SELECTION OF GARBAGE TRUCKS WITH RATIONAL PARAMETERS ACCORDING TO THE CRITERION OF MINIMUM WORK CYCLE TIME

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ABSTRACT

The article is devoted to the formation of a dependency for calculating the operating cycle time of a garbage truck as an optimization criterion and the determination of the main rational parameters of a garbage truck depending on operating conditions in the presence of an optimum objective function. The choice of a rational solution is based on single-criterion optimization based on the analysis of one criterion - the duration of the garbage truck's working cycle. By differentiating the duration of the garbage truck cycle to perform work operations by the mass capacity of the garbage truck container, the optimal mass of the garbage truck container is determined.

Keywords: garbage truck, municipal solid waste, cycle time, optimization, criterion, rational parameter.

INTRODUCTION

Rapid urbanization, an increase in the standard of living of the population in developing countries, the use of the method of small packaging of goods by entrepreneurs in order to obtain additional profit, etc., have greatly exacerbated the problem of municipal solid waste [1, 2, 3]. About 2,000 tons of municipal solid waste (MSW) is accumulated daily in Tashkent, which are transported to MSW landfills located outside the city by departments of the state unitary enterprise "Makhsustrans" and private firms for the collection and transportation of waste. The efficiency of using garbage trucks for collection and transportation is low for a number of reasons:

-Limited information provided by manufacturers or dealers of equipment;
- Disregard for real operating conditions during maintenance and repair of garbage trucks;
- Work beyond the limit loads during work operations;
- Lack of data on the cost of operating garbage trucks, etc.

In connection with the above, the choice of garbage trucks with rational parameters according to the criterion of the minimum operating cycle in the absence of data on the cost of maintenance costs is an urgent task.

Materials and Methods of Research

The collection and removal of solid waste is an important technological operation carried out by the municipal service of the city. The use of garbage trucks with rational technical parameters, depending on the operating conditions, is one of the important reserves for reducing energy, material and labor costs.

The choice of a garbage truck with rational technical and operational parameters for waste collection in the shortest possible time includes a number of stages;

-Determination of the features of the working cycle of the garbage truck as a cyclic machine;

- Formation of a reasonable criterion of mathematical dependence in the form of an objective function. Based on which you can choose the most rational machine;

- Development, based on the criterion, of a methodology for choosing a garbage truck with rational parameters for the corresponding operating conditions.

The garbage truck is a cyclically operating machine. Its purpose is the collection of solid waste, loading the waste into the body, compaction, grinding and transportation to the place of garbage reloading into a transport garbage truck. Then the work cycle is repeated. The collection and disposal of waste is an important sanitary-technological operation, which should be carried out as soon as possible. Garbage trucks usually have one engine, the power of which must be efficiently used for all operations of the working cycle.

When collecting garbage, the garbage truck moves at a minimum speed. In order to fully utilize the power and increase productivity at this stage, the garbage truck should be loaded as much as possible.

The operation of transporting garbage is performed at the highest (permissible by traffic safety standards) speed. At a constant engine power, the increase in productivity in this operation is due to a decrease in the weight of the load. These contradictions must be taken into account in the structure of the target criterion.

A garbage truck, as a sanitary-ecological machine, must collect and take out household waste in the shortest possible time intervals. As an optimization criterion for this case, it is advisable to use the performance of the garbage truck. This indicator will allow you to choose a machine that will provide debris removal at maximum performance in the shortest possible period of time. In this case, the collection and disposal of garbage is ensured in accordance with sanitary and environmental requirements.

The performance of the garbage truck depends on the geometric capacity V, m^3 of the body and the duration of the working cycle $t_ц$in sec. Performance is determined by the formula[4].

$$\Pi = \frac{3600 k_з k_и V}{t_{\Sigma ц}} \,, m^3 / h \,, \quad (1)$$

where $V -$ is the geometric capacity of the body, m^3; $k_з -$ body load factor; $k_и -$ coefficient of use of the garbage truck in time;

$t_{\Sigma ц}$ −total time of the working cycle, c.

The total cycle time is determined by the formula

$$t_{\Sigma ц} = t_{заг} + t_{пз.заг} + t_{манев} + t_{переезда} + t_{тр} + t_{хх} + t_{пз.тр}, с, \quad (2)$$

Formula (2) can be reduced to the form $(t_{тр} \approx t_{хх})$

$$\Pi = \frac{3600 k_з k_и V}{k_{всп.з} t_з + k_{всп.тр} t_{тр}} \,, m^3 / h \,, \quad (3)$$

The values of the coefficients $k_{всп.з}, k_{всп.тр}$ are experimental values and are determined by the formula

$$k_{всп.з} = 1 + \frac{t_{пз.заг} + t_{манев} + t_{переезда}}{t_{заг}} \; ; \quad k_{всп.тр} = 1 + \frac{t_{пз.тр}}{t_{тр} + t_{хх}}$$

Expressing in formula (3) the time for the loading operation ($t_{заг}$), the transportation operation and the return for a new portion of garbage ($t_{тр}$) through the technical and operational parameters of the garbage truck, we obtain

$$\Pi = \frac{k_3 V}{k_1 \frac{m_{кон}}{m} + k_2 \frac{f m l_{тр}}{N}} \, , м^3/ч, \qquad (4)$$

where $k_1 = f(k_{всп.з}, h_з, \vartheta_з), s$;

$$k_2 = \frac{k_{всп.тр} k_{гр} g}{\eta(1-\delta) k_{зд}}, m/s^2; \qquad k_3 = 3600 k_з k_и, \; s/h;$$

$V -$ geometric capacity of the body, m³;
$m_{кон} -$ mass capacity of the body in the yard container, kg;
$m -$ mass capacity of the body of the garbage truck, kg;
$f -$ coefficient of resistance to movement of the garbage truck, kg;
$l_{тр} -$ distance of garbage transportation to the place of disposal or to the place of reloading into a transport garbage truck, m;
$N -$ machine engine power, W;
$h_з -$ lifting height of the container when loading the body, m;
$\vartheta_з -$ container lifting speed, m/s;
$k_{гр} -$ coefficient taking into account the movement of the garbage truck with cargo and return without cargo;
$g -$ free fall acceleration, g=9.81 m/s²;
$\eta -$ transmission efficiency;
$\delta -$ average slip coefficient;
$k_{зд} -$ average engine load factor.

Analysis (4) shows that productivity has a maximum at the minimum value of the denominator-cycle time. The denominator has a minimum at a certain value of the mass capacity of the garbage truck m.

The garbage truck has one engine with power N.

When collecting and loading garbage, the speed of the garbage truck is minimal; in order to use its power, it must be loaded as much as possible, i.e. the reduction in t_z is provided by an increase in m.

During transportation, on the contrary, the speed ϑ is maximum, and in order to use the engine power, m should be reduced with an increase in ϑ.

The graph of function (4) depending on the mass capacity of the body m and the engine power of the base chassis N (with $l_{тр} = 5$ км, $k_{всп.з} = 60$) is given in Fig.1.

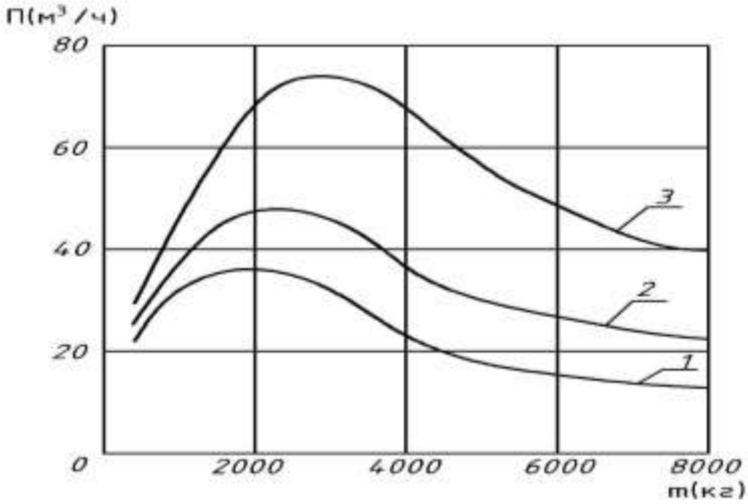

Fig.1. The dependence of the operational performance of the garbage truck P on the mass capacity of the body m and the engine power of the base chassis N at $l_{тр}$=5 km: 1-N=60 kW; 2-N=90 kW; 3-N=135 kW

On the graph, Fig. 2, the dependence of function (4) on the mass capacity of the body m and the distance of garbage transportation is given $l_{тр}(at\ \ N = 135\ kW, k_{всп.з} = 60\ )$

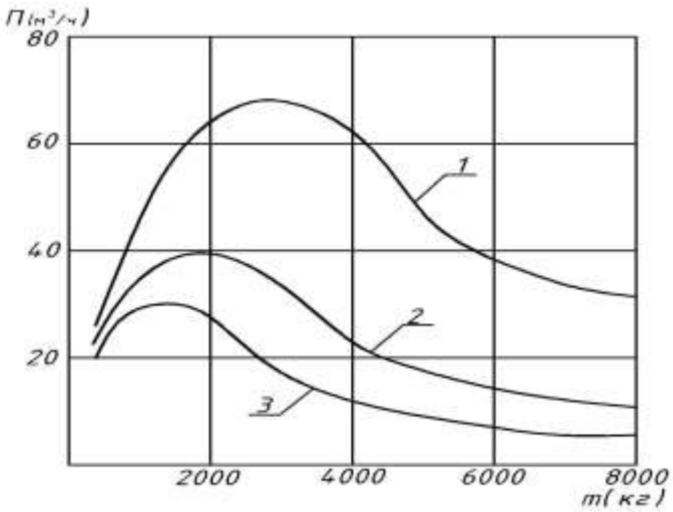

Fig.2. Dependence of the operational performance of the garbage truck П on the mass capacity of the body m and the transportation distance l_{tr} at N=135 kW: 1- l_{tr} =5 km; 2- l_{tr} =10km; 3- l_{tr} =20 km.

The optimal value of the mass is determined by equating the first derivative of the denominator in formula (4) to zero:

$$\frac{d}{dm}\left(k_1\frac{m_{кон}}{m} + k_2\frac{fml_{тр}}{N}\right) = 0$$

After differentiation we have

$$-k_1\frac{m_{кон}}{m^2} + k_2\frac{fl_{тр}}{N} = 0$$

From this expression, we determine the optimal m (we substitute the values of k_1 and k_2 into the formula), at which the performance will have a maximum value.

$$m_{опт} = \left(\frac{k_{всп.з}h_з\eta(1-\delta)k_{зд}m_{кон}N}{\vartheta_з k_{всп.m}k_{гр}gfl_{тр}}\right)^{1/2}, \qquad (5)$$

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Analysis of formula (5) shows that the optimal value $m_{опт}$ of the mass capacity of the body depends on a number of factors.

Graph of the dependence of the optimal value of the cargo capacity (5) $m_{опт}$ on the transportation distance $l_{тр}$ and the engine power of the base machine N is given in Fig.3.

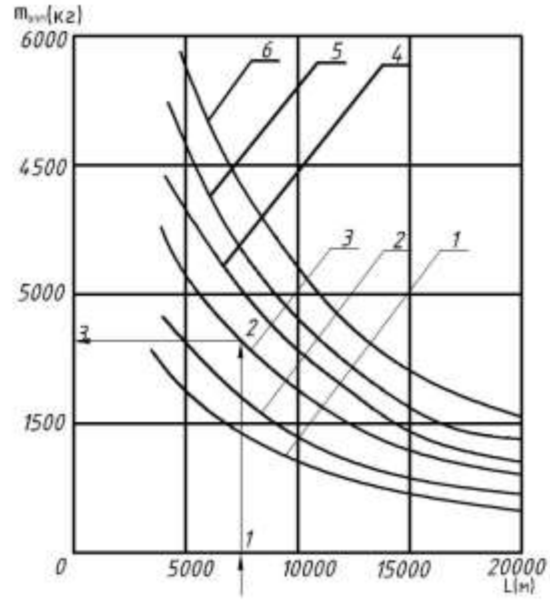
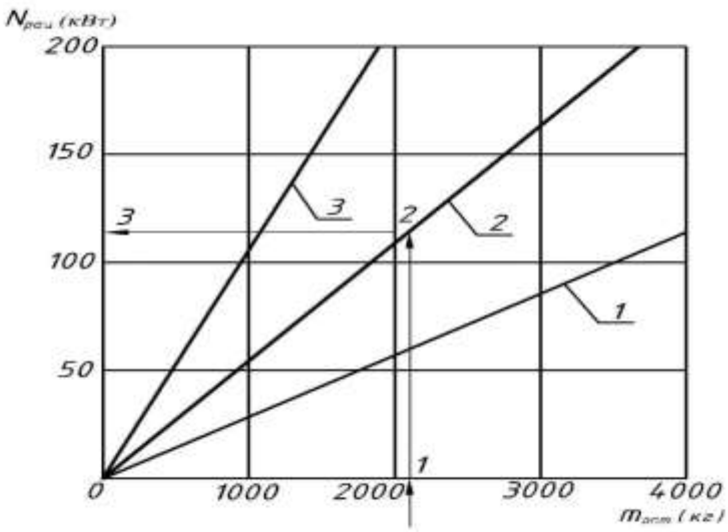


Fig. 3. Dependence of the optimal value of the mass capacity of the body $m_{опт}$ on the range of transportation of garbage $l_{тр}$ and engine power of the base machine N: 1-N=60 kW; 2-N=75 kW; 3-N=90 kW; 4-N=115 kW ;5-N=135 kW;6-N=150 kW

Based on (5), we determine the rational value of the power N depending on $m_{опт}$

$$N = \frac{k_{кон}}{k} l_{тр} m_{опт}, W \qquad (7)$$

The graph of function (7) depending on the mass capacity of the body $m_{опт}$ and the transportation distance $l_{тр}$is given in Fig.4.



The method for choosing a garbage truck with rational parameters is as follows.

At the beginning, a car is chosen that can work in conditions of travel on intra-quarter roads, in a cramped working area.

The value of rational power is checked, as shown in the graph (Fig. 4). Point 1 is marked on the horizontal axis according to the value $m_{опт}$ obtained in the graph of Fig. 3, as shown in Fig. 4. At point 3, we obtain the rational value of N. We choose a garbage truck with a capacity that best matches the capacity of $N_{рац}$. Rational power can be determined by calculation using formula (7).

From the existing garbage trucks, we choose the one whose parameters m and N most closely match the calculated ones.

CONCLUSIONS

1. Optimization criteria, or performance indicators, based on the analysis of which a rational decision is made. They are chosen taking into account the goals set for the manufacturer of the work (reducing production time, saving energy costs, saving labor costs, reducing the cost of work, and others).
2. The optimal parameters of the machine, set according to one of the efficiency criteria, may not coincide with those established according to other criteria.
3. In the structure of the enterprise of technical service and production of equipment, it is advisable to organize a structure that should:
- To give recommendations to buyers of equipment about the most rational machines necessary for the effective performance of work in the conditions of operation of the equipment;
4. Recommend to production the introduction of changes in the design of the machine that increase its efficiency.

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