Towards the justification of optimal volumes of repair production of locomotives of diesel tractions

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Abstract. A methodology and algorithm for determining the optimal volume of repairs with known cyclicity of repair production and between-repair runs of mainline diesel locomotives of the TE10 series and the UzTE16M series in various sectional designs is presented. The basic component of this methodology is the dynamic programming method in combination with the reliability characteristics of diesel locomotive components and probabilistic and statistical methods for their calculation. Planning of optimal volumes of repairs is carried out on the basis of a minimax criterion based on the value of the total operating costs for the maintenance of each repair unit of a diesel locomotive. It is recommended to continue this research with the aim of drafting block diagrams and developing working programs for computer hardware and software systems and computers with their subsequent implementation in the practice of working the locomotive complex of the Uzbek Railway. Key words: Method, locomotives, optimal volume, diesel locomotive, maintenance, current repairs, mileage between repairs, unit operating time, failure.

1 Introduction

Mainline diesel locomotives of the TE10M and UzTE16M series in various sectional designs are operated on the Uzbek railway in specific, “difficult” climatic conditions, namely: high outside air (ambient) temperatures, large differences in indicated air temperatures, barometric pressure and relative humidity, low amount of precipitation and strong winds that contribute to the occurrence of sandstorms. In addition, sections of railways differ in the difficulty (complexity) of the track profile. At this time, the applied structure of train maintenance schemes for the specified diesel locomotives and locomotive crews, in combination with severe climatic conditions, requires the establishment (justification) of an optimal repair production system in order to increase the operational reliability of diesel locomotives along the route of rolling stock. The above concerns the technical maintenance of TM2 (Technical Maintenance 2)
2 Objects and methods of research
development of a model for managing the life cycle of locomotives using modern methods of technical diagnostics, the most complete list of studies in this area is provided. Here, all researchers agree on one thing: for diesel locomotives of the TE10M series, the difference between the repair process schedule in the scope of TM2 and the standard repair schedule is as follows:

- the reliability of fastening the diesel unit to the diesel frame and the diesel frame to the locomotive frame is not checked, since in practice there were no cases of weakening of the foundation bolts on TM2;
- measurements of the sagging of the main journals of the lower crankshaft and the gaps in the motor axle bearings are carried out through one TM2, since during the mileage of a diesel locomotive between adjacent TM2, an increase in wear is not detected by the measuring instruments used in the depot;
- diesel injectors are removed and tested through one TM2;
- inspection of the frames of the bogies and the main frame of the diesel locomotive is carried out not by locksmiths of the integrated team, but by the foreman when accepting the locomotive for repair and by the inspector when releasing the locomotive from repair;
- inspection of the pump drive and integrated speed controller is carried out through one TM2;
- the sections of the refrigerator are not inspected by locksmiths of the integrated team, since the presence of leaks in the sections of the refrigerator is detected during operation by locomotive crews or during routine repairs of CR1 by locksmiths of the complex team;
- replacement of fine fuel filter elements of the “FETO” type is carried out after a mileage of 25 thousand kilometers in accordance with the operating instructions for these filters;
- testing of OPR1 (Oil Pressure Relay 1) and OPR2 (Oil Pressure Relay 2) is carried out with a portable testing device without removing them from the diesel locomotive;
- the air receiver compartment hatch covers cannot be removed.

However, until now, the necessary attention has not been paid to the development of scientific methods for optimizing the volume of work performed during inspections during maintenance and routine repairs of diesel locomotives. In this article, the author examines (proposes) one of the possible methods for determining the optimal volume of repair work at established frequencies and between repair runs of diesel locomotives.

3 Results and their discussion

When developing a methodology for determining the optimal volumes of repairs with known cyclicity of repair production and interrepair runs of diesel locomotives, the following scheme was analyzed.

Under operating conditions, starting from mileage \( l = 0 \), diesel locomotives operate in units of the same type. The duration of operation of these nodes until failure is characterized by a certain well-known distribution law with density \( f(l) \). At given constant mileage intervals equal to \( L_r \), scheduled repairs of units are carried out; the cost of repairing one unit is \( C_r \).

Let us determine the total costs of repairing components over a sufficiently large, compared to the average time to failure of a component \( \bar{L} \), mileage \( L \) km, including \( S \) repair cycles.

From this mileage interval, consider the mileage from \( l_k \) to \( l_{k+1} \) km (\( \Delta l = l_{k+1} - l_k \)).
\[ C_r = c_r \cdot P_r \]

\[ P_r = \lim_{s \to \infty} \frac{1}{n} \cdot \sum_{j=1}^{s} n_{pj} = \lim_{s \to \infty} \frac{n_r}{n} \]

\[ n_r = \sum_{j=1}^{S} n_r \]

\[ n_r = n \cdot f(l) \cdot \Delta l \]

\[ C_o = C_o + C_{po} \cdot P_o \]

\[ C_{po} = \]

\[ C_po \]

\[ P_o \]

\[ C_r = c_r \cdot P_r \]

\[ C_o + C_{po} \cdot P_o + C_o \cdot P_o + C_r \cdot P_r \]

\[ C(l) = \begin{cases} C_o + C_{po} \cdot P_o + C_r \cdot P_r & \text{if } l < L_0 \\ C_r \cdot P_r & \text{if } L_0 < l < L_r \\ \end{cases} \]

Due to the fact that a node failure can occur at any time in a given interval, or may not occur at all during the run \((0, L)\), the total operating costs for maintaining the node will be determined as the mathematical expectation of costs for the interval under consideration and will amount to \(E3S\) Web of Conferences **508**, 08013 (2024) GreenEnergy 2023

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\[ M[C(l)] = \sum_{j=1}^{s} \int_{l_0}^{l_{k}} (C_o + C_{ro} \cdot P_o + C_v \cdot P_e + C_r \cdot P_r) \cdot df(l) + \int_{l_k}^{l_{k+1}} (C_o + C_v \cdot P_e + C_r \cdot P_r) \cdot df(l) \]

\[ \min \max M[C(l)] \]

\[ M[C(l)] \geq M_1[C(l)] \]

\[ C_e = \min \sum_{i=1}^{n} M_i[C(l)] \]

4 Conclusion

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References


