

IDENTIFICATION OF PRODUCTION RESOURCES UNCLAIMED IN THE TRANSPORT PROCESS

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ABSTRACT

The relationship between reliability of road transportation and presence of an excess amount of production resources in the transport process is indicated. In order to reduce resource intensity of the transport process and the cost of transport work, a number of methodological recommendations on

identification of spare parts, fuel and tires reserves accumulated and unclaimed during road transportation have been proposed. Examples of practical implementation of the proposed recommendations are given. Particular emphasis is placed on the fact that the funds used do not require additional costs from carriers and bring obvious economic benefits.

Keywords: road transportation, transport process, consumption rates, material resources, production efficiency.

Background. Recently, practitioners have been actively discussing resource intensity and cost of road transportation. Resource intensity is expressed in the amount of resources expended per unit of work produced. Based on their own practical experience in organization and management of road transportation, the authors are confident that motor transport enterprises accumulate an excessive amount of material resources, including spare parts, tires, consumables, fuel and lubricants, energy resources, equipment, and special equipment.

The proof of this statement is complicated by the fact that the existing volume of consumption of material resources on motor transport is regulated and justified by the standards of technical operation. Attempts of transport business owners to reduce its resource intensity, as a rule, boil down to toughening of standards and rotation of managers, therefore they bring only short-term effect, which is extinguished by reducing the quality and performance of operating personnel [1, 2].

Despite the risk of punishment, managers of trucking companies are interested in having an excess amount (stock) of reserves of material resources. This situation is explained by the fact that reliability of fleet depends directly on the number of such reserves with the carrier, since probability of fulfilling the most complex freight request in this case increases [3–6].

The use of the term «identification», as applied to the problem under consideration, will be valid in the interpretation of «recognition». That is, it is necessary to recognize unclaimed (excess) reserves of production resources from the total resource consumption in the transport process. The use of such tools does not require additional costs from carriers, it is necessary only to learn how to identify hidden unclaimed reserves.

Objective. The objective of the authors is to consider identification of production resources unclaimed in the transport process.

Methods. The authors use general scientific methods, comparative analysis, graph construction, evaluation approach.

Results.

Phenomenon of unclaimed spare parts

The cost of spare parts, components and assemblies, especially when operating worn fleet, can reach a quarter of the operating costs of the carrier. In connection with the active use in practice of consignment warehouses, as one of the forms of transferring non-core functionality to outsourcing, maintenance by the carrier of its own natural stock resources is now fading into the background. Therefore, this article is not about planning the

loading of warehouse racks with spare parts, but about planning the budget of the carrier for their purchase.

A complete abandonment of warehouses in motor transport is a distant prospect. Currently, the storage racks contain consumables and non-liquid assets – spare parts purchased, registered, but not used in the repair process.

The emergence of illiquid assets is the result of improper planning by the carrier of the budget for spare parts. In addition, the inability to plan this item of expenditure leads to prolonged downtime of rolling stock due to waiting for the necessary spare part, due to its absence from the supplier.

The main mistake in planning the budget for spare parts is to determine the value of the reserve number of spare parts, guided by the so-called enlarged norms of their consumption. Enlarged norms are regulated by regulatory and technical documentation, for example, by the order of the Ministry of Transport of the Russian Federation [8], and represent the specific consumption of spare parts and materials, expressed in rubles per unit of run of rolling stock.

Using this approach to reservation of spare parts, it is difficult to fully take into account the factors affecting intensity of their consumption, such as, for example, depreciation of fleet and seasonality of its operation [9]. The level of detail of these standards is low and is not limited to a single part, but to a vehicle's assembly [ex.: 10]. In addition, for cars of new brands of models, especially for cargo vehicles, the magnitude of the enlarged consumption rates of spare parts and materials is not regulated [11, 12].

The solution to the problem of reserving spare parts and materials in the transport process is largely solved by developing nomenclature standards for their consumption. The nomenclature norms, as compared with the aggregated ones, have a number of advantages (Table 1).

The method of calculating the nomenclature norms of consumption of spare parts is based on a statistical analysis of their consumption and requires the presence of an array of source data. First of all, it is necessary to group fleet in operation into categories of run since the beginning of operation. Parametric range is set by the carrier independently. In this paper, ranking of run from the beginning of operation was made as follows: up to 100 thousand km; 100–200 thousand km; 200–300 thousand km; 300–400 thousand km; 400–500 thousand km; more than 500 thousand km.

Calculation of consumption rates is made for each type of spare part, according to the catalog, according

Table 1

Characteristics of enlarged and nomenclature consumption norms of spare parts

Enlarged norms	Nomenclature norms
• set in monetary terms (rub./km); • set per a node, a unit or a system of a car as a whole; • there is no need for a complex accounting system; • low complexity of calculations.	• set in natural terms (units/km); • set per a part that constitutes a node, a unit or a system; • possibility of reliable planning of spare parts in order to reduce the cost of transportation.

Table 2

The results of calculation of the nomenclature consumption rate on the example of the inter-axle cardan shaft of the dump truck KamAZ-55111, units/1000 km

Spare part name	Category of run of a vehicle from the beginning of operation, thous. km					
	Up to 100	100–200	200–300	300–400	400–500	Over 500
Cardan shaft inter-axle	Winter					
	0	0	0,5	0,11	0,4	0
	Spring					
	0	0	0,25	0,33	0,2	0
	Summer					
	0,06	0	0,09	0,26	0	0,33
	Autumn					
	0	0	0,25	0,25	0,11	0,33

Table 3

Examples of names of spare parts for dump truck KamAZ-55111, for which there is an unclaimed reserve in stock

Name of a spare part	Actual data				Estimated values		
Stock at the beginning of the reporting period, pcs.		Consumption, pcs.	Receipt, pcs.	Stock at the end of the reporting period, pcs.	Normative need, pcs.	Supply plan, pcs.	Unclaimed reserve, pcs.
1. Distribution shaft	16	4	2	14	0	0	14
2. Generator	0	0	6	6	0	0	6
3. Hydraulic cylinder fo body lift	1	3	3	1	0	0	1
4. Cylinder of KamAz (black)	26	10	32	48	16	0	48
5. Driven wheel	8	13	52	47	11	3	44
6. CCGT assembly	4	4	15	15	6	2	13
7. Power accumulator	33	7	20	46	35	2	44

to the number of categories of vehicle run since the beginning of operation and the considered seasons of operation. As a rate of consumption of spare parts, it is proposed to take their specific consumption for a list unit of a certain brand and a model:

$$H_{ij} = \overline{P}_{ij}^s \cdot (1 + k_{r.s.}), \quad (1)$$

where $\overline{P}_{ij}^s$ – average specific consumption of spare parts for the i -th category of run in the j -th season of operation, units/car; $k_{r.s.}$ – reserve stock coefficient.

The reserve stock coefficient is determined on the basis of the coefficient of uneven consumption of spare parts for cars during the year:

$$(1 + k_{r.s.}) = k_{un} = \frac{P_{ij}^{\max}}{\overline{P}_{ij}^s}, \quad (2)$$

where k_{un} , $P_{ij}^{\max}$ – respectively, the coefficient of uneven consumption of spare parts and the maximum specific consumption (units / car) for the i -th category of run in the j -th season of operation.

Then the formula for calculating the nomenclature rate of consumption of the spare part will take the form:

$$H_{ij} = \overline{P}_{ij}^s \cdot \frac{P_{ij}^{\max}}{\overline{P}_{ij}^s} = P_{ij}^{\max}. \quad (3)$$

An example of the results of the calculation of the nomenclature consumption rate of the inter-axle cardan shaft for KamAZ-55111 dump trucks is given in Table 2.

The next step is to calculate the plan for their delivery for the reporting period:



Characteristics of methods for fuel rationing in motor vehicles

Analytical	Instrumental	
	Automated	Automatic
Advantages		
• ease of calculation; • universality for any make and model of a car.	• lack of a factor of subjectivity; • possibility of taking into account the dynamics of influencing factors.	
Disadvantages		
• lack of methods for calculating the value of the correction factor (D); • inability to use when high dynamics of influencing factors.	• gross errors in measurements are not excluded; • high labor costs; • need for verification and certification of measuring instruments.	• need to equip vehicles with additional equipment; • presence of failures in the sensors.

$$P = \sum_{i=1}^m N_i \cdot n_i, \quad (4)$$

where m – number of considered categories of car run since the beginning of operation; n_i – number of cars of a certain brand and a model, units. To assess reliability of the generated plan, a planning error (δ) is calculated, in fractions showing the excess of actual costs for spare parts of their planned value for the reporting period, due to the random nature of the value (k_{un}):

$$\delta = \frac{\sum_{k=1}^f n_n \cdot P_c}{C_{tot.}}, \quad (5)$$

where n_n – number of parts, consumption of which in the reporting period exceeded the norm, units; P_c – price of a spare part, rub.; $C_{tot.}$ – total costs of spare parts in the planning period, rub.; f – number of names of spare parts.

According to the authors of this article, the value (δ), equal to 5–10 %, will not have a negative impact on the cost of road transportation. To compensate for the planning error, an insurance fund is provided, which is determined by the formula $F = C_{tot.} \cdot \delta$. (6)

The implementation of the proposed methodology is illustrated by the example of searching for illiquid spare parts for automotive vehicles of a large road-building company in Chelyabinsk region. Identification of unclaimed reserves of spare parts and materials is made by comparing the actual warehouse stocks of the enterprise, at the time of the analysis, and the delivery plan. A positive difference between these values indicates the presence of unclaimed reserves,

a negative difference indicates a shortage of spare parts. A fragment of the analysis results is given in the table 3.

The result of the calculations was the decision by the management of the company to transfer the function of transporting materials for the needs of road construction to outsourcing.

Fuels and lubricants

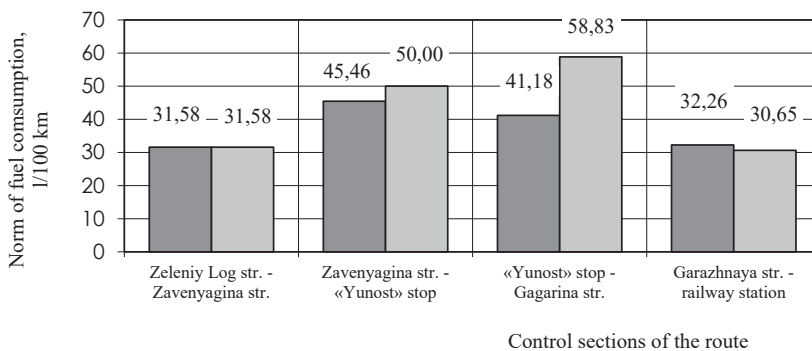
Identification of unclaimed reserves of fuel and lubricants at a motor company is based on standardization of their consumption. The guidance document [13] regulates calculation of the fuel consumption rate calculated per vehicle run of any brand and model, taking into account the influence of operating conditions: for example, season features, terrain, work in frequent stops (in this case, the correction factor D is introduced). The formula for calculating the rate of fuel consumption by buses:

$$Q_n = 0,01 \cdot N_s \cdot S \cdot (1 + 0,01 \cdot D) + N_{heat} \cdot T, \quad (7)$$

where N_s – base rate of fuel consumption by bus, l/100 km; S – run of a bus, km; N_{heat} – rate of fuel consumption for heater operation, l/h; T – duration of bus operation with switched-on heater, h; D – correction factor to the norm, %.

It should be noted that the method of calculating the value of the correction factor (D) is absent. It is established by the order of the enterprise. As a rule, the basis for determining the amendment to the base rate is fuel consumption of a vehicle fleet for the past reporting period or experience of other carriers in similar conditions.

The main problem of this method of rationing is the high dynamics of factors affecting the base rate [14, 15]. For example, accounting for hourly changes in the workload of the urban road network with existing

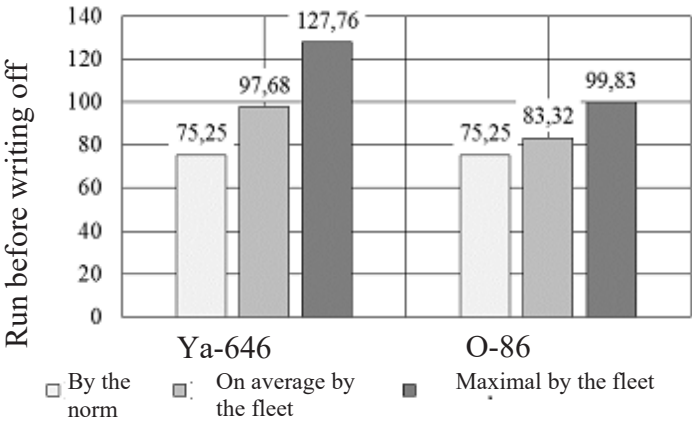


Pic. 1. Results of the calculation carried out according to the norms of diesel fuel consumption for the bus LiAZ-5256 on the route No. 7 (direct trip, weekdays to 1000).

Table 5

Results of identification of unclaimed reserves of diesel fuel during operation of buses
LiAZ-5256 ME «Maggortrans» on urban routes

Route	Trip	Diesel fuel demand, l/100 km					
		Summer period			Winter period		
		Method [13]	Proposed method	Unclaimed reserve	Method [13]	Proposed method	Unclaimed reserve
3	Direct	40,02	42,18	-2,16	69,88	48,11	21,77
	Return		41,13	-1,11		48,21	21,67
7	Direct		39,87	0,15	62,97	50,81	12,16
	Return		34,68	5,34		48,08	14,89
9	Direct		24,47	15,55	58,08	46,58	11,50
	Return		36,25	3,77		54,07	4,01
10	Direct		28,69	11,33	59,74	38,32	21,42
	Return		33,77	6,25		34,80	24,94
18	Direct		35,14	4,88	60,46	48,28	12,18
	Return		34,03	5,99		44,42	16,04
21	Direct		35,82	-4,20	64,75	50,66	14,09
	Return		42,57	-2,55		41,17	23,58
24	Direct		34,77	5,25	58,61	35,78	22,83
	Return		32,71	7,31		37,11	21,50
31	Direct		36,85	3,17	64,97	55,17	9,80
	Return		28,50	11,25		50,17	14,80



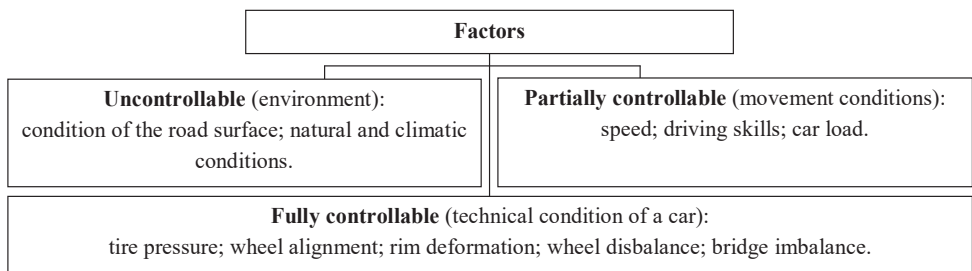
Pic. 2. Comparison of runs of tires before writing off.

methodological tools is impossible. This deficiency is compensated by many road carriers by setting the value of the amendment to the base rate «with a margin». However, this leads to formation at the end of the shift of excess fuel in the tanks of the operated vehicles. The possibility of selling such surpluses often motivates drivers to unauthorized fuel discharge, which causes significant damage to business owners. Compensation of the costs incurred by increasing the cost of transport services is unlikely to succeed, since it is fixed in the contract for transportation.

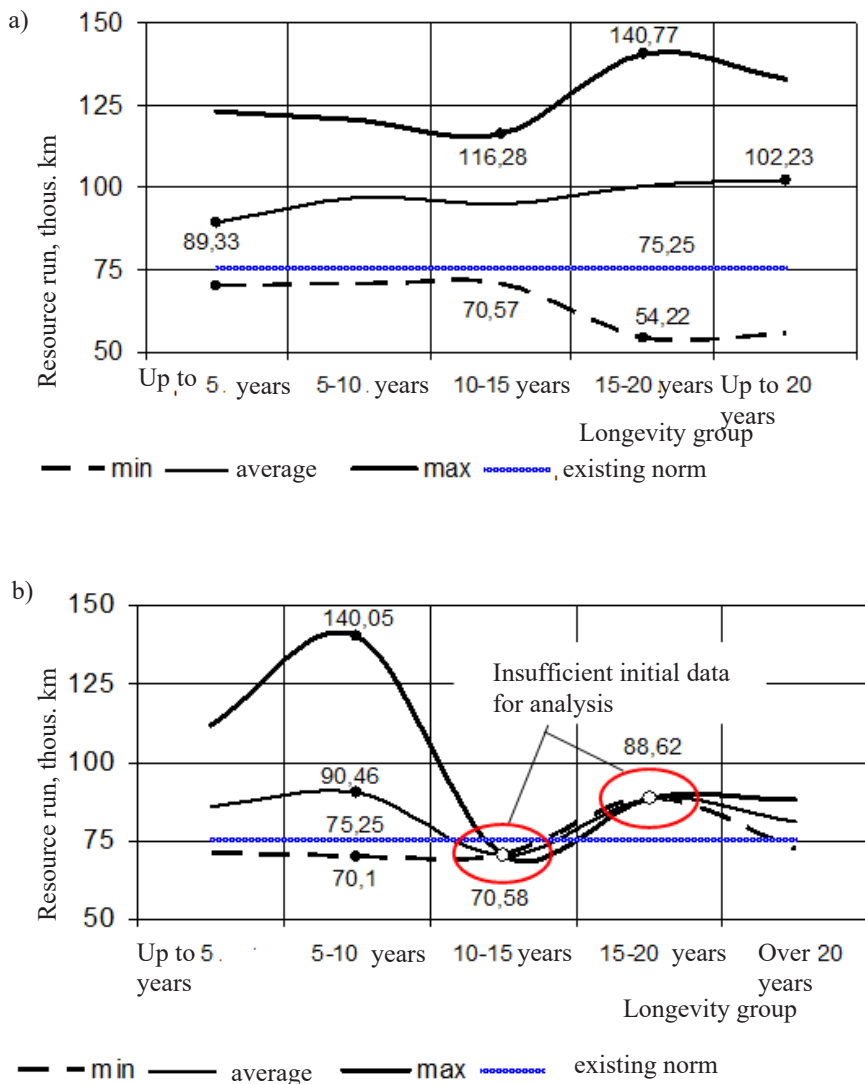
The way out of the current situation seems to be rationing of fuel consumption based on instrumental measurements. The advantage of «instrumental» norms in comparison with the above analytical method is that they are based on actual consumption of fuel by a car (Table 4).

A distinctive feature of the instrumental measurements is the use of special technical means. Automated method of regulation involves the use of instrumentation to collect the initial information. The participation of a person cannot be completely





Pic. 3. Factors, influencing tire wear.



Pic. 4. Results of calculation of resource run of tires Ya-646 (a) and tires O-86 (b) of LiAZ-5256.

excluded from this process, the role of which is reduced to measuring the actual level of fuel in a vehicle tank and fixing measurement results in a journal. Human labor is the cause of gross errors and high labor costs during measurements.

The development of technical means of continuous monitoring has intensified the use of

instrumental methods of fuel consumption rationing by automatically fixing the necessary information. In particular, «Maggortrans» applied a satellite monitoring system for rationing of diesel fuel consumption by LiAZ-5256 buses on urban routes.

To increase reliability of the initial data array, a schedule was drawn up for the buses to reach the

Table 6

Adjusted consumption rates of automobile tires Ya-646 for LiAZ-5256 bus with details on longevity groups

Longevity group	Adjusted consumption rate, units/1000 km
Up to 5 years 0,067	
5–10 years	0,062
10–15 years	0,063
15–20 years	0,060
Over 20 years	0,050
On average per groups	0,060

Table 7

Results of identification of unclaimed reserves of automobile tires in the transport process of the enterprise

Model of a bus	Need for automobile tires, pcs/year		Unclaimed reserve, pcs/year
	Existing norms	Adjusted norms	
PAZ-32053 (modifications), PAZ-4230	128	108	20
LiAZ-5256	331	248 (302)	83 (29)
NefAZ-5299	96	67 (92)	29 (4)
LiAZ-6212	52	42 (33)	10 (19)

Notes: for buses PAZ (modifications) and PAZ-4230 the need for tires O-79 is provided; for LiAZ-5256 and NefAZ-5299 without brackets – for tires Ya-646, in brackets – for tires O-86; for LiAZ-6212 without brackets – Ya-646, in brackets – Bel-108.

transportation routes and rationing was performed in the following sequence:

1. The route of movement is divided into control sections.

2. Statistical data is collected automatically in real-time mode (bus runs in control sections, time between stops, actual fuel consumption, other information).

3. The rate of fuel consumption is calculated, taking into account the actual needs in implementation of the task for transportation.

4. The obtained norms are compared with the results of calculations according to the method [13].

The rate of fuel consumption by a bus within the control area and for zero runs was determined by the formula:

$$Q_u = \overline{Q_{uj}} = 100 \cdot \frac{\sum_{j=1}^n \gamma_{ji}}{L^{sec} \cdot n}, \tag{8}$$

where $\overline{Q_{uj}}$ – mathematical expectation of the results of calculating the actual need for fuel when the bus is operating on the j -th route, $l/100$ km; γ_{ji} – result of a single measurement of fuel consumption when driving on the control section, l ; L^{sec} – length of the control section, km; n – sample size.

An example of the results of the calculation of the proposed operational standards is shown in Pic. 1.

Identification of unclaimed reserves of fuels and lubricants is made by comparing the needs for diesel fuel, calculated using the proposed option and methodology [13]. A positive difference between these values indicates the presence of reserves, a negative difference indicates a shortage of fuel and lubricants (Table 5).

From table 5 it follows that in some cases the use of the proposed norms for diesel fuel consumption gives a negative effect. However, the number of such cases is small and falls mainly on the summer period,

which is caused by delays in movement of buses in front of intersections during peak traffic congestion periods.

Tire identification

Tires are among the most costly elements. During the period of operation of the vehicle, the cost of tires, including the cost of a set of tires, for maintenance and repair can reach a third of the cost of a car [16].

Confirmation of the presence of unclaimed reserves of the transport process is the excess of the actual run of tires before regulatory write-off. The norms of the operational run of tires of buses, trucks and cars are regulated by the Ministry of Transport in the framework of the regulatory document [17]. Road haulers generally follow these guidelines.

In «Maggortrans», an analysis was made of the road performance of Ya-646 automobile tires (OJSC «Yaroslavl Tire Plant») and O-86 (PJSC «Omskshina»), operated on LiAZ-5256 buses. Comparison of the normative operational and actual run before writing off is shown in Pic. 2

The given example shows that, depending on the model under consideration, the average run of tires in a fleet exceeds its standard value by 10–30%. In this case, the presence of unclaimed reserves increases the cost of transportation, since the budget of the enterprise is planned on the basis of existing standards of operating run. Due to the fact that the existing methodological base of rationing of a tire resource is of an advisory nature, the automobile carrier has an opportunity to independently adjust the standards in order to prevent accumulation of stocks.

It is erroneous, when determining the normative amount of a tire run before writing off, to follow the so-called guarantee standard, which is contained in the set of accompanying documentation from the manufacturer. The guarantee rate only indirectly characterizes the life of a tire and indicates in time the limit of the manufacturer's liability for defects in its



work. It does not take into account the specifics of the carrier's production and the peculiarities of the local road and climatic conditions.

Adjustment of existing standards for the life of tires should be based on data on their actual run before writing off, taking into account factors affecting wear. The latter are classified according to three characteristics [18, 19]: uncontrollable factors, partially controllable and fully controllable (Pic. 3).

It should be noted the complexity of development of standards for operational run of tires for the entire set of combinations of influencing factors within a separate motor transport company, which is associated with a lack of statistical information. Sufficient accuracy of calculations is ensured by identifying and accounting for the key factor [20, 21].

So, for example, in ME «Maggortrans» it was determined by an expert method that, all other things being equal, the resource of a tire determines, to a greater extent, the skill of driving a car. At first glance, this seems obvious. However, it is equally obvious that there is still no objective measure of driving skills. It is equally possible to take the quantitative characteristic of this indicator: the total driver's experience, work experience at the enterprise, driving class, trouble-free performance. But the high turnover among drivers complicates the use of these positions as a measure of driving skills. In addition, in some cases, cars are operated not by one driver, but by the crew. And such a rotation makes many assessments difficult.

At Magnitogorsk enterprise, which operates the bus fleet, taking into account the specified specifics, the average work experience of a driver in production was taken as a gauge of driving skills. For convenience of calculations, the indicator was divided into five periods of employment: up to 5 years, 5–10 years, 10–15 years, 15–20 years, more than 20 years.

The initial data for calculations were taken from the register of writing off of automobile tires, as well as personal cards, which contain information: brand of a bus; its garage and state number, number of wheels; code of each bus installed on a bus; its serial number; run and installation date. Through statistical analysis, average and boundary values of run of a tire were determined before being written off for each longevity (it seems to me that there is no such word) group. Average run before writing off is taken as the normal operating run. The results obtained on the example of tires Ya-646 and O-86, operated on buses LiAZ-5256, are shown graphically in Pic. 4.

A similar analysis was conducted on automobile tires of O-79 and Bel-108 brands on buses PAZ-32053 (modifications), PAZ-4230, NefAZ-5299, LiAZ-6212. It was found:

- on average for a fleet of vehicles, regardless of the longevity group of drivers, run of automobile tires of various models prior to writing off is significantly higher than the rate of their operating run established at the enterprise;
- the least economically car tires are used on buses with longevity groups of drivers up to 5 years;
- dependence of the resource run of a car tire on driving skills is increasing, but not linear.

The adjustment of consumption rate of automobile tires in the physical units given per 1000 km of the bus run is made according to the formula:

$$N = \frac{n_s}{L^n}, \quad (9)$$

where n_s – number of sets of tires on a car, units; L^n – norm of operational run of a tire, km. An example

of the adjusted consumption rates of automobile tires Ya-646 for LiAZ-5256 bus is given in Table 6.

Identification of unclaimed reserves of automobile tires is made by comparing the needs of the fleet for the reporting period, calculated using the norms of their consumption before and after adjustment. A positive difference between these values indicates the presence of reserves, a negative one indicates a shortage of automobile tires in the transport process (Table 7).

It should be noted that the work on identification of reserves of spare parts, fuel and tires, which are accumulated and unclaimed in the main and auxiliary processes of road transportation, is easily automated. Recommendations for automating this process under the conditions of a trucking company are given in [22, 23].

Conclusions.

1. The main and auxiliary processes of road transportation are characterized by the use of an excess amount of reserves – the so-called production material resources, which include spare parts, fuels and lubricants, automobile tires.

2. Attempts of the transport business owners to reduce unclaimed reserves of material resources in the main and auxiliary processes of road transportation do not bring tangible effect, which is explained by the interest of the management of road transport companies in the presence of an excess amount of material resources, since this, in their opinion, increases the likelihood of uninterrupted transportation task.

3. To reduce the cost of road transportation, it is important not to increase stocks, but to be able to search for accumulated unclaimed reserves of material resources in the main and auxiliary processes.

4. The search for reserves of material resources at motor transport enterprise does not require additional costs from carriers, which will reduce the overall costs of the enterprise in the main and auxiliary transportation processes.

5. The proposed approaches to reducing unclaimed reserves of material resources in the main and auxiliary processes of road transportation, which are based on:

- when it comes to spare parts and components – on the calculation of the nomenclature consumption norms established in absolute terms for any part or assembly of a car. It is proposed to take as a nomenclature consumption rate of spare parts their specific actual consumption, taking into account the safety stock for groups of vehicles of a certain brand and model, run category and operating season;
- when it comes to fuel and lubricants – on instrumental automatic measurements of the actual fuel consumption, conducted individually for each route of the vehicle or its operation;
- when it comes to car tires – on averaging the actual run of tires before they are written off, taking into account the key factors affecting their wear.

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