TO THE ENERGY OF NON-ELECTRIFIED SECTIONS OF RAILWAYS

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ABSTRACT

An algorithm is proposed for the grapho-analytical method for calculating diesel fuel consumption for train traction. Curves of train speed and travel time for diesel locomotives on a virtual railway section are represented. A method for calculating diesel fuel consumption by diesel locomotives in the traction and idling modes of the train is represented. The research results can be implementation in the analysis and evaluation of the traction and energy efficiency of the transportation work of diesel locomotives under operating conditions.

АННОТАЦИЯ

Предложен алгоритм графоаналитического метода расчёта расхода дизельного топлива на тягу поездов. Представлены кривые скорости движения и времени хода поезда для локомотивов дизельной тяги на виртуальном участке железной дороги. Предложена методика расчёта расхода дизельного топлива тепловозами на режимах тяги и холостого хода поезда. Результаты исследований могут быть реализованы при анализе и оценке тягово-энергетической эффективности перевозочной работы локомотивов дизельной тяги в условиях эксплуатации.

Keywords: study, freight train, diesel locomotive, railroad, parameter, way, station, time, speed, section, virtual.

Ключевые слова: исследование, грузовой поезд, тепловоз, железная дорога, параметр, путь, станция, время, скорость, участок, виртуальный.

Introduction. Efficient and rational use of fuel and energy resources, taking into account the widespread reduction in diesel fuel consumption for train traction for mainline diesel locomotives in operating conditions, now continues to be a very urgent problem.

This problem can be solved by further improving the energy resources management system and ensuring the throughput and carrying capacity of railways at the lowest material costs.

For many years, the Department of «Locomotives and Locomotive Economy» of TSTU has been conducting theoretical studies to improve the energy efficiency of using diesel locomotives, which are based on the "classical" traction calculation for different types of traction railway rolling stock.

Statement of the research problem. Recently, despite the intensive and widespread electrification of the Uzbek railways, about thirty percent of these roads fall on non-electrified sections, where railway transportation of goods and passengers of different structure, view, type and content is carried out by diesel traction locomotives.

Moreover, about fifty percent of the entire operating locomotive fleet of JSC "O'zbekiston temir yo'llari" are mainline (train) diesel locomotives of the TE10M and UzTE16M series in various sectional designs.

The purpose of this study is to substantiate the algorithm and methodology for calculating the consumption of diesel fuel by mainline diesel locomotives (locomotives diesel traction) for train traction in relation to a virtual section of the railway.

The formulated goal of the research is realized through the methods [1,2] of the theory of locomotive traction, the object and subject of research.

The object of study is three-section mainline (train) freight diesel locomotives of the 3TE10M and UzTE16M3 series, the main design features and traction performance characteristics of which are given in [3,4] and a virtual section of the railway.

The subject of the study is the kinematic parameters of the movement of a freight train of a unified mass of
the composition and the parameters of the energy efficiency indicators of the studied diesel locomotives 3TE10M and UzTE16M3 on a given section of the railway.

The given (accepted) virtual section of the railway with a length of \( L = 8.6 \) kilometers, consisting of four elements of the track profile, is shown in Fig. 1, three of which are ascents with a steepness of +1.5 \( \% \) and +2.0 \( \% \), and one element is a descent with a slope equal to \( i_{dp} = -2.73 \% \).

Freight trains of a unified mass of composition \( Q = 3000 \) tons and the number of axles \( m = 200 \) axles consist of fifty-four axle cars on rolling bearings (roller). There are no permanent or temporary warnings or speed limits. Brake pads are cast iron – \( \nu_{est} = 0.33 \) kN/kN, and the length of the receiving and dispatch tracks is \( l_{rd} = 1050 \) m.

**Research results and their analysis.** The implementation of the purpose of this research is based on the following main provisions of the proposed generalized algorithm for performing traction calculation:

- Choosing the parameters of the state of the material and technical base and the conditions for organizing the railway transportation of goods by locomotives on a given (accepted) section of the account;
- Developing models for driving a freight train of various masses, organized by locomotives without stops and with stops at intermediate stations, sidings and separate points;
- Solve the differential equations of motion of a freight train, using a graphical method to determine the speed and travel time of the train on a given (accepted) section of the railway;
- Perform traction calculations on a given section of the railway (Fig. 1) and the results obtained are processed by known methods of mathematical statistics with their subsequent analysis;
- Determine the values of diesel fuel consumption by locomotives for train traction in quantitative and monetary terms.

![Figure 1. Fragment of the tracioned calculation option for locomotives of diesel traction on a virtual section of the railway](image)

The movement of the train is described by a differential equation [2]:

\[
\frac{dv}{dt} = \zeta u
\]

(1)

where \( v \) - is the speed of movement, m/s;
\( t \) - train travel time, s;
\( u \) - specific resultant force of the train, N/kN;
\( \zeta \) - is the actual acceleration of the train, kNm/Ns².

The methodology for substantiating the kinematic parameters of the movement of freight trains and the parameters of the main energy indicators of the transportation work of the investigated diesel locomotives 3TE10M and UzTE16M3 initially provides for the compilation of a table and the construction of a diagram of the specific of resultant forces of the train.

Further, based on the recommendations of [1,2] and similarly to [5], a curve is constructed for the speed and time of the train on a given virtual section of the railway.
On fig. 1 shows the constructed curves for the speed \( V = f(S) \) and travel time \( t = f(S) \) of a freight train with a unified mass of the train \( Q = 3000 \) tons and the number of axles \( m = 200 \) axles for the studied diesel locomotives 3TE10M and UzTE16M3 on a virtual section of the railway, where marked: Art. \( P \) - freight train departure station; \( t \) and \( t_{xx,t} \) are, respectively, the travel time of a freight train in the modes of traction and idling, braking (in Fig. 1, this mode of driving a freight train is not used); \( f \) and \( k \) incl. - respectively, the driver controller is turned off and on, that is, the idle mode of the freight train.

The basis for constructing (calculating) the trajectory of a freight train is the principle of maximizing the use of power and traction and operational qualities (properties) of a locomotive [6], taking into account the kinetic energy of the train on each element of the track profile track, which for diesel locomotives 3TE10M and UzTE16M3 is the 15th nominal position the driver’s controller at full field (FF), as well as the first (FW1) and second (FW2) stages of field weakening of traction motors.

The consumption \( E \) of diesel fuel by a diesel locomotive spent on moving the train along the section is calculated by the formula:

\[
E = G_f \cdot t_t + g_{id} \cdot t_{id,b}, \text{kg}
\]  

(2)

where \( G_f \) is the consumption of diesel fuel by diesel locomotives at the nominal position of the driver controller, \( \text{kg/min} \); \( t_t \) is the total operating time of the diesel locomotive in the traction mode, \( \text{min} \); \( g_{id} \) is the consumption of diesel fuel by a diesel locomotive in idling and braking modes, \( \text{kg/min} \); \( t_{id,b} \) is the total time of locomotive movement in the idling and braking mode, \( \text{min} \).

The consumption of diesel fuel by a diesel locomotive in the traction mode at the 15th position of the controller of the driver and idling of the train is, respectively, \( G_f = 25.4 \) kg/min and \( g_{id} = 1.14 \) kg/min (3TE10M diesel locomotives), \( G_f = 22.65 \) kg/min and \( g_{id} = 0.69 \) kg/min (diesel locomotives UzTE16M3).

The specific consumption of diesel fuel is determined by the formula:

\[
e = \frac{E \cdot 10^4}{g \cdot L}, \text{kg/10}^4 \text{ t km gross}
\]  

(3)

The unit cost of rail transportation of various cargoes for diesel traction locomotives was determined by the formula:

\[
c_f = \frac{E \cdot \Pi_f}{10^3 \cdot L}, \text{ (thousand soum)/km}
\]  

(4)

where \( E \) is the consumption of diesel fuel per trip, \( \text{kg} \); \( L \) is the length of the virtual section of the railway, \( \text{km} \) (\( L = 8.6 \) km); \( \Pi_f \) – sale price of one ton of diesel fuel, thousand soum/t (\( \Pi_f = 1770.45 \) thousand soum/t).

In table 1 shows the results of traction calculation - the parameters of kinematic and energy indicators of the efficiency of using three - section mainline (train) freight diesel locomotives 3TE10M and UzTE16M3 on a virtual section of the railway in quantitative and monetary terms.

Analysis of the research results showed that UzTE16M3 diesel locomotives, in comparison with 3TE10M diesel locomotives, provide a reduction in the consumption of full-scale diesel fuel for train traction and the cost of rail transportation of various views, types, content and structure of cargo, on average, by approximately 11.04 - 11.05 percent.

### Table 1.

<table>
<thead>
<tr>
<th>Indicators of the transportation work of the studied diesel locomotives on a virtual section of the railway, non - stop traffic</th>
</tr>
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<tbody>
<tr>
<td><strong>Kinematic</strong></td>
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<tr>
<td>Train motion speed ( V, \text{km/h} )</td>
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<tr>
<td></td>
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<tr>
<td>1</td>
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<tr>
<td>Diesel locomotives 3TE10M</td>
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<tr>
<td>72.68</td>
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<tr>
<td>Diesel locomotives UzTE16M3</td>
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<tr>
<td>72.68</td>
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</tbody>
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Conclusion. The research methodology proposed by the author and the kinematic parameters of the movement of a freight train, the kinematic and energy indicators of the transportation operation of three-section mainline (train) freight diesel locomotives of the 3TE10M and UzTE16M3 series, of course, can be implemented in the analysis and evaluation of the traction and energy efficiency of the transportation operation of diesel locomotives on virtual and identical real sections of the Uzbek railways.

The results of the research are also recommended for use in the practice of the locomotive complex of JSC "O'zbekiston temir yo'llari" in substantiating the effectiveness of different types of locomotive traction in real operating conditions.

Reference: