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SYSTEM FOR THE MAINTENANCE OF LOCOMOTIVE OPERATIONAL RELIABILITY

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Abstract. A reliable and safe process of passenger and freight transportation is determined by the selected mode of use of rolling stock, efficient application of technical maintenance and repair systems, as well as strict work and technological discipline. When operating a rolling stock fleet, it is very important to enhance the indicators of its reliability and economic efficiency. This depends on the rolling stock design, technical maintenance and repair system, existing repair complex, organization of repair works, and qualification of the staff.
The number of unscheduled repairs demonstrates that the quality of repairs and its organization is not of the sufficient level. Each year due to unscheduled repairs LG incurs great loss associated with the idle time of locomotives, additional expenses for materials, work costs and fuel consumption.

Keywords: railway, locomotive, technical condition, repair system.

1. Introduction

A reliable and safe process of passenger and freight transportation is determined by the selected mode of use of rolling stock, efficient application of technical maintenance and repair systems, as well as strict work and technological discipline. When operating a rolling stock fleet, it is very important to enhance the indicators of its reliability and economic efficiency. This depends on the rolling stock design, technical maintenance and repair system, existing repair complex, organization of repair works, and qualification of the staff. It is very important to perceive and to adapt information technologies in the proper way which would enable to systemize the existing information and answer the following main questions when using it: at what periodicity scheduled repairs should be performed without using additional funds seeking to maintain the necessary technical condition of the rolling stock, how many spare parts should be held in storage in order to perform scheduled and unscheduled repairs with the minimum costs, how to enhance the reliability of equipment components and aggregates. All the factors listed are directly associated with unscheduled repairs (hereinafter – NSR).

The number of unscheduled repairs demonstrates that the quality of repairs and its organization is not of the sufficient level. Each year due to unscheduled repairs LG incurs great loss associated with the idle time of locomotives, additional expenses for materials, work costs and fuel consumption.

2. Change of technical condition

The technical condition of operated locomotives impairs because their parts and mechanisms wear out, connections become loose, equipment components get off-tune, and different malfunctioning occurs. With the course of time, physical and mechanical qualities of locomotive equipment components and aggregates impair, as a result whereof the locomotive reliability decreases.

The reliability reserve compiled while designing and manufacturing a locomotive gradually reduces, and having achieved a specific level, the locomotive may break down. Such failures cause accidents in the railways; violate train traffic schedules; increase the number of non-planned repairs, as a result whereof material loss associated with the idle time of locomotives and repair costs is sustained.

The key factors determining the technical condition of locomotives is operation technology and its conditions, also periodicity of technical maintenance (TM), current repairs (CR) and major repairs (MR), composition and quality of works (see Fig. 1).

The system of maintenance, current and major repairs is of a cyclical nature. A repair cycle is called the least recurrent period in the operation of a locomotive during which all specified technical types of maintenance and repairs are performed under the established procedure (see Figure 2). Currently, no second volume current repairs CR-2 are performed.

The following types of technical maintenance have been established for locomotives:

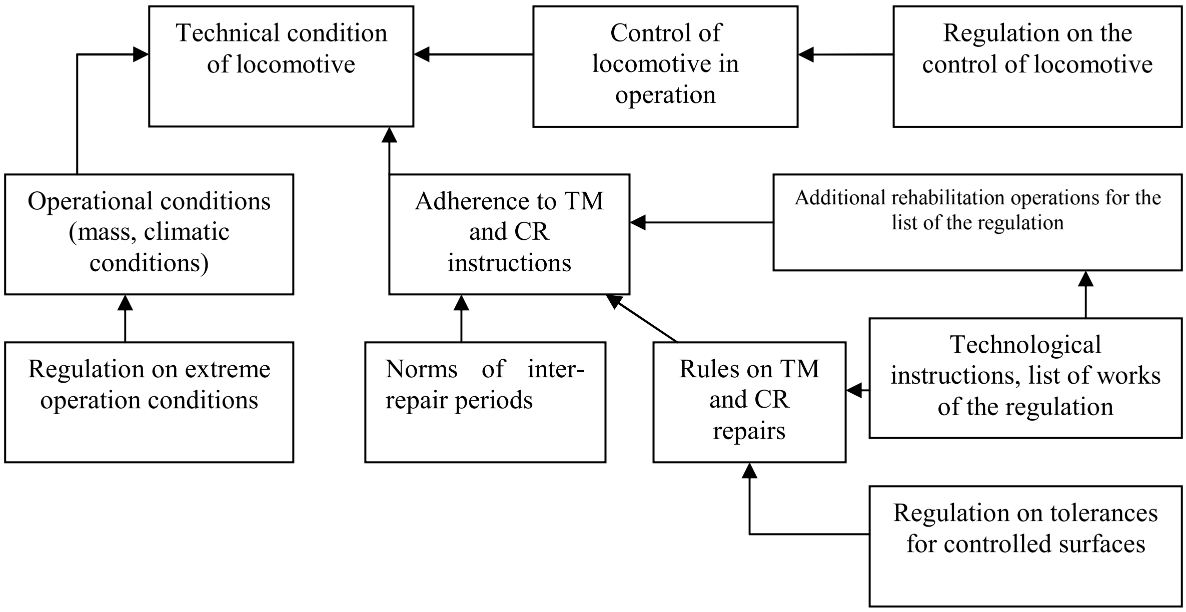

Fig. 1. The system of main factors assessing the technical condition of rolling stock

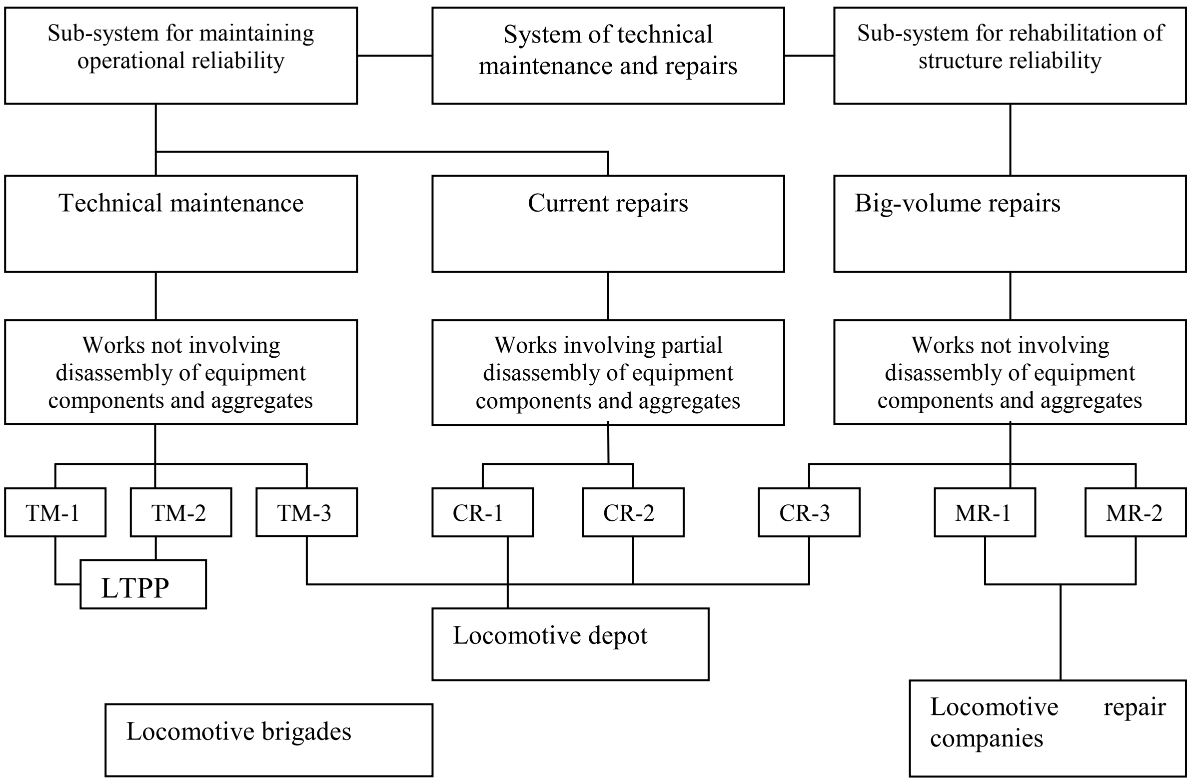

Fig. 2. Structure of the technical maintenance and repair system

– technical maintenance TP-1 – is performed by locomotive brigades by accepting and transferring a locomotive during its operation according to a particular list of works approved by the Rolling Stock Economy Service;

– technical maintenance TP-2 – is performed by qualified machinists of rolling stock repairs in specialized maintenance stations that must be supplied with the necessary technological equipment, tools and a particular reserve of materials and spare parts;

– technical maintenance TP-3 – is performed by specialized and complex brigades in locomotive depots;

– technical maintenance TP-4 – grinding of wheel-treads without rolling out thereof from under the locomotive.

Technical maintenance is intended: to warn about the occurrence of failures; for lubrication of the rubbing wheel pairs during an inter-repair period; for special control of locomotive underframe, brake equipment, and automatic locomotive interlocking, etc.

Current repairs are intended for the restoration of the main operational indicators and performance of locomotives. Revision, replacement, repairs and rehabilitation of particular equipment components, testing and adjustment are carried out during the repairs.

The following types of current repairs have been established for locomotives:

– current repairs CR-1 – during this type of repairs, TP-3 volume repairs and additional works associated with the dismounting and mounting of particular equipment components and aggregates are performed. It also includes determination of the lubricating gap in bearings of the crack shaft, rheostat tests and adjustment of a locomotive.

– current repairs CR-2 – during this type of repairs, partial disassembly of the internal combustion engine is performed involving the disassembly of the crank/piston unit, dismounting, repairs and adjustment of particular electric apparatuses, checking of the axial/engine bearings, etc. Currently, CR-2 repairs of freight locomotives are not performed.

– current repairs CR-3 – during this type of repairs, disassembly of the internal combustion engine, rolling out and disassembly of bogies, grinding of wheel treads and simple revision of wheel pairs, revision and repairs of electrical traction engines, etc. are performed.

Also, the first and second volume major repairs MR-1 and MR-2 are performed during which the following operations carried out:

– MR-1 is intended for the renewal of operational indictors, suitability and reserve of locomotives using repairs and the replacement of worn-out and broken equipment components and aggregates. Also, condition of the remaining constituent parts is checked by eliminating the defects identified.

– MR-2 is performed seeking to fully renew the locomotive reserve by rehabilitating the main equipment components and aggregates (components of internal combustion engines, bogie frames, etc.), to adjust them and fully replace electric wiring and cables, as well as upgrading them.

The main direction of works seeking to improve the technical maintenance and repairs system of locomotives is increasing the inter-repair kilometrage. This would enable to use the technical resources of equipment components and aggregates to the maximum extent what would have a crucial effect on the safety of running and reliability of operation.

3. Analysis of costs of inter-repair kilometrages and labour-consumption of freight-mainline locomotives

Based on the information provided (see Table 1), it is possible to see several interesting aspects.

Firstly, in all railway undertakings (except for Ukraine and the Russian Federation), the very same machinery is maintained by applying different grids for technical maintenance and repairs. Secondly, in case of Belarus, smaller inter-repair intervals were fixed for TM-3 and CR-1. Only one reason may be provided to account for this phenomenon – the technical condition of rolling stock is so poor that the number of unscheduled repairs is significantly bigger than expected by the operating organization, which being unable to control the quality of spare parts supplied and repairs, is forced to carry out "minor" maintenance more often, this way expecting to enhance the general technical reliability. This is not the best measure to achieve the goals set; on the contrary, the more often a unit or a component is repaired, the greater probability that it will get out of order without using the reserve fixed for it.

Getting back to the inter-repair kilometrage, it could be stated that the kilometrage fixed by a plant-manufacturer is adhered to only partially. A number of inter-repair kilometrages are bigger than fixed by the plant-manufacturer. It would be interested to find out why? What has an effect on the decisions of railway undertakings, and why a plant-manufacturer could not fix other – bigger inter-repairs intervals?

Of course, these are complex solutions. In my opinion, reference is made to the economic rationalism principle, yet this goal may be achieved only by maintaining a particular degree of technical reliability. Technical reliability, in its turn, depends on a number of circumstances, first of all, on

Table 1. Comparison of inter-repair kilometrages in the neighbouring countries

	Recommendation of plant-manufacturer	Lithuania	Belarus	Ukraine	Russian Federation
M62, 2M62 (with 14D40 engine)					
TM-3	10 000	12 000	7 500	10 000	10 000
CR-1	50 000	60 000	30 000	50 000	50 000
CR-2	120 000	–	120 000	150 000	150 000
CR-3	240 000	240 000	240 000	300 000	300 000
MR-1	720 000	720 000	720 000	600 000	600 000
MR-2	1 440 000	1 440 000	1 440 000	1 200 000	1 200 000

operational conditions of a rolling stock (profile, climatic conditions, train weights, etc.), quality of repairs and spare parts, etc. Thus, reliability, to put it more precisely, the operational reserve of aggregates and equipment components turned out to be bigger under corresponding conditions than it was fixed by a plant-manufacturer, and railway undertakings guided by statistical data and engineering insight, decided to increase the inter-repair intervals. Is this the limit, and how accurately is it possible to calculate and forecast inter-repair intervals with consideration to specific operational conditions? This is an interesting subject that should be analyzed separately.

Still and all, operational conditions are not everything. The reliability of a rolling stock significantly depends also on the design, the concept itself and technologies applied in the rolling stock. The more progressive technical solutions are adapted when designing a rolling stock, the less maintenance and repairs they "require" during operation. This may be proved by comparing the machinery operated since long ago and the new one. Table 2 provides inter-repair kilometrage of a new locomotive ER-20CF.

By comparing inter-repair kilometrages of the new and existing locomotives, it is evident that inter-repair kilometrages of the new machinery are bigger by a third than of the currently used ones at the present time (see Fig. 3). This means that it will be necessary to withdraw a locomotive from operation for the maintenance purposes less seldom. Correspondingly, the locomotive fleet for the transportation of such freight flows will become smaller.

Table 2. Inter-repair kilometrage of ER 20 CF

Type of repairs	Kilometrage, km
TM-3	20 000
ER-1	80 000
ER-3	320 000
MR-1	960 000

An analysis of costs shows that the repairs of rolling stock and other associated costs comprise about a fourth of all costs of the rolling stock economy. Thus, the optimizing of this part of costs is a weighty input into the competitiveness of the rolling stock economy.

Another very important circumstance – how much labour and spare parts are to be put into a locomotive when it arrives for technical maintenance or repairs? In other words, how long will a locomotive stand in the repair position, and how much funds will have to be allocated for checking or rehabilitating the technical condition of a locomotive. Comparisons on the consumption of repair works are provided in Tables 3 and 4.

Locomotives ER 20 CF have been put into operation only recently, therefore there are no possibilities to compare the consumption of labour associated with more difficult repairs.

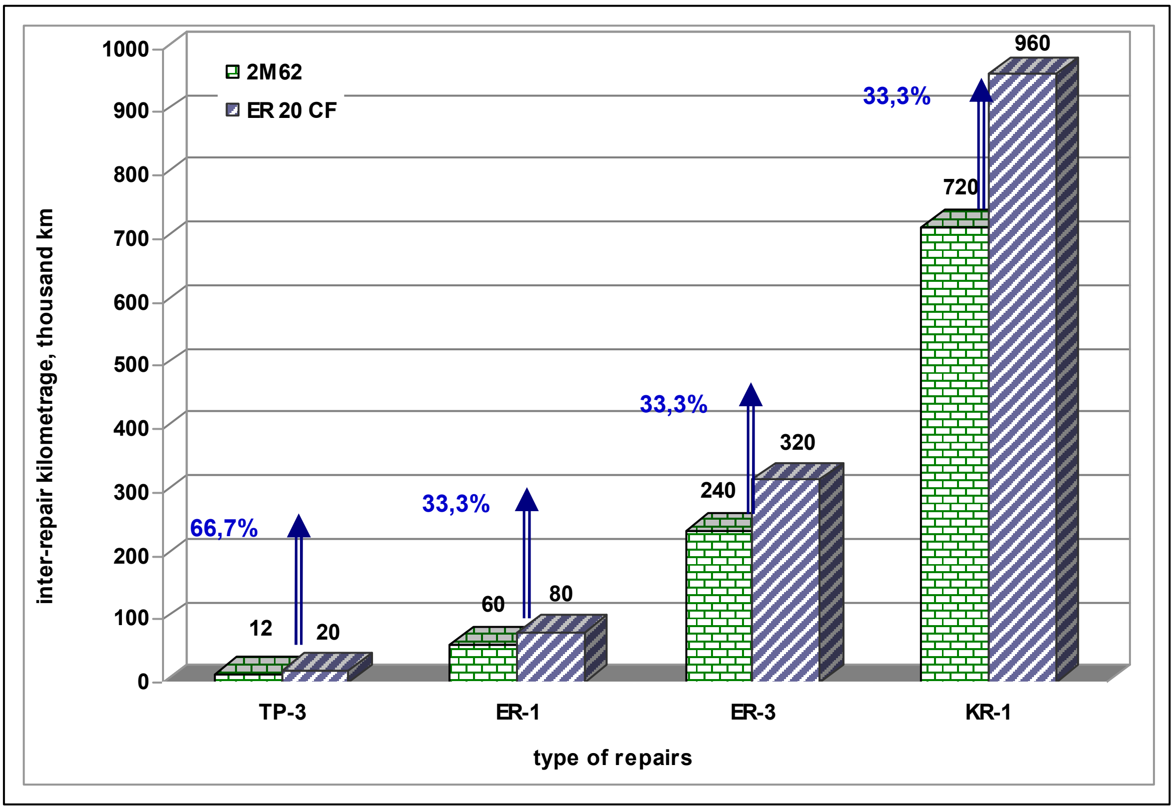

Fig. 3. Comparison of periodicity of inter-repair kilometrages of freight-mainline railway locomotives 2M62 and CR 20 CF

Table 3. Comparison of consumption of maintenance and repair works by different type diesel locomotives at the time of TM-3 maintenance

Specialisation of machinists	Consumption of labour by types, persons hour/locomotive		
	2M62	2M62M	ER 20 CF
Chassis	30,71	18,80	3,5
Electrical equipment	15,86	18,99	4,0
Diesel and auxiliary equipment	18,6	21,19	8,0
Automatic brake and pneumatic equipment	9,6	9,01	2,0
Accumulator battery	8,17	10,59	2,0
KMP and ALS (KLUB-U)	7,326	7,826	2,0
IN TOTAL	90,266	86,406	21,5

Table 4. Comparison of consumption of maintenance and repair works by different type diesel locomotives at the time of CR-1 maintenance

Specialisation of machinists	Consumption of labour by types, persons hour/locomotive		
	2M62	2M62M	ER 20 CF
Chassis	67,49	60,99	4,0
Electrical equipment	36,07	32,92	6,0
Diesel and auxiliary equipment	151,76	21,19	10,0
Automatic brake and pneumatic equipment	29,23	15,24	3,0
Accumulator battery	35,30	17,01	2,0
KMP and ALS (KLUB-U)	10,96	10,92	14,0
IN TOTAL	330,81	158,27	39,0

4. Conclusions

1. First of all, I would like to draw attention to the upgraded 2M62M locomotives, where the performance of TM-3 enables to save a small number of working hours, although the whole power-plant in this locomotive has been replaced into a more modern one. However, the consumption of labour for CR-1 repairs already manifestly demonstrates the benefit of the new technology, since the consumption of labour is twice as less.

2. Although traditionally the equipment components requiring the greatest maintenance have already been replaced in the upgraded locomotive, the remaining part nevertheless still requires a lot of attention. This is evident by comparing the consumption of labour of 2M62 and ER 20 CF locomotives for TM-3 and ER-1. The difference is obvious – the consumption of labour is 4 times smaller at the time of TM-3 and CR-1.

3. By comparing the self-cost of repairs we will notice that among the old locomotives and ER 20 CF this difference is two times. Not four times, as it was in case with the consumption of labour. This is the result of the need for more expensive spare parts and higher qualification employees.

4. Thus, in terms of the rolling stock economy it is evident that changes in the economy will be very big. Four times less repair positions, staff, warehousing premises will be necessary. By serving the very same number of rolling stock depots will have to maintain considerably smaller premises. A possibility for a more efficient labour opens up in the rolling stock economy.

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