Features of realization of life cycle of commercial vehicles in western Siberia

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Abstract. The management of a trucking enterprise is considered on the basis of reducing costs and increasing profitability during the life cycle operational period of the vehicles. Economic evaluation of the variants of the use of vehicles passed the normative operation period was carried out.

1. Introduction
Effective management of a trucking enterprise is not possible without planning and controlling the costs of rolling stock operation. Expenses for the cars operation are one of the components when pricing of transport services. In turn, the operating costs and cars profitability depend on their life cycle.

Sequentially arising periods: design, production, installation, storage, operation and disposal, are the car life cycle.

The car life cycle is realized by the car manufacturer and the owner buys the car. The car manufacturer realizes designing, manufacturing, installation and storage as well as can influence the car utilization. Influence involves the design of the car, taking into account its subsequent disposal, creation of conditions and organization of car reclaiming processes. The owner acquires the car and realizes the stages of its operation and utilization. The operational phase in turn may include vehicle modernization, repair and maintenance. The time of reclaiming of a car depends on the nature and conditions of its operation.

2. Materials and methods
For commercial vehicles, in terms of economic feasibility, it is important for the life cycle of the car, and at what time point it will be rational to stop the operation and reclaim it.

Let us consider the car operation process. In the operation process, every vehicle undergoes the maintenance, current and major repairs. For each car, the manufacturer enshrines a standard operating life; within this period there is a need for major repairs of the units and assemblies of the car. The major repair is intended for the regulated restoration of lost performance of cars and aggregates. Restoration of the main parts during major repair should ensure a level of quality close to or equal to the quality of new products [1].

Each owner of the car, especially commercial, solves the problem in the process of operation: what is better – to carry out a major overhaul of the car to restore its consumer properties or to buy a new vehicle with the reclaiming of the car that has passed its standard operating life.

Let us analyze the operation of commercial vehicles from the technical and economic point of view. What will be more expedient – to carry out a major repair of the car and continue to operate it or buy a new car and reclaim the old one.

Research was carried out at transport enterprises of the OAO NK Rosneft group in Western Siberia.
Let us compare the advantages and disadvantages of two options (projects) of car exploitation by conducting a SWOT-analysis based on a survey of the engineering and technical composition of enterprises (Table 1).

| Options /evaluation | Acquisition of new cars | Cars major repair |
|---------------------|-------------------------|-------------------|
| **Advantages**      | - high resource and reliability of new equipment; | - less financial costs in comparison with the buying of new cars; |
|                     | - improving the quality of services through the use of more productive cars (more complete in the design, as in the context of 10 years, it is significantly changing); | - increase of professionalism of repair personnel; |
|                     | - attraction of additional financial resources through the reclaiming of cars; | - development of invention and innovation; |
|                     | - reduction of costs for current repairs and reduction of stocks of spare details in warehouses; | - low time for project implementation |
|                     | - improving labor conditions for drivers and maintenance personnel |                     |
| **Disadvantages**   | - high project costs; | - low resource of overhauled automobiles; |
|                     | - possible reductions in stuff and related benefits | - increase in vehicle repair costs; |
|                     |                     | - increase of stocks of spare details in warehouses; |
|                     |                     | - lack of reserves to improve the quality of transport services; |
|                     |                     | - relatively low major repair runs |

Table 1. Table SWOT-analysis

On the basis of empirical studies, it was found that new cars can realize more customer orders by increasing the intensity of their use in comparison with the cars that have undergone major repairs. The increase in the operation intensity of new cars is due to greater consumer compatibility. This is connected most often with the fact that automakers regularly improve the consumer properties of cars. More comfortable car performance is more competitive in the market.

Let us consider the main differences between the operation of new cars and cars that have undergone major repairs. One of the operational indicators is the truck availability rate — $\alpha_t$; it determines the proportion of working time during which the truck fleet is in good repair and can be used in the transport process.

Coefficient of technical readiness ($\alpha_t$) is calculated by the formula:

$$\alpha_t = \frac{(AD_{hoz} - AD_{rem} - AD_{to})}{AD_{hoz}}, \quad (1)$$

where $AD_{hoz}$ — truck-days on the farm;
$AD_{rem}$ — car-days are under repair;
$AD_{to}$ — car-days in maintenance.

The coefficient of technical readiness is one of the indicators characterizing the performance of the car and truck fleet [2]. The coefficient of technical readiness is higher for new cars in comparison with cars after overhaul.

Fleet utilization of motor vehicles is the indicator characterizing the degree of use of the truck fleet for a calendar period. It is defined as the ratio of the car-days in operation to the value of car-days in the farm.

For any commercial enterprise, this coefficient should tend to a maximum, thus, let us obtain the objective function:
Fleet Utilization (KIP) \((\alpha_m, t) \rightarrow \text{max} \). \( (2) \)

With the increase in the operation life of the truck park, fleet utilization changes during time \(t\). It is important that its decline occurs as slowly as possible.

The data on the change in fleet utilization in instrumentation (theoretically) for new machinery and overhauled equipment are given in Table 2, respectively.

Table 2. Dynamics of change in fleet utilization

| Name / year                        | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|------------------------------------|------|------|------|------|------|------|------|------|------|------|------|
| Buldozers B -170                   | 0.77 | 0.75 | 0.73 | 0.69 | 0.67 | 0.65 | 0.63 | 0.6  | 0.57 | 0.54 | 0.51 |
| Rippers T-25.01                    | 0.76 | 0.74 | 0.72 | 0.69 | 0.67 | 0.65 | 0.63 | 0.6  | 0.57 | 0.54 | 0.51 |
| Pipelayers TT-163 T-170            | 0.77 | 0.75 | 0.73 | 0.69 | 0.67 | 0.65 | 0.63 | 0.6  | 0.57 | 0.54 | 0.51 |
| Truck crane KC-35714               | 0.77 | 0.75 | 0.73 | 0.69 | 0.67 | 0.65 | 0.63 | 0.6  | 0.57 | 0.54 | 0.51 |
| KZKT-7428 with semitrailer KZKT-9101| 0.72 | 0.7 | 0.68 | 0.65 | 0.64 | 0.63 | 0.62 | 0.6  | 0.57 | 0.54 | 0.51 |
| KrAZ-260B with CHMZAP-99865        | 0.73 | 0.71 | 0.69 | 0.65 | 0.64 | 0.63 | 0.62 | 0.6  | 0.57 | 0.54 | 0.51 |
| URAL-44202 with semitrailer CHMZAP-9906 | 0.72 | 0.7 | 0.68 | 0.65 | 0.63 | 0.62 | 0.6  | 0.57 | 0.54 | 0.51 |
| URAL-43204                         | 0.76 | 0.74 | 0.72 | 0.69 | 0.67 | 0.65 | 0.63 | 0.6  | 0.57 | 0.54 | 0.51 |
| Tatra-815 UDS-114                   | 0.79 | 0.77 | 0.75 | 0.72 | 0.7 | 0.68 | 0.65 | 0.62 | 0.58 | 0.54 | 0.51 |

| Change in fleet utilization of equipment after the major repair |
|---------------------------------------------------------------|
| Bulldozers B -170                                           | 0.73 | 0.72 | 0.71 | 0.68 | 0.63 | 0.59 | 0.52 | 0.43 | 0.33 | 0.29 | 0.23 |
| Rippers T-25.01                                              | 0.72 | 0.7 | 0.68 | 0.64 | 0.6 | 0.55 | 0.5 | 0.44 | 0.37 | 0.29 | 0.23 |
| Pipelayers TG-163 T-170                                      | 0.74 | 0.72 | 0.68 | 0.64 | 0.6 | 0.55 | 0.51 | 0.45 | 0.38 | 0.3 | 0.23 |
| Mobile crane KS-35714                                        | 0.74 | 0.72 | 0.68 | 0.65 | 0.6 | 0.55 | 0.49 | 0.43 | 0.36 | 0.29 | 0.23 |
| KZKT-7428 with semitrailer KZKT-9101                         | 0.67 | 0.65 | 0.63 | 0.6 | 0.58 | 0.56 | 0.5 | 0.44 | 0.37 | 0.3 | 0.23 |
| KrAZ-260B with CHMZAP-99865                                  | 0.68 | 0.68 | 0.66 | 0.63 | 0.6 | 0.56 | 0.5 | 0.44 | 0.36 | 0.3 | 0.23 |
| URAL-44202 with semitrailer CHMZAP-9906                      | 0.70 | 0.69 | 0.68 | 0.64 | 0.59 | 0.52 | 0.44 | 0.39 | 0.31 | 0.26 | 0.23 |
| URAL - 43204                                                  | 0.72 | 0.7 | 0.67 | 0.64 | 0.6 | 0.56 | 0.5 | 0.44 | 0.36 | 0.28 | 0.23 |
| Tatra - 815 UDS-114                                           | 0.76 | 0.73 | 0.7 | 0.66 | 0.61 | 0.55 | 0.5 | 0.44 | 0.34 | 0.24 | 0.2 |

Based on the results of empirical and theoretical studies, the change in the fleet utilization instrumentation is as follows (Fig. 1). From the graph, it is obvious that in the initial period of the project realization, the fleet utilization is practically the same, however, with time \(t\), the intensity of the decrease in the fleet utilization in the equipment after major repairs much larger, and the instrumentation of new and repaired equipment differs almost twofold in 10 years. That is, the resource of equipment after major repairs is much lower.

The figure shows the initial period of the project. For the new equipment during this period, there is acquisition, delivery, registration in the bodies of the State Traffic Safety Inspectorate and the
Rostekhnadzor as well as commissioning. For the old equipment, this is the period of the directly overhaul, and when replacing the number of units, registration in the bodies of State Traffic Safety Inspectorate and Rostekhnadzor.

It should be noted that according to statistics, the cost of overhaul is estimated at about 80% that of the cost of a new car or tractor.

The technical and economic calculation was based on the use of equipment for 10 years (the life-time recommended by the manufacturer). As a rule, the useable life expectancy of transport and tractor equipment lies, approximately, within these limits.

It is advisable to use the indicators of economic efficiency and time of recovery of outlay (project) taking into account the time factor, based on the concept of the flow of real money, in calculating the yield and the payback period of both options [3,9]. It involves measuring the inflow and outflow of real money for the entire life cycle of the car [4], i.e. for the entire investment period, starting from the investment of the first ruble and ending with the last year of the car's existence. Obviously, money has a temporary value, i.e. the value of the ruble invested in the project during the investment period changes, so the calculations were carried out taking into account the discounting.

The calculation of economic efficiency was carried out according to the specific indicator "costs per ruble of income", costs per 100 motor-hours (m/h) of work or costs per 1000 km of mileage. In the calculations, the operating revenue are compared, which is brought by the new and the overhauled equipment, a costs comparison required for the equipment operation and a comparison of the specific indicators per output unit [10].

Calculation of maintenance and repair costs consists of three parts: calculating the amount of maintenance, (performed by [5]), calculating the cost of labor and calculating the cost of materials. In these calculations, the costs for maintenance and repair per 1000 km of mileage (100 m/h of work) are determined, for new machinery and equipment after the major overhaul (Table 3).
Table 3. Costs for maintenance and repair for new machinery and equipment after the overhaul. Total repair costs, rub. Costs for maintenance and P per 1000 km (100 m / h of operation) Total repair costs, rub. The cost of maintenance and P per 1000 km (100 m / h of work)

| Name                  | New machinery | Equipment after overhaul |
|-----------------------|---------------|--------------------------|
|                       | Total repair costs, rubles | Maintenance and repair costs per 1000 km (100 m/h of work) | Total repair costs, rubles | Maintenance and repair costs per 1000 km (100 m/h of work) |
| Bulldozers B -170    | 80931.21      | 809.31                   | 126820.27                  | 1268.20               |
| Rippers T-25.01       | 338218.06     | 3382.18                  | 504035.70                  | 5040.36               |
| Pipelayers TG-163 T-170 | 104943.08   | 1049.43                  | 168128.71                  | 1681.29               |
| Mobile crane KS-35714 | 497555.29     | 497.56                   | 731881.32                  | 731.88                |
| KZKT-7428 with semitrailer KZKT-9101 | 945708.3 | 945.71                   | 1445851                   | 1066.50               |
| KrAZ-260B with CHMZAP -99865 | 529579.7 | 529.58                   | 775239                    | 623.76                |
| URAL -44202 with semitrailer CHMZAP -9906 | 345792.7 | 345.79                   | 597779.1                  | 399.64                |
| URAL-43204           | 279479.78     | 279.48                   | 484850.53                  | 484.85                |
| Tatra-815 UDS-114     | 969784.21     | 969.78                   | 1314977.35                 | 1314.98               |

Further, to determine the amount of operating costs, the following indicators were established: the volume of transport services, the total annual mileage and total fuel consumption.

In accordance with regulatory documents approved by the Ministry of Transport, the fuel consumption rate should be increased by 5% [6] for cars older than 8 years.

Knowing that the fall of the instrumentation for the overhauled equipment with the time occurs more intensively than the fall of the instrumentation of new equipment, it is quite enough to bring the indicators in one year of using the technology. Indicators of profitability of machinery for 2015 are presented in Table 4.

As can be seen from the table, when comparing the options by one unit the option of acquiring the new equipment certainly benefits, both in terms of profit and cost.

A comparison of the profit indicators (Figure 2) and the changes in costs (Figure 3) for the operating options are as follows:

Despite the longer payback period of the project for acquiring new equipment, the profit from this option is higher than that of the overhaul and maintenance of old equipment. The option of operating the equipment after the overhaul wins only for a shorter payback period of investment.
Table 4. Indicators of profitability of options for 2015

| Name                        | new  | old  | Profitability, thou. rubles. | Costs for 1000 km of mileage (100 m/h of work), thou. rubles. |
|-----------------------------|------|------|-------------------------------|---------------------------------------------------------------|
| fleet utilization           |      |      | Profitability, thou. rubles. | Costs for 1000 km of mileage (100 m/h of work), thou. rubles. |
| Bulldozers B -170           | 0.77 | 0.73 | 481.34                       | 399.0966                                                      |
| Rippers T-25.01             | 0.76 | 0.72 | 957.21                       | 753.8751                                                      |
| Pipelayers TG-163 T-170     | 0.77 | 0.74 | 550.21                       | 465.9078                                                      |
| Mobile crane KS-35714        | 0.77 | 0.74 | 652.17                       | 585.0546                                                      |
| KZKT-7428 with semitrailer KZKT-9101 | 0.72 | 0.67 | 2142.71                       | 1935.893                                                      |
| KrAZ -260B with CHMZAP -99865 | 0.73 | 0.68 | 2035.12                       | 1885.402                                                      |
| URAL-44202 with semitrailer CHMZAP -9906 | 0.72 | 0.70 | 838.50                        | 783.9671                                                      |
| URAL-43204                  | 0.76 | 0.72 | 673.82                        | 598.5667                                                      |
| Tatra-815 UDS-114           | 0.79 | 0.76 | 912.10                        | 827.6743                                                      |
|                             |      |      |                               |                                                               |
|                             | 9243.17 | 8235.44 | 194.47                       | 208.21                                                      |

Figure 2. Comparison of profitability indicators
Figure 3. Comparison of costs indicators

The option of acquiring the new machinery wins both in terms of costs and profitability indicators per unit, as well as by the profitability of the project for the entire investment period. The new machinery has got a higher truck availability rate and fleet utilization, as, firstly, the efficiency of transport increases, and secondly, in connection with the reduction in the number of machinery, the number of car-days in the farm is reduced. This factor when calculating these coefficients is in the denominator and with its reduction the calculated factor is increased.

In addition, the old equipment is used for reclaiming, and the enterprise receives a material benefit from putting it into scrap (Table 5). The gain was determined based on the weight of the car and the approximate cost of a ton of car scrap 1700 rubles.

Considering the economic performance of the car operation before the onset of major repairs and after that, the authors conclude that it is more expedient to operate the automotive equipment before major repairs and then hand it over for reclaiming. Limitation of the life of cars may also be carried out at the legislative level. The Russian Ministry of Industry and Trade proposed setting a deadline for the cars operation. After this time, the machine will have to be disposed without fail [7, 8].

Table 5. Benefit from putting equipment into scrap metal

| Name                  | Benefit, thous. rubles |
|-----------------------|------------------------|
| Bulldozer B -170     | 27.03                  |
| Ripper T-25.01       | 65.17                  |
| Pipelayer TG-163 T-170 | 39.1                   |
| Mobile crane KS-35714 | 27.2                   |
| KZKT-7428            | 35.7                   |
| KrAZ-260B            | 21.72                  |
| URAL-44202           | 13.77                  |
| URAL-43204           | 14.53                  |
| Tatra-815 UDS-114    | 37.06                  |
| Total                | 281.28                 |

3. Conclusion
The economic evaluation of the operational period of the vehicle life cycle confirms the proposed assumption that it is economically inexpedient to carry out major repairs after the recommended service
life of vehicles due to the costs increase. This assumption is confirmed also by the decrease in the profitability of cars after major repairs.

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