ON POSSIBLE WAYS OF MODERNIZATION OF DOMESTIC DIESEL LOCOMOTIVES

Nerevyatkin, Constantine A., *Moscow State University of Railway Engineering (MIIT), Moscow, Russia.*

ABSTRACT

The objective of the author is to investigate technical requirements and possible ways of modernization of current freight diesel locomotive fleet. The author uses analysis, comparative method and evaluation method. The author suggests approaches to modernization of diesel locomotives 2TE25K andTEP80 to be further used for freight traffic. The article describes main technical specifications for multipurpose locomotive that can be used both for passenger and commuter train haulage at not electrified railways. The author argues that diesel locomotive TEM21 is suitable for that purpose once it is modernized. Meanwhile, locomotive fleet needs to be replenished with new machines that could effectively replace outdated models.

The article offers three different modernization programs for locomotives of domestic production, designed for different purposes, – freight, passenger, shunting locomotives. Demonstrated options are based on optimization calculations, carried out with the participation of students of MIIT. Changes in locomotives' parameters and related operational benefits are estimated.

Keywords: *railway, locomotives for freight carriage, modernization, calculation options, operating experience, design prospects.*

Background. *According to the results of optimization of technical and economic calculations it can be assumed that the core of the freight locomotives fleet for railways in Russia (about 43%) will be locomotives with calculated tangent pulling force of 520 kN. Moreover, their capacity for a diesel engine must have two gradations, namely 3200 kW and 4000 kW. Obviously, locomotives with such technical parameters can be either a one-section sixteen-wheel locomotive, or a two-section locomotive. In the latter case, the thrust of one section is 260 kN and diesel power is 1600–2000 kW.*

In developing the project of a two-section locomotive with estimated tangential traction force 2×260 kN, nominal capacity of diesel 2×1600 kW and axial formula 2 (3_o–3_o) it seems appropriate to consider the modernization of 2TE25K locomotive [1], experimental operation of which identified a number of deficiencies, in particular:

- *life time reduction of 12CHN26 / 26 diesel due to increased nominal capacity of 2500 kW;*
- *low reliability of traction motors of EDU-133 type, operating in continuous mode with capacity of about 370 kW and increased current load.*

The essence of proposals to modernize 2TE25K locomotive:

1) reduction of calculated tangential traction of a section from 300 to 260 kN;

2) reduction of speed of continuous mode from 24 to 17 km / h and design speed from 120 to 100 km / h;

3) reduction of nominal efficient capacity of locomotive power plant from 2500 to 1600 kW, which allows, firstly, to reduce fuel consumption in operation and, secondly, to reduce a degree of forcing of 12CHN26 / 26 diesel and, consequently, to increase its life time;

4) reduction of nominal power of EDU-133 traction motor from 370 to 230 kW, which will reduce its linear current load and temperature factor in the continuous mode, improve potential conditions on the collector while driving with the design speed and as a result increase reliability;

5) changes in the design of the roof cooling device of a locomotive: reduction of the number of sections of air-water radiator, replacement of two-row location of sections with single-row, application of, instead of two ventilators with a diameter of 1600 mm, one ventilator with a larger diameter of 2000 mm; according to preliminary estimates, received by the student I. A. Lebedev, relative power takeoff for air pumping through the cooling device eventually decreases from 4,8 to 2,6% of the effective capacity of a diesel engine [2].

Objective. *The objective of the author is to investigate technical requirements and possible ways of modernization of current locomotive fleet.*

Methods. *The author uses analysis, comparative method and evaluation method.*

Results. *Thus, the proposed modernization program for 2TE25K locomotive allows bringing values of its main technical parameters (calculated traction, design speed, power) to the sound level, set by optimization of technical and economic calculations and enhances life time, efficiency and reliability of a locomotive in operation.*

In turn, assessing the possibility of creating a freight sixteen-wheel locomotive with a sectional capacity of diesel engine of 4000 kW, it is necessary to bear in mind the option based on the modernization of TEP80 locomotive [3]. According to results of preliminary calculations carried out with the participation of the student D. V. Pantyukhin, it must assume [4]:

1) replacement of 20CHN26 / 26 diesel of 4410 kW capacity with 16CHN26 / 26 diesel of 4000 kW capacity (with preservation of two-stage gas turbine charging);

2) increase in thrust coefficient of the locomotive, the value of which must be at least 0,28–0,29, through the use of asynchronous traction motors (analogue – 2TE25A locomotive [5]) or DC motors with separate excitation and compensation winding (analogue – SD70M-2 locomotive [6]);

3) use of traction gear reducer with increased transmission ratio and increased width of the ring gear;

4) increase in the diameter of driving wheels of the locomotive from 1220 mm to 1250 mm.

Given the experience of domestic and foreign locomotive building (in particular, creation of freight locomotive 2TE70 based on passenger locomotive TEP70BS [7]), there is a reason to believe modernization program of TEP80 locomotive to be realistic because single-section locomotive will be equivalent in strength to two-section rod-type machines of 2TE10 and 2TE116 types.

Special attention should be paid to modernization of TEM21 locomotive [8] for its use in passenger and commuter traffic as a multipurpose. Now within non-

electrified railway junctions passenger and suburban traffic is carried out by traction rolling stock of different types and series. They are main line locomotives (e. g. TEP70), shunting locomotives (CHME3 or TEM2), one-car rail buses PA1 (motor-rail cars), and two-three- cars PA2 (diesel trains). It is clear that such a variety of designs do not reduce the cost of repairs, maintenance and operation. Furthermore, the use of powerful main line diesel locomotives for passenger trains of a small composition or with relatively low speeds is often unjustified.

Therefore, the interest in the possibility to use a single, unified traction unit for service and passenger and commuter trains is logical.

According to results of calculations carried out in conjunction with the student D. S. Odin, for the conditions of Tambov railway junction [9], it was found that driving of passenger trains with specified scheduled speeds can be achieved by:

- *locomotive with capacity of a diesel engine of the order of 2300–2450 kW (trains «Moscow-Tambov» with compositions of 18 and 22 cars);*
- *locomotive with capacity of a diesel engine of the order of 1100–1200 kW (train «St. Petersburg-Tambov» with composition of 5 cars and train «Moscow-Balashov» with composition of 18 cars).*

Main parameters of the locomotive for driving of commuter trains, in turn, are determined on the basis of technical requirements regulated by the order of JSC «Russian Railways» of 30.01.2009 № 181r «On approval of types and main characteristics of multiple units». Traction calculation for a train of three loaded passenger cars established that its starting up to a speed of 60 km / h with an average acceleration of 0,4 m /s² is provided by a locomotive with diesel engine nominal capacity of 1200 kW and a service building weight of 84 tons. The specific traction power for one- and two-cars trains in this case is 7,5–9,8 kW /t net, which is consistent with current requirements to ensure traction of commuter train of such a composition (specific thrust power is at least 7,0 kW / t) [10].

Conclusions. *Thus, to ensure passenger and commuter traffic a multi-purpose locomotive with following technical parameters can be used:*

- *capacity of diesel engine of 1200 kW;*
- *service weight of 84 tons, axial formula $2_0–2_0$, axle load 21 tonnes;*
- *calculated tangential thrust of 125 kN (in terms of driving a 18-car train on the estimated ascent $10^0/_{00}$);*
- *calculated speed of 27 km / h;*
- *design speed of 120 km / h.*

Such a locomotive must serve passenger trains «Moscow-Tambov» with joint of two sections, and other passenger and commuter – one section.

A prototype of such a passenger locomotive could be TEM21 locomotive with a diesel engine D49 type (8CHN26 / 26), forced to 1200 kW. Given that the desired value of the passenger locomotive traction coefficient is low (about 0,15) asynchronous traction motors are to be replaced with DC motors EDU-133, that is, the use of relatively inexpensive and reliable electric AC- DC transmission.

REFERENCES

1. Main line freight locomotive 2TE25K «Peresvet» [*Magistral'nyj gruzovoj teplovoz 2TE25K «Peresvet»*]. http://www.tdrzd.ru/activity/delivery/production/locomotive/2te25k_peresvet. Last accessed 21.04.2015.

2. Nerevyatkin, K.A., Lebedev, I. A. Modernization of 2TE25K locomotive for improving its performance [*Modernizacija teplovoza 2TE25K dlja povyshenija jeffektivnosti ego raboty*]. Proceedings of the scientific-practical conference «Science Week 2013 Science of MIIT – for Transport». Under general editorship of Kruglov, V. M. Moscow, MIIT, 2013, p. III-90.

3. Experimental passenger locomotive TEP80 with capacity of 4410 kW [*Opytnyj passazhirskij teplovoz TEP80 moshhnost'ju 4410 kVt*]. http://www.zdrf.org/posts/4eae5ff1bac85e0001000029. Last accessed 21.04.2015.

4. Nerevyatkin, K.A., Pantyukhin, D. V. Modernization of TEP80 locomotive for possible use in cargo traffic [*Modernizacija teplovoza TEP80 dlja vozmozhnosti ispol'zovanija v gruzovom dvizhenii*]. Proceedings of the scientific-practical conference «Science Week 2013. Science of MIIT – for Transport». Under general editorship of Kruglov, V. M. Moscow, MIIT, 2013, p. III-91.

5. Main line freight locomotive 2TE25A «Vityaz» [*Magistral'nyj gruzovoj teplovoz 2TE25A «Vitjaz'»*] http://www.tdrzd.ru/activity/delivery/production/locomotive/2te25a_vityaz. Last accessed 21.04.2015.

6. Locomotive EMD SD70M-2 [*Teplovoz EMD SD70M-2*] http://promplace.ru/katalog-zhd-transporta/teplovoz-sd70m2–107.htm. Last accessed 21.04.2015.

7. Main line freight locomotive 2TE70 JSC «Kolomensky Plant» [*Magistral'nyj gruzovoj teplovoz 2TJe70 OAO «Kolomenskij zavod»*]. http://old.tmholding.ru/main/catalog/products/3334/3335/3858 Last accessed 21.04.2015.

8. Experimental shunting locomotive TEM21 [*Opytnyj manevrovyj teplovoz TEM21*]. http://old.tmholding.ru/main/catalog/products/650/651/1450. Last assessed 21.04.2015.

9. Nerevyatkin, K.A., Odin, D. S. Multi-purpose locomotive for the use in passenger and commuter traffic [*Mnogocelevoj teplovoz dlja ispol'zovanija v passazhirskom i prigorodnom dvizhenii*]. Proceedings of the scientific-practical conference «Science Week 2013. Science of MIIT – for Transport». Under general editorship of Kruglov, V. M. Moscow, MIIT, 2013, p. III-90–III-91.

10. Nazarov, O. N. Type and technical requirements for prospective rolling stock for passenger transportation [*Tipazh i tehnicheskie trebovanija k perspektivnomu podvizhnomu sostavu dlja perevozki passazhirov*]. *Zheleznodorozhnyj transport*, 2003, Iss. 2, pp. 14–20.

Information about the author:
Nerevyatkin, Constantine A. – Ph.D. (Eng.), associate professor at the department of Electric trains and locomotives of Moscow State University of Railway Engineering (MIIT), Moscow, Russia, +7 (495) 6842191.

Article received 10.10.2014, accepted 18.01.2015.

The article is based on the papers, presented by the authors at the International scientific and practical conference «Rolling Stock's Design, Dynamics and Strength», dedicated to the 75th anniversary of V. D. Husidov, held in MIIT University (March, 20–21, 2014).