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COMPARING THE PERFORMANCE OF DIESEL LOCOMOTIVES FOR PASSENGER TRANSPORTATION

Summary. Railway transport usually employed for passenger transportation embraces passenger locomotives, diesel trainsets and electric trains as well as railcars. Diesel or electric trains are mostly used on suburban routes, while passenger or electric locomotives haul the carriages on interurban routes.

СРАВНЕНИЕ ПРОИЗВОДИТЕЛЬНОСТИ ПАССАЖИРСКИХ ТЕПЛОВОЗОВ

Резюме. Железнодорожный транспорт, обычно используемый для пассажирской транспортировки, охватывает пассажирские локомотивы, дизель-поезда и электропоезда, а также дрезины. Дизель- или электропоезда главным образом используются на пригородных маршрутах, в то время как пассажирские или электрические локомотивы используются для тяги вагонов на междугородных маршрутах.

1. INTRODUCTION

In Lithuania, only about 9 % of railways have been electrified yet, therefore, the choice of the type of traction and vehicle for passenger transportation is a significant problem. For this purpose, a comparative analysis of diesel locomotives and their performance (based on the cost analysis of the consumed fuel, diesel oil, as well as maintenance and repairs) should be performed. This paper presents and discusses the results obtained in the investigation of the above problems.

2. FUEL CONSUMPTION

Fuel consumption depends on many factors (e.g. mass of the rolling stock, its speed, axle loading, carriage structure), however, since the operating conditions of rail vehicles are similar, these factors are equally important for all of them. On the other hand, service life and technical condition of a rail vehicle are the most important factors determining its fuel consumption. Thus, fuel consumption is the main indicator of the performance of traction rolling stock. Usually, it is expressed as a relative value, e.g. 1000 tkm or 10000 tkm. This quantity is referred to as relative fuel consumption. This method of calculating fuel consumption per unit of work is quite satisfactory for freight locomotives. However, as far as passenger locomotives are concerned, the above indicator shows the work done in carrying

containers rather than passengers. Therefore, it is used only when passenger flows do not differ considerably.

The dependence of relative fuel consumption of passenger locomotives of various age and the power of 2200 kW on various factors, established in investigating their performance, is shown in Fig 1. About 80 % of experimental data are in the solution interval ± 2 % of the presented equation (1).

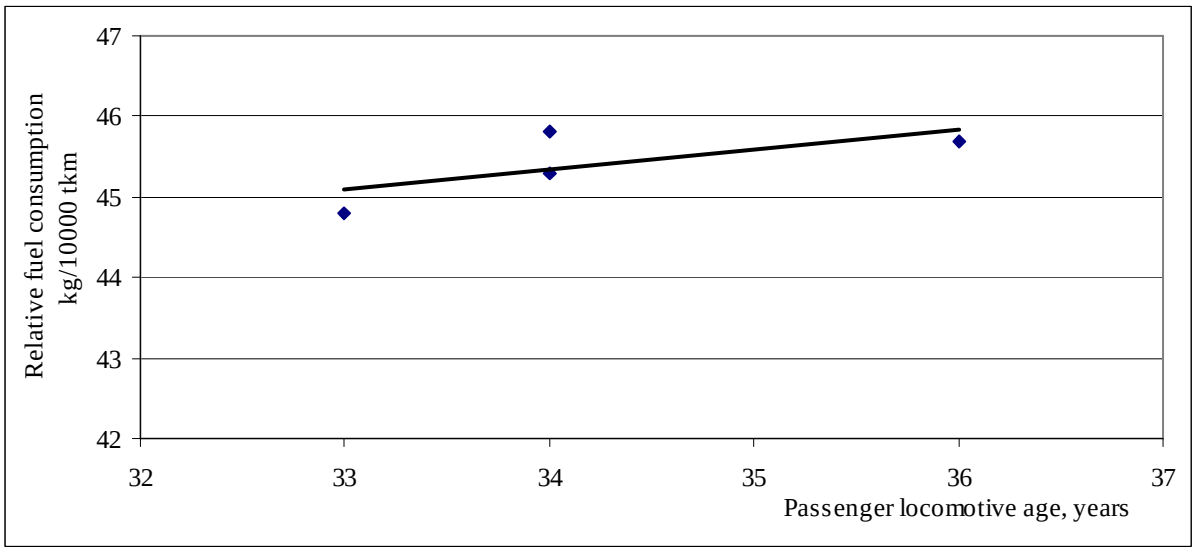

Fig. 1. The relationship between relative fuel consumption of passenger locomotives and their age
Рис. 1. Зависимость между относительным потреблением топлива пассажирских локомотивов и их возрастом

As shown in Fig 1, the variation of fuel consumption of passenger locomotive is about 0.3 kg / 10000 tkm. (0.7 %) per year. Mathematically, the relationship between relative fuel consumption and the locomotive age may be expressed by a linear equation:

$$d_{kel} = 0{,}687 \cdot x + 21{,}46\,; \qquad (1)$$

where: x is the age of a locomotive, years; d is relative fuel consumption, kg / 10000 tkm.

The variation of relative fuel consumption of diesel trainsets with the power of 736 kW is shown in Fig 2.

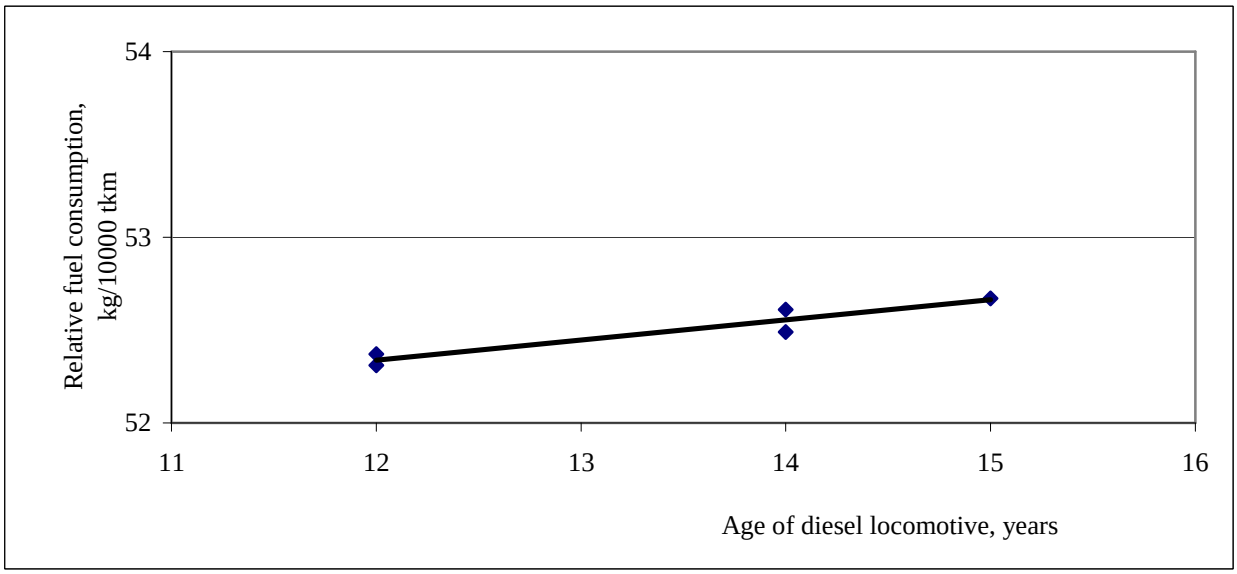

Fig. 2. Variation of fuel consumption of diesel locomotives
Рис. 2. Изменение потребления топлива для тепловозов

As seen in the diagram, fuel consumption of diesel trainsets, which are getting older, is uniformly increasing by approximately 0.12 kg / 10000 tkm. (0.23 %) annually (which is 2.5 times lower than that for diesel locomotives). Relative fuel consumption variation can be expressed by the following equation:

$$d_{Ddyz\_t} = 0{,}108 \cdot \mathrm{x} + 51 \tag{2}$$

In the service life range from 12 to 15 years, 12 to 15 years, 80 % of experimental data are in the solution interval ± 0.2 % of the equation (2).

Therefore, it is more economical to carry passengers by diesel locomotives than by diesel trainsets, though the comparison is relative because diesel locomotives are twice as old as diesel trainsets. On the other hand, the upgraded diesel trainsets allow for varying the number of carriages (when required) more freely as well as using only one motor coach, while having the driver's cab in the other. Moreover, when less fuel is consumed, a smaller amount of pollutants (CO, CO_2, NO_x, C_xH_y, and solid particles) is released into the atmosphere.

3. OIL CONSUMPTION

Other materials are used by traction rolling stock besides fuel. The amount of diesel oil used is closely connected to the rolling stock condition. Diesel oil is not a source of power, therefore, its use indicates a poor state of the engine. The relationships between relative oil consumption and the age of the locomotives are given in Figs 3, 4.

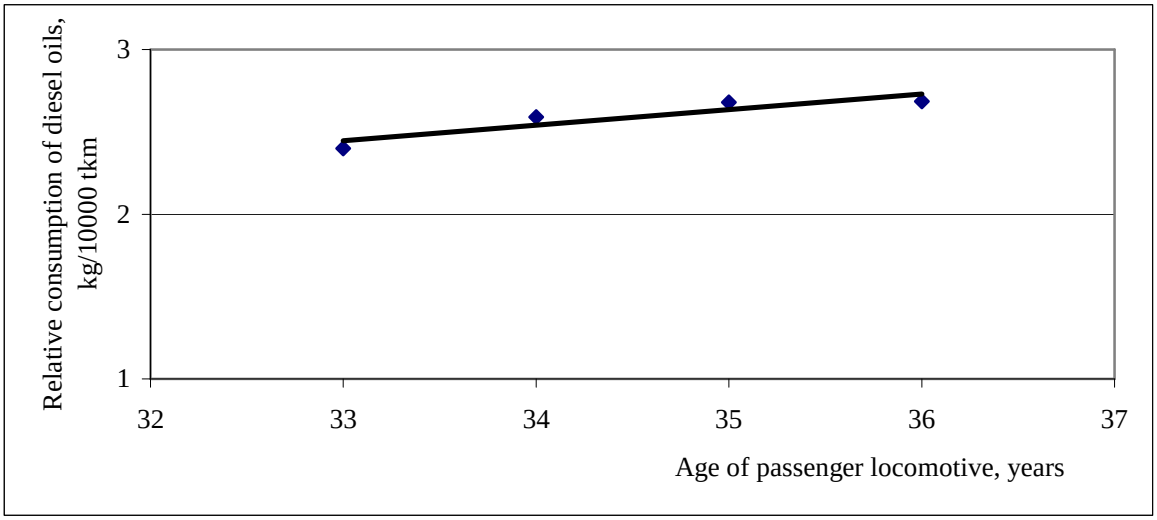

Fig. 3. The relationship between relative consumption of diesel oil by passenger locomotives and their age
Рис. 3. Зависимость между относительным потреблением дизельного топлива пассажирскими локомотивами и их возрастом

As shown in Fig 3, the consumption of diesel oil by passenger locomotive grows by about 0.095 kg / 10000 tkm. (2.1 %) per year. The relationship between relative diesel oil consumption by passenger locomotives may be described by the following mathematical expression:

$$a_{Kel} = 0{,}069 \cdot x + 0{,}238\,. \tag{3}$$

where: a is relative diesel oil consumption, kg/10000 tkm.

The variation of relative oil consumption by diesel trainsets, depending on their age, is shown in Fig 4.

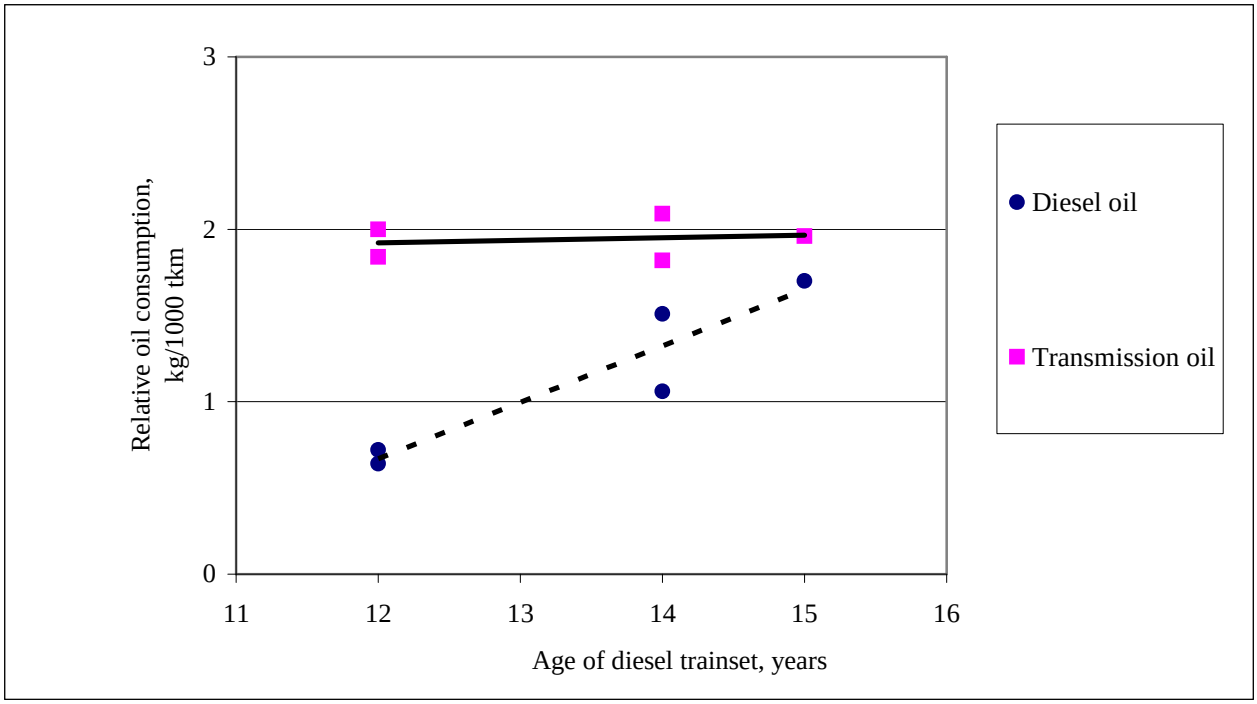

Fig 4. Variation of relative diesel and transmission oil consumption by diesel trainsets
Рис. 4. Изменение относительного потребления дизтоплива и трансмиссионного масла дизель-поездом

As shown in Fig 4, relative diesel oil consumption by diesel trainsets does not vary considerably, making about 2 kg / 10000 tkm. The annual consumption of diesel oil by diesel trainsets varies according to the expression:

$$a_{Dyz\_t} = 0{,}0147 \cdot x + 1{,}745\,. \tag{4}$$

The variation of annual consumption of transmission oil by diesel trainsets may be described by the formula:

$$a_{tr} = 0{,}3275 \cdot x + 3{,}262\,; \tag{5}$$

where: a_{tr} is relative transmission oil consumption, kg / 10 000 tkm.

4. REPAIR COSTS

Maintenance and repair of rolling stock may be assessed in hours of terminal delay. This evaluation method was used because delay hours are easy to calculate and to operate. The delay time actually indicates the amount and effectiveness of repair work in Lithuania. It also shows the reliability of rolling stock. Another aspect is the correctness of this approach. The statistical data shows that terminal delay time (in hours) is proportional to the expenses. It means that the relationship between terminal delay time and the locomotive age will be equal to the similar cost relationship. The relationships between relative terminal delay and the locomotive age are presented in Figs 5, 6.

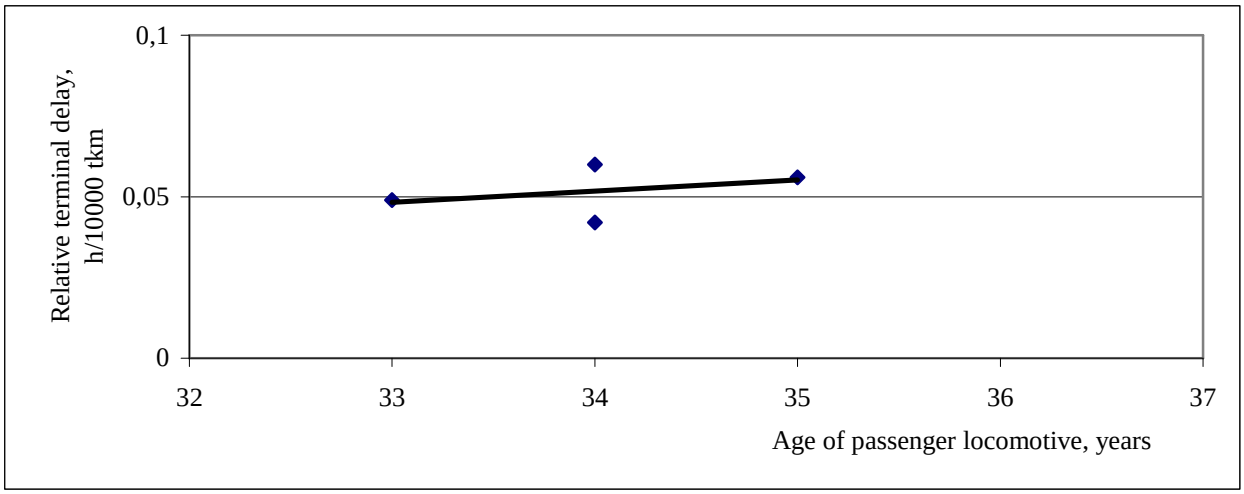

Fig. 5. The relationship between relative delay time and age of passenger locomotives
Рис. 5. Зависимость между относительным временем простоев и возрастом пассажирских локомотивов

As shown in Fig 5, variation of relative passenger locomotive delay time makes about 0.0035 h/10000 tkm (7 %) per year. By approximating the relationship given in Fig 5, we get the regression equation:

$$p_{Kel} = 0{,}0035 \cdot x - 0{,}067\,; \tag{6}$$

where: p is relative terminal delay, h/10000 tkm.

Fig 6. The relationship between relative delay time and age of diesel trainsets
Рис. 6. Зависимость между относительным временем простоев и возрастом дизель-поезда

As shown in Fig 6, the variation of relative terminal delay of diesel trainsets is about 0.033 h/10000 tkm (20 %) per year. By approximating the relationship given in Fig 6, we obtain the following equation:

$$p_{DR1A} = 0{,}0329 \cdot x + 0{,}243\,. \tag{7}$$

5. CONCLUSIONS

1. Fuel consumption by diesel trainsets, expressed in kg/10000 tkm., is about 12 % higher than fuel consumption by passenger locomotives.

2. Fuel consumption by passenger diesel locomotives increases with their age according to linear dependence, while fuel consumption by passenger diesel locomotives increases by 0.7 % and by diesel trainsets – by 0.23 % per year.

3. Relative diesel oil consumption by passenger locomotives increases by about 2.1 % per year. Relative diesel oil consumption by diesel trainsets grows insignificantly.

4. Relative terminal delay of passenger rolling stock increases in time according to linear dependence: for diesel locomotives it increases by about 7 % per year, while for diesel trainsets the increase is 20 % per year.

5. The investigation results show that, taking into account fuel and diesel oil consumption as well as time of terminal delay due to repair, it would be more rational to use passenger locomotives if the routes are long and passenger flows are relatively large. To determine more exactly rational route length, some additional research is needed.

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