Achilov Umarbek Rustamovich, student
Suyunbayev Shinpolat Mansuralievich, Doctor of Technical Sciences Tashkent State Transport University

DEVELOPMENT OF A PROGRAM FOR CALCULATINGTHE OPERATING COSTS OF TRACTION SUPPORT FOR FREIGHT TRAINS

Relevance of the topic. The main criterion for determining the boundaries of traction shoulders for freight trains is operating costs. of traction arms for the movement of freight trains is operating costs. Currently, when determining the length of the section of circulation of train locomotives, the change in wagon traffic by day of the year is not taken into account and is determined by its average number. Statistics show that rail wagon traffics change significantly throughout the year. Based on this, the change in daily car numbers at a particular station included in the train formation plan is 159 cars, as shown in Figure 1 during the year.

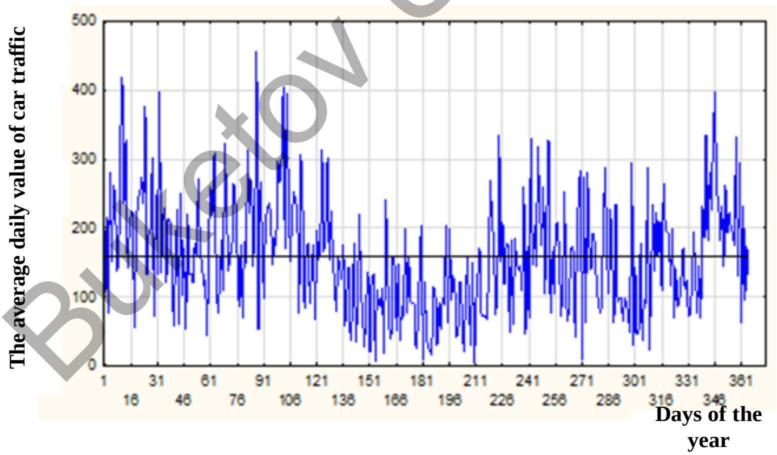

Figure 1. The change in wagon traffic in a certain direction relative to their average number per year

As can be seen from Figure 1, during most of the year (195 days), the wagon traffic decreases and increases in comparison with its average value. This, in turn, indicates the need to determine the length of the traction arms for on the basis of technical and economic calculations, taking into account the size of uneven train traffic during the year. Currently, it is not possible to automatically calculate the operating costs for the traction of freight trains for tomorrow.

The purpose of this work is to develop a program for calculating the operating costs of traction support for freight trains, taking into account the uneven movement of wagons.

Today, there are a number of scientific papers devoted to the efficiency of using an elongated traction arm in the movement of freight trains [1-4]. In all the studied scientific papers, it was recommended to set the length of traction arms for a one-year period, based on the average value of train traffics.

Based on the available scientific works, it was proposed to determine the optimal length of the locomotive service area using the following target function, which includes the total operating costs:

$$E_{pr} = \frac{N_e}{24} \cdot \frac{(1+\alpha_{o.r})}{(1-\beta_n)} \cdot \left(\frac{2 \cdot L_e}{V_{uch}} + t_{as} + t_{ay}\right) \cdot \left(365 \cdot e_{Mt} + \frac{C_{br} \cdot K_{br}}{1-\delta} + E_p \cdot C_e\right) + N_e \cdot e_r \cdot (365 \cdot l_{sl} + 0{,}96 \cdot \propto_{sl} \cdot L_e^2) \rightarrow min \quad (1)$$

However, the objective function has the following restrictions:

$$L_d^{min} \leq L_e \leq \begin{cases} L_{yon}^{max} \\ L_{TXK-2}^{max} \end{cases}; \; t_m^{min} + t_k \leq t_{as} \leq 12 + t_k; \; t_m^{min} + t_k \leq t_{ay} \leq 12 + t_k.$$

where $\alpha_{o.r}$ – share fleet of locomotives, associated with the complexity of their operational control (regulation) on an elongated area of movement; β_n – share is faulty locomotives; t_{as}, t_{ay} – time spent by train locomotives in the main and reverse depot, hour; N_e – the number of freight trains on the section of the turnover of locomotives, trains;

e_{Mt}, e_r – accordingly, the consumption rate of one locomotive-hour and locomotive-kilometer and, sum/Lok-hour(Lok km); C_{br} – annual contents of one locomotive crew, sum; K_{br} – state teams on one locomotive fleet; δ – coefficient considering going to work instead of sick and on leave; l_{sl} – distance locomotive from the place of its uncoupling from arriving trains to the trailer key to send the train, km; $\propto_{sl}$ – the number of cases of faults locomotives per year per train-kilometre route; E_p – normative coefficient of efficiency of capital investments; C_e– procurement price of traintion locomotive, sum; L_d^{min}– initial length of the traction of the shoulder, km; L_{yon}^{max}– the maximum length of the traction shoulder km, the limited fuel capacity of the locomotive; L_{TXK-2}^{max}– the maximum length of the traction of the shoulder, limited distance access the locomotive of the train to the second inspection, km; t_m^{min} – the maximum value of the standard time spent on uncoupling from the train and hitching to the next train, hour.

By dividing the elements of formula (1) into immutable and variable parameters, an algorithm for calculating the operating costs of traction for freight trains was developed (Fig. 2), and a computer program was created based on it (Fig. 3). The C# programming language was used. Based on the developed program, the operating costs were calculated when determining the rational length of the locomotive handling sections from 200 to 1000 km (in increments of 200 km) for two variants:

1. The movement of freight trains is organized separately for each traction arm.

2. The movement of freight trains is organized in the order of combining both traction arms.

Based on the change in the cost ratio for the two options, the rational length of the locomotive handling section was determined depending on the size of train traffic (Fig. 4).

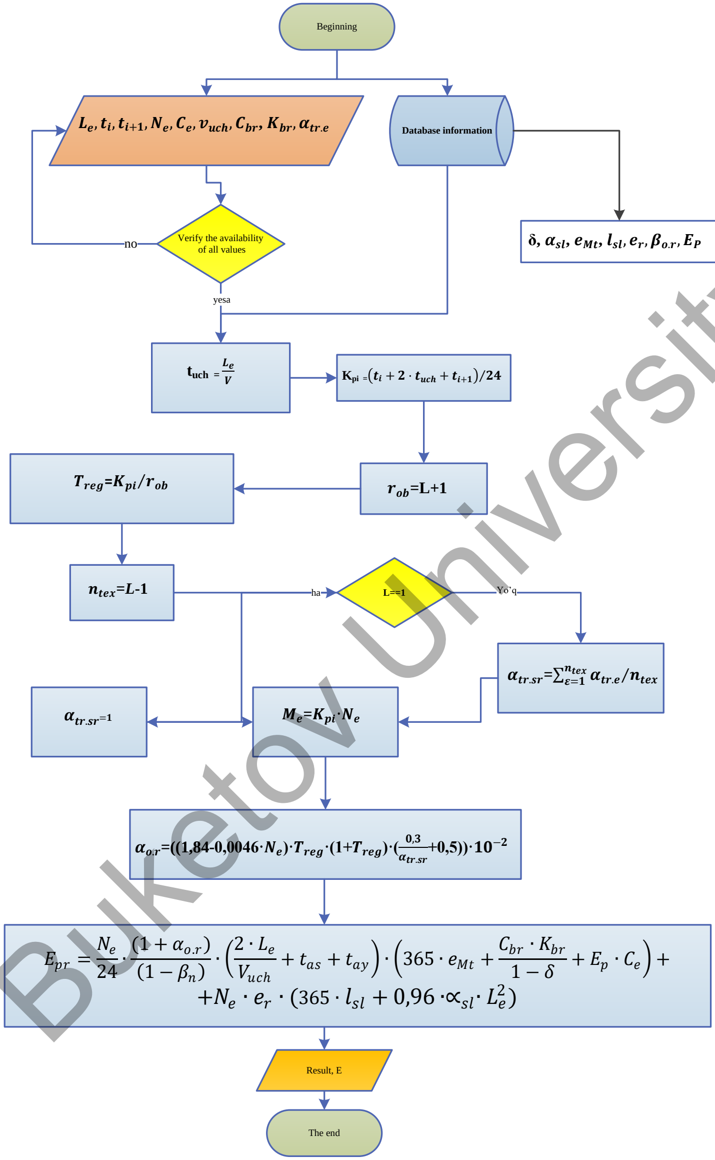

Figure 2. Algorithm for calculating the operating costs of traction of freight trains

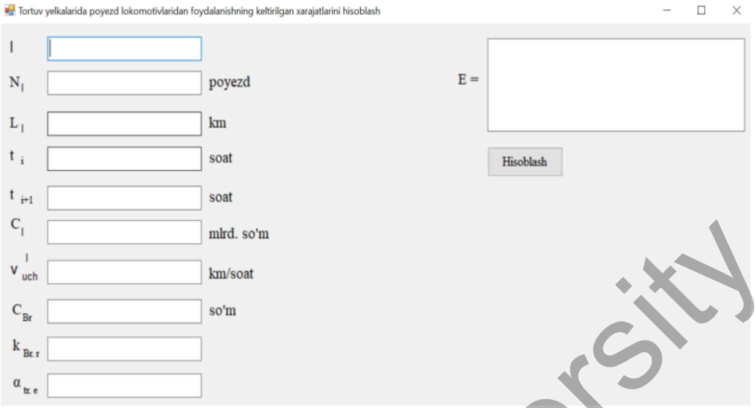

Figure 3. The working window of the program for calculating the operating costs of traction support for freight trains

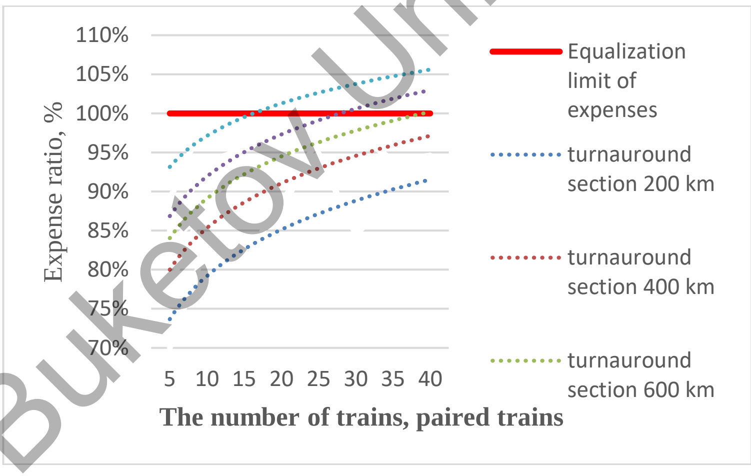

Figure 4. Change in the cost ratio for separate and combined versions of traction arms depending on the size of train traffic

As can be seen from Figure 4, it is advisable to set the rational length of traction arms based on the estimate of operating costs depending on the movement of trains.

Scientific novelty: based on the developed program for calculating the operating costs of traction for freight trains, the rational length of the locomotive circulation sections is justified.

Practical significance: a program has been developed for calculating the operating costs of traction for freight trains. The results of this study show that the use of the developed program will lead to savings in operating costs of railways due to the rational use of the existing fleet of freight locomotives on traction arms.

Perspective of use: This program can be used in higher educational institutions, research laboratories, design institutes, as well as in the locomotive industry to assess the cost of operating freight train locomotives on traction arms. In the future, it can be adapted to the requirements of private companies that have their own locomotives for operation on main lines.

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Балтабекова А.А., магистрант
Кельдибекова А.Б., PhD, қауымдастырылған профессор
Академик Е.А. Бөкетов атындағы Қарағанды университеті

PYTHON ПРОГРАММАЛАУ ТІЛІНДЕ ДЕРЕКТЕРДІ ВИЗУАЛИЗАЦИЯЛАУ

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