ANALYSIS OF TECHNICAL MAINTENANCE AND REPAIR SYSTEM OF MODERN PASSENGER ROLLING STOCK

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Abstract. For passenger transportation, safe rolling stock operation and to secure maximal value of fleet preparedness, during exploitation scheduled technical maintenance and scheduled repairs are performed. Currently, only passenger operator in Lithuania is SC “Lithuanian railways” that carries scheduled technical maintenance and repair system. It means that repairs are performed accordingly the run and exploitation period of particular rolling stock. This system allows keeping up high level of rolling stock reliability, but economic index of exploitation in this case is low. Researches not only confirm the expedience of the modern rolling stock procurement in economical sense, but that allows also the higher degree of comfort and safety.

Keywords: railways, passenger transportation, technical maintenance, repair system.

1. Introduction

In Lithuania for local communication diesel and electric trains are in use. Fleet of rolling stock is being modernized, therefore currently old and new rolling stock with different systems of technical maintenance and repair are in exploitation.

For passenger transportation, safe rolling stock operation and to secure maximal value of fleet preparedness, during exploitation scheduled technical maintenance and scheduled repairs are performed. Currently, only passenger operator in Lithuania is JSC “Lithuanian railways” that carries scheduled technical maintenance and repair system. It means that repairs are performed accordingly the run and exploitation period of particular rolling stock. This system allows keeping up high level of rolling stock reliability, but economic index of exploitation in this case is low. According the long-term experience of maintenance divisions, very often components and systems that are in good order are under repair, because documentation requires it. By contraries, when rolling stock get old, elements, components and units are not always in good order between scheduled repairs and in this case there is need for unplanned or larger extent intermediate repairs. When such system is in use, there are big expenses suffered because of additional stuff and prompt procurement of spare parts.

2. Comparison of the maintenance and repair systems of modern and old passenger rolling stock

For improvement of exploitation of rolling stock, producers of new high level rolling stock applied modern engineering, achievements of information technologies and new manufacturing principles. In new rolling stock acquired by SC “Lithuanian railways”, on-board computers and electronic diagnostic systems are installed. These innovations allow to reduce the extent of scheduled repairs and to avoid additional operational works. The use of diagnostic systems allows optimization of functioning of the technical maintenance and repair system. Modern technical maintenance means only change and complement of the exploitation materials and maintenance of basic components. During scheduled repairs diagnosis of main systems and assemblies of rolling stock is carried out computing personal computers with special programme equipment. After diagnosis of disordered components, only technical faults with critical reliability are under repair.

In consideration of the fact that big amount of expenses of undertakings is incurred by scheduled repairs and maintenance of engines and gears, modern manufacturers of rolling stock improving these units changed their repair systems also. Power-plants are provided with diagnostic equipment for the supervision of technical conditions. Materials of high quality in common with modern technologies used in manufacturing process, allow to extent periods between scheduled repairs. It turned to become the reason of the technical maintenance system perfection and the extent of the period between scheduled repairs of the particular rolling stock. In modern technical maintenance and repairs system, same as of older rolling stock, maintenance and repairs are concurrent.
Fig. 1. The interrepair run of diesel passenger trains

with upkeep of engines and gears, but scarcely repeatable. Furthermore, new system of rolling stock maintenance is related with work hours, meanwhile maintenance of old rolling stock is carried according the run. The interrepair periods are measured in hours. Estimating that one hour is equal to 32 km of the run, after the conversion of motohours into kilometers, we can compare the extent of interrepair periods of the modern and the old rolling stock. The table placed below shows the comparison of the periodicity of scheduled and big repairs of the old diesel train DR1A that is very common in Lithuanian railways and rolling stock of the new type 620 M [2–3].

In the diagram (Fig. 1) we see that in the new rolling stock repair system exists routine repair of second extent (further ER-2) that does not exist in scheduled repair system of old rolling stock. Also, we can notice that the interrepair run of the units of modern rolling stock is bigger than the run of the old ones. For modern rolling stock TP-3 and ER-1 are performed 5 times rarer, ER-3 is performed more than 3 times rarer, KR-1 and KR-2 two times rarer.

3. Comparison of the expenses for scheduled repairs

For evaluation of the expenses for the use of the repair and maintenance systems of the old and the modern rolling stock, we will estimate the number of repairs during exploitation period for both types of rolling stock and the conditional expenses for every type of repair. After that we compare results.

We consider that the performance time of rolling stock set by manufacturer is 30 years. According to statistic data of JSC “Lithuanian railways”, we can suggest that without taking into account unplanned repairs, one unit of rolling stock (train or motrisa) has the run of 100,000 km per year. Having such data we are able to rate the number of scheduled repairs for modern and old rolling stock during the exploitation time.

\[
[KR_D^1] = \frac{3,000,000}{120,000} = 2; \quad (1)
\]

\[
[KR_D^2] = \frac{3,000,000}{600,000} - [KR_D^1] = 3; \quad (2)
\]

\[
[ER_D^3] = \frac{3,000,000}{150,000} - [KR_D^1] - [KR_D^2] = 15; \quad (3)
\]

here: \( [KR_D^1] \) – number of big repairs of first extent of diesel passenger train DR1A (further KR-1 per 30 years; \( [KR_D^2] \) – number of big repairs of second extent of diesel passenger train DR1A per 30 years; \( [ER_D^3] \) – number of routine repairs (ER-3) of diesel train DR1A per 30 years.

To put the case that rolling stock of modern type after one year of exploitation will have the same run as the old ones, we estimate the number of scheduled repairs of 620 M:

\[
[KR_E^2] = \frac{3,000,000}{2,048,000} = 1; \quad (4)
\]

\[
[KR_E^1] = \frac{3,000,000}{102,400} - [KR_E^2] = 2; \quad (5)
\]
\[
[ER_E^3] = \frac{3000000}{512000} - [KR_E^1] - [KR_E^2] = 3 ; \quad (6)
\]
\[
[ER_E^2] = \frac{300000}{256000} - [ER_E^3] - [KR_E^1] - [KR_E^2] = 6 ; \quad (7)
\]

here: \([KR_E^2]\) – the number of KR-2 of 620 M (automotrisa) per 30 years; \([KR_E^1]\) – the number of KR-1 of 620 M (automotrisa) per 30 years; \([ER_E^3]\) – the number of ER-3 of 620 M (automotrisa) per 30 years; \([ER_E^2]\) – the number of ER-2 of 620 M (automotrisa) per 30 years.

Modern rolling stock that JSC “Lithuanian railways” uses currently are not repaired yet, but taking into consideration that undertaking has in exploitation modernised diesel trains DR1AMv (with MTU engines) for 6 years already, and knowing that for this rolling stock the expenses of ER-3 consists 60 percent of the expenses of ER-3 for DR1A, we can conclude that for 620 M and DR1AMv the expenses of ER-3 will differ marginally. For evaluation of unplanned expenses, faults of counting and additional costs for procurement of the equipment, we consider that ER-3 of 620 M is 25 % cheaper than ER-3 of DR1A. After counting of technical maintenance expenses of third extent (further TP-3) for DR1A and 620 M, we can see that TP-3 expenses for 620 M is 40 % less. Taking into consideration this information and experience of other countries [1], we can conclude that the rate 0,75 of the difference in price of scheduled repairs of the modern and old rolling stock is correct. Expenses for ER-2 in the system of repairs of modern rolling stock, performing ER-2 to the old rolling stock under the common practice of undertaking, consists 60 % of ER-3.

Considering this data, it is possible to estimate conditional expenses for scheduled repairs during 30 years of exploitation. For this purpose we thus indicate prices of scheduled repairs of DR1A:

\[ER_{KE}^3 = a ; \quad (8)\]
\[KR_{KD} = b ; \quad (9)\]
\[KR_{KD}^2 = c . \quad (10)\]

\((I_1)\) – the sum of expenses of scheduled repairs of DR1A during 30 years of exploitation:

\[I_1 = 15a + 3b + 2c . \quad (11)\]

Prices of 620 M scheduled repairs we indicate thus:

\[ER_{KE}^2 = 0,6 \times ER_{KE}^3 = 0,6 \times 0,75a ; \quad (12)\]
\[ER_{KE}^3 = 0,75a ; \quad (13)\]
\[KR_{KE}^1 = 0,75b ; \quad (14)\]
\[KR_{KE}^2 = 0,752 . \quad (15)\]

\((I_2)\) – the sum of expenses of scheduled repairs of 620 M during 30 years of exploitation:

\[I_2 = 6 \times 0,6a + 3 \times 0,75a + 2 \times 0,75b + 0,75c = 6a + 1,5b + 0,75c \quad (16)\]

We can see that the expenses for ER-3 there are 2,5 times less.

If we compare coefficients of the equations (11) and (16), we will estimate the advantage of the modern rolling stock scheduled repair system.

According the dimension of the coefficients of the scheduled repair prices in figure 2, we see that the expenses of scheduled repairs for 620 M during 30 years of exploitation (without expenses for unplanned repairs) are more than two times less than the same expenses of DR1A.

One of the main factors that allows extending the interrepair run of modern rolling stock is appliance of diagnostic systems. These systems are dedicated to

![Fig. 2. Coefficients of the scheduled repair prices](image-url)
supervise technical condition of units and components. Modern diagnostic system recorders parameters of power-plant, gear, safety system, additional equipment, brakes and other rolling stock components, analyses them and transfer this information to the driver of the train. It should be noted that the start of rolling stock means a lot of operations related to estimation of technical conditions of supervised systems. After some mistake or abnormal operation, system informs the driver. If the discovered breakdown is big and can disturb the exploitation of rolling stock or rolling stock is in a bad technical condition and cannot be operated, systems of diagnosis and control do not allow starting the operation. If such breakdown occurs during the trip, there is emergency regime provided that will secure the operation to the end of the ride.

The system of computerised diagnosis and the use of special programme equipment decrease expenses of scheduled repairs. The diagnosis is being performed before scheduled repairs and planned maintenance survey. Thus the breakdowns are being established and eliminated during scheduled repairs. That allowed to abandon the big repairs of power-plants after 300 000 km of the run and to increase the interrepair period two times.

The implementation of modern technologies in the new rolling stock allowed increasing of interrepair periodicity, to lessen exploitation expenses and to change the control of rolling stock. Modern locomotive is controlled by one person. The use of diagnostic system allowed to eliminate the driver assistants, whose one of the functions was to control the operational parameters of the power-plant.

5. Conclusions

1. For modern rolling stock TP-3 and ER-1 are being performed five times rarer, ER-3 is being performed more than three times rarer, KR-1 and Kr-2 – two times rarer.
2. The coefficients of the prices of the modern rolling stock scheduled repairs are more than two times less than the ones for old rolling stock.
3. Researches not only confirm the expedience of the modern rolling stock procurement in economical sense, but that allows also the higher degree of comfort and safety.

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