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The Methodology of the Operating Cost Accounting in Identifying Mileage of Efficient Motor Vehicle Operation

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ABSTRACT

The article considers the current approach to the calculation of unit costs for maintenance and repair of the rolling stock of the automobile transport. In order to more accurately determine unit costs and the moment of the write-off of a car, the method of cost accounting for the operation of motor vehicles has been developed. The proposed method is of operational nature. Unlike the existing approach, it allows to track the intensity of cost increment at a constant total aggregate cost. Since the maintenance operation interval is a constant measure of the technical condition of any vehicle, this method allows comparing the intensity of cost changes for various models of cars within their class. Thus, it can be one of the criteria for the scientific substantiation of the selection of transportation vehicles.

Keywords: Unit Cost, Maintenance Operation, Auto Service, Write-off Time, Operation
JEL Classifications: D46, O31

1. INTRODUCTION

Here are a few examples when the economic indicators are accepted as the main criterion for making decisions about the timing of rolling stock operation and (or) its selection.

The aim of the study (Igolokin, 2010) is to define the resources of city buses. The paper discusses a method of bus resource modeling. As a complex index of the technical state of a bus, its operating efficiency is accepted, defined as the ratio of machine hours of actual work for the period under review to planned machine-hours during the same period of time. For a given (planned) value of operating efficiency, the values of the main indicators of technical operation of buses: f - exploitation period till work-off time; L_c - mileage before write-off; R_c - total costs for maintenance operation (MO) and auto service (AS); dt and dL - costs for MO and AS of the bus considering the cost, given respectively to the time of operation and 1,000 kilometers of mileage.

An index of operating efficiency of the bus, in which the stop of its operation provides a minimum of costs for MO and AS in view of its cost, is determined. It was also concluded, that the main drawback of existing methods is the lack of accounting for exploitation profits. This condition is required for in real market conditions it is required for foreign buses purchased with substantial mileage, because regulatory or recommended values for them do not exist, and there is necessity to introduce the concept of a comprehensive economic criterion for determining the overall limit of buses condition.

In the end, according to the proposed method of determining the resource of city buses, the increase of bus resources limit approximately up to 100 thousand km is expected.

In this case, a substitution of a complex indicator of "quality of a car" by economic indicator arises, and such determinants for the operation of city buses factors as the comfort and safety of passengers, environmental and safe condition of the vehicle are not taken into account.

In the work (Prokhorov, 2008), the methodology of rational write-off of city buses working in the city, which includes the write-off of rolling stock according to economic criteria, using the method of dynamic programming, is given. The required minimum total cost Z^* for the entire period of operation of the bus is defined as:

$$Z^*(0)=\frac{1}{1-\alpha^N}\left\{r(0)+ar(1)+...+a^{N-1}\cdot r(N-1)+a^N\left[p-\varphi(N)\right]\right\}$$

where α - discounting factor; N - steps (years) of buses replacement; r - the annual operating costs; φ is the residual value, thousand rubles; p - the initial cost of the bus, thousand rubles.

The calculations in the work (Prokhorov, 2008) made it possible to determine that the optimal period of use of urban buses LiAZ amounts to 7 years. This result is well correlated with developments in this study, but in accordance with the work (GOST R 53480-2009), the limiting condition is the condition of a product in which its further operation is invalid or impractical by reasons of economic, environment and risk. It is fair to say that the work (GOST R 53480-2009) is applied since 2009 and the work (Prokhorov, 2008) was published in 2008.

In the work (Migachev, 2012) a system of relative factors underlying the methodology of rational choice of rolling stock by the criterion of "conditional technical costs" (CTC) was proposed. In general, this method gives an opportunity to assess the effectiveness of various organizational-technical measures aimed at improving the efficiency of trucks operation. The value of CTC is determined according to the existing methods of calculation of fuel, lubricants, tires consumption and cost of spare parts for cars. Then the multiplication of the values by the value of these materials is performed in order to obtain their absolute values. When comparing different cars on this indicator, a corresponding type can be achieved by dividing by the scope of transport work performed by cargo vehicles for the reporting period. In this case, economic decisions are used not only to determine the operation period of the car, but also to select the rolling stock.

Definitely, not only the increase in operating costs of rolling stock and reducing its reliability, but also observance of environmental indicators and safety indicators work are modern requirements to the operating organizations and individuals.

Identifying the mileage of efficient vehicle operation $l_{c(i)}$ is an important element of a vehicle life cycle management system (VLCMS) (Vorontsov, 2006; GOST R ISO 14040-99, Gurbanov, 2005).

The availability of information on the predicted, planned or ongoing mileage of each car (database $l_{c(i)}$) allows:

1. Car dealers to develop a strategic program for the release of production, to adjust the size of the network maintenance of their models of motor vehicles (MV) (service station dealers), to plan the development or reduction of the activity in a particular region or geographical area;
2. Operating organizations to manage the age structure of the MV park, to efficiently plan the performance indicators of MV and the cost of their maintenance and operation (Avdon'kin, 1993; Bondarenko, 1996; Denisov and Bazhenov 2010);
3. Enterprises involved in MV utilizing and recycling to determine production capacity and their geographic arrangement (Dyachenko, 2002).

Thus, the mileage of efficient operation is a restriction, which allows to optimize the processes of management of material and energy flows at the local stages of VLCMS and in the system as a whole. It should be noted that the methodological basis of forecasting (basic indicators of MO and AS) to determine the moment of write-off and timing operation of the MV, today is quite well developed and understood. But significant scientific and technical progress in the design of MV and the changing requirements of the operating environment force to adapt it to changing conditions.

The objective of this study is to prove that the problem of adaptation of the system of technical operation of the car to current conditions is to be solved not for the maximum long term operation of the car but for achieving a given required levels of reliability, safety, environmental safety and efficiency of cars within a certain mileage.

Upon reaching this level the car must be taken off the operation even if it is not worn out.

2. METHODS

The actual distribution of the operating costs associated with the operation of the automobile transport rolling stock shows that the largest relative share includes the cost of fuel, MO, operating repair (OR) and the wages of drivers. Moreover, it is obvious that maintenance and repair costs are characterized by the maximum dynamics of change, depending on the operating time or mileage of MV. As a rule, for optimizing the operation lifetime of the MV with account of unit costs a target function is used which allows to minimize total unit costs $d(t)$ of the maintenance of the MV depending on their age or mileage:

$$d(t)=\frac{R^c+S}{t_c}\rightarrow \min$$

where R_c means total costs of maintenance and OR of MV; S - means the cost of new MV; t_c - means the optimal time for write-off of MV.

Therefore, total unit costs are determined in relation to the planned or actual mileage of MV up to their write-off, thereby averaging the values of all components of the cost structure.

In order to manage the "aging" processes or analyze the loss of the efficiency of MV it is reasonable to evaluate the costs of MV operation more differentially depending on the time of its operation or mileage (Terentiev, 2015). This is possible in case when the method of operational account of costs of MV operation is applied to assess the dynamics.

Let us consider the following conditions:

1. Change in the unit costs R_c is a continuous increasing function $R_e(l)$;

2. Dependence of the change in the costs $R_e(l)$ of operation on the mileage of the car since the start of operation is approximated by a linear function;
3. The mileage within routine maintenance of the car is used as the cost interval (Terentiev and Prudovsky, 2014).

Thus, the method of operational accounting of costs of MV operation is represented as follows:

1. The costs of each MP are evaluated:

$$R_{ej} = \sum_{i=1}^{n} r_{ij}\text{, RUB} \qquad (2)$$

where R_{ej} - means costs on the j interval of the mileage of the MV; r_{ij} - means costs upon the i item within the j maintenance interval, RUB.

2. Unit costs of MV operation are evaluated:

$$R_{cj} = \frac{\sum_{i=1}^{n} r_{ij}}{\Delta l_j} \cdot 1000\text{, RUB /1000 km} \qquad (3)$$

where R_{cj} - means unit costs within the j maintenance interval RUR/1000 km; r_{ij} - means costs upon the i item within the j maintenance interval, RUB; Δl_j - means the mileage corresponding to the maintenance regulation, km.

For comparison, the unit costs of the MV operation with account of the mileage since the beginning of the operation are determined as follows:

$$R_{lj} = \frac{\sum_{i=1}^{n} r_{ij}}{l_j} \cdot 1000\text{, RUB/1000 km} \qquad (4)$$

where R_l - means unit costs on the j mileage interval since the beginning of the MV operation, RUB/1000 km; r_{ij} - means costs upon the i item on the j maintenance interval of the mileage since the beginning of the MV operation, RUB; l_j - means the mileage since the beginning of the MV operation corresponding to the Maintenance Regulation, km.

Statistics show that the function of cost increasing on each maintenance interval is polynomial in general, but it is well approximated into the linear dependence. Let us illustrate the change in the total costs of MV operation (Figure 1):

1. Total costs since the beginning of the operation (R_l^{Σ});
2. Total costs within the maintenance interval (R_M^{Σ}).
   The change in corresponding unit costs of MV operation is presented in Figure 2:
   a. Unit costs (R_{lj});
   b. Unit costs (R_{cj}).
3. The notional residual cost (NRC) of the car is determined as follows:

$$S_0(l) = \frac{Scar}{l_j}\text{, RUB/1000 km,} \qquad (5)$$

where S_{car} - the cost of the car (RUB).
The NRC use is conditioned by its neutrality with respect to the life of the useful life of the MV.

When determining the residual cost of the MV with the application of the amortization method, the planned life of the vehicle is generally established. In this case the life of the MV should be determined on the basis of the costs of its operation. By the nature of the reduction of the residual value the NRC corresponds to the amortization method - reducing balance method (Loginova, 2011). To apply this method of determination of the vehicle residual cost it is enough to use the coefficient considering the depreciation percentage:

$$S_0 car = C_{car} \frac{S_{car}}{l_j}\text{, RUB/1000 km} \qquad (6)$$

where C_{car} - means the coefficient of transition to the method of determination of the vehicle residual cost through depreciation - reducing balance method.

4. Graphic and analytical links between indicators R_{cj}, S_{0car} are determined based on the data of experimental studies (data of the VLCMS). Figure 3 presents a curve of changes R_{cj}, $S_{0\,car}$ for the taxi car working in the conditions of Saint Petersburg.

Figure 1: Total costs of motor vehicle operation

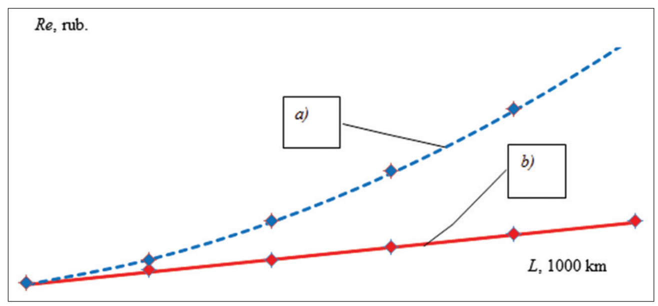


Figure 2: Unit costs of motor vehicle operation

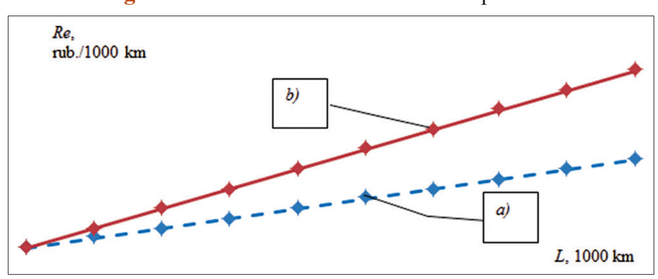
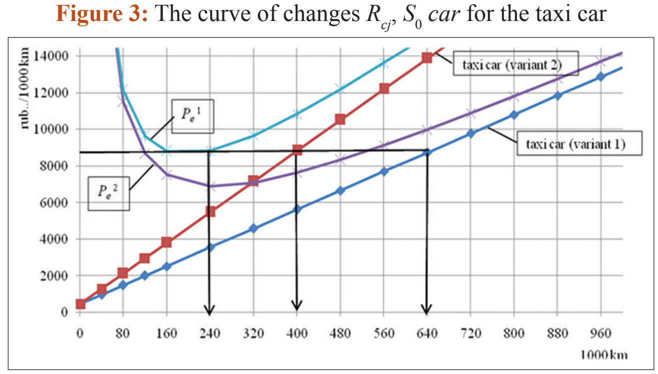


Figure 3: The curve of changes R_{cj}, S_0 *car* for the taxi car



5. The effectiveness parameter of the MV (P_v) is calculated as follows:
   - Variant 1:

$$P_e^2(l) = R_l(l) + S_{0car}(l), \text{ RUB/1000 km} \quad (7)$$

   - Variant 2:

$$P_e^1(l) = R_c(l) + S_{0car}(l), \text{ RUB/1000 km} \quad (8)$$

6. The minimum value (P_v) and its corresponding mileage value prior to the vehicle write-off l_w:
   - Graphically:

   $P_v^1 \approx$ 8,500 RUR/1,000 km when lw ≈ 160 th. km.
   $P_v^2 \approx$ 6,500 RUR/1,000 km when lw ≈ 240 th. km.
- Analytically:

$$P_e(l) = C_{car}\frac{S_{car}}{l} + C \cdot l + b$$

$$P_v^{'}(l) = -\frac{C_{car}S_{car}}{l^2} + C = 0$$

$$l_s = \sqrt{\frac{C_{car}S_{car}}{C}} \quad (9)$$

3. RESULTS

The results of calculation of the mileage of the effective vehicle operation upon the variants under consideration (Table 1) are presented below:

l_s^2 = 195 th. km, l_s^1 = 248 th. km.
P_v^2 = 8,652 RUB/1000 km, P_v^1 = 6,892 RUB/1000 km.

4. CONCLUSION

The proposed methodology is operational. At constant total aggregate costs this methodology, in contrast to the current approach (Khasanov, 2013), allows to monitor the intensity of their increment. Since the maintenance interval is a constant measure of the technical status of any MV, this methodology allows to compare the rate in cost changes for different car models within a certain vehicle class. It means that it may be one of the criteria (Terentiev, 2015) of the scientific basis for the choice of a MV for transportation.

Table 1: Results of the calculation of the parameter P_v

Vehicle type	Notation	Variant 1		Variant 2	
		L_s	P_v	L_s	P_v
Taxi car	Taxi car	248	6892	195	8652

The present article has considered the maintenance costs only; an integrated approach implies the account of the costs of the current repair, overhaul, if necessary, as well as the account of the various forms of car purchase (leasing, hire-purchase of the rolling stock). These amendments will correct the mileage of the effective vehicle operation. In each case it is necessary to make amendments to the methodology.

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