Research of Fuel and Energy Indicators of Modernized Diesel Locomotives (Uzte16m) on the Section of the UzbekRailway

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Abstract. The article considers the fuel and energy efficiency of the use of modernized diesel locomotives on the hilly-mountainous section of the Uzbek railway. Indicators were researched by the methods of the theory of locomotive traction. Three-section diesel locomotives of the UzTE16M3 series have been modernized at the facilities of enterprises in Uzbekistan. Taking into account the fact that locomotives have been in operation for more than 5-6 years, it is advisable to analyze the main indicators of the energy efficiency of transportation work. The results obtained characterize the dynamics of the transportation process in the real conditions of the organization of rail transportation of goods. The results of the research will be useful for the organization of operation in the network of Uzbek railways with a hilly-mountain type of track profile.

Keywords: Indicators, locomotive, diesel, UzTE16M3

1 Introduction

The events associated with the pandemic, the introduction of restrictions around the world have changed the balance of cargo transportation. It is large transit cargo flows pass through Uzbekistan, and rail transport continued to operate during this period. In order to ensure timely delivery of goods, it is necessary to have an appropriate locomotive fleet. The fleet of locomotives has recently been intensively updated, and mainly electric locomotives on asynchronous traction electric motors are purchased. Also, programs for the electrification of new sections of the railway network are being actively implemented in Uzbekistan. Despite all of the above, a significant part of the transportation is carried out by diesel locomotives. For many reasons, sections of railways laid through desert and hilly areas, where the distance between settlements is greater, remain not electrified for many reasons. One of such sections is Marokand-Navoi.
Currently, more than 50% of all sections of the locomotive fleet are freight diesel locomotives. 30% of the total number of diesel locomotives are locomotives of the UzTE16M series [1].

Increasing the efficiency of using modernized diesel locomotives is implemented through an integrated approach to the development of driving modes, which will subsequently ensure fuel and energy optimization. The basic prerequisites for the mentioned developments are the widespread conduct of theoretical and experimental analyses to substantiate the parameters of the main indicators of the transportation operation of diesel locomotives and evaluate the effectiveness of the use of resource-saving technologies in managing the operating modes of their power plants in real conditions of operating organization.[2,3]

2 Methods

The main challenge in terms of energy efficiency for the transportation work of the diesel locomotives on railway sections is to improve their performance in real-world conditions. This can be achieved in a variety of ways, including organizational, technological, constructive and technological. The authors of the research[2-8] suggest improving the operational reliability of the locomotives, systems and assemblies along the route, not only by improving service maintenance and repairing the locomotives but also by taking advantage of the latest developments in the electrical sector and computer technologies in operational conditions. The research[9,10] focuses on the potential of reducing the fuel and energy consumption of train traction, where it is proposed to reduce the total diesel fuel consumption by diesel and electric traction rolling stock by optimising the operating modes of the power power plants (systems) of the diesel and electric traction. In this article, a research was made of the traction performance of the modernized diesel locomotives of the UzTE16M3 series, taking into account the conditions of the Uzbek railways. Since the selected section is not electrified and transportation is carried out by diesel locomotives, a locomotive of the UzTE16M3 series was chosen as an object. To optimize the analysis, the selected site was straightened (Marokand - Navoi) (Table 1).[11-13]

2.1 Research methodology

The technique consists in the development of mathematical models that take into account the nature of the behavior of the train when traction of a freight train is carried out by 3-section locomotives on a hilly-mountain profile of the Marokand-Navoi section, which is part of the joint-stock company JSC "O'zbekiston temir yo'llari"[14-20]. According to the generally accepted requirements for the analysis of traction performance of locomotives for research, the profile was straightened and the optimal masses of the train were selected. Also, the current speed limits on this section were taken into account. If we characterize the railway section, then the following should be noted:

- the length of the section is 140.5 km.
- the section contains 99 elements (including straightening)
- about 60% of the sections are characterized by a change in rises on average from 0 to +4.8%/0 and descents from 0 to - 5.8%/0(Table 1)

The locomotives is modernized on the basis of proven bodies of diesel locomotives of the 3T10M series. In the process of modernization of UzTE16M3 diesel locomotives, such elements as a new diesel generator 1A-9DG (with a diesel engine 1A-5D49), a microprocessor control system for a diesel generator USTA-75-02, a KLUB-U system, a modern driver’s console based on digital semiconductor solutions were installed. To implement the research, a series of calculations was performed on the selected section for
There are three different types of train movements. The train movement without stops and the train movement with stops at interchanges, sidings and isolated points were used in the calculations. The total diesel fuel consumption and the funds by diesel locomotives UzTE16M3 are shown in table No. 2. [14,15]

Table 1. The values of the travel time of trains of various masses in the research area by hauls (per pass) and intermediate stations, sidings and separate points for deceleration — acceleration

<table>
<thead>
<tr>
<th>Railway hauls</th>
<th>Distance, km</th>
<th>Time of passing the hauls, min</th>
<th>deceleration/acceleration time, min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>train weight, t</td>
<td>train weight, t</td>
</tr>
<tr>
<td>Marokand</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Juma</td>
<td>8,75</td>
<td>7,8</td>
<td>7,7</td>
</tr>
<tr>
<td>Norbulak</td>
<td>29,05</td>
<td>22,03</td>
<td>22,25</td>
</tr>
<tr>
<td>Katta Kurgan</td>
<td>24,01</td>
<td>20,89</td>
<td>21,35</td>
</tr>
<tr>
<td>Rzd. No. 28</td>
<td>11,25</td>
<td>10,7</td>
<td>10,95</td>
</tr>
<tr>
<td>Zirabulok</td>
<td>16,84</td>
<td>14,8</td>
<td>15,55</td>
</tr>
<tr>
<td>Ziyovuddin</td>
<td>27,16</td>
<td>19,45</td>
<td>18,95</td>
</tr>
<tr>
<td>Navoi</td>
<td>23,49</td>
<td>16,94</td>
<td>16,65</td>
</tr>
<tr>
<td>Total</td>
<td>140,55</td>
<td>112,61</td>
<td>113,4</td>
</tr>
</tbody>
</table>

3 Results of researching

As a result of the research, it can be seen that the driving mode of a train with such locomotives practically does not have intervals of movement at a constant speed. Uniformly slow and uniformly accelerated regimes prevail over almost the entire repetition interval (see table 2)

Table 2. Natural diesel fuel consumption and cash costs of UzTE16M3 diesel locomotives at the selected section.

<table>
<thead>
<tr>
<th>№</th>
<th>Railway hauls</th>
<th>Train traffic</th>
<th>Train traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Without stops</td>
<td>With stops</td>
</tr>
<tr>
<td></td>
<td></td>
<td>total consumption per trip, E, kg</td>
<td>specific consumption for the trip, e, kg/ (1 km gross)</td>
</tr>
<tr>
<td>1</td>
<td>Marakand - Juma</td>
<td>108,08</td>
<td>39,91</td>
</tr>
<tr>
<td>2</td>
<td>Juma - Norbulak</td>
<td>122,01</td>
<td>14,38</td>
</tr>
<tr>
<td>3</td>
<td>Norbulak - Katta Kurgan</td>
<td>112,18</td>
<td>15,72</td>
</tr>
<tr>
<td>4</td>
<td>Katta Kurgan - Rzd. No. 28</td>
<td>87,99</td>
<td>26,38</td>
</tr>
<tr>
<td>5</td>
<td>Rzd. No. 28 - Zirabulok</td>
<td>220,25</td>
<td>41,81</td>
</tr>
<tr>
<td>6</td>
<td>Zirabulok - Ziyovuddin</td>
<td>147,32</td>
<td>18,63</td>
</tr>
<tr>
<td>7</td>
<td>Ziyovuddin - Navoi</td>
<td>127,25</td>
<td>18,22</td>
</tr>
<tr>
<td>8</td>
<td>Marokand - Navoi</td>
<td>924,46</td>
<td>21,84</td>
</tr>
</tbody>
</table>
From the data obtained, the following conclusions can be drawn:
1. The overall journey duration of the train for non-stop movement is non-linearly related to the train's mass change. A 20% drop in train mass results in a 0.71 percent decrease in total train movement time, whereas a 20% rise in train mass results in a 0.4 percent increase in time.
2. The average calculated values of the acceleration and deceleration time of a freight train with a unified train mass of 3000 tons are 1.32 and 1.81 minutes, respectively.
3. An increase in the mass of the train by 500 tons increases the time for the acceleration of the train, and also changes the mode of operation of the diesel generator set. When the train is traction in such cases, as a rule, there is always acceleration with maximum effort and more increased fuel consumption.
4. Fuel consumption for one acceleration or deceleration of a freight train with a unified mass of a train of 3000 tons is about 30.71 kg, and the average consumption for three masses of a freight train is 32.99 kg.

Table 2 shows the averaged numerical values of the consumption of full-scale diesel fuel and the cost of funds without stops and with stops at intermediate stations, sidings and separate points. The graphical dependences of the change in the kinematic parameters of goods train movement and the energy efficiency indicators of the examined diesel locomotives for both types of movement are shown in Figs. 1 and 2.

Fig. 1. Kinematic parameters of the movement of freight trains

Fig. 2. Parameters of energy efficiency of UzTE16M3 diesel locomotives
Fig. 1 denotes the technical speed of movement, respectively, without stops $V$ and with stops $V'$; the time of the train running without stops and with a stop, respectively, total for the sections of the section $t_p, t'_p$, in the traction mode $t_t, t'_t$, in the idling and braking mode $t_{xx,t}, t'_{xx,t}$.

Fig. 2 denotes the consumption of full-scale diesel fuel for a trip without stops and with stops, respectively, total (full) $E, E'$ and specific $e, e'$; the cost of funds, respectively, without stops $C_t$ and with stops $c't$ at intermediate stations, sidings and separate points.

The analysis was carried out by comparing the averaged values of the above-mentioned indicators of one type of freight train movement in relation to another. It should be noted that when comparing the calculated data and real consumption indicators with approximate masses and the recommended driving mode, the discrepancies in the results amounted to 12.4%.

The analysis showed that the movement of freight trains without stops in relation to similar movement with stops provides [9-14]:

- a decrease in the total time of the train by 17.53 minutes with an average estimated time per stop of 2.49 minutes and an increase in the technical speed of movement by 10.11 km/h;
- the values of the shares of movement in the modes of traction, idling and braking, respectively, at 34.01 and 65.02 percent;
- increase - decrease, respectively, of the values of the shares of movement in the modes of traction and idling, braking by approximately 3.3 percent;
- decrease in driving time in traction, idling and braking modes, respectively, by 10.25 minutes (~21.1 percent) and 7.49 minutes (9.02 percent) to movement with stops at intermediate stations;
- reduction of the total (total) and specific consumption of full-scale diesel fuel per trip, on average, by approximately 21 percent;
- total (full) and specific consumption of full-scale diesel fuel for [15-20] one stop, respectively, at 33.3 kg and 0.79 kg/104tkm gross;
- reduction of the given unit cost of funds by approximately 2920 som / km (or 20 percent).

4 Conclusions

Despite the fact that the diesel locomotives are very similar in design to the 3T10M series locomotives, the diesel generators, the converter part, as well as the control systems have been significantly upgraded, which, according to the results, has a positive effect on traction performance.

If we characterize the results of the diesel locomotive consumption in this section, then we can say that the profile itself, although it does not have sections with serious long rises and curves, the train speed graph does not have sections with constant speeds, which in turn increases the number of accelerations and decelerations. As a result, the amount of time when it is necessary to load traction units to maximum modes increases. All this increases fuel consumption at a distance.

The results obtained will help to correct the existing modes of train movement to reduce consumption and increase the speed of mass trains.

References


17. Calculating cargo securing elements on a railway platform under the impact of a spatial force system, Turanov, K., Ruzmetov, Y., Vlasova, N. E3S Web of Conferences, 2019, 135, 02006.