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The “Journal of Transport” publishes the most significant results of scientific and applied research carried out in universities of transport profile, as well as other higher educational institutions, research institutes, and centers of the Republic of Uzbekistan and foreign countries.

The journal is published 4 times a year and contains publications in the following main areas:

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- Organization of the Transportation Process and Transport Logistics;
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- Car Service;
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Tashkent State Transport University had the opportunity to publish the scientific-technical and scientific innovation publication “Journal of Transport” based on the Certificate No. 1150 of the Information and Mass Communications Agency under the Administration of the President of the Republic of Uzbekistan. Articles in the journal are published in Uzbek, Russian and English languages.

CONTEXT / MUNDARIJA

Automation of operational control of wagon flows in the technological cycle industrial enterprises of railway transport

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Abstract: The article examines the role of the station duty officer in managing train traffic and shunting operations. The problems associated with the subjectivity of decision-making, the lack of clear regulations and centralized control systems are identified. Measures are proposed to automate the process of distributing cars using mathematical algorithms and set theory. An analysis of possible combinations of delivering cars to freight facilities and minimizing their waiting time is conducted. Using the example of the Zavodskaya station, the effectiveness of the modeled formulas is demonstrated, which made it possible to reduce the idle time of cars.

Keywords: railway transport, station attendant, shunting operations, automation, optimization algorithms, mathematical combinatorics, set theory, wagon delivery, minimization of waiting time, logistics

1. Introduction

In the conditions of railway transport, the work of the duty officer at the station plays a key role in ensuring the timely and rational movement of trains and shunting operations. However, in a situation where there are no clear orders, regulations or automated programs determining the order of supply and distribution of cars, the duty officer is forced to rely on his own experience, intuition and subjective assessments.

This approach, although it can be effective in non-standard or crisis situations, is associated with a number of significant risks. Firstly, the subjectivity of the decisions taken can lead to deviations from the optimal plan, which in turn can cause an increase in time and material costs. For example, incorrect distribution of cars can disrupt the rhythm of the technological process, cause train delays or create conflicts between different departments.

Secondly, making decisions based on the personal preferences or interests of the station attendant may become a factor in corruption or abuse of power, which is contrary to the principles of transparency and equality in customer service.

Thirdly, the lack of a centralized management system and standard algorithms leads to a significant increase in the workload of operational personnel, which increases the likelihood of errors under stress or time pressure.

2. Research methodology

From a scientific point of view, this problem highlights the need to implement modern automated traffic management and shunting systems based on optimization algorithms and big data processing. Such systems can take into account a wide range of factors, including the current state of the infrastructure, customer priorities, weather conditions and other parameters, ensuring decision-making based on objective data.

In addition, formalization and standardization of wagon distribution procedures should be accompanied by regular training of station attendants in modern planning methods and work with automated systems. This will minimize the influence of the human factor, increase the reliability of rail transportation and improve the overall quality of transport process management.

The variants of the sequence of delivery of groups of wagons depending on the number of freight objects and shunting locomotives are subject to the theory of mathematical combinatorics [104,105,38]. According to the theory of mathematical combinatorics, the number of options for transferring groups of wagons going to n objects with k shunting locomotives obeys the following law [104,105]:

$$C_n^k = \frac{n!}{k!\cdot(n-k)!}, \qquad (1)$$

$n -$ number of cargo objects, $n=10$;
$k -$ number of shunting locomotives, $k=6$.

Combination formula: $C_{10}^6 = \frac{10!}{6!\cdot 4!} = 210$

Thus, if the locomotives can deliver the objects in any order and it only matters which 6 of the 10 objects are selected for shunting, then the total number of combinations is 210.

Based on the condition that 6 locomotives work for 10 objects, then at the first feed we express the following combination: locomotives work on 1 2 3 4 5 6 objects, while in the second feed of this combination the locomotives will work on 7 8 9 10 objects, and so on, for all subsequent 209 combinations. It is required to determine the minimum waiting time for cars for the second feed.

The station has 10 freight facilities and 6 shunting locomotives. The waiting time in wagon hours depends on the number of wagons sent to each freight facility and the minimum duration of wagon delivery time.

The time costs for the delivery and removal of wagons to each of the cargo facilities are determined by the process schedule and can be presented in parametric form as follows:

$t_1 - t_{10}$ −times characterizing the process of supplying and removing wagons for each of the objects, starting from the first and ending with the tenth.

The number of wagons allocated for delivery to freight facilities on the station tracks is designated in the following parametric form:

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$n_1 - n_{10}$ –the number of cars from the first to the tenth object, respectively.

The station duty officer must distribute the shunting locomotives in such a way that, when performing operations to deliver and remove groups of wagons to freight facilities, the waiting time (wagon-hours) of groups of wagons to which a locomotive has not been assigned is minimized.

In this case, it is necessary to first send groups of wagons with the longest waiting time (wagon-hours) at the first delivery. Groups of wagons, assigned and not assigned to locomotives, at the first delivery to freight objects can be represented in the form of the following set theory:

$$N_1 \in \begin{Bmatrix} n_1 n_2 n_3 n_4 n_5 n_6 \\ t_1\ t_2\ t_3\ t_4\ t_5\ t_6 \end{Bmatrix} N_2 \in \begin{Bmatrix} n_7 n_8 n_9 n_{10} \\ t_7\ t_8\ t_9\ t_{10} \end{Bmatrix} \quad (2)$$

The waiting time for the delivery of wagons to freight facilities depends on the following elements:

$$\sum T_{wait} \in \begin{Bmatrix} T_{w1}, T_{w2}, T_{w3}, T_{w4}, T_{w5}, \\ T_{w6}, T_{w7}, T_{w8}, T_{w9}, T_{w10} \end{Bmatrix}. \quad (3)$$

The objective function for minimizing the waiting time of cars (car-hours) of groups from set theory will be the following:

$$\sum T_{wait} \to min \quad (4)$$

The minimum value of the objective function must be achieved. For the objective function to achieve the minimum value, the sum below must achieve the minimum value:

$$T_{wait}^2 = n_{max\,k+1} \cdot t_{min\,k+1} + n_{max\,k+2} \cdot t_{min\,k+2} + \cdots + n_{max\,i} \cdot t_{min\,i}, min. \quad (5)$$

$$\begin{Bmatrix} t_{min\,1}^2 \le t_{min\,2}^2 \le t_{min\,3}^2 \le t_{min\,4}^2 \\ n_{max\,1}^2 \ge n_{max\,2}^2 \ge n_{max\,3}^2 \ge n_{max\,4}^2 \end{Bmatrix}, \quad (6)$$

$[n_{max\,4} - n_{max\,1}]$ - the number of cars in the second set;

$[t_{min\,1} - t_{min\,4}]$ - the shortest in terms of time for filing - cleaning cars from the first set.

3. Research results

The results of the research obtained during the implementation of the simulated formula at the Zavodskaya station of JSC Uzmetkombinat are as follows: 30 wagons are accepted into the Zavodskaya station as a train, the distribution of these wagons for 10 freight objects for transfer and removal forms 210 combinations according to [38].

Based on the conditions of the simulated formula, cars distributed in descending order (for example, in the sequence 1:2:4:6:8:7 or 3:5:9:10), when distributed among freight objects with the largest number of cars and delivery-removal time, have a downtime of 93 minutes.

4. Conclusion

Automation of train traffic control and shunting operations is a necessary condition for increasing the efficiency of railway stations. The absence of centralized systems leads to subjectivity of decisions, which increases time and material costs, and increases the workload of personnel. The use of mathematical methods, including set theory and combinatorial analysis, allows formalizing the process of distributing cars, optimizing their supply and minimizing waiting time. The implementation of optimization algorithms helps to reduce the likelihood of errors, ensure the rhythm of the technological process and increase the transparency of operations. Experimental studies conducted at the Zavodskaya station confirmed the effectiveness of the proposed approach, which demonstrates the prospects of its application for improving the management of transport processes in the railway industry.

References

[1] Gmurman V.E. Probability Theory and Mathematical Statistics. - 12th ed., revised. - M.: Higher. school, 2006. - 479 p.

[2] Khudayberganov, S. K., & Suyunbayev, S. M. (2019). Results of application of the methods “sologub” and combinator sorting in the process of forming multi-group trains at the sorting station. Journal of Tashkent Institute of Railway Engineers, 15(4), 62-72.

[3] Kayumov Sh.Sh. Effective scheme of closing the hatches of railway gondola cars during loading and unloading operations / Sh.Sh. Kayumov - Text: direct. // Proceedings of the international scientific and practical online conference “Formation of intellectual capital in the context of digital transformation: experience, challenges, prospects”. Part I. -2022. - P. 315-317.

[4] Rasulov M.Kh., Kayumov Sh.Sh.U. Development of a device for efficient closing of unloading hatches of gondola cars during cargo operations in transport // Izvestia Transsib. - 2023. - No. 4 (56). - P. 56-63.

[5] Information site – [Electronic resource]. – https://randomus.ru/quick?from=1&to=6&count=1&norepeat=1&sort=1(date of access 15.11.2024).

[6] John J. Coyle, Robert A. Novack, Brian Gibson, Edward J. Bardi. Transportation: A Supply Chain Perspective. / Cengage Learning, 2010. ISBN 032478919X, 9780324789195, 528 p.

[7] Rodrigue, Jean-Paul, Comtois, Claude, Slack, Brian. The Geography of Transport Systems. DOI: 10.4324/9781315618159.

[8] Stroh, Michael B. A Practical Guide to Transportation and Logistics / Michael B. Stroh.- 3rd ed. p. cm. Includes bibliographical references and index. ISBN 0-9708115-1-9.

[9] Ibragimova G., Kayumov Sh. Simulation of the location of logistics terminals on the railways of the republic of uzbekistan: simulation of the location of logistics terminals on the railways of the republic of uzbekistan //Resource-saving technologies in transport. - 2022. - Vol. 2022. - No. 2022. - P. 44-46.

[10] Ermakova A.V. Determination of the reserve capacity of station elements with the allocation of time intervals for servicing non-public tracks [Text] / A.V. Ermakova, N.A. Mukovnina // Bulletin of the St. Petersburg University of Railway Engineering. St. Petersburg–2015 – No. 3 (44). – P. 39–44.

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