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**ҒЫЛЫМ ЖӘНЕ ЖОҒАРЫ БІЛІМ МИНИСТРЛІГІ**

**Л.Н. ГУМИЛЕВ АТЫНДАҒЫ ЕУРАЗИЯ ҰЛТТЫҚ УНИВЕРСИТЕТІ**
**КӨЛІК – ЭНЕРГЕТИКА ФАКУЛЬТЕТІ**

# *«КӨЛІК ЖӘНЕ ЭНЕРГЕТИКАНЫҢ ӨЗЕКТІ МӘСЕЛЕЛЕРІ: ИННОВАЦИЯЛЫҚ ШЕШУ ТӘСІЛДЕРІ» XI ХАЛЫҚАРАЛЫҚ ҒЫЛЫМИ-ТӘЖІРИБЕЛІК КОНФЕРЕНЦИЯСЫНЫҢ БАЯНДАМАЛАР ЖИНАҒЫ*

# *СБОРНИК МАТЕРИАЛОВ XI МЕЖДУНАРОДНОЙ НАУЧНО – ПРАКТИЧЕСКОЙ КОНФЕРЕНЦИИ: «АКТУАЛЬНЫЕ ПРОБЛЕМЫ ТРАНСПОРТА И ЭНЕРГЕТИКИ: ПУТИ ИХ ИННОВАЦИОННОГО РЕШЕНИЯ»*

# *PROCEEDINGS OF THE XI INTERNATIONAL SCIENTIFIC-PRACTICE CONFERENCE «ACTUAL PROBLEMS OF TRANSPORT AND ENERGY: THE WAYS OF ITS INNOVATIVE SOLUTIONS»*

**Астана, 2023**

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**А43 Актуальные проблемы транспорта и энергетики**: пути их инновационного решения: XI Международная научно – практическая конференция, г. Астана, 16 марта 2023/Подгот. Ж.Д. Курмангалиева, У.Ш. Кокаев, Т.Т. Султанов – Астана, 2023. – 709с.

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В сборник включены материалы XI Международной научно – практической конференции на тему: «Актуальные проблемы транспорта и энергетики: пути их инновационного решения», проходившей в г. Астана 16 марта 2023 года.

Тематика статей и докладов участников конференции посвящена актуальным вопросам организации перевозок, движения и эксплуатации транспорта, стандартизации, метрологии и сертификации, транспорту, транспортной техники и технологии, теплоэнергетики и электроэнергетики.

Материалы конференции дают отражение научной деятельности ведущих ученых дальнего и ближнего зарубежья, Республики Казахстан и могут быть полезными для докторантов, магистрантов и студентов.

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## СЕКЦИЯ/ SECTION 1
### Көлікті пайдалану және жүк қозғалысы мен тасымалдауды ұйымдастыру/ Организация перевозок, движения и эксплуатация транспорта/Organization of transport, traffic and transport operation

**UDK656.22.05**

# STUDIES OF THE BASIC SPECIFIC TRAFFIC RESISTANCE OF DIFFERENT TYPES OF FREIGHT CARS

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**Abstract.** The primary specific resistance to the movement of freight wagons is a key parameter for normalizing the time and energy consumption of trains. Although the "Rules of Traction Calculations" calls for dividing wagons into six groups when calculating this resistance, in practice (using the traditional method), appropria teregulations are developed based on the separation of train wagons into two groups (4th and 8th lips). One of the main reasons for this is the inability to account for the unique features of each wagon in a given train. To address this issue, a program was developed for determining the necessary parameters of wagons for traction calculations based on their identification numbers. This soft ware can be accessed through the website https://trainlocomotive.netlife.app/. Using this program, a method for calculating the primary specific resistance to the movement of freight wagons has been developed. Field sheets of freight it trains moving through the Uzbekistan Temir Yullari railway station were analyzed. As a result, it was discovered that nearly half of the freight train composition consists of empty wagons, while the proportion of loaded gondola cars and tanks is 23%. The primary specific resistance to the movement of wagons in such a mixed composition is calculated using both traditional and developed methods.

## Introduction

In the calculation of the operating costs of railway transport, the movement of locomotives and wagons is considered as one of the main accounting elements. In order to increase the capacity of railway sections and optimize the technical and economic calculations related to the transportation of trains, it is necessary to correctly calculate the movement of the train. Currently, research has been carried out on the technical and economic importance of the fundamental resistance of wagons to movement, and a number of scientific studies have been conducted to investigate energy consumption issues. For example, in [1], the results of the initial hase of investigating train resistance are presented. Formulas for determining train resistance have been analyzed by researchers in the US and abroad, and factors that cause significant variations in different formulas have been discussed. Various models that take into account t atmospheric resistance in determining train resistance have been developed using computer programs that consider various factors. The article titled [2], investigates the impact of aerodynamic phenomena on the resistance and fuel consumption of vehicles equipped with dieselengines managed by Romanian railway companies. The study concludes that the resistance characteristics have a direct impact on fuel consumption and that the minimum fuel consumption is achieved with minimal resistance. Furthermore, it was observed that at speeds above 85 km/h, the over all resistance value is significantly reduced.

In the field of train operations, a series of scientific works have been carried out to optimize the movement of trains based on the calculations made by our country's scientists [3-5]. However, in the process of implementing the seoptimization calculations, the basic principle of considering all types of wagons when calculating the resistance to movement has not been taken into account.

**Automating the process of determining the primary resistance of various types of freight wagons to train movement**

"According to the information brochure on the 8-unit system for numbering freight cars, freight cars with a gauge of 1520 mm are classified into 6 types (covered wagons, flatcars, open-top wagons, tank cars, hopper cars, and others) [6]. The "Rules for Calculating Train Operations" that have been produced up to this day were analyzed [7-8]. As a result, it was determined that the parameters necessary for calculating the movement resistance of cars are divided into 6 groups in the car rolling calculations to calculate the basic resistance to train movement of freight cars. In this case, all calculations are performed for 2 types of railway tracks (with and without a ballast) and 2 types of bearings (roller bearings and plain bearings) for freight cars. Investigations were carried out taking into account the cargo parameters in the territory of the Uzbekistan Railways JSC for freight cars with plain tracks and roller bearings. The movement resistance to train movement of freight cars is calculated as follows for the 6 groups mentioned above when the speed ($v$) is reached:

First group - four-axle open half-car (pv) wagons, the weight of which exceeds the load capacity of six tons per axle ($q$):

$$\omega_{a.pv.4}^{\prime\prime(q>6)} = 0{,}53 + \frac{3{,}6+0{,}08\cdot v+0{,}00275\cdot v^2}{\bar{q}_{o.pv.4}^{q>6}}, \text{ N/kN} \quad (1)$$

Second group - tank wagons with a carrying capacity of more than six tons, designed to be loaded with liquids or gases (sys) that are subject to regulation by weight:

$$\omega_{a.sys.4}^{\prime\prime(q>6)} = 0{,}642 + \frac{2{,}925+0{,}0473\cdot v+0{,}00275\cdot v^2}{\bar{q}_{o.sys.4}^{q>6}}, \text{ N/kN} \quad (2)$$

The third group - flatbeds (pl), covered wagons (kr), and other wagons (pr) with a load capacity of more than six tons that can be carried by a single ox:

$$\omega_{a.pl,kr,pr.4}^{\prime\prime(q>6)} = 0{,}7 + \frac{3+0{,}1\cdot v+0{,}0025\cdot v^2}{\bar{q}_{o.pl,kr,pr.4}^{q>6}}, \text{ N/kN} \quad (3)$$

Fourth group - empty four-axle wagons with a weight capacity less than six tons per axle:

$$\omega_{a.4}^{\prime\prime(q\le6)} = 1{,}0 + 0{,}044\cdot v + 0{,}00024\cdot v^2, \text{ N/kN} \quad (4)$$

The fifth group is eight-axle wagons:

$$\omega_{a.8}^{\prime\prime} = 0{,}7 + \frac{6+0{,}0377\cdot v+0{,}00214\cdot v^2}{\bar{q}_{o.8}}, \text{ N/kN} \quad (5)$$

The sixth group - Refrigerated cars (rf) with a capacity of more than six tons, carrying goods that require cooling during transportation:

$$\omega_{a.rf}^{\prime\prime(q>6)} = 0{,}68 + \frac{3+0{,}1\cdot v+0{,}00255\cdot v^2}{\bar{q}_{o.rf}^{q>6}}, \text{ N/kN} \quad (6)$$

If a train consists of k (k=1÷6)groups of cars, the basic braking force of the freight cars in the train is calculated as follows

$$:\overline{\omega_a^{\prime\prime}} = \frac{\omega_{a.pv.4}^{\prime\prime(q>6)}\cdot\Sigma Q_{br.pv.4}^{q>6}+\omega_{a.sys.8}^{\prime\prime(q>6)}\cdot\Sigma Q_{br.sys.4}^{q>6}}{\Sigma Q_{br}} + \frac{\omega_{a.pl,kr,pr.4}^{\prime\prime(q>6)}\cdot\Sigma Q_{br.pl,kr,pr.4}^{q>6}+\omega_{a.4}^{\prime\prime(q\le6)}\cdot\Sigma Q_{br.4}^{q\le6}+\omega_{a.8}^{\prime\prime}\cdot\Sigma Q_{br.8}+\omega_{a.rf}^{\prime\prime(q>6)}\cdot\Sigma Q_{br.rf}^{q>6}}{\Sigma Q_{br}}, \text{ N/kN} \quad (7)$$

here,$\Sigma Q_{br}$ – represents the gross weight of the train

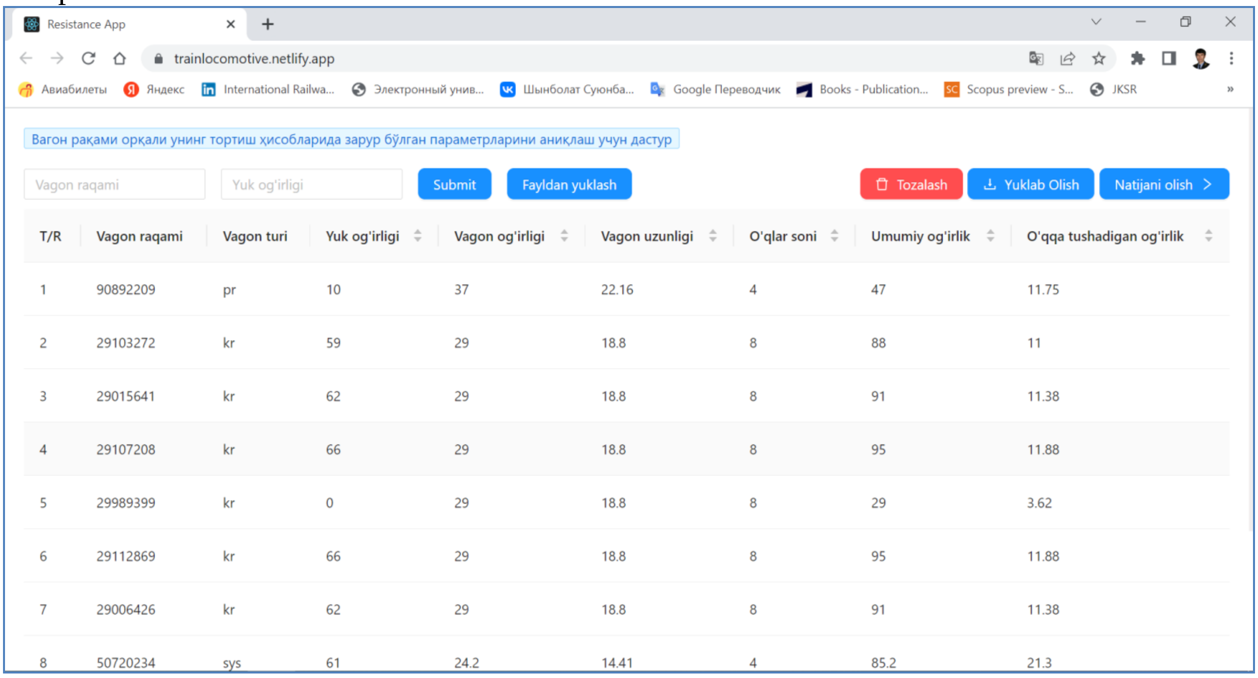
To calculate the rolling resistance of the wagons in motion, the wagons are divided into two groups, namely, four-axle and eight-axle wagons, in order to perform the current calculations. Their values are determined using formulas (3) and (5), respectively. [9-10]. The main reason for this is the complexity of identifying the contribution of different types of wagons in the composition of the train.

In operation, each freight train consists of different types of wagons and compositions loaded with different types of cargo. These, in turn, form trains with the same number of wagons made up of the same type. This allows for varying energy consumption in the different freight trains composed of similar sets of wagons. To calculate the operating costs for each train composition, the relevant parameters of the wagons in the composition (type, number of axles, length, and weight) and the weight of the cargo (net) must be determined through the calculation of the transport accounts. The parameters of the wagons are identified by their numbers, and the weight of the cargo can be determined based on the natural gauge of the train.

A database of the parameters for all six types of freight wagons was developed based on the "Manual for the Classification of Freight Wagons with 1520 mm Gauge and an 8-digit Numbering System". Using this database, a program was developed to identify the necessary parameters for the calculation of the transport accounts based on the wagon number.

A fragment of the results obtained from using the developed program can be seen in Figure 1. The program developed for the EHM calculates the following parameters in an automated manner based on the 8-digit number and net weight $q_n^k$ of the wagon taken from the natural gauge of the train:

- The total number of wagons in the train composition $\sum m$;
- The type $T_t^k$, number of compartments $K_o^k$, length $l_d^k$, and weight $q_t^k$ of each wagon in the composition.

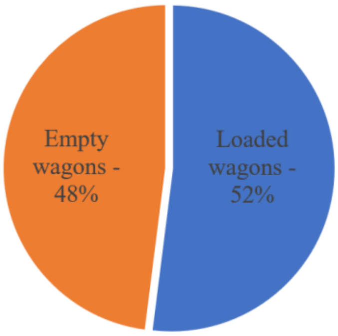



| T/R | Vagon raqami | Vagon turi | Yuk og'irligi | Vagon og'irligi | Vagon uzunligi | O'qlar soni | Umumiy og'irlik | O'qqa tushadigan og'irlik |
|---|---|---|---|---|---|---|---|---|
| 1 | 90892209 | pr | 10 | 37 | 22.16 | 4 | 47 | 11.75 |
| 2 | 29103272 | kr | 59 | 29 | 18.8 | 8 | 88 | 11 |
| 3 | 29015641 | kr | 62 | 29 | 18.8 | 8 | 91 | 11.38 |
| 4 | 29107208 | kr | 66 | 29 | 18.8 | 8 | 95 | 11.88 |
| 5 | 29989399 | kr | 0 | 29 | 18.8 | 8 | 29 | 3.62 |
| 6 | 29112869 | kr | 66 | 29 | 18.8 | 8 | 95 | 11.88 |
| 7 | 29006426 | kr | 62 | 29 | 18.8 | 8 | 91 | 11.38 |
| 8 | 50720234 | sys | 61 | 24.2 | 14.41 | 4 | 85.2 | 21.3 |

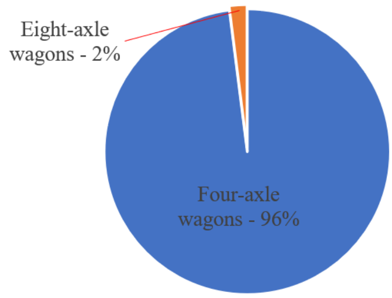
Figure 1.Fragment of the results obtained using the developed program.

In this way, the parameters necessary for the calculation of the draft of the wagons, including the main resistance to the movement of freight wagons, based on the weight $q_n^k$ of the cargo and the number of 8-digit wagons taken from the natural section of the train, were identified in an automated way.

**Results and Discussions.** The section of railway track from Chukursay to Sariyog'och in Uzbekistan Railways is considered one of the busiest freight corridors. In the course of the investigation, a separate analysis was carried out of the train traffic, types of wagons, and their condition (loaded or empty) for this section of railway track (Figures 2 and 3).




a) Results of observing the condition of the wagons (loaded or empty)




b) Results of the study of wagon axles

Figure 2. The results of studying the composition of trains on the “Chukursay-Saryogoch” railway section

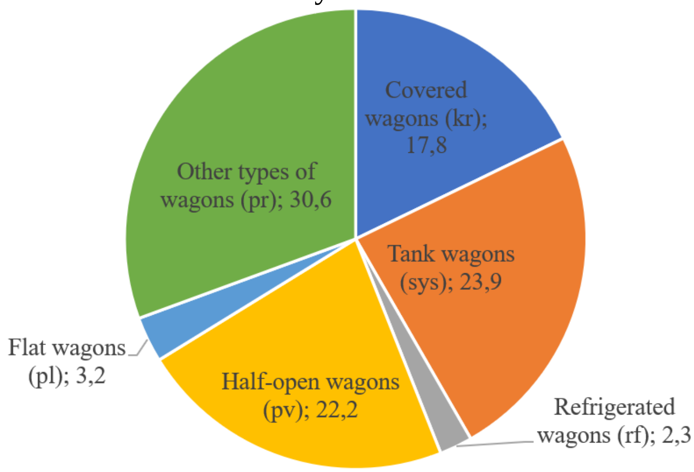



Figure 3. The results of studying the types of wagons in the composition of trains on the “Chukursay-Sariyogoch” railway section.

According to the second figure, it was observed that empty wagons in freight trains on the "Chukursay-Saryogoch" railway section constitute an average of 48% for the middle-sized wagons and 2% for the eight-axle wagons. Due to the small size of the eight-axle wagons, we will investigate the effect of the movement of four-axle freight wagons on the dynamics of the train. However, it was found that there are approximately half-empty wagons in the train composition on the investigated railway section. It is possible to observe the increase in the number of empty wagons in foreign railway systems as well [11].

The above findings indicate the necessity of separately calculating the dynamic resistance of the fourth group of wagons based on formula (4) during movement.

According to Figure 3, on the “Chukursoy-Sariyog'och” railway section, half-open wagons in the freight train consist have an average weight of 22.2%, tank cars have an average weight of 23.9%, and covered wagons have an average weight of 2%. Due to the small weight of covered wagons, it is necessary to calculate the separate solutions of the half-open wagons and tank cars for their movement using the formulas (1) and (2), respectively.

Therefore, the calculation of the movement of loaded wagons in the freight train with a weight distribution of 48% for empty wagons, 23% for loaded half-open wagons and tank cars has been made using the program developed for determining the main resistance (Figure 4).

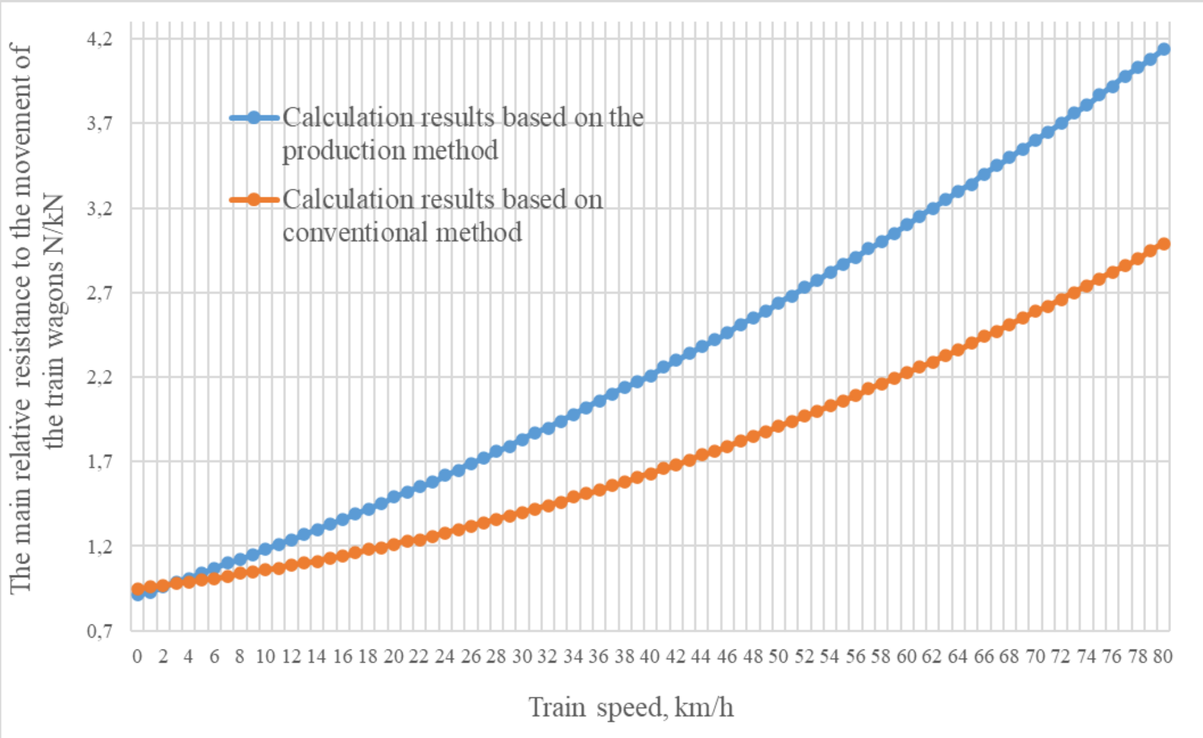



Figure 4. Results of calculating the traction resistance of freight wagons in the train composition.

According to Figure 4, it is necessary to calculate the differential expression of the resistance of freight cars based on movement speed for various types of train movements.

**Conclusion.** According to the "Rules for calculating train operations" developed in accordance with the 8-digit numbering system for freight cars with a 1520 mm gauge, freight cars are divided into 6 types (boxcar, platform, half-open car, tank car, hopper car, and others). The rules specify that freight cars should be grouped into 6 sets for the purpose of calculating the main resistance of trains. However, in practice, calculations of the resistance of trains during their movement on the tracks and the consumption of electrical energy are carried out by dividing freight cars into 2 sets (with 4 and 8 axles). The main reason for not taking into account all types of cars and all sets in the calculation of resistance is the absence of an appropriate instrumental means.

In the course of the research, a program was developed to identify the necessary parameters in the calculations of the wagon's movement based on the wagon number. This program was designed to automatically identify the necessary parameters in the calculations of the wagon's movement through the website https://trainlocomotive.netlify.app/. By using this program, the necessity of calculating the energy consumption of the train's primary resistance due to the movement of freight cars was determined. As a result, the program allows for the correct measurement of the travel time and energy consumption of trains based on the differentiated types and conditions (loaded or empty) of the freight cars in the train's composition.

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## WAYS TO SOLVE THE PROBLEM OF CONGESTION OF THE ASTANA CITY ROAD NETWORK

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Annotation. The intensive development of the transport infrastructure of Astana, the capital of Kazakhstan, along with the improvement of services to the economy and population of the city revealed a few previously non-existent problems in this area. Now the task of unloading the city during rush hours is becoming more urgent, and its solution requires the development of new technical and organizational solutions, one of which is the use of a system of "intercepting" parking.

Keywords: road network, road transport, traffic congestion, rush hour, "intercepting" parking, public transport, megapolis.

Currently, one of the most pressing problems of megacities is the congestion of the road network with car flows, the number of which is increasing from year to year.

The problem of traffic congestion is also characteristic of the capital of the Republic of Kazakhstan – the city of Astana.

The main reason for the transport problem lies in the initial layout of the city without considering the possibilities of widespread use of personal cars. During the construction of the current capital, it was assumed that the number of residents of the city would not exceed 500 thousand people, but as of January 1, 2023, the population of Astana amounted to 1,212,070 residents, while a third of the residents registered personal cars - this is more than 450 thousand vehicles [1].

The next reason is the long wait of Traffic Police officers in case of an accident, so even a small collision of two cars leads to traffic paralysis.

Another problem is the unsatisfactory condition of the roadway in a few places and the long and insufficiently organized repair of streets and roads [2].