Impact Factor: 9.9 ISSN-L: 2544-980X

Research of Operation of Diesel Locomotives 3te10m at the «Marokand – Kattakurgan» Section of «O'zbekiston Temir Yollari» Jsc

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Annotation: The results are presented of solving a local problem of transport energy on the hilly-mountainous section of Marokand - Kattakurgan of the Uzbek Railway when moving freight trains of different weights with stops at intermediate stations, organized by three-section mainline freight diesel locomotives of the 3TE10M series. Kinematic parameters of the movement of freight trains and energy indicators of the transportation work of the diesel locomotives under study were obtained in the form of tabular data and graphical dependencies. Analytical expressions (regression equations) are proposed to determine the values of the parameters of the main indicators of the transportation process on a given hilly and mountainous section of Marokand - Kattakurgan, which are described by a polynomial dependence of the second degree.

Key words: investigation, cargo train, diesel locomotive, railway track, exploitation, the haul, analyses, the station, hilly - mountainous.

The primary and urgent task of Uzbekistan Railways JSC is the widespread implementation of increasing the efficiency of using mainline (train) traction rolling stock of electric and diesel traction in a variety of conditions for organizing their operational work on existing and newly built electrified and non-electrified sections of the Uzbek railways.

In this regard, undoubtedly, a significant direction of theoretical and experimental research conducted by employees of the department of “Locomotives and Locomotive Facilities” of Tashkent State Transport University together with specialists from linear enterprises of the locomotive complex and other structural divisions of the railway industry of Uzbekistan is the development of promising resource-saving technologies for the prudent use of fuel and energy resources for train traction under operating conditions.

These studies solve a local problem of transport energy related to the substantiation of the parameters of the main indicators of the transportation work of mainline (train) freight diesel locomotives of the TE10M series in the process of their implementation of rail cargo transportation on one of the real sections of the railway of «Uzbekistan Temir Yollari» JSC.

The object of the study is three-section mainline freight diesel locomotives of the 3TE10M series and the straightened track profile of the hilly-mountainous section of Marokand - Kattakurgan of Uzbekistan Temir Yollari JSC.

The subject of the study is the main indicators and parameters of fuel and energy efficiency of the transportation work of diesel locomotives on a given hilly - mountainous section of the railway track.

To achieve the stated goal of the research, the initial data [1] and the mathematical models developed by the authors for driving freight trains with mainline (train) freight diesel locomotives 3TE10M were

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used for the studied conditions of organizing the transportation process on a given, of hilly-mountainous section of Marokand - Kattakurgan JSC "Uzbekistan Railways" [2], as well as methodologys of the theory of locomotive traction [3], according to which a series of traction calculations were performed, based on the well-known principle of the full (maximum) use of power and traction qualities (properties) of the locomotive [4], taking into account the maximum value of the kinetic energy of the train as it passes each specific path profile element. The movement of freight trains with different masses of trains in the range from Q_1 = 2500 t to Q_3 = 3500 t and a fixed differentiation of their change within ΔQ = 500 t, but the same number of axles in the trains equal to m = 200 axles, was carried out by the mentioned 3TE10M diesel locomotives with stops at intermediate stations, sidings and separate points.

A characteristic feature of the three-section mainline (train) freight diesel locomotives 3TE10M are the following distinctive design features [2].

The modernized three-section mainline freight diesel locomotive 3TE10M is equipped with a microprocessor power control system for diesel generator USTA-75-02 (unified diesel locomotive automation system), the CLUB-U system (integrated locomotive safety device) and a unified control panel (UCP). In addition, in order to ensure control and monitoring of parameters in three sections in the electrical circuit of the base diesel locomotive 2TE10M, changes were made to the connections of interfaces and control panels of each section, as well as start preparation systems, diesel start and fire alarm systems.

In table 1 and in Fig. 1 shows the results of traction calculations for three different options for driving a freight train with 3TE10M diesel locomotives on the Marokand - Kattakurgan section when moving with stops at intermediate stations, sidings and separate points, taking into account the differentiation of the mass of the train in the range from Q_1 = 2500 t to Q_3 = 3500 t by the amount ΔQ = 500 t and a constant number of axles consisting of m = 200 axles.

Table 1 The main indicators of the transportation work of diesel locomotives 3TE10M on the hauls of the Marokand - Kattakurgan section, movement with stops

Option of calculation traction	**Conditions transportation work**			**Train running movement time, min**			**Diesel fuel consumption**			**Money costs**	
	train composition mass Q, t	number of axles m, axles	technical speed movement, V_{tech}, km/h	general t_x	in traction mode t_{tr}	in idling and braking modes $t_{id,br}$	общий	удельный		full C_f, thousand soums	specific c_f, thousand soums /km
							per trip E, kg	natural fuel e, kg/10^4 tkm gross	standard fuel e_{st}, kg/10^4 tkm gross		
1	2	3	4	5	6	7	8	9	10	11	12
Stretch Marokand – Juma, *L* = 8,75 km											
1	2500	200	56,84	9,60	4,30	5,30	114,40	50,31	71,95	202,54	22,269
2	3000	200	56,84	9,60	4,40	5,20	116,81	42,81	61,22	206,81	22,738
3	3500	200	54,57	10,00	5,30	4,70	138,92	43,64	62,40	245,95	27,042
Stretch Juma – Nurbulak, *L* = 29,00 km											
1	2500	200	68,99	24,80	7,50	17,30	208,72	29,28	41,87	369,53	12,959
2	3000	200	66,83	25,6	8,15	17,45	225,	26,33	37,66	398,83	13,987

				0			27				
3	3500	200	65,93	25,95	8,35	17,60	230,48	23,09	33,02	408,05	14,311
Stretch Nurbulak – Kattakurgan, *L* = 24,00 km											
1	2500	200	61,67	23,50	6,05	17,45	172,35	28,54	40,81	305,14	12,632
2	3000	200	59,64	24,3	6,40	17,90	181,69	25,07	35,85	321,67	13,316
3	3500	200	59,89	24,20	6,7	17,50	188,79	22,33	31,93	334,24	13,837

Analysis of the results of traction calculations regarding a scheduled freight train with a unified mass of the train Q_2 = 3000 tons and the number of axles in the train m = 200 axles allowed us to draw the following conclusions.

1. The average total travel time of the train is 0.986 hours, and with an increase or decrease in the mass of the train by ΔQ = 500 tons, this time also increases or decreases, respectively, by 1.09 and 2.69 percent.
2. The technical speed of the train, on the contrary, with a similar change in the mass of the train, tends to increase and decrease within the same limits, and on average it is approximately 62.98 km/h.
3. The total and specific average consumption of diesel fuel for traction of trains are, respectively, 525.28 kg and 28.69 kg/10^4 tkm gross.
4. Reducing the mass of the train by ΔQ = 500 tons ensures a decrease in the total consumption of diesel fuel by 5.71 percent and an increase in the specific consumption of diesel fuel by 13.12 percent, and an increase in the mass of the train by ΔQ = 500 tons contributes to an increase in the total and a decrease in the specific consumption of diesel fuel, respectively, by 6.57 and 8.67 percent.
5. Reducing the mass of the train by ΔQ = 500 t leads to a decrease and increase by 1.02 percent, respectively, in the indicators of the use of modes traction and idling, braking [4], and with an increase in the mass of the train by ΔQ = 500 t there is an increase and decrease of these indicators, respectively, by 1.98 percent.
6. An increase in the mass of the train by ΔQ = 500 tons leads to an increase in the total and unit costs of transportation by approximately 6.57 percent, and with a decrease in the mass of the train by ΔQ = 500 tons, these indicators decrease by approximately 5.71 percent.

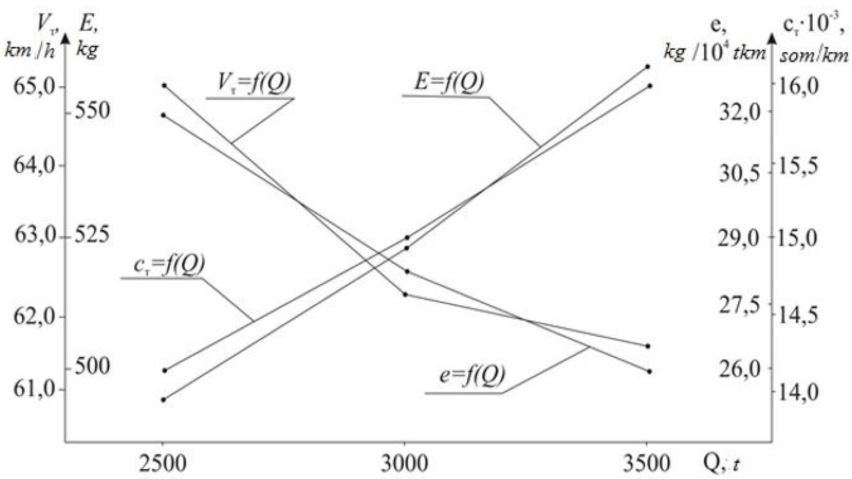

Figure 1. Dynamics of transportation work indicators of 3TE10M diesel locomotives on the Marokand – Kattakurgan section, movement with stops

According to the table 1 and fig. 1, based on the standard Microsoft Excel Office program, we calculated analytical expressions (regression equations) intended to determine the values of the parameters of the main indicators of the transportation process on a given hilly and mountainous section of Marokand - Kattakurgan, organized by mainline freight diesel locomotives 3TE10M with stops at intermediate stations, sidings and separate points of any i – th mass Q_i of a freight train with a sufficient value of approximation reliability $R^2 = 1.0$ (a necessary condition for reliability is $R^2 \geq 0.8$), where index Q_i = 1,2,3 – option of calculation traction.

Here, the dynamics of the mentioned parameters depending on the mass of the freight train is described by a polynomial dependence of the second degree with one hundred percent accuracy of their calculation.

Total train running time $t_{tr\ run}$, min:

$$t_{tr\ run} = -0{,}475Q_i^2+3{,}025Q_i+55{,}35 \quad (1)$$

Train running time in traction mode t_{tr}, min:

$$t_{T}= 0{,}15Q_i^2+0{,}65Q_i+17{,}05 \quad (2)$$

Train running time in idling and braking modes $t_{id,br}$, min:

$$t_{id,br} =-0{,}625Q_i^2 + 2{,}375Q_i+38{,}30 \quad (3)$$

Technical speed movement V_{tech}, km/h:

$$V_{tech} = 1{,}045Q_i^2 – 5{,}895Q_i + 69{,}89 \quad (4)$$

Total diesel fuel consumption per trip E, kg:

$$E = 2{,}26Q_i^2+23{,}12Q_i+468{,}49 \quad (5)$$

Specific consumption of natural diesel fuel e, kg/10^4tkm gross:

$$e = 0{,}63Q_i^2–5{,}6Q_i+36{,}95 \quad (6)$$

Total cash costs C_f, thousand soums:

$$C_f = 4Q_i^2+40{,}94Q_i,+829{,}43 \quad (7)$$

Specific cash costs c_f, thousand soums /km:

$$C_f = 0{,}065Q_i^2+0{,}662Q_i,+13{,}429 \quad (8)$$

To summarize the above, it should be noted that the research results obtained by the authors are recommended to driver-instructors in heating engineering and specialists of the operation workshop of the Samarkand and Bukhara locomotive depots of «Uzbekistan Temir Yollari» JSC for the development of measures aimed at increasing the fuel and energy efficiency of the use of three-section mainline (train) freight diesel locomotives 3TE10M in real conditions of organizing the movement of freight trains on the hilly - mountainous section of Marokand - Kattakurgan in the direction Samarkand - Navoi - Bukhara of the Uzbek railway.

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