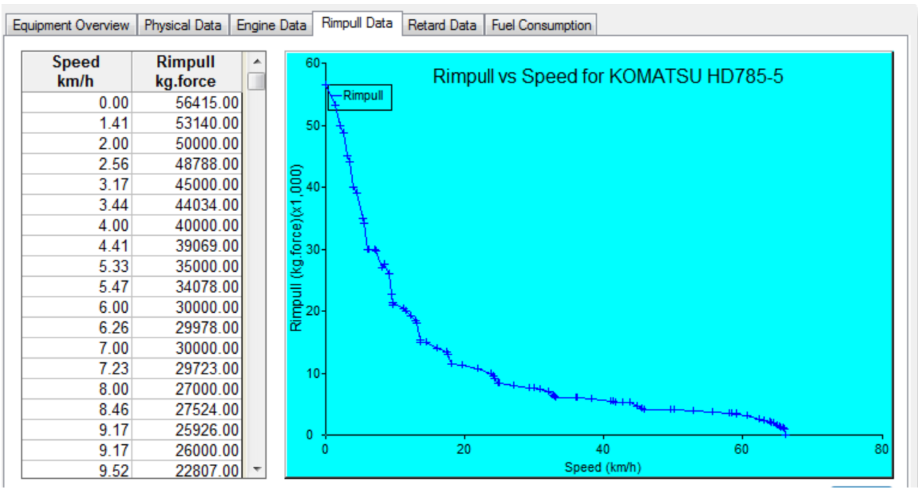
where:

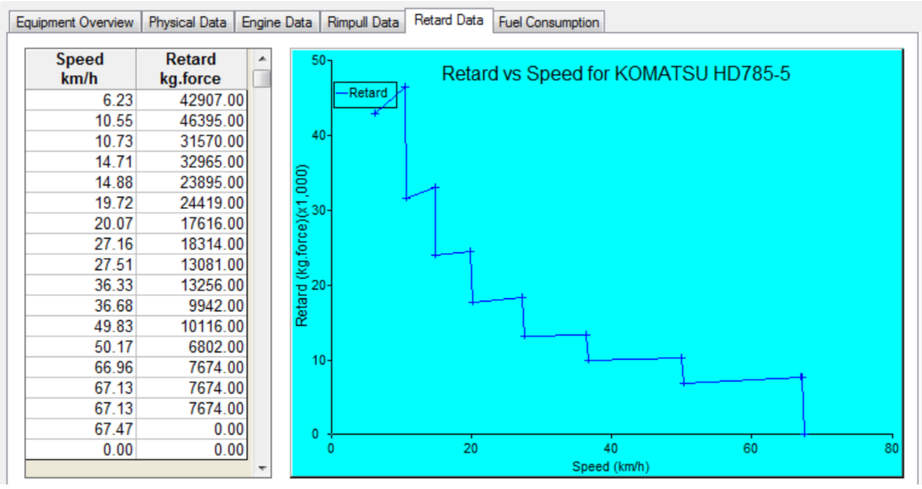
- N_k – actual truck capacity (t),
- Tc – time of a transport cycle (Talpac simulation of real conditions),
- k_{vh} – time utilization (adopted as 50 min / 60 min or 0.833)

It is specific is that the software simulates the loading into trucks for all shifts in a year and as a result gives an average, so that the exploitative, i.e. the truck operating capacity is represented by the following formula [10]:

$$Q_h = \frac{\sum\left(\begin{array}{c}\textit{All simulated}\\ \textit{transport cycles in a year}\end{array}\right)}{\left(\begin{array}{c}\textit{Total number of}\\ \textit{simulated shifts in a year}\end{array}\right)} \div (\textit{Operative time in a shift})$$

The speed of a truck is affected by the characteristics of a transport route (slope and rolling resistance), technical characteristics of a truck and classic driving conditions such as the periods of acceleration, deceleration and constant driving on a given transport route. From the technical characteristics of a truck, the Talpac uses the "rimpull" and "retard" graphics, i.e. a dependence of the movement speed and force that a truck can overcome at that speed. The following figure shows an example of the rimpull and retard curve for one truck from the Talpac software database (Figure 5).





Speed km/h	Retard kg.force
6.23	42907.00
10.55	46395.00
10.73	31570.00
14.71	32965.00
14.88	23895.00
19.72	24419.00
20.07	17616.00
27.16	18314.00
27.51	13081.00
36.33	13256.00
36.68	9942.00
49.83	10116.00
50.17	6802.00
66.96	7674.00
67.13	7674.00
67.13	7674.00
67.47	0.00
0.00	0.00

Figure 5 *"Rimpull" and "Retard" graphics of a truck from the data base of the Talpac software*

The force that a truck must overcome is affected by the force created by the truck weight and material in a truck basket, the rolling resistance force and the characteristics of transport route (slope). The geometric relationship of these forces is shown in the following figure in an example of the truck slope (Figure 6) [10].

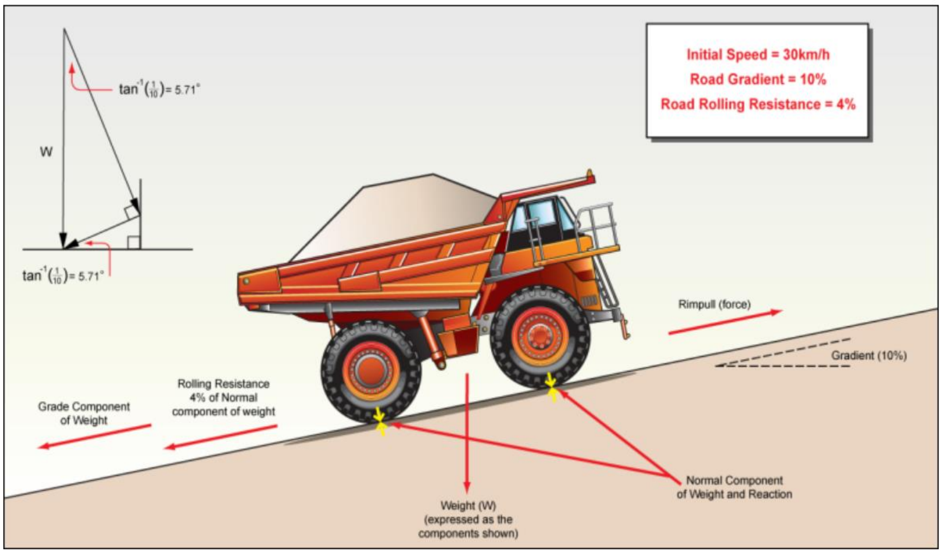


Figure 6 *Schedule of forces affecting the movement of truck* [10]

SOFTWARE CALCULATION OF THE TRUCK FUEL CONSUMPTION

To calculate the fuel consumption, the assumption is that the fuel consumption is directly related to the percentage of “rimpull” force used to the maximum. The software calculates the fuel consumption for each segment of the route separately, for the movement of full and empty truck, thus resulting in the final fuel consumption for the entire transport route. The following figure shows a diagram showing the ratio of actual and maximum “rimpull” force of a particular truck, which is the basis of software determination the fuel consumption (Figure 7) [8, 9, 10].

Software calculation of the fuel consumption in each segment of the relation is performed by the following formula [7]:

$$\Delta f = \left(\frac{R_u}{R_m} \cdot \frac{(F_{100} - F_0)}{60} + \frac{F_0}{60}\right) \cdot \Delta t$$

where:

- Δf – fuel consumption for individual segment of the transport route (l),
- R_u – required rimpull force
- R_m – maximum rimpull for the selected truck type
- F_{100} – fuel consumption at 100% of rated engine power (l/h)
- F_0 – idle fuel consumption (l/h)
- Δt– time of truck movement on a single route

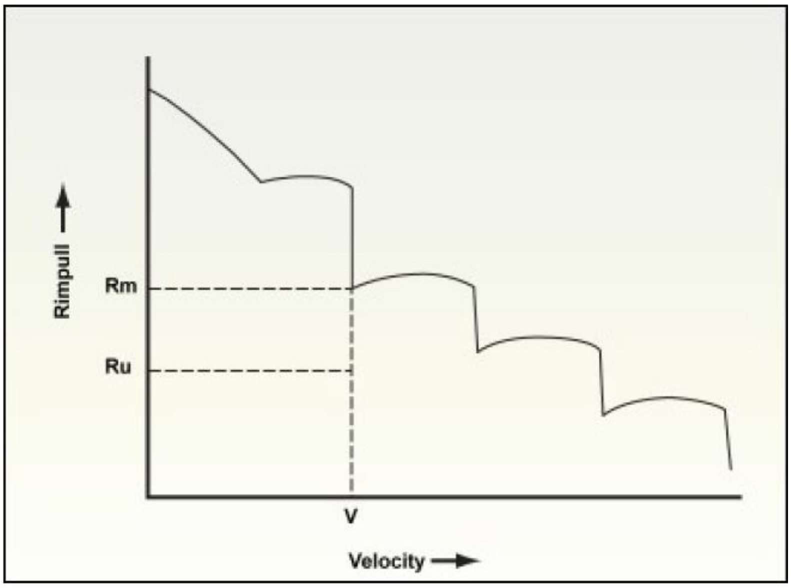


Figure 7 *Ratio of the used and maximum”rimpull” force* [10]

The total fuel consumption (f_t) is obtained by accumulating the fuel consumption in all individual segments, with the addition of fuel consumption in which the machine did not operate effectively, i.e. losses due to a truck waiting for loading whereby the fuel consumption is determined solely by the idle fuel consumption (F_0). So the average hourly fuel consumption for a transport route can be represented by the following formula [10]:

$$F = \left(f_t \cdot N_{\frac{cycle}{h}}\right) + $$
$$+\left[60 - \left(N_{cycle/h} \cdot T_{cycle}\right)\right] \cdot \frac{F_0}{60}, l/h$$

where:

f_t – total fuel consumption of a transport cycle (l)

$N_{cycle/h}$ - number of transport cycles in one hour

T_{cycle} – transport cycle time (min)

The fuel consumption standard (l/t) is obtained from the calculated values of operating hour capacity (t/h) and the average hourly fuel consumption (l/h) for each transport route, while the average weighted value of the standard of all transport routes is taken as the annual fuel standard in that year.

The Talpac does not calculate the oil and lubricant consumption, but it is adopted up to 5% of the weighted average fuel consumption software results, or if known, the oil and lubricant standard is adopted according to the manufacturer's recommendations for the equipment selected.

DETERMINING THE REQUIRED NUMBER OF TRUCKS

Since the Talpac processes one route in detail, and there are several routes over a period (year), the determining the number of truck is done by the classical procedure, i.e. over the truck annual capacity.

The annual capacity of a truck is calculated by the following formula:

$$Q_{year} = Q_h \cdot n_{h/year} \cdot k_{mr} \cdot k_r, \text{ t/year}$$

where:

Q_h(t/h) – exploitation (operating) hourly capacity of a truck (average weighted value of software results)

$n_{h/year}$ – number of working (operating) hours per year

k_{mr} – coefficient of the mechanical machine availability (to be adopted around 85% provided that it is not calculated through the number of operating hours in the year $n_{h/year}$)

k_r – coefficient of the physical machine availability (about 90 to 95% is adopted)

The required number of trucks is determined by the following formula:

$$N_{truck} = \frac{A_{year}}{Q_{year}},$$

where:

A_{god} – annual production of the ore and waste (t).

CONCLUSION

The advantage of using the Talpak software in analyzing the discontinuous loading and transport connections is the ability to quickly see the impact of a route change, loading and transport mechanization and other technological parameters of loading and transport on the economic parameters of the transport system and expected production results. The software has a database of loading and transport equipment most commonly used at the open pits in the world. Since the accuracy of the software results depends on the accuracy of input data, the software application is conditioned by the qualitative determination of all the necessary input parameters of the transport system being analyzed.

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