

MODELING OF A SET OF MACHINES

¹**Maksudov Zakir Talibzhanovich**

Tashkent State Transport University, Candidate of
Technical Sciences, Associate Professor

E-mail: maksudov-55@mail.ru,

²**Kudaybergenov Mavlyan Saidakbarovich**

Tashkent State Transport University, assistant of the
department "Engineering of technological machines"

E-mail: kudaybergenov.m.s.@mail.ru.

<https://doi.org/10.5281/zenodo.7427473>

ARTICLE INFO

Received: 30th November 2022

Accepted: 10th December 2022

Online: 12nd December 2022

KEY WORDS

Road base, road construction
machines, excavator, dump
truck, bulldozer, volumetric
weight of soil, loading time.

ABSTRACT

Statistical modeling or grapho-analytical methods of scientifically based organization of the work of the machinery in solving problems, as well as modeling the technological process of the work of the machinery in order to form an optimal machinery set and the road construction machine sets participating in this process, as well as developing an algorithm block diagram of this modeling is appropriate.

The modeling of the work of the road construction machines included in the set of machines is carried out in the following sequence, that is, using the block diagram of the algorithm presented in Fig. 1.

Introduction: Optimizing the set of excavator-transport machines during the restoration of the highway, modeling the work of the road equipment in the set when forming the set of machines for the construction of this road element, taking into account the interdependence of some machines in the set, if the main-leading machines participate in this relationship, optimizing their work process for the rest of the auxiliary machines as well is relevant. This requires the implementation of optimal formation of a set of machines in several stages. Therefore, the optimization indicators of the first stage also affect the rest of the road equipment, they can be taken as the main primary indicator, and based on them, the remaining machines in the set can be calculated, that is, the required number can be determined.

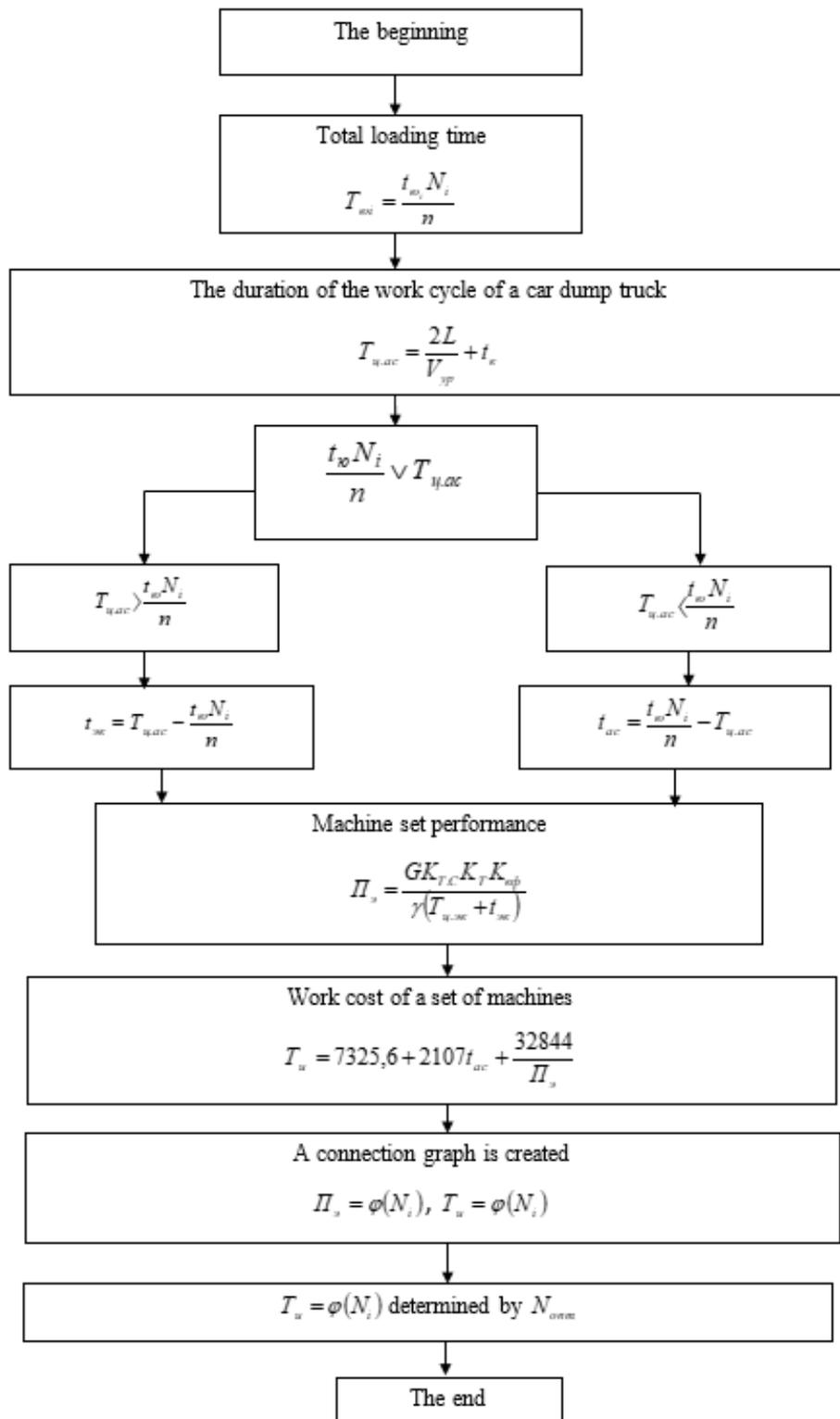


Figure 1. Algorithm block diagram for modeling and calculating a set of machines.

It is important to model the road work in the excavator-transport cooperation, that is, to optimize the road equipment in the process of loading and transporting soil, and to ensure their continuous operation, because the work process of other road equipment included in the machine set also depends on them.



The optimal set of machines for the restoration of the road surface consists of bulldozers, scrapers, motor graders and excavators, auxiliary machines: bulldozers, compactors (light, medium and heavy types), water sprinklers, motor graders, and reserve machines.

A set of bulldozer machines is used when the height of the road base is up to 2 m, a set of auto grader machines is used for a height of the road base up to 0.6 m, a set of scraper machines is used for a height of up to 6 m, and a set of excavator-transport machines is used for any height of the road base.

The main technical and economic task is to solve the problem of the optimal number of dump trucks in the set of machines. When solving this problem, it is important to take into account the duration of stopping all the machines included in the machine set, and its impact on the machine set's productivity and cost of work (treatment of 1 m³ of soil).

Material and methods. Depending on the number of dump trucks in the set of machines, the duration of their suspension t_{ac} and loader excavator t_{ex} varies, and also affects the cost of loading and transporting 1 m³ of soil. The minimum cost of work determines the optimal number of dump trucks in the set of machines.

The cost of loading and transporting 1 m³ of soil during the construction of a road base is determined by the following expression:

$$T_t = \frac{\gamma}{2GK_{td}K_{lc}} \cdot [X_{m-c} \cdot (T_{ct} + t_e) + 2X_t L] + \frac{X_{m-c.ex}}{P_e} + M_{wc} + X_s \quad (1)$$

the expression, G - car-dumper load carrying capacity, t;

K_{td} - use of a truck-dump truck coefficient;

γ - volumetric weight of soil, t/m³, $\gamma = 1,4...1,6$ t/m³;

K_{lc} - car-dumper load carrying coefficient;

t_e - that the excavator comes to load the car-dumper duration of waiting, s;

X_{m-c} - the cost of driving a truck-dumper, sum/s;

T_{ct} - excavator operating cycle time for soil loading duration, s;

X_t - it does not matter if the car-dumper traveled 1 km 1 mash-hour work cost, sum/km;

L_t - soil transportation distance, km;

$X_{m-c.ex}$ - 1 mash-hour of the work of the excavator in loading soil cost, sum/s;

P_e - operational productivity of the machine set, m³/h;

M_{wc} - Hire an auxiliary worker corresponding to 1 m³ of soil

X_s - cost (price) of 1 m³ of soil, sum/m³.

The expression for calculating the operational performance of the excavator-transport machine set, taking into account the loading machine in the construction of the road base:

$$P_e = \frac{G \cdot K_{tr} \cdot K_{or} \cdot K_{lc}}{\gamma \cdot (T_{ct} + t_e)} \quad (2)$$

the expression, K_{tr} - a coefficient that takes into account the loss of time due to technical reasons;

K_{or} - taking into account the loss of time due to organizational reasons (lack of work schedule, lack of electricity, materials, etc.) coefficient.

Modeling the operation of a set of machines consisting of the main-leading machines in the excavator-transport pair and determining the optimal values of the main-leading machines is carried out in the following sequence:



1. In the system, the time of falling demand i is determined and the number of the tractor-dumper is filled: if the value of $q = a$ consists of two or more zeros, then a low-order digital car is obtained.

2. The loading time of the truck-dumper type is formed according to the law of distribution of loading time. The load time distribution law is determined according to the timing results or from the results of previous research.

3. T_i and T_{i-1}^n values are compared:

$$T_i < T_{i-1}^n$$

4. If $T_i < T_{i-1}^n$, then the loading technique is busy when the demand of type i decreases. Then the modeling is done in the following order:

a) the waiting time (stopping time) for loading a car-dumper of type i is determined:

$$T_{ai} = T_{i-1}^n - T_i \quad (3)$$

b) the start and end time of loading of the type i truck is determined:

$$T_i' = T_{i-1}^n; \quad T_i' = T_{i-1}^n - t_{ni} \quad (4)$$

c) the total time of parking waiting for the loading of a truck-dumper is determined:

$$T_{ai} = T_{ai-1} + T_{ai} \quad (5)$$

5. If $T_i > T_{i-1}^n$, the loading technique (excavator) will be free when the demand for the type falls, the calculation is carried out in the following sequence:

a) the time of the excavator waiting for demand of type i is determined:

$$t_{ei} = T_i - T_{i-1}^n \quad (6)$$

b) the start and end time of loading of the type i car-dumper is determined:

$$T_i' = T_i; \quad T_i^n = T_i' + t_{ni}$$

c) the total time of the excavator waiting for demand is determined:

$$T_{ei} = T_{ei-1} + t_{ei} \quad (7)$$

6. We determine the total time spent filling the previous machine:

$$T_{ni} = T_{n-1} + t_{ni} \quad (8)$$

7. Car-dumper cycle time is determined as follows:

$$t_{ci} = T_c - t_n \quad (9)$$

8. Then the loading of the next type of truck-dumper is determined:

$$T_a = T_i^n + t_{ui} \quad (10)$$

9. The number of loaded trucks is determined:

$$K_i = K_{i-1} + 1$$

10. The condition for completion of statistical modeling is checked. Modeling continues if $K_i < r$. In this case, the value T_a is entered as the primary data for loading the car-dumper of type i and the generalized value T_c as the result of modeling.

If $K_i \geq r$, the average dwell time for loading a car-dumper is determined:



$$\bar{t}_{ac} = \frac{T_{ac}}{r} \quad (11)$$

11. The average value of an excavator waiting for a dump truck is determined:

$$\bar{t}_{ac} = \frac{T_{\text{эκ}}}{r} \quad (12)$$

12. Excavator productivity is determined by the expression P_e .

13. The cost of loaded and transported soil is determined by the expression T_t .

The work process optimization condition, moreover, the set of machines is considered optimized, the value N of the number of cars and trucks corresponds to the value of the cost of work $C_{e \min}$.

It is possible to form an optimal set of vehicles without using IBM in the optimization of each road technique or vehicle in the set of machines used in the construction of the road.

The optimal set of machines for road rehabilitation consists of the following road construction machines and vehicles. We will consider in practice the formation of the optimized system of the excavator-transport vehicle complex in the restoration of the road surface and its calculation. Machines include excavators, auxiliary machines, bulldozers, motor graders, light, medium and heavy compactors, water sprinklers and dump trucks, as well as dump trucks. The process of restoring the road base is seen from a certain distance.

When forming an optimal set of machines, the primary parameters are based on the performance of the set of machines, the number of machines, the indicators and sizes of road equipment, the cost of work (transportation of 1 m³ of soil), etc.

The optimal number of dump trucks in a set of machines is performed in the following sequence by the graphoanalytical method.

1. The total waiting time for loading a car-dumper N_i is determined by the following expression:

$$T_{ni} = \frac{t_{ni} N_i}{n} \quad (13)$$

expression, n - is the number of loading machines.

The number of dump trucks N_i value is taken up to $N_i = 2...10$. This value largely depends on the distance of transportation of soil.

2. The duration of the work cycle of a truck-dumper is determined by the following expression, without taking into account the loading time:

$$T_{c.ac} = \frac{2L}{V_v} + t_c \quad (14)$$

expression, t_c - additional time spent on pouring, turning, etc., s;

V_v - average speed of the truck-dumper, km/s;

L - transportation distance, km.

3. We compare the duration of the work cycle time of the dump truck and the total time of its loading:



$$\frac{t_{ni}N_i}{n} \geq T_{c.ac} \quad (15)$$

If $T_{y.ac} \geq \frac{t_{yo}N_i}{n}$, the loading machine is stopped, that is, the excavator has to wait for the truck to load. In this case, $t_{\text{эК}}$ is determined by the expression:

$$t_{\text{эК}} = T_{y.ac} - \frac{t_{yo}N_i}{n} \quad (16)$$

If $T_{c.ac} \leq \frac{t_n N_i}{n}$, then the waiting time t_{ac} for the truck to be loaded.

4. Excavator-transport combination performance is determined by the expression (2).
5. The cost of loading and transporting one cubic meter (1 m³) of soil is determined by expression (1).
6. Productivity P_e and the cost of transporting 1 m³ of soil are calculated for the value of the number of vehicles $N_i = 2...10$ up to.
7. A graph of the dependence of functions $\Pi_{\text{э}} = \varphi(N_i)$ and $T_T = \varphi(N_i)$ on the values of calculation results is constructed.

8. According to the constructed graph $T_T = \varphi(N_i)$, the minimum value of T_T is determined, and the corresponding number of dump trucks, that is, the optimal number N_i , is determined.

Conclusion: It ensures continuous high-efficiency operation of all the technological machines included in the set of machines during the restoration of the defined N_i highways. The soil, which is brought in a continuous flow, ensures that the optimal set of vehicles will be completed within the specified time.

References:

1. Vavilov A.V. Machines for the maintenance and repair of roads and airfields: Proc. allowance / A.V. Vavilov, A.M. Shchemelev, D.I. Bochkarev and others; Ed. Dr. tech. sciences, prof. A.V. Vavilov. - Minsk: BNTU, 2003. - 408 p.
2. Shemelev A. M. Machines for public utilities: Textbook, manual / m. Shemelev, A. V. Vavilov, V. M. Pilipenko. - Minsk: Strinko, 2003. - 376 p.
3. Dovgyalo V.A. Machines and equipment for the maintenance of highways: textbook. allowance / V.A. Dovgyalo; M-in transp. and communications Rep. Belarus, Belarus. state transp. - Gomel: BelSUT, 2016. - 288 p.
4. V.I. Balovnev, G. Kustarev and others. Road-building machines and complexes. Publishing house "Sibadi". Moscow. Omsk. 2001. 522 st.
5. Maksudov Z.T., Kudaybergenov M, Ismailov J. On the frequency of service maintenance of the "SHANTUI SD 32" bulldozer in terms of fuel consumption and machine production, Collection of scientific papers of the eighth international scientific-practical conference, pp.151 -154, Almaty, (2019).



6. K.J.Rustamov, S.I. Komilov, M.S. Kudaybergenov, Sh.X.Shermatov, Sh.Sh. Xudoyqulov. Experimental Study of Hydraulic Equipment Operation Process. Construction Mechanics, Hydraulics and Water Resources Engineering.. -pages 5, 2021-year. <http://conmechhydro.tech/>.
7. Maksudov Z.T., Kudaybergenov M.S., Ernazarov J.Z. Methods of determining the number of road vehicles when forming a set of machines. International Scientific and Practical Conference "Actual Issues of Science". -12345678, 2022. 10.528.
8. Zokir Maksudov*, Mavlyan Kudaybergenov , Sh Kabikenov and Aydana Sungatollakzy. The machines optimal set development for the construction of automotive roads elements based on the "Norm" for machines employment cost. Tashkent State University of Transport. E3S Web of Conferences 264, 02031 (2021) <https://doi.org/10.1051/e3sconf/202126402031> CONMECHYDRO - 2021