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Economic evaluation of using upgraded hopper cars for transportation of hot pellets and agglomerate of 20-9749 model

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Abstract
The rolling stock is the basis for efficient and high-quality transportations; the level of its technical condition and structure influences the quality of the transportation process, productivity and final financial performance of the rail transport. However, the state of transport vehicles, their physical and moral deterioration have reached a critical level today. The article analyzes the results and peculiarities of the evaluation of effective use of freight cars of improved designs, reduction of expenditure for the renewal of freight cars rolling stock and rail transportations. As an example, the calculation of the projected economic benefits from the improvement of hopper car through the introduction of the elements in the system that significantly reduce the cost of this type of cars was represented. According to the results of the calculations, the projected economic benefits from the use of modernized cars of 20-9749 model were determined and the cost-effectiveness of the implementation of measures to improve the cars design was proved. The results of this analysis suggest that the improvement of the hopper cars design for the transportation of hot pellets and agglomerates of 20-9749 model has a significant economic effect that is more than 60 million UAH; at a projected purchase plan of these cars in the next 5 years, it will be about 600 units, which will allow the economic feasibility of introduction of these modernization methods.
Key words: RAILWAY TRANPORT, TRANSPORT MECHANICS, EVALUATION OF ECONOMIC EFFICIENCY OF PELLET CARS

Formulation of the problem

The strategic objectives and priorities in the development of rail transport [1-4, 8-13] of Ukraine in the coming period include: renewal of fixed production assets, primarily rolling stock, technical re-equipment, improving performance of repairs. In solving these problems, railroad car economy performs several functions as the efficiency of the railways is largely dependent on the size, structure and technical condition of the rolling stock and its technical and economic characteristics. The rolling stock is the basis to provide effective [1, 3, 7, 10-13] and qualitative transportations; the quality of the transportation process, performance and final financial performance of the railways are dependent on the level of its technical condition and structure.

The purpose of this article is to analyze the results and peculiarities of the assessment of effective use of freight cars with improved designs and to reduce the costs for the renewal of freight cars and railroad freight traffic. As an example, the calculation of the projected economic benefits from the improvement of hopper cars through the introduction in the system of elements that significantly reduce the cost of this type of cars was represented.

The presentation of the main research material

Railway transport of Ukraine has a significant freight cars rolling stock. Special-purpose cars are the most effective for transportations [5, 6]. It is known that one of the first types of cars that should be renovated are hopper cars for the transportation of hot pellets. Improving the design of the car is aimed at reducing the prime cost of the products, as well as to reduce specific amount of metal of the car to 470 kg due to improvement of frame side wall - bracing piece of channel beam No 14 (wagon) is replaced by the channel beam No 10; extreme bracing piece consisting of two channel beams No 16 is rotated by 90°; the changes to reduce the thickness of the sheets were introduced: a) at the half log from 12 mm to 10 mm; b) sheathings from 6 mm to 5 mm with ability to apply a corrugated profile with a thickness of 5 mm; the use of stacked embodiment of a centre sill between centre bearer and half log instead of a solid one. This centre sill design allows us significantly reduce the prime cost of pellet cars by the use in the construction of their centre sills of I-beams with random length. Previously, these random length I-beams went to waste materials. At this time, all I-beams for pellets-producers enterprises are purchased as a specialized railway car rolled product at prices higher than for the general machine rolled product; improving of the unloading system is carried out by performing the unloading unit of the round tube, namely a hollow structure. The lubrication system is excluded from the unloading system, which in the previous version included a number of oil-filled devices, as well as it required additional seasonal services; making the weld above the centre plate arrangement instead of the usual cast design allows reducing the weight of this arrangement by 20% (about 50 kg per car). In order to have safe transportations and the goods arrival at their destination on time, it is necessary to update the fleet of freight cars to create new and more advanced cars. According to the data, there is a projection of the cars number to be excluded on service life, which analysis shows that the pellet cars fleet is in critical condition (Fig. 1).

Required working fleet of the pellet cars with taking into account the influence of the cars turnover up to 2020 is as follows (Fig. 2).

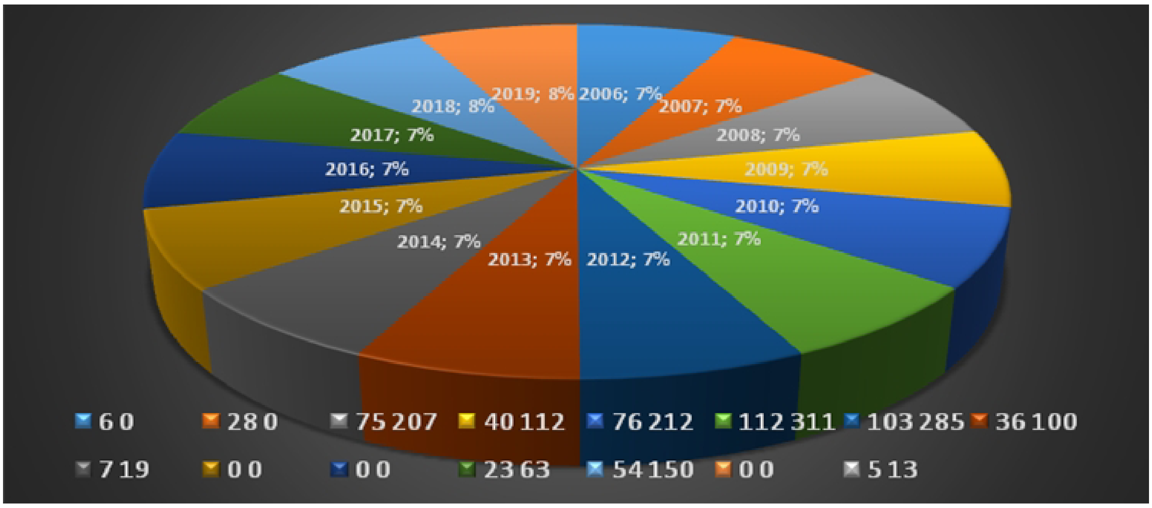


Figure 1. The forecast of pellet cars fleet [2]

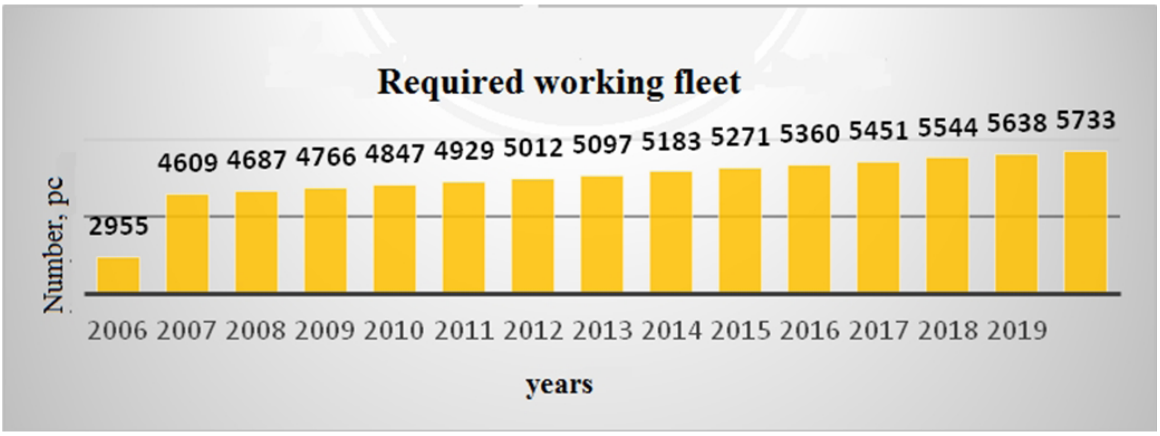


Figure 2. Required working fleet of the pellet cars [2]

After analyzing the data, it can be concluded that every year the demand for pellet cars increases. 62.8 thousand (56.5%) out of 111.2 thousand of freight cars have expired their established terms of operation. It was extended for 47.3 thousand of cars after a major overhaul on the basis of technical solutions. Non-working freight car fleet is 34.5 thousand items. The average wear of freight cars is 89.65%. Available cars designed in the 50s of the 20th century have the unsatisfactory dynamic properties. The critical velocity, beyond which the stability of the car against derailment is not guaranteed, for the most cars when empty does not exceed 70 km / h.

The impact forces on the rail track greatly exceed permissible, which leads to premature disorder of the rail track, intensive wear of wheels and rails. The empty-weight-to-carrying-capacity ratio is higher than foreign analogues by 30-40%.

The need to upgrade the rolling stock for the next 5 years is 22.6 billion UAH. Fig. 3 shows the diagram of the pellet cars purchases plan.

When the data are substantiated, it can be argued about the need to study the overall economic efficiency from creating cars with improved design and development of their components.

The question of the advisability of creation and use of improved designs of cars is justified on the basis of the calculation of the economic effect due to the annual production of advanced cars [3]. The annual economic effect from the introduction of a new technology, inventions and innovations is a total savings of all types of productive resources (human labor, materials, capital investments), which are obtained in the production and exploitation of new technology.

Figure 3. The forecast of pellet cars purchases plan [2]

The annual economic effect of creating a product that has no analogues is generally determined by the following formula [5]:

$$E = (P - E_i C_2) \cdot N_4, \qquad (1)$$

where P – profit from sales of new products or profit increment ($P_2 - P_1$) from the sale of high-quality products, UAH;

C_2 - specific capital investments in the production of new products or specific additional capital investments related to improving the quality of products, UAH;

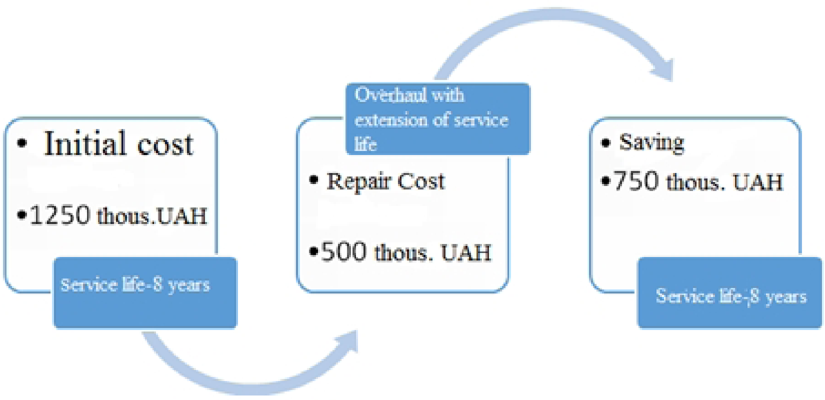
N_4 – the volume of new products or high-quality products in the target year.

Considering that improving car design does not require additional equipment, it can be argued that the specific capital investments are reduced to zero.

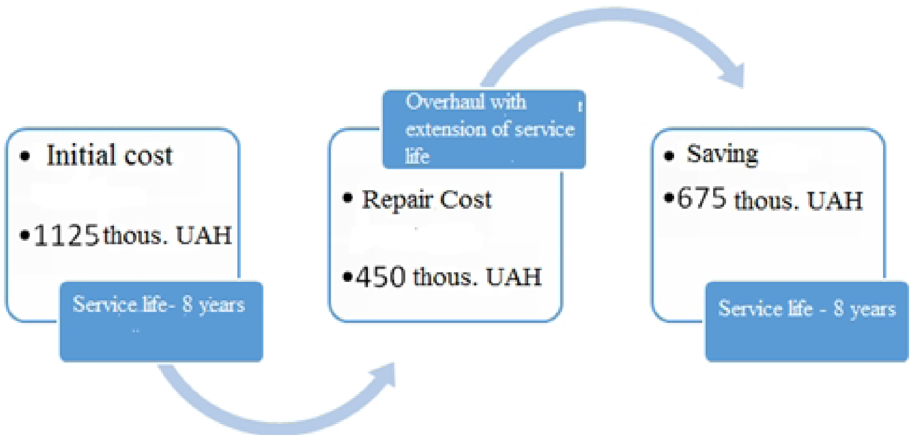
It is also noteworthy that improving the system of unloading due to the implementation of unloading unit of a round tube (hollow structure) provides the exclusion from unloading system of lubrication system, which in the previous design included a number of units filled with oil, as well as it required additional seasonal services that can be noted as positive saving of this improvement.

Let us consider in more details the components of profit from the sale of pellet cars of advanced designs. Design improvements of the pellet cars will reduce the initial cost of the car by 25-30 thousand UAH due to the light weight sections. The use of stacked embodiment of a center sill between centre bearer and half log will save another 35-40 thousand UAH on the metal waste. Improving the unloading system due to the implementation of the unloading unit from the round tube (hollow structure) allows getting another extra 2 thousand UAH, and the exclusion from unloading system of the lubrication system, which in the previous design included a number of units filled with oil, as well as requiring additional seasonal service brings another saving on maintenance costs in the life cycle of the car is about 25 thousand UAH.

Also, profit can be shown as a reduction in the initial cost of the car by 10% due to design improvements, as well as in the operation - the ability to transport 1 ton cargo more is about 13%.



a – before improvement



b – after improvement

Figure 4. Savings due to the extension of pellet cars service life

If we take into account that the initial cost of a typical pellet car in average is 1,250 thousand UAH, the improved car cost is 1,125 thousand UAH due to the reduction of the cost by 10%. If we consider the pellet car in operation, in average 1 car gives profit of 65 thousand USD per year. The ability to transport by 1 ton of metal more will allow further earn of 8,450 UAH, which is 73.5 thousand UAH. It should also be noted that a typical pellet car life cycle is 8 years. At this time, due to the fact that the thermal conditions of loading have been significantly changed, about 90% of the pellet cars by carrying out the overhaul prolong its lifetime by 2-fold (Fig. 4).

Considering the above, the projected profit of the pellet car design improving can be determined by the following formula:

$$P= P_1+ P_{2+} P_{3+} P_4 \quad (2)$$

where P_1 – projected profit from improving the design by the use of the more light weighted profiles is 30 thousand UAH;

P_2 – projected profit from the use of join embo- diment of centre sill between the centre bearer and the half log is 40 thousand UAH;.

P_3 – the projected profit from the performance of the unloading unit from a round tube is 2 thousand UAH;

P_4 - projected profit from the cost of servicing the lubricating system in the unloading system is 25 thousand UAH;

P_5 – projected profits from the operation of the car is 8450 UAH.

$$P = 30+40+2+25 = 97 \text{ thous. UAH}$$

Considering the data of forecasted purchases plan of pellet cars wagons for subsequent years (Fig. 8), as well as application of pellet cars with improved designs, the effectiveness of the use of modernized hopper cars of 20-9749 model can be evalueted according to formula 1 (Table. 1).

Table 1. The calculation of the projected economic effect

Years	Plan of pellet cars purchases	The projected economic effect of improving the design, thousand UAH	The projected economic effect of improving the design and operation of cars, thousand UAH
2016	250	24250	26375
2017	150	14550	15825
2018	10	970	1055
2019	100	9700	10550
2020	100	9700	10550
Sum	610	59170	64355

Conclusions

After analyzing the data in Table 1 and taking into account the above, it can be stated that the improvement of the design of hopper cars for the transportation of hot pellets and agglomerate of 20-9749 model has a significant economic effect, which is more than 60 million UAH. At a projected purchase plan of these cars in the next 5 years, it will be about 600 units that proves the economic feasibility of implementation of these modernization methods.

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