Software package for evaluation of efficiency of motor vehicle fleet operation

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Abstract. The article describes an improved approach to assessing the efficiency of using the road transport of enterprises based on the assessment of the technical readiness factor of the fleet using the average daily mileage and specific idle time in maintenance and operation. The software implementation of this method in MS Excel is shown, the results of application and the results obtained are analyzed approbation at the enterprise of the metallurgical industry.

1. Introduction
The problem of increasing the efficiency of motor vehicles operation in modern economic realities is one of the most frequently encountered tasks for motor transport enterprises of all forms of ownership [1-3].

At the same time, the key task is to fulfill the transport task on transportation.

The transportation task, with other equal factors, is ensured by:
1. Increase of the productivity of motor vehicles.
2. Increase of time of the vehicle being in serviceable condition.

At the majority of enterprises the considerable potential of increase of efficiency of work of motor vehicles consists in an increase of level of working capacity of cars (improvement of technical operation) which is scaled up by an indicator "coefficient of technical readiness" (CTR). There are several ways to determine a CTR [5] and, using one or the other methods, it is possible, deliberately or accidentally, to obtain significantly different CTR values.

For effective management of the motor transport fleet it is necessary to have objective information about its current condition. With proper application and consideration of all factors and conditions of motor vehicles, calculation by any method should give equally correct result. Unfortunately, this does not always happen in practice.

2. Materials and methods
The use of the standard formula for calculating CTR as the ratio of the number of serviceable cars (car-days) to the list often leads to a significant error in the calculations. To eliminate it, first of all, it is necessary to take into account the idle time in the defective state taking into account possible presence of a vehicle in the correct or defective condition during one shift (i.e. in hours or fractions of
shift). Secondly, in order to correctly calculate the CTR, it is necessary to take into account all the conditions when the vehicle is inoperable: delivery from the line, waiting for spare parts, waiting for posting, time of maintenance and repair works, etc. Taking into account only the labor intensity of maintenance and repair in the calculation unreasonably overstates the CTR values and is unacceptable. In addition, using the CTR value alone to assess the performance of the technical service is not enough, one should use the value of specific idle time in maintenance and repair (man-hour/1000 km mileage) [5]. Meeting these requirements allows one to receive reliable objective values for the analysis of efficiency of motor vehicle fleet operation and work of technical service of an enterprise.

Thus, the methodology for calculating the CTR taking into account these comments is as follows.

To calculate the CTR value it is necessary to differentiate two possible vehicle conditions:

a) in good working order - it is in service and may be allowed for use;

b) faulty (including routine maintenance) - it is in the technical service and cannot perform transportation.

The moment of transition between states should be accurately recorded by a responsible person with documentary evidence. The sum of time when the vehicle is in all possible (two) states is equal to 100%, and this is used to control the correctness of accounting. Formula for calculating CTR:

\[ \alpha_T = \frac{1}{1 + B_\Sigma \times L_{CC}} \]  

(1)

where \( B_\Sigma \) is the total specific idle time of the analyzed vehicles in maintenance and technical repair (being in faulty condition), shift/1000 km for the analyzed period of time;

\( L_{CC} \) – average daily mileage of the analyzed vehicles for the analyzed period of time, thousand km.

The total specific idle time of a vehicle in maintenance and technical repair \( B_\Sigma \) is defined as the sum of the i-th specific idle time for certain types of technical actions:

\[ B_i = \frac{t_i}{X_i} \text{ shift/1000 km} \]  

(2)

where \( t_i \) – average vehicle idle time during the i-th technical effect, shifts,

\( X_i \) – mean time to failure, the i-th technical action, thousand km.

The mean time to failure \( X_i \) is determined by the following formula:

\[ X_i = \frac{L_\Sigma}{n_i}, \]  

(3)

where \( L_\Sigma \) is the total mileage of all analyzed motor vehicles for the calculation period, thousand km;

\( n_i \) is the number of failures for each calculated group of the i-th technical actions, units.

As the duration of the shift is taken the time of the vehicle in hours per day, i.e. for vehicles working 8 hours a day, 1 shift is equal to 8 hours, for vehicles working around the clock, 1 shift is equal to 24 hours.

It is recommended to calculate the total specific idle time in a faulty state by the following types of technical actions/conditions:

a) actual time of the vehicle staying in the maintenance and repair area;

b) waiting for evacuation;

c) evacuation to repair site;
d) diagnostics;  
e) paperwork;  
f) waiting for spare parts;  
g) waiting for a post;  
h) other unaccounted vehicle time.

To implement the abovementioned method of calculating CTR values for the motor transport fleet, a software macro has been developed in MS Excel environment with the possibility of synchronization and automatic data download from the systems of telematic control of equipment, as well as the working environment of enterprise fleet management (for example, 1C software). The appearance of the working variant of the CTR calculation macro is shown in Figure 1. An example of CTR calculation together with the data analysis block for CTR calculated values and specific idle time in maintenance and repair is shown in Figure 2.

| Car group mileage 08.02.20 | 41 771 km | Average daily mileage of 1 car | 163,168 km | 0,163168 thousand km |
|--------------------------|-----------|--------------------------------|-------------|----------------------|
| Number of orders | Total loss of time (hours) | Average downtime (hours) | Mileage to failure, km | Average idle time, shifts | Specific downtime in maintenance and repair, shifts |
| 1 service | 4 | 19 | 4.75 | 1044,8 | 0,198 | 0,0190 |
| 2 service | 3 | 72 | 24 | 13923.7 | 1,000 | 0,0718 |
| Waiting for repair | 6 | 247 | 41,166667 | 6961,8 | 1,715 | 0,2464 |
| Emergency repair | 1 | 12 | 12 | 41771,0 | 0,500 | 0,0120 |
| Request repair | 12 | 56 | 4,666667 | 3480,9 | 0,194 | 0,0559 |
| Repairs | 31 | 376 | 12,13 | 1347,5 | 0,505 | 0,3751 |
| Total | | | | | | 0,7800 |

CTR | 0,8871 |

**Figure 1.** Example of the working screen of the CTR calculation macro
The obtained values are automatically transferred to the summary table by divisions, models, subordinates etc. Subsequently, the calculated values are analyzed and compared in a month, quarter, year, and also compared with previous periods. An example of a summary analytical table is shown in Figure 3 (data of vehicles are hidden for reasons of data non-disclosure).

Figure 2. Example of operation of the analysis block of calculation data

The developed software tool for collection, calculation and analysis of information allows (under the condition of integration into the existing electronic document flow environment) to calculate CTG...
values and specific idle time in an automated mode in maintenance and repair, to carry out the primary analysis of reasons of fulfillment/non-fulfillment of planned indicators, to monitor the achievement of key performance indicators and thresholds in an automated mode, as well as to minimize the subjectivism of evaluation and human factor in the calculation and analysis of indicators.

The application of the developed software tools within the framework of activities of one particular enterprise of the metallurgical industry in 2019-2020 allowed to reveal a number of work features:

1. The calculation method is sensitive to the accuracy of accounting for changes in technical conditions, it requires prompt fixation and timely data transfer to the central server.
2. Operation of road construction and utility vehicles with high idle time while waiting for work results in extremely low CTR values with the overall good condition of the machines.
3. The analysis of efficiency indicators of motor transport fleet is only possible at a complex estimation of CTR values, specific idle time in maintenance and repair, and also average speed of movement that demands participation of an expert.
4. It is clearly shown that the discrepancy between the working hours of a vehicle and the work of the maintenance and repair service leads to an increase in specific idle time and a decrease in CTR.
5. The proper objectivity and reliability of data can be achieved only with automated and centralized data collection from motor vehicles using remote telematic transport control systems.

3. Conclusion
The given methodology sets the goal - to assess the efficiency of the technical service.
Having received the time that the car is in a faulty condition, we get the time that the car is in good working order. Comparison of this time with the operating time of cars on the line gives an indicator of the efficiency of the operation (commercial operation) service: how effectively the time spent by cars in good condition is used. This indicator can be specified in hours, shifts or percentages.

Thus, we have 2 indicators of the technical service performance and 3 indicators of the operation service.

Technical service (technical operation of vehicles):
1. Specific downtime in TO and TR, shifts / 1000 km.
2. CTR.

Maintenance service (commercial vehicle operation):
1. Clock in good condition / clock on line.
2. Productivity, tons (tkm).
3. Cost of transportation, USD / km (USD / tkm).

The widespread introduction of these performance indicators by production will help identify weaknesses in the technical and commercial operation of vehicles and improve key performance indicators.

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