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Improving the standardization of wagon standby time at the sorting station

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Abstract. The aim of the work is to improve the methods of determining the standby time of transit recycling wagons at the sorting station. Systems analysis, analytical, graphical modeling, Ishikawi scheme and methods of comparing the performance of transit and local carriages were used. The reasons for the extra time lost by the wagons at the railway stations were given. Methods of adjusting the stopping time of wagons at the sorting station and their advantages, disadvantages and error rates were studied. The options and time costs of moving the wagon from one loading to the unloading location were analyzed, and the negative factors that cause the wagons to be overstayed at the sorting station were identified. In order to increase the level of performance of the sorting station performance and speed up the delivery of goods, a four-step method of reasonable standardization of the stopping time of wagons was recommended. This method allows you to analyze the time spent on each operation of the wagon on the road, to identify and eliminate inefficient time losses in a timely manner, to identify negative factors and increase the accuracy of standardization methods by 5-10%. Key words: Sorting station, transit wagon, wagon stay time at the station, calibration, calibration method, internal and external factor, inefficient time loss.

1 Introduction

Sorting stations play an important role in the effective organization of the transport process by rail. The main task of these types of stations is to distribute wagons at the destination stations in accordance with the plan of train construction in the minimum time intervals and to build new trains from them in a timely manner. [1-4].

The sorting station serves transit recyclable and non-recyclable as well as local wagons [1, 4]. Of these, the most important indicator of the work of marshalling yards is the time spent by transit wagons with processing [2-6]. Therefore, when developing a technological process for the operation of a station, the norms for the time spent by wagons are set separately for transit with processing [2, 4, 6].

At present, at most sorting stations, the stand-by time of wagons is set mainly using the methods recommended in the “Technological operation of the station” [2]. In this case, it is

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important to correctly set the waiting time of transit recycling wagons, which is the main quality indicator of the station.

In any modern type of sorting stations, the greatest loss of time in the processing of wagons is due to waiting for the completion of operations [2, 4, 5, 7]. The main reasons for this are as follows [1]:

– inadequate station work planning;
– lack of information;
– weak interdependence of departments and farms involved in a single technological process;
– negligence or incompetence of the staff involved in the process of receiving, distributing, constructing and dispatching trains;
– inefficient waste of time in the work process and the factors that cause them [2].

These factors, in turn, negatively affect the compliance of transit and domestic wagons with the established stopping time standards. Therefore, in order to eliminate such factors as above, it is advisable to further improve the methods of adjusting the standing time of wagons at the sorting station.

2 Methods

At present, in practice, the time spent by a transit wagon with processing is reflected in the form DO-24 VTS and includes elements (fig. 1) [1, 2].

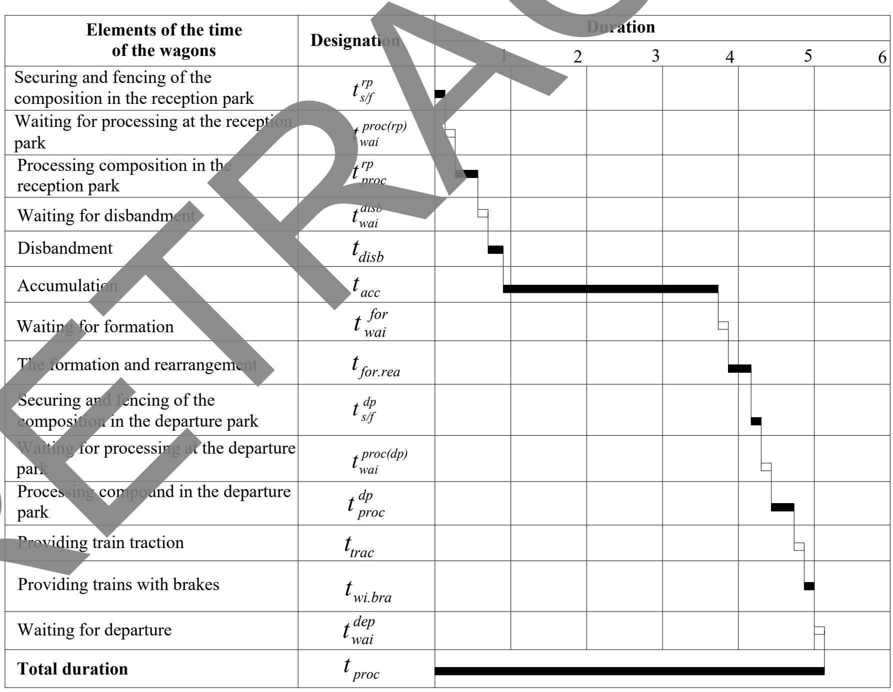

Fig. 1. Standby time elements of the transit recycling wagon at the sorting station and their duration

The above elements formulate formulas (1)-(4) for station parks as follows:
reception park:

$$t_{rp} = t_{s/f}^{rp} + t_{wai}^{proc(rp)} + t_{proc}^{rp} + t_{wai}^{disb}, \text{ h} \tag{1}$$

sorting park:

$$t_{sp} = t_{acc} + t_{wai}^{for} + t_{for.rea}, \text{ h} \tag{2}$$

departure park:

$$t_{dp} = t_{s/f}^{dp} + t_{wai}^{proc(dp)} + t_{proc}^{dp} + t_{trac} + t_{wi.bra} + t_{wai}^{dep}, \text{ h} \tag{3}$$

disbandment consists of the following elements:

$$t_{disb} = t_{arr} + t_{thr} + t_{diss} + t_{ups}, \text{ h} \tag{4}$$

where t_{arr} – time for a locomotive to arrive at the reception park; t_{thr} – time of the thrust of the train to the top of the; t_{diss} – time to dissolve the train from the hill; t_{ups} – time for upsetting wagons on the way to the sorting park.

(1)-(4) the formula forms the following on the sorting station:

$$t_{proc} = t_{rp} + t_{disb} + t_{sp} + t_{dp}, \text{ h} \tag{5}$$

Using the elements of fig. 1 for the analysis of the average time spent by a transit wagon at the sorting station, expands the possibilities of searching for unproductive time losses and subsequent elimination of the causes of their occurrence.

At the sorting station, two different methods are used to determine the transit and standby time of domestic wagons (Figure 2). [1, 3].

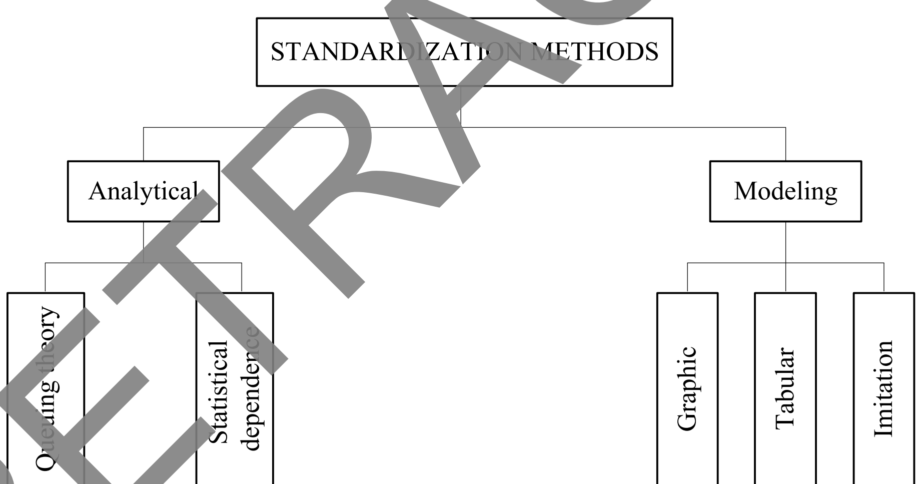

Fig. 2. Methods of determining the standing time of wagons at the sorting station

The main advantages, disadvantages and error rates of the calculation results obtained in the regulation of the stopping time of wagons at the sorting station of the methods shown in Figure 2 are given in Table 1.

Table 1. Characteristics of the methods of adjusting the standing time of wagons at the sorting station

№	Methods	Dignity-Advanteges	Disadvantages	Error rate
1	*Analytical*	1) simplicity of the model and low costs of computer time; 2) the ability to formulate analytical calculation ratios; 3)the ability to reflect multitasking work; 4)inter-operational expectations of wagons are taken into account; 5) the queues of operations are reflected.	1) the input stream is considered as the simplest; 2) the difficulty of obtaining analytical expressions for systems of great complexity; 3) the impossibility of describing parallel processes; 4) the difficulty of taking into account the uneven arrival of trains and trains.	Till 50%
2	*Graphic*	1) visibility and convenience of the analysis of the work of the station; 2) study well the technology of the station.	1) the complexity of the work; 2) the uneven arrival of train flows and wagon flows to the station is not taken into account; 3) fluctuations in the duration of technological operations are not taken into account; 4) the norms for the time spent by wagons are unrealistic and underestimated; 5) the work of the system for providing trains with locomotives and crews is not taken into account.	Till 20%
3	*Tabular*	1) the uneven arrival of train flows and wagon flows to the station is taken into account; 2) the possibility of modeling for any period of time; 3) get more accurate results.	1) high complexity of calculations; 2) does not allow to correctly take into account the occupation of the tracks, the work of locomotives, hostility in the necks, etc.	
4	*Imitation*	1) allows you to describe the simulated process with greater adequacy than other methods; 2) has a certain flexibility of varying the structure, algorithms and parameters of the system; 3) the use of computers significantly reduces the duration of testing compared to other methods.	1) complexity of model development; 2) large labor costs for conducting experiments and processing their results.	Till 5-10%

Note: The error rates of the methods given in Table 1 [8] are based on scientific work.

The analytical method has been used by many scientists at different times to measure the standing time of wagons at the sorting station [12-19]. For example, Professor N.N. Shabalin [10] proposed the following formula for determining the average stopping time of transit recycling wagons at the sorting station

$$t_{proc} = t_{proc}^{rp} + t_{wai}^{disb} + t_{hump} + t_{acc} + t_{wai}^{for} + t_{for.rea} + t_{proc}^{dp} + t_{wai}^{dep}, \text{ h} \qquad (6)$$

where is t_{hump} − hump technological interval, h.

At the same time, formula (6) does not take into account the influence of such elements as securing and fencing the train in the arrival and departure park, waiting for the train to be processed upon arrival and departure, and providing the train with traction and brakes.

The author of these items is described by the average waiting time

$$t_{wai} = \frac{\psi^2 \cdot (1 + v_{ser}^2)}{2 \cdot r \cdot (1 - \psi)}, \tag{7}$$

where is $\psi, v_{ser}^2 -$ respectively, the load factor of the input channel and the variation of the duration of service; $r -$ average hourly intensity of arrival of trains.

Also G.S. Vasiliev [11] proposed an empirical formula to determine the average waiting time for wagons at stations

$$t_{wai} = y \cdot \frac{n_{fre}^{pas} \cdot \left(8{,}1 \cdot \gamma_{sl}^2 - 8{,}65 \cdot \gamma_{sl} + 2{,}35\right)}{n_{wai}}, \tag{8}$$

where is $y -$ numerical factor; $\gamma_{sl} -$ slide loading; $n_{fre}^{pas} -$ daily number of passenger and freight trains; $n_{wai} -$ average queue length waiting for service.

The main disadvantages of analytical methods in all cases, they are used to determine the average time spent by wagons only in the subsystems of the station.

A typical technological process [10] recommends normalizing the time spent by a transit and local wagon at a marshalling yard using either tabular or graphical modeling methods. Although it is difficult to determine the stopping time of wagons using these methods (Table 1), the graphical method is widely used in practice..

Graphic modeling is an image of the marshalling yard for the processing of transit and local wagon flows during the day. On the daily schedule, the arrival and departure times of trains are taken in accordance with the train schedule. The duration of the reception, sorting, dispatch parks and processing of wagons on the sorting hill of the station, as well as the time of entry and exit of wagons on the freight yard and station tracks are given in the technological work of each station.

In this regard, the norms for the time spent by wagons, established on the basis of this method, turn out to be significantly underestimated, and the time losses are overestimated.

Despite the shortcomings mentioned above and in Table 1, the graphic method is currently used at the sorting stations (Chukursay, Khovast, Bukhara-1, etc.) owned by JSC "Uzbekistan Railways". One of the main reasons for using this method is that the stations are not equipped with modern technical means and devices.

The tabular modeling method consists in sequentially comparing the intensity of arrival of trains to the station and trains (wagons) to the station's fleets with the intensity of their output after processing for the simulated period. As a result of simulations, the probabilities of the states of the wagons and the time they are under operations are determined. And, the norms for the time spent by wagons at the station are quite approximate.

The simulation modeling method is one of the modern methods and its development is quite complicated. At the same time, a special algorithm is developed for the desired station on the sequence of processing of wagons (based on the "technological process of the station"), on the basis of which a model is created on a computer. The created simulation model mainly consists of three tabs (tabs) [12]: parameters, graph and log. On the "Parameters" tab, information about train flows and its processing is indicated. After the simulation process is completed, on the "Schedule" tab, an automatic train processing schedule is built for the specified period. Based on it, a table is compiled for the receipt and processing of wagons at the station.

The use of this method has no restrictions on the complexity of the described objects in the study of station systems. In addition, it allows solving a number of tasks to improve the technologies of the marshalling yard: to identify elements that limit the throughput and processing capacity, to justify the regulation of the time spent by railcars by elements, to evaluate the effectiveness of measures for the long-term development of the station.

Despite the complexity of developing an simulation model, it allows to achieve high efficiency in analyzing, evaluating the work of sorting stations and taking into account inefficient time losses.

3 Results and Discussion

Currently, the standard time for transit and domestic carriages at any sorting station is based on last year's statistics, and on this basis the time limit for the calendar year (in some cases, a separate time limit is set for each month) is set. However, the results of the study (Table 1) showed that such a method of regulation is not effective enough. It is therefore recommended that the standardization of wagon standby time at the sorting station be carried out in four stages. They are as follows:

1) Analysis of the process of the wagon from one loading to unloading (Fig. 3));

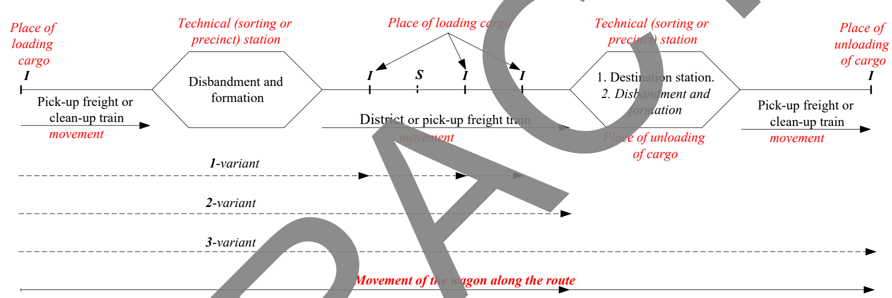

Fig. 3. Movement of the wagon from the place of loading to the place of unloading of cargo. I – intermediate station; S – siding.

This figure shows 3 variants of the scheme of movement of the wagon on the road from the loading address (intermediate station) to the loading address (technical or intermediate station):

In Option 1, once the wagon is loaded, it travels by train or pick-up train to the technical (sorting or section) station and participates in the distribution and construction of trains at that station. After that, the train at the technical station is sent to the place of unloading (intermediate station) by a national train formed in accordance with the schedule. In this option, the wagon can lose up to 60-70% of the total time spent on the road, mainly at the technical station.

In option 2, according to option 1, the section formed at the technical station is sent by train to the next technical station and the cargo is unloaded from the wagon in the yard of that station or on the way to the station. In this option, the wagon can lose up to 80-90% of the total time at the unloading facility (cargo yard and station road) in addition to the technical station.

In Option 3, after arriving at Technical Station 2 along the route under Option 1 and Option 2, the train is dispatched to the unloading point (intermediate station) by a team or freight train formed in accordance with the train construction plan at this station. In this option, too, the wagon may lose time as in Option 1.

2) Analyze the time the wagon spends along the way;

In the above options, the wagon will spend different times along the way. The length of time depends on several factors: the technical equipment of the railway line; technical parameters of locomotive and wagon; modernity of train traffic control systems; qualifications of employees involved in the technological process; technological work process of technical stations; train schedule schedule type; railway infrastructure, etc.

Based on the statistics of JSC "Uzbekistan Railways" analyzed the average time spent by the wagon on the road from loading to unloading (Figure 4).

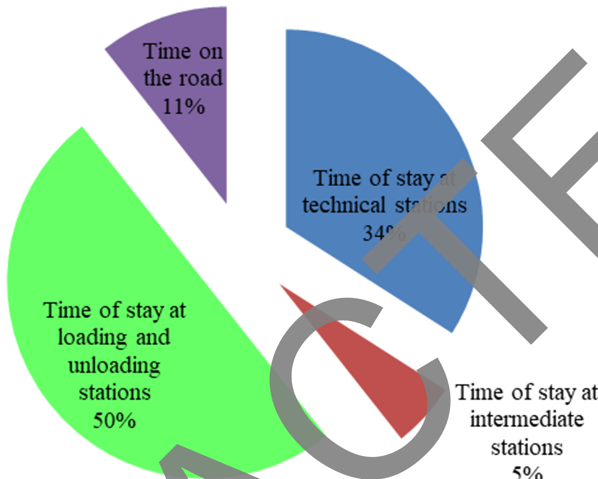

Fig. 4. Percentage of time the wagon is at different locations along the way

From the results of the analysis it can be concluded that at technical and loading and unloading stations (in most cases the loading and unloading station is the technical station itself) the duration of the wagon is more than 80% of the total time. This means that four-fifths of the total time spent on the road is spent on technical stations. This indicator, in turn, indicates the need for accurate and technologically sound regulation of the time of wagons at technical stations, as well as the need to further improve the methods of standardization..

3) Analysis of the time of the wagon at one station;

During the journey to the destination by wagon, there is a crossing (train crossing), intermediate (unloading, disconnection or connection of wagons from the train, train crossing) and technical (unloading, recycling, new train construction, transfer to the unloading facility)) can perform a variety of operations at stations. According to Figure 4, it is important to analyze the compliance of the wagon at the technical and loading and unloading stations with the time norms (Figures 5 and 6). Because the correct regulation of these times and control over their implementation will allow not only to increase the quality of station work, but also to reduce the main performance of railway transport, ie the delivery time of goods.

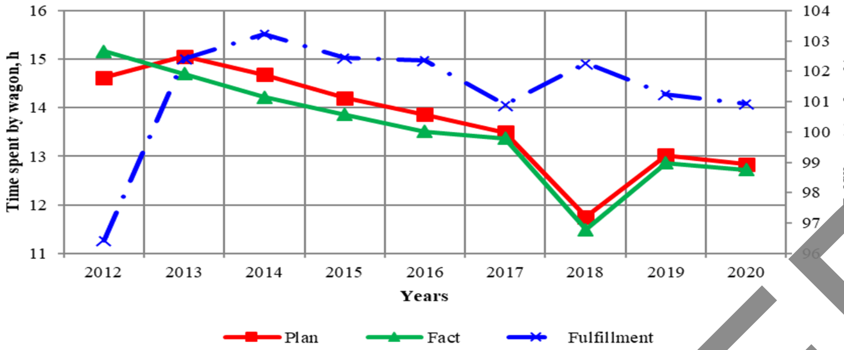

Fig. 5. The average stopping time of a transit wagon at one station

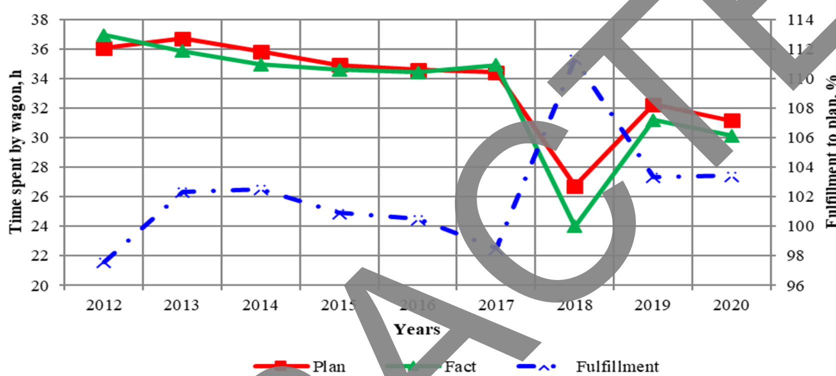

Fig. 6. The average stopping time of a domestic wagon per load operation

Figures 5 and 6 analyze the average stopping times of domestic wagons in transit at one station and in one freight operation over the years. The results of the analysis showed that the stopping time standards of wagons were met by an average of 101,4% (transit) and 102,3% (local) during the years studied. However, there is an average difference of 0,12 ÷ 0,54 hours for transit wagons and 0,19 ÷ 2,72 hours for domestic wagons between the set time norm (plan) and the time actually spent. This means that there is an inefficient loss of time in the process of carrying out technological and loading operations with wagons. This, in turn, necessitates the identification, systematization and analysis of negative factors that affect the process of performing various operations with wagons at the station

4) Identify and systematize the factors that negatively affect the standing time of the wagon at the station.

Factors that negatively affect the stopping time of the wagon [13-19] were divided into four groups as a result of scientific studies: continuous, random, external and internal (Fig. 7).

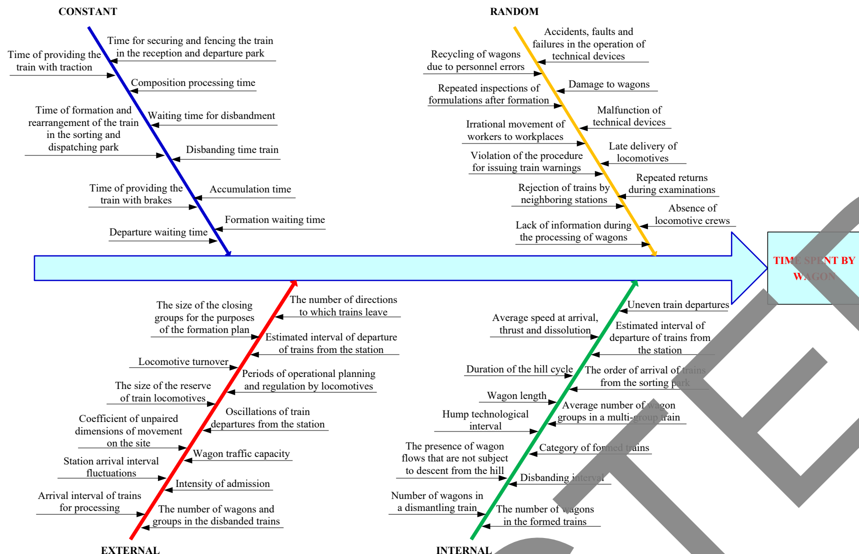

Fig. 7. Factors that negatively affect the standby time of the wagon at the sorting station

Existing regulatory methods typically take into account constant, external, and internal factors. However, the effect of random factors is not taken into account. This results in inefficient time losses in the operation of the sorting station. It is therefore recommended to add another parameter to formula (5).

The formula for determining the standby time of transit recycling wagons, taking into account the inefficient time losses in the operation of the sorting station

$$t_{proc} = t_{rp} + t_{disb} + t_{sp} + t_{dp} + \sum t_{itl}, \text{ h} \quad (9)$$

where $\sum t_{itl}$ – total inefficient time losses in sorting station operation, h.

In setting the time limit for transit recycling wagons to stand at the sorting station $\sum t_{itl}$ taking into account the parameter can also reduce the error rate of the existing methods (Table 1) by 5-10%. This method can also be used to standardize the time spent at transit non-transit and local wagons at stations.

4 Conclusions

The maximum time losses of wagons during the journey are due to maintenance, including sorting stations. Excess time loss at these stations is caused by waiting for technological operations.

The advantages and disadvantages of the methods of standardization of transit and standby times of local wagons at the sorting station show that the most effective way to analyze the performance of wagon stop times and control inefficient time losses is simulation modeling.

Many scientists have been involved in the regulation of wagon standby times at the sorting station at different times, but the parameters that make up the standby stages and standby time are different. Therefore, it was recommended to carry out the standardization of the standby time of the transit recycling wagon, which is the main quality indicator of the work of the sorting station, in four stages..

The advantage of the proposed method is the ability to analyze all the time spent by the wagon on the road from loading to unloading, to identify vulnerabilities in the overall chain, to analyze the implementation of time standards for transit and domestic wagons over the years and to identify factors negatively affecting downtime. As a result, the error rates of the calibration methods are reduced by 5-10%.

References

1. Butunov D.B. Improvement of technical experimental methods for organization of wagon flows and management evaluation at sorting stations. Dis. ... doc. Phil. (PhD). (Tashkent: TashIIT. – 2019)
2. B.B. Dilmurod, et.al., European Journal of Molecular & Clinical Medicine **7**, 2, 277-290 (2020)
3. K.B. Mukhammadiev, I.M. Mirzakulov, A.H. Karimov, Methodological Fundamentals of Formation of Ecological Culture in Students (2022)
4. D.B. Butunov, A.M. Bashirova, Academic research in educational sciences, **2(9),** 445-451. (2021). https://doi.org/10.24412/2181-1385-2021-9-445-451
5. D. Butunov, et.al., E3S Web of Conferences **460**, 06002 (2023). 1-9 pp. https://doi.org/10.1051/e3sconf/202346006002
6. Standard technical operating process of sorting station operation. Moscow, Transport Publ.,192 pages. (2003) http://scbist.com/scb/uploaded/1_1388200184.doc
7. D. Butunov, et.al., E3S Web of Conferences **389**, 05026 (2023). 1-10 pp. https://doi.org/10.1051/e3sconf/202338905026
8. A.E. Aleksandrov, Science and technology of transport **2**. 54-56 (2008)
9. D. Butunov, et.al., E3S Web of Conferences **402**, 03017 (2023). 1-12 pp. https://doi.org/10.1051/e3sconf/202340203017
10. Shabalin N.N. Optimization of process of processing of wagons at stations (M.: Transport, 1973)
11. G.S. Vasiliev *Norms for calculating the plan for the formation of trains* Vestn. VNIIZhT. **8,** 51-54 (1964)
12. S.S. Kotelnikov *Simulation modeling of stations operation* Modern problems of the transport complex of Russia: interuniversity. Sat. scientific. works – Magnitogorsk: Publishing house of Magnitogorsk. state tech. unver-ta them. G.I. Nosov. 2011 – p. 82–86
13. K.B. Mukhammadiev, Z.Sh. Tursunov, Use of Historical Materials of Ecological Content in the Process of Continuing Education (2022)
14. V.A.Bolotin, V.V.Efimov, J.R.Kabulov// Proceedings of Petersburg Transport University **3 (24).** 45-54 (2010)
15. J. Qobulov, J. Barotov, E3S Web of Conferences. Ural Environmental Science Forum on Sustainable Development of Industrial Region, (UESF 2023). DOI: 10.1051/e3sconf/202338905042.
16. A. K. Yusupov, S. T. Boltayev and Q. A. Kosimova, "Determination of the Required Number of Brake Shoes to Stop the Spontaneous Departure of Rolling Stock on Station Tracks" 2023 International Ural Conference on Electrical Power Engineering (UralCon), Magnitogorsk, Russian Federation, 2023, pp. 516-521, doi: 10.1109/UralCon59258.2023.10291136.

17. Bobrovsky V.I. et.al., Functional modeling of the work of railway stations: monograph; Dnipropetro. nat. un-t railway - d. transport them. acad. V. Lazaryan. (Dnepropetrovsk: 2015)
18. M. Saburov, et.al.,AIP Conference Proceedings **2432**, 030091 (2022). 030091-1-030091-5. https://doi.org/10.1063/5.0090343
19. Buriyev Sh., Butunov D., Pardayeva U. Non-productive time losses in sorting park operation, The scientific heritage **1,** 74 (74), 28-31 (2021), DOI: 10.24412/9215-0365-2021-74-1-28-31