UDC 629.4.018; 629.018

Improvement of methods and models of choice of types of acceptance trials of modernized locomotives

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Abstract
In article the aspects of development of the acceptance test concept of new and modernized traction rolling stock are considered. Analysis of acceptance tests types is made and new concept of tests for modernized locomotives is developed. According to the concept, optimizing model of choice of tests type, which allows to reduce costs for acceptance tests, is built.
Keywords: MODERNIZATION, LOCOMOTIVES, ACCEPTANCE TESTS, MODEL, CONCEPT

Introduction

The railway transport undoubtedly plays a significant role in economy of Ukraine. Some part of carrying cargo and passengers, which is provided with the railroads, proves it. Now hauling operations in Ukraine are provided by engines of electric and diesel traction. Considering the fact that on many indicators electric traction is efficient, it is economically expedient to use it on the railroads as electric and diesel locomotives. Lately such factors as: reduction of traffic volume, where it is un-profitable to carry out electrification of the railroads, increase of technological level of diesels, improvements of their economic and ecological indicators, and also development of hybrid locomotives promote using of diesel locomotives. Therefore works directed on theoretical and pilot studies of locomotives are actual.

Analysis of literary data and statement of a problem

Many scientific developments made on the basis of such scientific institutions as "VNIIZT", JSC "Luganskteplovoz", Public enterprise "State research center of railway transport of Ukraine", Dnipropetrovsk National University of Railway Transport named after Academician V. Lazaryan, Ukrainian State University of Railway Transport, East Ukrainian national university named after V. Dahl, National enterprise "UkrNIIVE" and others is devoted to questions of testing of traction rolling stock (TRS). The strongest contribution into this direction was made by: Basov G.G., Bogaevsky O. B., Bodnar B. E., Golubenko A.L., Golovinov G.G., Gorbunov N. I., Gorobets V. L., Grishchenko S.G., Gundar V.P., Dalyokaya V. H., Donchenko A.V., Dyomin R. Yu., Dyomin Yu.V., Masliyev V. G., Matyash V.A., Mokrousov S. D., Myamlin S.V., Noskov B. I., Samsonkin V. N., Tartakovsky E.D., Tkachenko V.P., Falendysh A.P., Chernyak A.Yu., Chernyak Yu.V., and others.

In the works they consider, generally results of certain types of tests and test of subsystems of TRS. But in works of the specified scientists insufficient attention is paid to the methods of a choice of types and volumes of tests and forecasting of characteristics of TPS with the use of test results.

In legal requirements of system arrangement on production [1-4], tests and quality control of production (GOST 15.001-88, GOST 16504-81, DSTU 3021-95; GSTU 32.0.08.001-97) the main requirements to introduction of TRS as the production for railway transport in operation and their testing sequence are specified. Terms and definitions of the categories connected with test and control are presented, types of tests on the main signs of properties are systematized. In [5] types of tests and indicators defined are picked up, as well as the list of characteristics controlled at acceptance tests of a traction rolling stock. On the basis of these references and carried-out analysis [6-11] types of tests of a traction rolling stock, in particular locomotives are systematized.

Purpose and research problems

Conducted researches pointed at the solution of scientific and practical task, i.e. the increase of efficiency of carrying out tests of TRS on the basis of use of models of choice of types and programs of acceptance tests.

Development of choice model of acceptance test types

Systematization includes the following classification characteristics and types of tests in accordance with DSTU 3021-95:

A) Purpose of tests (control, comparative, defining)

B) Development stages of production (acceptance)

C) Conditions and test point (bench, natural, tests with models usage, operational)

D) Characteristic of object (functional, safety tests).

It is expedient to include tests on the basis of conditions and test point, which additionaly specify these signs, namely stationary, ride and operational trials on working capacity. Under stationary tests we mean the tests of TRS in the conditions corresponding to conditions of its use according to direct appointment within station, roundhouse or factory railways with direct assessment or control of the defined characteristics of TRS properties. As ride tests it is understood tests of TRS in the conditions corresponding to the conditions of its use according to direct appointment with running on the main railsways (during operation as well) with direct assessment or control of the defined characteristics of TRS properties. Under operational tests for working capacity we understand operational trials during 5000 km of run or 300 business hours of TRS work, which are carried out after bench, stationary and ride tests.

Studies confirm corresponding properties of TRS characteristics. They can be grouped according to three complex main requirements. The first group of properties covers characteristics of safety. Thus the category of safety is understood in a complex. It includes the traffic safety and operation of vehicles; safety of control and maintenance from the engine crews and service personnel; ecological safety (safety of impact on environment). The second group of properties includes the characteristics defining functional operability of TRS (productivity, appointments, traction properties). The third group of properties includes economic characteristics and indicators of efficiency (fuel and oil consumption).

Types of tests depending on the physical nature of the working processes characterizing properties and characteristics of object of tests are also systematized. Grouping according to these signs is possible to apply at a choice of tests type for the modernized TRS. Results of systematization are given in fig. 1.

According to [7] acceptance tests of production for railway transport should be carried out in the volume, which allows defining influence of changes on properties of initial production.

At customer's request during modernization, acceptance tests can be carried out as comparative tests of samples of the initial and revised production. If changes which were made, are uniquely estimated by the expert or specified way and are confirmed by results of the previous tests, omission of acceptance tests is allowed.

Taking into account these requirements the new concept of a choice of types of acceptance tests of the modernized locomotives was developed:

1. Carrying out acceptance tests to confirm the compliance of the valid indicators of a locomotive to standard values according to the specification.

2. Taking into account conditions of modernization, basic data on use of engineering solutions and designs of a locomotive in general to carry out exceptions of tests, which repeatedly confirm the data available.

For example, tests of those units, which were not improved, can not be carried out, and the units improved don't influence their work. This situation is grounded with use of functional block diagrams of the regular and modernized locomotive [8-9].

3. Possibility of tests exception, as their carrying out isn't required by standard documentation. Thus this group of tests can be carried out according to their choice on optimizing model.

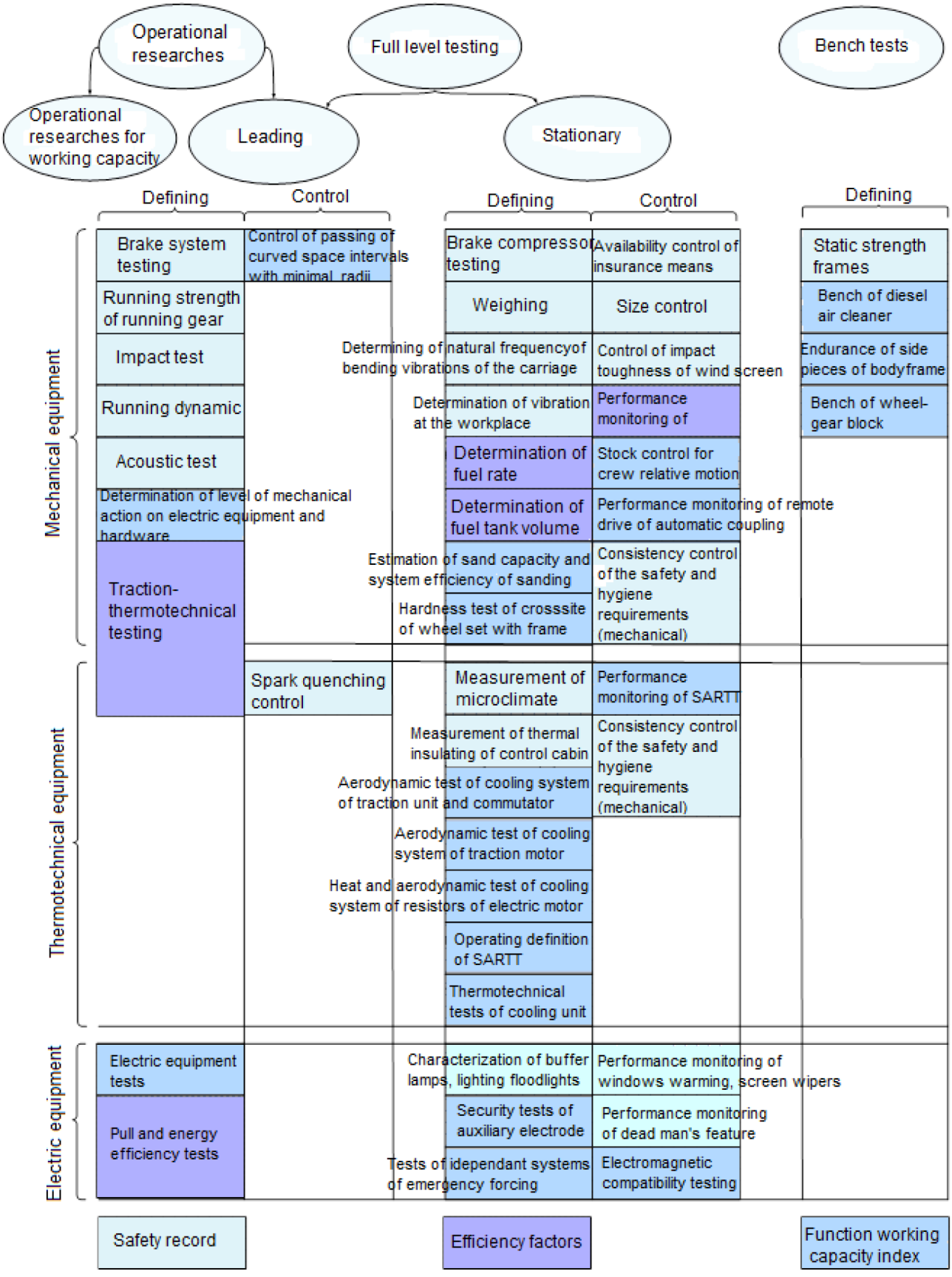

Figure 1. Systematization of tests types for traction rolling stock

4. Possibility of replacement of carrying out some types of optional tests for use of settlement and mathematical models. This opportunity can be realized on condition of check of model on adequacy and, respectively, smaller costs of modeling, than of carrying out tests with corresponding accuracy.

5. Ensuring necessary level of reliability of definition of indicators of the modernized locomotive as a result of carrying out acceptance tests at the minimum expenses that is reached by optimization of a choice of tests types on optimizing model.

There are various options of modernizations of TRS, which differ in depth and an orientation of the updated equipment and size of changes of the main technical and economic indicators. As the choice of tests type depends on these factors, there is a need in criterion of comparison of the initial and modernized locomotive. The coefficient of comparison of technical solution bases can act as such criterion [7]

$$K_B = 1 + (H_0 - H_m)\cdot k_E + (S_0 - S_m)\cdot k_S + (F_0 - F_m)\cdot k_F\,, \quad (1)$$

where $(E_0 - E_m)$ - comparison of information entropy of indicators of engineering solutions efficiency of the regular and modernized locomotives;

$(S_0 - S_m)$ – comparison of relative complexity of technical solutions of the regular and modernized locomotives;

$(F_0 - F_m)$ – comparison of complexes of physics and technology effects applied in the regular and modernized locomotives;

k_i – weight coefficients of influence.

Considering this criterion we will build model of choice of types of reception tests of the modernized locomotives. There is a final number of various tests U_i, $i = 1...N$ of locomotives. Some of these tests, depending on modernization type, are definitely carried out surely $U_0 \in U_i$. Each type of tests confirms the value of corresponding locomotive indicator or disproves it. A priori, reliability of P_i index is defined by amount of information

$$d\overline{P_i} = H = -k\sum_{i=1}^{n} \overline{p}_i \log_a \overline{p}_i, \quad (2)$$

where $\overline{p}_i$ – probability of result $\overline{P_i}$ $(0 \le p_i \le 1, \sum_{i=1}^{n} p_i = 1)$.

Test operation U_i reduces H for ΔH_{ui}.

$$\Delta H_{ui} = H - H_{ui}\,, \quad (3)$$

where

$$H_{ui} = -k\sum_{i=1}^{n} p_i \log_a p_i\,. \quad (4)$$

Then formalization of problem of choice of tests types is defined by criterion function and restriction on reliability of test results:

$$\begin{cases} \dfrac{\Delta H_{mi}}{\tilde{N}_i^m}\cdot U_i^m + \dfrac{\Delta H_{ei}}{C_i^e}\cdot U_i^e \to \min \\ \forall (P_i(\alpha_i)) \ge \dfrac{|P_i(\alpha_i)|}{K_{Bi}} \\ P_i(\alpha_i) = f(U_i) \\ P_i(\alpha_i) = P_i(|X_j - \overline{x}_j| \le \varepsilon_j) \end{cases}, \quad (5)$$

where $(\Delta H_{mi},\ \Delta H_{ei}) \in \Delta H_{ui}$ – change of informational entropy of an indicator as a result of modeling or experiment carrying out;

C_i^m, C_i^e – costs for modeling and experiment respectively;

U_i^m, U_i^e – types of models or experiments respectively;

$P_i(\alpha_i)$, ε_j – confidential probability and significance level of test results.

According to the developed concept and suggested models there were chosen the types of acceptance tests of the modernized locomotive of M62 series with diesel EMD645 and the massifs of the controlling parameters corresponding to them.

The following indicators when carrying out natural tests must be defined:

$$U_0 = \{S_T, \sigma_i, m_i, P_k, P_i^B\}, \quad (6)$$

where S_T – braking length during service and emergency braking;

σ_i – tension from static, quasistatic and dynamic loadings;

m_i – weight and weighings of a locomotive;

P_k – compressor productivity;

P_i^B – standard indicators of operation safety (including ecological).

Considering the purpose of modernization of a locomotive of M62 increase of profitability, the indicators, defined during reception tests, are chosen:

$$U_i = \begin{Bmatrix} F_k(V), N_k, g_e, g_o, B_x, t_i, & \eta_i \\ \omega_{(t)}^n, T_o, \omega_{(t)}^{нр}, T_o^{нр}, T_y, T_{сл.у}^{м}, K_{Т.И.} \end{Bmatrix}, \quad (7)$$

where $F_k(V)$ – traction performance;

N_k – tangent diesel-locomotive rating;

g_e, g_o -average operating costs of diesel fuel and oil respectively;

B_x – idling fuel consumption;

t_i – coolant temperature at various load modes;

η_i – performance factors of main and auxiliary equipment;

$\omega^{n}_{(t)}, T_o$ – failure rate and failure intervals in the case of an error respectively;

$\omega^{пр}_{(t)}, T^{пр}_o$ – parameter of failure flow and failure interval during scheduled repairs respectively;

T_y – specified no-failure operating time;

$T^{м}_{сл.у}$ – oil life;

$K_{т.и.}$ – operating efficiency.

Conclusions

Developed concept and models of a choice of reception tests types of the modernized locomotives allows to increase efficiency of clearance for operation of traction rolling stock due to a rational choice of controlled indicators and cost cutting for tests of TRS.

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