Ways of the Freight Turnover Increasing of the Far Eastern Northern Latitudinal Railway

Yu G Larchenko¹, G A Shusharina², E I Muravskaya³

¹Faculty of Energy and Management, Komsomolsk-na-Amure state university, Lenina, 27, Komsomolsk-na-Amure 681013, Russia

E-mail: Galinalmk@yandex.ru

Abstract. The article analyzes the main tasks of ensuring the efficient use of rolling stock, approved by the Government of the Russian Federation in the strategic program for the development of railway transport until 2030. One of the key tasks in this field of activity is to increase freight turnover within the country and beyond due to the modernization of the fleet of freight main locomotives and the reconstruction of individual sections of the railway. In this regard, the results of a comparative analysis of two series of locomotives - 3TE25KM and 3TE10MK according to the main technical characteristics are proposed for consideration, main indicators of the operational work of diesel locomotives that affect the amount of cargo turnover are described. The implementation of the cargo turnover plan of the Far Eastern northern latitudinal railway is analyzed - these are Komsomolsk-na-Amure-Volochaevka II and Komsomolsk-na-Amure-Sovetskaya Gavan. In conclusion, results of testing a new locomotive are presented, based on their technical and economic characteristics, such as the amount of work performed, technical speed, average daily productivity of the locomotive and a number of other indicators.

1. Introduction

In 2008, the Government of the Russian Federation approved the “Strategy for the development of railway transport in the Russian Federation until 2030”. Within the framework of this strategic program for the development of railway transport, the main problems of the industry and possible solutions are identified. Main tasks of the development of the railway in terms of freight transportation are singled out. They are railway engineering modernization, transport costs reduction, transport infrastructure improvement, achieving mobility of railway transport, ensuring and improving the quality and safety of freight transportation, and the realization of the country's transit potential [1-4].

Currently, as part of the implementation of the strategic development program, the Russian Railways Open Joint-Stock Company (hereinafter, Russian Railways) has faced the need to solve 2 top-priority tasks: updating rolling stock and expanding individual sections of the railway network.

In this regard, a long-term development program for Russian Railways until 2025 was approved. In accordance with it, by 2024 it is planned to increase the volume of transportation of the Baikal-Amur and Trans-Siberian railways to 180 million tons and complete renewal of the locomotive fleet [5, 6]. In 2019, the company acquired 738 new locomotives for the entire railway network. 252 units of transport (out of 738) were sent to Baikal-Amur Railway sections [7, 8].
2. Topicality
Studying main provisions of the long-term development program of Russian Railways until 2025 related to the modernization of the freight locomotive fleet and comparing the actual performance of the new rolling stock with planned indicators, as well as with data on the efficiency of using the existing railway transport will justify the need for further acquisition and expansion of a new series locomotives in order to increase cargo turnover.

3. Materials and methods
The aim of this work is to study main technical and economic indicators of the new series of 3TE25KM locomotives, as well as their analysis during operation on main sections of the Far Eastern Railway.

In the research process, basic general logical methods of scientific knowledge were used: analysis, synthesis, abstraction, generalization, induction, and deduction.

The main sources of information for the theoretical and empirical study were orders of the Government of the Russian Federation, reports of the Ministry of Transport of the Russian Federation and the president of Russian Railways, results of the market study for the goods transportation by rail and the works of domestic and foreign authors in this field of research, for instance, N. E. Aksyonenko, M. G. Danilina, A. F. Ivanenko, B. M. Lapidus, D. A. Macheret, A. S. Misharin, N. P. Tereshina, V. A. Podsonin.

4. Theory
At present, the Russian Railways company primarily uses locomotives of the 3TE10MK series equipped with internal combustion engines (diesels) to provide freight traffic on non-electrified sections of railways. Today, diesel locomotives of this series provide continuous movement of freight trains along the route Taksimo - Tynda - Novy Urgal - Komsomolsk-na-Amure - Sovetskaya Gavan weighing up to 5600 tons with the required standard indicator of 7100 tons [8, 9]. To solve this problem, new generation 3TE25K2M diesel locomotives were launched into production. Their target parameters are as close as possible to the design requirements for the new generation rolling stock in the program for the strategic development of railway transport until 2030:
- axial loads 27 - 30 ton-forces;
- reduction of specific fuel and electricity consumption for train traction by 10% - 15%;
- increase in MTBF by 30% - 40%;
- distributed thrust control system over the air;
- a single block control system and on-board diagnostics;
- resource bandages not less than 1 million km;
- application of an asynchronous traction drive [10-13].

Let us consider the main technical characteristics of the used main diesel locomotive and the new main diesel locomotive (table 1) [14-17].

| Table 1. Characteristics of diesel locomotives of the 3TE10MK and 3TE25K2M series. |
|------------------------------------------|-----------------|-----------------|
| Technical data                          | 3TE10MK         | 3TE25K2M        |
| Number of sections                      | 3               | 3               |
| Diesel locomotive power, kW             | 2210            | 3100            |
| Service weight, t                       | 138             | 147             |
| Static load from a wheel pair on rails, tf | no more than 23 | no more than 27 |
| Velocipede velocity, km/h               | 23.0            | 27.6            |
| Efficiency                              | 0.284           | no less than 0.8|
| Track width, mm                         | 1520            | 1520            |
| Fuel supply, kg                         | 6300            | 7000            |
| Sand supply, kg                         | 1006            | 1500            |
| Locomotive length, mm                   | 16969           | No more than 20000 |
| Height, mm                              | 4948            | 5005            |
The new mainline diesel locomotive (3TE25K2M) has the highest grip weight, engine power and reserves of sand and fuel.

A system of indicators is used to characterize the use of locomotives [18, 19].
- average gross train weight is calculated as the ratio of the gross freight turnover to the average daily mileage of the rolling stock, i.e. distance traveled;
- technical speed of the train is the average distance traveled by the locomotive along the route per hour;
- local train speed is the average distance traveled by the locomotive along the route per hour, taking into account downtime at intermediate stations;
- average daily productivity of a locomotive is the turnover of rolling stock per day;
- fuel consumption for the meter of work performed is calculated by the formula (1).

\[ e = \frac{E}{Q}\text{k} \times 10^{-4}, \]  

where \( e \) - specific fuel consumption, \( kg/10^4*km \);

\( E \) - fuel consumption for traction, kg;
\( Q \) - gross volume of work performed, \( t*km \);
\( k \) - 1,45 - thermal equivalent of diesel.

The most important operational indicator of the railway is cargo turnover. Cargo turnover is the volume of work performed to move a certain mass of cargo at a given distance. There are net freight turnover and gross freight turnover. The net cargo turnover takes into account only the movement of the cargo of a given mass, and the gross cargo turnover takes into account the cargo mass together with the tare mass of the rolling stock [20].

The ratio of net and gross cargo turnover characterizes the efficiency of the locomotive, its actual value currently does not exceed 0.6 [20].

5. Results
In January 2020, the Far Eastern Railway locomotive fleet was expanded to include 12 3TE25K2M diesel locomotives. The main route for the movement of new mainline diesel locomotives is Komsomolsk-na-Amure - Volochaevka II and Komsomolsk-na-Amure - Sovetskaya Gavan. Until the end of 2020, it is planned to purchase 40 locomotives of a new type [21].

Table 2 shows the main results of the operation of the 3TE25K2M series locomotive for February 2020 along the previously indicated traffic route.
Table 2. Results of the 3TE25K2M diesel locomotive operation in February 2020.

| Number | Volume of work performed, million tons *km gross | The average weight of the train, t | Fuel consumption, kg / 104 t * km | Average local speed, km / h | The average daily productivity of a locomotive, t *km |
|--------|-----------------------------------------------|---------------------------------|---------------------------------|-----------------------------|-----------------------------------------------|
|        | plan  | actual | plan  | actual | plan  | actual | plan  | actual | plan  | actual |
| 1      | 1852.3| 22.1    | 3643  | 3878.1 | 62.0  | 40.7    | 30.2  | 32.6    | 1320  | 2086.1 |
| 2      | 1852.3| 30.2    | 3643  | 4718.0 | 102.6 | 49.3    | 30.2  | 31.3    | 1320  | 2476.6 |
| 3      | 1852.3| 28.7    | 3643  | 4132.2 | 109.0 | 55.0    | 30.2  | 31.4    | 1320  | 2150.3 |
| 4      | 1852.3| 38.9    | 3643  | 4566.1 | 130.7 | 48.7    | 30.2  | 32.0    | 1320  | 2538.4 |
| 5      | 1852.3| 24.7    | 3643  | 4033.4 | 111.4 | 65.4    | 30.2  | 31.3    | 1320  | 2101.4 |
| 6      | 1852.3| 31.2    | 3643  | 4016.3 | 119.0 | 55.4    | 30.2  | 31.1    | 1320  | 2068.6 |
| 7      | 1852.3| 32.4    | 3643  | 4621.7 | 121.5 | 54.4    | 30.2  | 30.3    | 1320  | 2330.5 |
| 8      | 1852.3| 34.2    | 3643  | 4497.7 | 178.7 | 75.9    | 30.2  | 29.9    | 1320  | 2317.2 |
| 9      | 1852.3| 29.5    | 3643  | 4564.6 | 158.8 | 77.9    | 30.2  | 30.9    | 1320  | 2375.8 |
| 10     | 1852.3| 26.1    | 3643  | 4275.5 | 108.6 | 60.4    | 30.2  | 30.9    | 1320  | 2231.0 |
| 11     | 1852.3| 37.7    | 3643  | 4331.1 | 179.4 | 69.1    | 30.2  | 30.8    | 1320  | 2473.7 |
| 12     | 1852.3| 30.8    | 3643  | 4591.9 | 129.8 | 61.1    | 30.2  | 31.7    | 1320  | 2401.7 |
| Total  | 1852.3| 366.4   | 3643  | 4352.2 | 1511.6| 59.4    | 30.2  | 31.2    | 1320  | 2295.9 |

Implement action of a plan, %  
- 19.8 - 119.5 - - - 103.2 - 173.9

From Table 2 it is seen that the quality performance of the new main locomotive associated with the use of rolling stock power (weight), time (speed) exceed the planned values. In addition, a general indicator of the use of rolling stock is the average daily productivity of the locomotive. It also exceeds the planned (normative) values.

Let us compare the results of the work of 2 series of locomotives - 3TE10MK and 3TE25K2M according to the main quality operational indicators (Table 3).

Table 3 demonstrates and confirms conclusions obtained during the testing and further operation of the new 3TE25K2M series locomotives. According to the main quantitative and qualitative operational indicators, an increase in the values of indicators was obtained:
- average daily productivity of the locomotive - 39.6%;
- average train weight - 23.4%;
- average technical speed - 2.9%;
- average district speed - 6.9%;
- average daily mileage - 13.2%.

Despite the positive experience in operating a new series of locomotives in certain sections of the Far Eastern Railway, tasks related to individual indicators of the use of traction rolling stock over time remain unresolved - this is the average downtime at the stations. So, the average downtime of commissioned locomotives in February amounted to 283.7 hours.
Table 3. Comparison of the operational indicators of diesel locomotives of the 3TE25K2M series and 3TE10MK for February 2020.

| Number | The volume of work performed on an accrual basis, thousand tons * km | Average daily productivity, thousand tons * km | The average weight of the train, t | Average technical speed, km / h | Average local speed, km / h | Average daily mileage, km |
|--------|---------------------------------------------------------------|--------------------------------------------|----------------------------------|--------------------------------|---------------------------|------------------------|
| 1      | 22085.6                                                       | 2086.1                                     | 3878.1                           | 44.9                           | 31.5                      | 537.9                  |
| 2      | 52282.9                                                       | 2476.6                                     | 4718.0                           | 43.4                           | 31.3                      | 524.9                  |
| 3      | 81021.8                                                       | 2150.3                                     | 4132.2                           | 44.7                           | 31.5                      | 520.4                  |
| 4      | 119926.1                                                     | 2538.4                                     | 4566.1                           | 45.2                           | 32.1                      | 555.9                  |
| 5      | 144633.4                                                     | 2101.4                                     | 4033.4                           | 44.7                           | 31.3                      | 521.0                  |
| 6      | 175788.9                                                     | 2068.6                                     | 4016.3                           | 45.1                           | 31.0                      | 515.0                  |
| 7      | 208159.3                                                     | 2330.5                                     | 4621.7                           | 44.5                           | 31.6                      | 504.3                  |
| 8      | 242309.9                                                     | 2317.2                                     | 4497.7                           | 44.3                           | 31.1                      | 515.2                  |
| 9      | 271849.4                                                     | 2375.8                                     | 4564.6                           | 45.2                           | 30.7                      | 520.5                  |
| 10     | 297907.4                                                     | 2231.0                                     | 4275.5                           | 45.1                           | 31.6                      | 521.8                  |
| 11     | 335584.2                                                     | 2473.7                                     | 4331.1                           | 46.1                           | 31.6                      | 571.2                  |
| 12     | 366361.9                                                     | 2401.7                                     | 4591.9                           | 44.6                           | 31.4                      | 523.0                  |
| Average| 2295.9                                                       | 4352.2                                     | 44.8                             | 31.4                           | 527.6                    | 466.0                  |

3TE25K2M

| Number | The volume of work performed on an accrual basis, thousand tons * km | Average daily productivity, thousand tons * km | The average weight of the train, t | Average technical speed, km / h | Average local speed, km / h | Average daily mileage, km |
|--------|---------------------------------------------------------------|--------------------------------------------|----------------------------------|--------------------------------|---------------------------|------------------------|
| 1298   | 36522.8                                                       | 1657.4                                     | 3709.9                           | 44.7                           | 29.2                      | 446.8                  |
| 1423   | 41793.7                                                       | 1802.7                                     | 3567.8                           | 43.3                           | 29.1                      | 505.3                  |
| 1320   | 32135.1                                                       | 1472.3                                     | 3302.3                           | 42.6                           | 29.8                      | 445.8                  |
| Average| 1644.1                                                       | 3526.7                                     | 43.5                             | 29.4                           | 466.0                    | 466.0                  |

3TE10MK

| Number | The volume of work performed on an accrual basis, thousand tons * km | Average daily productivity, thousand tons * km | The average weight of the train, t | Average technical speed, km / h | Average local speed, km / h | Average daily mileage, km |
|--------|---------------------------------------------------------------|--------------------------------------------|----------------------------------|--------------------------------|---------------------------|------------------------|
| 1      | 139.6                                                       | 123.4                                     | 102.9                            | 106.9                          | 113.2                    |

6. Conclusion
One of the most important problems in ensuring the efficient use of traction is the increase in the volume of transported goods. One way to solve this problem is to use more powerful locomotives that can operate in different climatic conditions. The positive experience of introducing new locomotives indicates the need for further expansion of the locomotive fleet in the sections of the Far Eastern Railway. However, during the operation of the new traction rolling stock, there are also problems associated with downtime at turnover points for non-technical reasons. In this regard, the task of infrastructure modernization is of particular importance. Its need is spelled out and approved in the Strategic program for the development of railway transport in the Russian Federation until 2030.

7. References
[1] Rail Transport Development Strategy in the Russian Federation until 2030 Received from http://www.consultant.ru/document/cons_doc_LAW_92060/4fa0a1723fc315e72f8bd97e119a1101f59ac132/
[2] Lapidus B M, Lapidus L V 2017 Smooth seamless transport system - an innovative model of the future: nature, essence, determinants of quality Bulletin of Moscow University. Series 6: Economics 2 pp 45-64
[3] Gorbunov A A 2018 Transport policy of the state: institutions, resources, technology PSASC: Politics. Social Studies. Art. Sociology. Culture: Scientific and Sociocultural Journal 66 pp 17-21
[4] Teryoshina N P, Podsorin V A, Danilina M G 2019 Globalization and labor productivity in the transport sector World of Transport volume 17 2 pp 118-129

[5] Long-term development program of Russian Railways Open Joint Stock Company until 2025 Received from http://www.consultant.ru/document/cons_doc_LAW_320741/94e5946265357ab18409fb076fc b01d97b35d28/

[6] Karapetyants I V 2018 Global Trends in the Development of Freight Rail Transport World of Transport volume 16 4 pp 130-139

[7] By 2025, Russian Railways will completely renew the locomotive fleet on the Trans-Siberian Railway and the BAM. Gudok newspaper 26856 7 Received from https://www.gudok.ru/news/?ID=1490621

[8] In 2020, 40 locomotives of a new type will arrive on the Far Eastern Railway Gudok newspaper 26856 7 Received from https://www.gudok.ru/news/?ID=1490662

[9] Smol’yaninov A V, Cherepov O V 2013 General course of railway transport (Ekaterinburg: USURT) p 139

[10] Report on the implementation of the Transport Strategy of the Russian Federation for the period until 2030. Reporting period: 2017 Received from https://www.mintrans.ru/documents/7/9489

[11] Report on the implementation of the Transport Strategy for the period until 2030, approved by order of the Government of the Russian Federation of November 22, 2008 No. 1734-r. Reporting period: 2018 Received from https://www.mintrans.ru/documents/7/10041

[12] The dynamics of the railway transportation market in 2018-2019 Received from https://digitalrzd.ru/l/obzor_rynka_perevozok_sentyabr_2019.pdf

[13] Mishustin V A, Frolova A V, Nefedieva E V 2019 BAM strategic development Int. Scientific and practical Conf. The role and importance of science and technology for the development of modern society (Samara) (Sterlitamak: AMI) pp 92-95

[14] Osyaev A T, Nikiforov V A 2013 Reliability Issues forced locomotive 2TE25K Bulletin of VNIIZhT 6 pp 66-72

[15] Nerevyatkin K A 2015 On possible directions of modernization of domestic diesel locomotives World of Transport vol. 13 2 pp 58-62

[16] Levin A I, Buslayeva I I, Zudov G YU 2016 Operational reliability of modernized diesel locomotives in cold climates Bulletin of Irkutsk State Technical University vol. 20 9 pp 168-174

[17] 3ТЭ25К2М – new diesel locomotive with great potential Transmashholding 3 Received from https://tmholding.ru/journal_files/Transmashholding_3(2017).pdf

[18] Charter of railway transport of the Russian Federation Received from http://www.consultant.ru/document/cons_doc_LAW_40444/6426c5413ebac6d78a5cd5849d561 02464e0c075/

[19] Macheret D A, Chernigina I A, Kudryavtseva A V, Lednei A Yu 2017 General technical and economic course of railways ed D. A. Macheret (Moscow: RUT (MIIT)) p 364

[20] Teryoshina N P, Podsorin V A, Danilina M G 2018 Railway Economics (Moscow: RUT (MIIT)) p 265

[21] Kunilovskii G 2019 Far East is waiting for new diesel locomotives Newspaper Far Eastern Railway 223 Received from https://www.gudok.ru/zdr/171/?ID=1486719&archive=52265