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Research Article

DETERMINING THE NEED FOR TRAIN LOCOMOTIVES IN THE CONDITIONS OF TRAINE MOVEMENT IMPAIRMENT

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ABSTRACT

This article presents the methods of determining the need for train locomotives in conditions of imbalance of train traffic. To check the reliability of the obtained results, as an example, the indicators of use of electric locomotives for the AV circulation section were analyzed. Also, an algorithm for determining the fleet of electric locomotives needed to service freight trains has been developed.

KEYWORDS

Indicators of the use of locomotives,turns, equipment, tortuv shoulders, interval between trains.

INTRODUCTION

In the conditions of the market economy and the reconstruction of railway transport, the use of effective technology of the transport process, aimed at improving economic indicators, increasing the quality of transport, the prestige and attractiveness of railway transport, and the search for methods of its implementation, is one of the urgent issues of our time.

The modern needs for the quality of transportation require the need to increase the regularity, accuracy and rhythm of operation of all railway lines. At the same time, reducing freight costs and increasing their profitability largely depends on the development and implementation of a number of systems, the optimization of which affects the improvement of railway transport. One of them is a complex system for managing the use of locomotives. For this, important measures aimed at improving the service of the transportation process by locomotives and locomotive brigades are being developed. However, determining the need for train locomotives is recognized as one of the urgent issues in almost all railways of the world, in a situation where train traffic is variable.

MAIN PART

When calculating the need for locomotives, it can be divided into two parts: main and additional.

A basic need- this is the minimum number of locomotives required to serve a certain number of freight trains running at a certain frequency under ideal conditions, that is, to ensure the minimum calculated locomotive cycle time in the traffic schedule.

Additional need occurs as a result of locomotives staying longer than the accepted technological time standards due to waiting for the train at the turning points.

After calculations, both of these requirements should be increased, taking into account the uneven movement caused by the change in the daily train flow.

The basic need for locomotives is calculated by the following formula:

$$M_o = \theta_p \cdot N/24 \quad (1)$$

here θ_p – calculated turnover of locomotives, hours;

N – average size of freight traffic, pair of trains

The calculated turnover of locomotives is determined based on the following formula:

$$\theta_p = \frac{2 \cdot L}{v_y} + \left(\frac{2 \cdot L}{L_{tex}} - 2\right) \cdot t_{tex} + t'_o + t''_o + \frac{2 \cdot L}{L_{ek}} \cdot t_{ek} \quad (2)$$

here L – length of locomotive circuit section, km;

v_y – section speed, km/h;

t_{tex}, L_{tex} – respectively, the transit train's stopping time at the technical stations without changing the locomotive and the distance between these stations, km.;

t'_o, t''_o – minimum technological (calculated) stay time of locomotives at turning points;

t_{ek}, L_{ek} – respectively, the time of equipping the locomotive at the technical stations and the walking distance between the equipments, km.

The basic need for the locomotive fleet can be determined by the average interval (Isr min.) of freight trains moving between passenger trains:

$$\mathrm{M_o} = \frac{\theta_p}{I_{sr} 1/60} \quad (3)$$

In long-distance circulation sections it is equal to-$I_{sr} = 1440/N$, and in short-distance sections:

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$$I_{sr} = \frac{1440-[\varepsilon_p+1)\cdot I_p\cdot N_p}{N} \quad (4)$$

here $\varepsilon_p -$ the coefficient of displacement of freight trains by passenger trains;

$I_p -$ the interval between passenger trains in the schedule of trains (non-packaged), min.;

$N_p -$ number of passenger trains, train.

With the help of the coefficient of daily imbalance of the flow of cars (y), it is possible to take into account the increase in the basic need for locomotives caused by the daily imbalance of the flow of cars, that is: M_o^n

$$M_o^n = M_o \cdot y \quad (5)$$

y- the fluctuation of the flow of cars, which is equal to the value of the mean square deviation between the maximum and minimum value of the flow of cars increased by one and a half, i.e.σ

$$y = \frac{1{,}5\cdot\sigma}{u} \quad (6)$$

In this case:

$$I'_{sr} = \frac{I_{sr}}{1+y} \quad (7)$$

here $u -$ the average size of the flow of wagons in the planned period;

$I_{cp} -$ the average interval in the running of freight trains, taking into account the imbalance.

Total demand for locomotives, taking into account the imbalance

$$M'_o = M_o + M_o^n \quad (8)$$

By substituting the value from formula 1, we get:M_o

$$M'_o = \frac{\theta_n\cdot N\cdot(1+y)}{24} \quad (9)$$

The additional need for locomotives consists of two parts:$M_{\mathrm{dop}}^{\mathrm{n}}$

M_{dop}^{ob} —the need that arises due to the fact that the end time of technological operations does not coincide with the time interval of the departure of freight trains, as well as the omission of passenger trains and imbalances in the arrival and departure of freight trains, that is, delays at turning points.

M_{dop}^{n} —the need that arises due to the provision of services for the withdrawal of trains from round stations on a long circuit section in conditions of imbalance of train traffic.

For a plot with several tortuous shoulders:

$$M_{dop}^n = \frac{\sum T_{dop}}{24} + 0{,}5\cdot\Pi \quad (10)$$

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hereП – the number of turning points, including the number of stations delimiting the turning sections;

$\sum T_{dop}$ – total additional delay of locomotives at all turning points;

$$\sum T_{dop} = \frac{[24 \cdot k_s - \sum t_{st} + 2 \cdot N_p \cdot (t_{ob} + \varepsilon_i \cdot I_p - I'_{er})]}{I'_{sr}} \cdot [(\varepsilon_p + 1) \cdot I_p - I'_{sr}] \quad (11)$$

here k_s – the proportionality coefficient of the placement of passenger trains in the traffic schedule. It is approximately equal to:

$$k_s = 0{,}8 + 0{,}2 \cdot N_p \quad (12)$$

here $\sum t_{st}$ – stopping time of passenger trains at the turning point of locomotives;

$\varepsilon_i \cdot I_p$– time chart of a passenger train on a freight train.

For sections delimiting turning points, half of is taken. The method of analytical determination of $\sum T_{dop} \sum T_{dop}$

An additional number of locomotives is needed to ensure the daily increase in the volume of traffic in conditions of unbalanced traffic:

$$M_{dop}^{ob} = \frac{\theta_p \cdot n_y}{24} \cdot \left(\frac{\theta_p}{t_p} - 1\right) \quad (13)$$

here t_p – locomotive work planning period.

The general need for locomotives consists of basic and additional parts:

$$M = M'_o + M_{dop}^{ob} + M_{dop}^{n} \quad (14)$$

If the number of freight trains exceeds a certain critical value, additional delays of locomotives at the turning points begin to occur:

$$N_{kr} \geq \frac{[1440 - (\varepsilon_p + 1) \cdot I_p \cdot N_p]}{[(\varepsilon_p + 1) \cdot I_p]} \quad (15)$$

ANALYSIS OF FOREIGN AND LOCAL LITERATURE

Engineering and technical staff of the All-Russian Research Institute of Railway Transport (BRTTITI) "Railway Operation" Department and "Locomotive Operation" Department and Technical Department of the Central Directorate and MPS "Locomotive Farming" guidelines for calculating the necessary locomotive fleet have been developed by the General Administration [1].

Also [2] the scientific work is based on the systematization and generalization of materials related to the performance of locomotives, the analysis of shortcomings in this important branch of railway transport, and recommendations for further improvement of the performance of practically tested locomotives are given. Analytical formulas for determining the time of stay of freight locomotives at the turning point were also recommended. In [3], the present state of the use of freight locomotives and the analysis of scientific works were performed. As a

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result, the condition "no train is absolutely waiting for a locomotive to depart from the station" was used to calculate the fleet of locomotives in freight traffic. In most cases, failure to meet this condition was found to result in increased dwell times of locomotives at turnpike points, which was addressed by using modeling to change this indicator in a positive direction. In [4], the influence of the time of freight locomotives at the turning point on the locomotive fleet was studied. As a result, it has been determined that the waiting time of freight trains at the turning points of locomotives at the same movement size varies within a certain interval, and it is scientifically proven that the accuracy level is not high when determining this amount of time using analytical formulas. In [4], the influence of the time of freight locomotives at the turning point on the locomotive fleet was studied. As a result, it has been determined that the waiting time of freight trains at the turning points of locomotives at the same movement size varies within a certain interval, and it is scientifically proven that the accuracy level is not high when determining this amount of time using analytical formulas. In [4], the influence of the time of freight locomotives at the turning point on the locomotive fleet was studied. As a result, it has been determined that the waiting time of freight trains at the turning points of locomotives at the same movement size varies within a certain interval, and it is scientifically proven that the accuracy level is not high when determining this amount of time using analytical formulas.

[5-10] researched the effect of increasing train locomotive productivity, automating the process of calculating the fleet of locomotives, and the effect of the section speed of trains on the performance indicators of locomotives.

The main goal of the above research is to achieve the most benefits with the least cost, to improve the indicator of the effective use of locomotives [11]

HARMONY OF THEORETICAL AND PRACTICAL RESEARCH

Below is an example of calculating the required fleet of electric locomotives, taking into account the imbalance of train traffic, and these calculations were carried out using nomograms and calculation tables. The numerical values of the coefficients of the calculation formulas are indicated in the instructions for calculating the locomotive fleet. For the AV circulation section of electric locomotives (conditional railway section) (Fig. 1), the following performance indicators were adopted (Table 1).

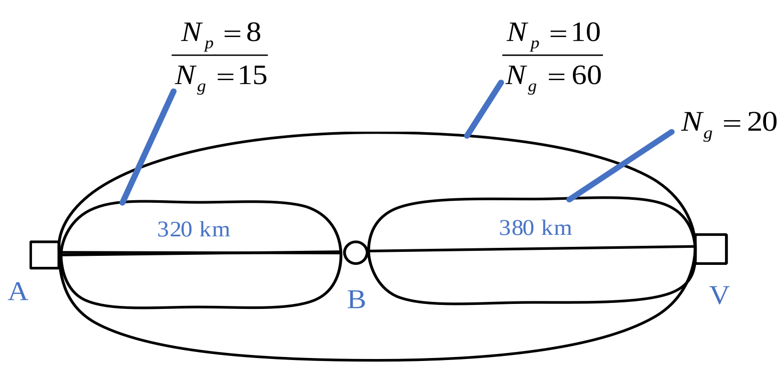

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Figure 1. Scheme of locomotive circulation sections and zones

In the research work, the following indicators were selected as initial data on the conditional railway section:

- number of thermal trains;N_sb=3 even

- the average number of wagons in the train;m=60 wagons

- mean square deviations of the flow of cars , , car; 〖σ〗_(A-V)=312σ_(A-B)=128σ_(B-V)=112

- hours of maintenance of locomotives, taking into account equipment, reception, delivery; clock;t_l-t_V=t_ob=2,0t_b=0,6

- coefficient of displacement of freight trains by passenger trains;ε_p=3,0

- coefficient of displacement of freight trains by thermal trains;ε_sb=4,0

- hours of passenger trains staying at technical stations;t_pas=0,15

- hours of scheduled operation of electric locomotives.t=24

- distance between technical stations in km.L_tex=350

- hours of staying at technical stations.t_tex=0,15

A-V it is necessary to determine the fleet of electric locomotives necessary for the service of freight trains on the section.

Table 1

Indicators of use of electric locomotives for the A-V circulation section

Indicator name	Pullover shoulder		
	A-V	A-B	BV
Length L, km.	700	320	380
Number of freight trains, pair of trains N_g	60	15	20
Number of passenger trains, pair of trains N_p	10	8	-
Section speed in cargo movement, km/sv_u	50	50	50
Interval between passenger trains in the package, hours I_p	0.166	0.166	-

The algorithm for solving this problem is presented in Figure 2.

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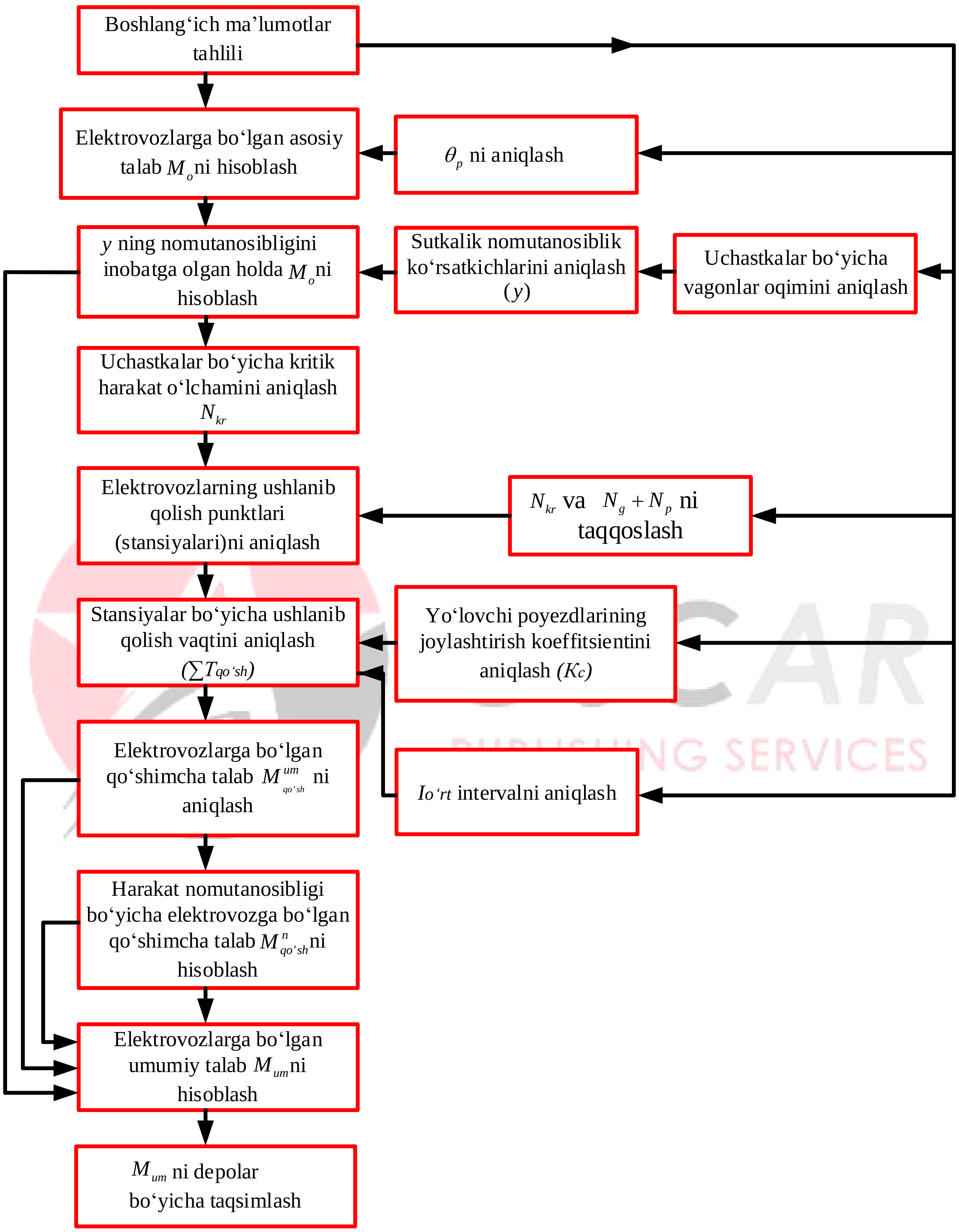

Figure 2. Algorithm for determining the fleet of electric locomotives needed to serve freight trains on a conditional railway section

We will step by step determine the operating fleet of electric locomotives necessary to serve freight trains on a conditional railway section:

1. Calculated circulation of electric locomotives on tortuv shoulders A-V, A-B, BV (formula 2):

$$\theta_{\text{p}}^{A-V} = \frac{2 \cdot 700}{50} + \left(\frac{2 \cdot 700}{350} - 2\right) 0{,}5 + 2 + 2 = 33{,}0 \text{ hours};$$

$$\theta_{\text{p}}^{A-B} = \frac{2 \cdot 320}{50} + 2 + 0{,}6 = 15{,}4 \text{ hour};$$

$$\theta_{\text{p}}^{B-V} = \frac{2 \cdot 380}{50} + 0{,}6 + 2 = 17{,}8 \text{ hours};$$

2. According to formula 1, the main need for electric locomotives was determined. The obtained results are presented in Table 2.M_o

Table 2

The results obtained from the approximate rotation of electric locomotives on the traction shoulders AB, BV

Plots	he	θ_p	M_o	M'_o	M_{dop}^{ob}	M_{dop}^{n}	M
A-V	0.13	33.0	82.5	93.2	22	4	119.2
A-B	0.21	15.4	9.6	11.6	…	…	…
BV	0.14	17.8	14.8	16.9	…	…	…

3. The daily imbalance of the flow of cars (y) leads to an increase in the basic need for locomotives by the value of y+1, i.e.$M'_o = M_o \cdot (y+1)$

The coefficient of daily imbalance of the flow of cars:

$$y = \frac{1{,}5 \cdot \sigma}{U} = \frac{1{,}5 \cdot \sigma}{N \cdot m}$$

$$y^{A-V} = 1{,}5 \cdot \frac{312}{60 \cdot 60} = 0{,}13;$$

$$y^{A-B} = 1{,}5 \cdot \frac{128}{15 \cdot 60} = 0{,}21;$$

$$y^{B-V} = 1{,}5 \cdot \frac{112}{20 \cdot 60} = 0{,}14.$$

The values for the given plots are given in Table 2.M'_o

4. Additional delays of electric trains appear at points A and B (stations), due to the volume of traffic approaching these stations above the critical stations calculated by formula 15 and it is equal to a double freight train for section AB and a double freight train for section B-V. The calculation of the need for electric locomotives for the "AB" and "BV" sections is

carried out in a similar way to the following calculation for the "AV" section. The results of calculations are presented in Table 2.$N_g^{A-B} = 60 + 15 = 75 N_g^{B-V} = 60 + 20 = 80$

5. Additional delays at points A and B are calculated to calculate according to formula 13. For this, according to formula 12, the coefficient that ensures the placement of passenger trains on sections AB and AV in proportion to the train schedule, and according to formula 4, the average distance between freight trains moving between passenger trains interval should be calculated. $M_{dop}^{ob} \sum T_{dop}\, k_s I_{sr}^{AB}$

for section A-B;$k_s^{\mathrm{A-B}} = 0{,}8 + 0{,}2 \cdot (10 + 8) = 4{,}4$

$$I_{sr}^{AB} = \frac{1440 - (3+1) \cdot 10 \cdot 18}{75 \cdot (1 + 0{,}21)} = 8\ min. \approx 0{,}133\ hour.$$

Section for A-V $k_s^{\mathrm{A-V}} = 0{,}8 + 0{,}2 \cdot 10 = 2{,}8$

$$I_{sr}^{AV} = \frac{1440 - (3+1) \cdot 10 \cdot 10}{80 \cdot (1 + 0{,}13)} = 11{,}5\ min. \approx 0{,}191\ hour.$$

The additional delay at station A is equal to:

$$\sum T_{dop}^{A} = \frac{[24 \cdot 4{,}4 - 0{,}15(10+8)2 + 2 \cdot (10 + 8092 + 3{,}0 \cdot 0{,}166 - 0{,}133)]}{0{,}133} \cdot$$

$$\cdot [(3+1) \cdot 0{,}166 - 0{,}133] \text{ locomotive clock;}$$

Additional delays at station V are equal to:

$$\sum T_{dop}^{V} = \frac{[24 \cdot 2{,}8 - 0{,}15 \cdot 10 + 2 \cdot 10 \cdot (2 + 3{,}0 \cdot 0{,}166 - 0{,}191)]}{0{,}191} \cdot$$

$\cdot [(3+1)0{,}166 - 0{,}191]$ locomotive clock

Average value for both points:

$\sum T_{adit}^{A-V} = \frac{740+277}{2} = 508{,}5$ locomotive clock

By skipping passenger trains, the additional demand caused by imbalances in the arrival and departure of freight trains, that is, due to delays at the turning points, is determined as follows (formula 10):

$$M_{dop}^{n} = \frac{508{,}5}{24} + 0{,}5\Pi \cong 22 \text{ electric locomotive}$$

The calculation cycle of locomotives for the general circuit section AB was 33 hours, that is, 24 hours more than the planning period, due to which there is a certain complexity of control under unbalanced traffic conditions, which requires additional electric locomotives and it is calculated according to formula 13 for the AV section:

$$M_{adit}^{\text{об}} = \frac{33 \cdot 60 \cdot 0{,}13}{24}\left(\frac{33}{24} - 1\right) = 4 \text{ electric locomotive}$$

CONCLUSION

In order to determine the operating fleet of locomotives necessary for the service of freight trains on the railway section, it is necessary to carry out work on the distribution of units of torque in the main depot in proportion to the total circulation of locomotives of each depot. This will lead to a significant improvement in locomotive utilization in the future.

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