

ZMIANA ZŁOŻONYCH WSKAŹNIKÓW GOSPODARCZYCH ZUŻYCIA OSOBOWEGO TABORU KOLEJOWEGO

A CHANGE OF COMPLEX ECONOMIC INDICATORS OF PASSENGER ROLLING STOCK DETERIORATION

Szereg kryteriów opisujących stan lokomotywy z różnych perspektyw może być używanych do oszacowania ich stanu. Kilka złożonych albo zintegrowanych kryteriów obrazujących stan ogólny lokomotyw Diesla może też być alternatywnie używanych w takim przypadku. Zintegrowany wskaźnik wyników charakteryzujący stan lokomotyw może być wyrażony przez opisane funkcjonalne zależności. Analiza dostępnych metod dla złożonej oceny stanu taboru kolejowego pokazała, że wydajność całkowita lokomotywy może być opisana przez bezwymiarowy wskaźnik.

Słowa kluczowe: lokomotywa, lokomotywy z napędem Diesla, kryteria zintegrowane, dieslowski skład pociągu, paliwo, olej napędowy, naprawa.

Various criteria describing the state of a locomotive from various perspectives can be used to assess its performance. Some complex or integrated criteria reflecting a general state of Diesel locomotives can also be used. An integrated performance indicator characterizing the locomotive performance is expressed by the following functional relationship. The analysis of the available methods for complex evaluation of the locomotive condition has shown that overall performance of the locomotive can be described by a dimensionless indicator.

Keywords: locomotive, diesel locomotives, integrated criteria, diesel trainset, fuel, diesel oil, repairs.

1. Introduction

One of the main economic indicators (criteria) of rolling stock deterioration is the increase of maintenance expenses when it is aging. The present research is aimed at developing and comparing the criteria of passenger rolling stock deterioration, which would take into account expenses on fuel, diesel oil and repairs. The analysis of fuel, oil and repair costs as well as their variation in time will enable the development of complex economic criteria, describing fuel, diesel oil and repair costs and their comparison [1,4].

2. The analysis of maintenance costs

The statistical data obtained from Vilnius locomotive depot show that fuel costs of passenger locomotives make 20.6-22.3 EUR/10000 tkm, oil costs make 0.6-0.7 EUR/10000 tkm, and repair costs – 0.3-0.4 EUR/10000 tkm. These costs vary when the locomotives are aging. Percentage distribution of expenses also varies in time. Percentage distribution of costs for passenger locomotive is shown in Fig. 1.

The analysis of histograms in Fig. 1 shows that fuel costs make the largest component of costs for passenger locomotives.

For diesel trainsets fuel costs make 25.6-26.2 Eur/10000 tkm, diesel oil costs make about 0.5 Eur/10000 tkm, and repair costs – 1.2-3.1 Eur/10000 tkm. Their percentage cost distribution slightly differs from that of passenger locomotives (Fig. 2).

The analysis of data presented in Figs 1 and 2 shows that the percentage of repair costs is increasing most rapidly both for diesel trainsets and passenger locomotives (due to this increase the percentage of fuel costs is decreasing). For passenger locomotives the increase considered makes about 10 % per year,

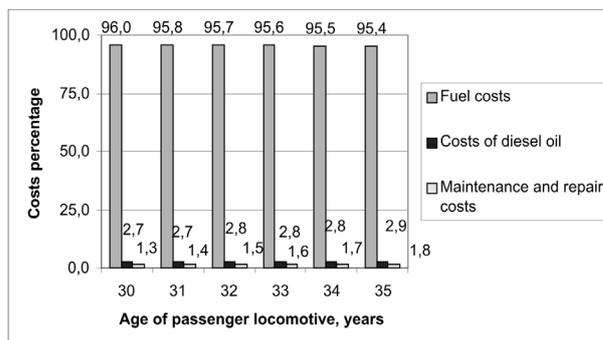


Fig. 1. Percentage distribution of costs for passenger locomotive

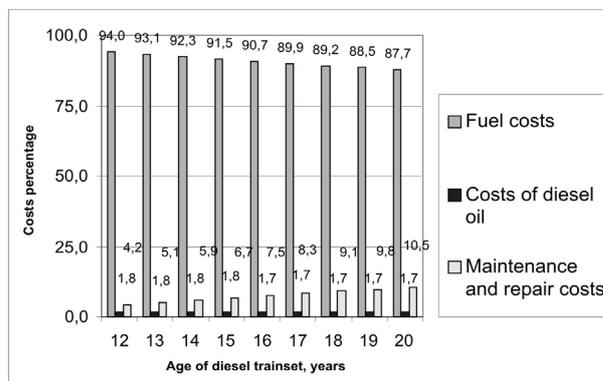


Fig. 2. Percentage distribution of costs for diesel trainset

while for diesel trainsets it is about 70 % per year. Since about 40 % of traction rolling stock failures are engine failures [5], it can be assumed that engine condition in diesel trainsets is worse,

since their operating conditions are more difficult because of heavier loads.

The research has shown that, when renewing traction rolling stock (by purchasing new locomotives), special attention should be devoted to fuel costs. Engine design and transmission should be chosen particularly carefully. For example, the efficiency of thermal engines (a part of thermal energy converted to work) usually ranges from 15 to 35% [2,3,6], depending on their design. Fuel costs are directly related to efficiency.

It should be stated that oil costs are growing considerably with the increase of diesel trainset age. However, this is accounted for by the peculiarities of their engine design.

3. Developing a complex criterion for assessing traction rolling stock performance

A complex criterion for assessing traction rolling stock performance should take into account costs of fuel, oil and unscheduled repairs. It can be expressed as follows:

$$K = d \cdot I_d + a \cdot I_a + p \cdot I_p \quad (1)$$

where: K is a complex criterion of traction rolling stock performance, EUR/10 000 tkm; d - means relative fuel consumption, kg/10 000 tkm; a - denotes relative oil consumption, kg/10 000 tkm; p - denotes relative costs of unscheduled repairs, h/10 000 tkm; I_d - denotes relative costs per unit of fuel, EUR/kg; I_a - denotes relative costs per unit of oil, EUR/kg; I_p - means costs per arbitrary unit of unscheduled repairs, EUR/h.

Based on the data of the earlier research [3], it can be stated that a complex criterion K for passenger locomotives will be of the form:

$$K_{Kel} = (0,687 \cdot x + 21,46) \cdot I_d + (0,069 \cdot x + 0,238) \cdot I_a + (0,0035 \cdot x - 0,0672) \cdot I_p \quad (2)$$

The criterion K for diesel trainsets will be respectively of the form:

$$K_{DT} = (0,005 \cdot x^2 - 0,025 \cdot x + 51,92) \cdot I_d + (0,0147 \cdot x + 1,745) \cdot I_a + (0,00329 \cdot x + 0,243) \cdot I_p \quad (3)$$

where x is the age of traction rolling stock, years.

4. The relationship between complex economic criterion of rolling stock and its age

Since not all road vehicles of Vilnius depot are used uniformly, it is more rational to express complex criteria in terms of their mileage, rather than age (as in formulas (2) and (3)). Based on the formulas (2) and (3) and the current price of fuel, diesel oil and repair in Lithuania (which is 0.483 EUR/kg, 0.248 EUR/kg and 0.095 EUR/h, respectively), it is possible to calculate the values of complex rolling stock performance criteria, depending on its age. By multiplying the age of a rail vehicle by its mean annual mileage (run), it is possible to calculate the mileage of a road vehicle of a particular age and, then, to obtain the dependence of complex criterion on mileage (according to the data provided by Vilnius locomotive depot, the average annual mileage of passenger locomotives is 68.4 thous. km, while for diesel trainsets it makes 104.4 thous. km.). The relationships between complex economic criteria of passenger locomotives and diesel trainsets and their mileage (run) are presented in Figs 3 and 4, respectively.

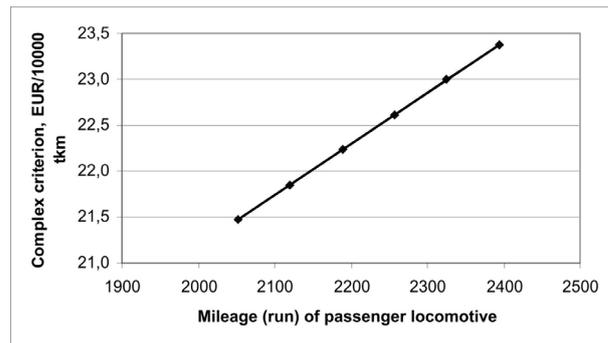


Fig. 3. The relationships between complex economic criterion of passenger locomotives and their mileage (run)

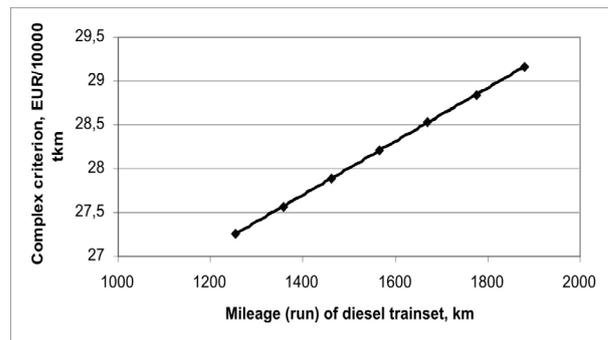


Fig. 4. The relationship between complex economic criterion of diesel trainset and mileage (run)

The relationship given in Fig. 3 is expressed by the equation:

$$K_{Kel} = 0,0056 \cdot r_{kl} + 10,06 \quad (4)$$

where: r_{kl} is the mileage (run) of passenger locomotive, thous. km.

The relationship given in Fig. 4 is expressed by the equation:

$$K_{DT} = 9 \cdot 10^{-19} \cdot r_{dt}^2 + 0,0031 \cdot r_{dt} + 23,43 \quad (5)$$

where: r_{dt} is the mileage (run) of diesel trainset, thous. km.

The comparison of equations 4 and 5 shows that both Complex economic criteria of passenger locomotives have linear dependence on their mileage (run), while the coefficients of direction are 0.0056. Complex economic criteria of diesel trainsets have dependence.

These values show that the variation rate of the complex economic criterion of diesel trainsets in time is by 1.8 lower than that of passenger locomotives. This can be accounted for by lower deterioration rate of diesel trainsets.

Further research of these problems should involve the determining of the above complex criterion for the condition when the maintenance costs of traction rolling stock are higher than the income obtained in the respective period of time, i.e. the use of rolling stock is not rational, taking into account the required expenses on fuel, oil, maintenance and repairs. The criterion should be a non-dimensional value and take into account the variation of a complex criterion in operation.

5. Conclusions

- Complex economic criteria for assessing the process of rolling stock aging based on fuel, diesel oil and repair costs were developed.
- Complex economic criteria of passenger locomotives have linear dependence on their mileage (run), while the coefficients of direction are 0.0056.
- Complex economic criteria of diesel trainsets have dependence.
- The growth of the complex economic criterion value for diesel trainsets is by 1.8 times slower than that for passenger locomotives because of less heavier deterioration of these trainsets.

6. References

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