MODELING FACTOR OF THE MAIN INDICATOR OF WORK OF A SORTING STATION

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Abstract:

The purpose of this article is to improve the methods of rationing the time spent by wagons at the sorting station based on the use of factor expanse. To solve the tasks set, the methods of system and factor analysis, statistical data processing, mathematical logic and factor modeling were used. An analysis of research papers on the topic of research is made and, as a result of the analysis, scientific tasks are established. Random factors influencing the processing of wagons at the sorting station are determined and formulated. An info-logical scheme and a factorial model have been developed on the example of the indicator “the time spent by transit wagons with processing” at the sorting station. The developed factorial models make it possible to study their changes depending on the action of factors, to carry out an accurate assessment of the work of the station staff and to correct the norm for the time spent by wagons.

Keywords: sorting station, factors, time spent by wagons at the station, info-logical scheme, causes of losses, factorial modeling.

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1. Introduction

The sorting stations of the railway network play an important role in the operation of railway transport, the implementation of the plan for the formation of freight trains, the rhythm of the transportation process, the rational use of vehicles, increasing the turnover of wagons, fulfilling the deadline for delivering goods, etc.

A particularly important role in ensuring the implementation of these issues is played by the qualitative indicators of the sorting station, including the average time spent by transit wagons with processing, without processing and local wagons at the station [1-6]. Therefore, in the theory and practice of operational work, the correct establishment of their norms and the implementation of these norms, as well as the development of calculation methods, are always relevant. However, its actual values in each day and month deviate significantly from their average daily values [6], adopted during technical regulation [1]. The reason for such a deviation in the work of the sorting station can be many random factors.

To eliminate these shortcomings, it is advisable to calculate and establish the norms for the time spent by at the sorting station based on factorial modeling.

Analysis of research works

The issues of analysis, evaluation and systematization of factors affecting the non-fulfillment of the time limit for the presence of wagons at the sorting station and the development of methods for factor modeling of the main qualitative indicators of the station's work are devoted to the work of many scientists. [7-13]. However, in these works, the issues of the relationship between the elements of the time spent by wagons and the influencing random factors of their non-fulfillment have been little studied. For example, the authors of [7] note that in order to reduce the time spent by a transit wagon with processing, it is necessary to analyze the work of a sorting station, taking into account negative factors in the process of disbanding and forming trains. However, the authors do not indicate the reasons for the occurrence of such factors and their relationship with each other and the impact on the elements of the time the wagons are at the station.

In [8], the average time spent by wagons in the receiving depot of a sorting station is determined as follows

$$t_{rd} = t_{wai}^{pro} + t_{pro}^{rd} + t_{wai}^{disb} + t_{pre}^{disb}, h \quad (1)$$

where $t_{wai}^{pro}-$ waiting time for processing, h; $t_{pro}^{rd}-$ time for processing the composition in the reception park, h; $t_{wai}^{disb}-$ waiting time for disbanding, h; $t_{pre}^{disb}-$ time for preparatory operations, h.

The author notes that the time spent by wagons depends on both external, independent of the station, and internal technological factors (Fig. 1). At the same time, figure 1 does not take into account the element of time for securing and fencing the train in the receiving park, as well as the influence of random factors.

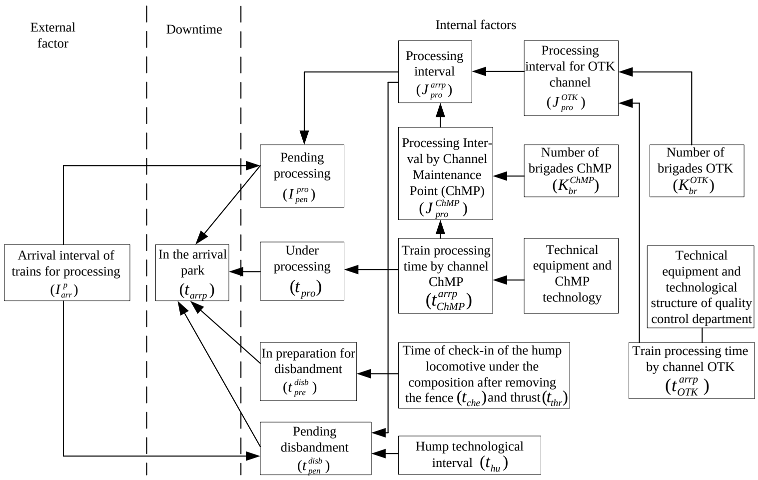

Fig. 1. Structural diagram of the dependence of the time spent by transit wagons with processing in the receiving park

In [9], he developed a sorting station model for normalizing its performance. Based on the simulation results, the element-by-element time spent by transit wagons with processing at the station is determined. When modeling, the probabilistic characteristics of train flows and the intensity of their service are taken into account, but random factors are not taken into account, which significantly reduces its adequacy.

In [10], he proposes to determine the average time spent by transit wagons with processing to describe the action of limiting elements based on the formula

$$t_{proc} = t^{rd}_{pro} + t^{disb}_{wai} + t_{hu} + t_{acc} + t^{for}_{wai} + t_{for} + t^{dp}_{pro} + t^{dep}_{wai}, h \quad (2)$$

where $t_{hu}-$ time hump interval when the train is disbanded, h; $t_{acc}-$ time spent by wagons under accumulation, h; $t^{for}_{wai}-$ waiting time for formation in the sorting station, h; $t_{for}-$ time to complete formation, h; $t^{dp}_{pro}-$ time to process the train in the departure park, h; $t^{dep}_{wai}-$ waiting time for departure in the departure park, h.

Formula (2) does not take into account some elements of the “time spent by transit wagons with processing at the sorting station”, which are described in [5] and the influence of random factors is not considered.

In [11], a technical and operational model was developed for organizing the movement of wagon traffic for the rational formation of trains. This model supplements the theoretical problem of train formation with new approaches to assessing the factors influencing the organization of wagon flows. However, when modeling the operation of the plant, the values of the factors are considered as inter-operational expectations, and not random factors.

In [12], the work on the organization of wagon flows at the sorting station was analyzed in order to reduce the time spent by wagons. As a result of the analysis, recommendations are given to reduce inter-operational expectations when forming trains.

In [13], he developed a model to improve the quality of the organization of the sorting station based on events. However, the simulation does not take into account random factors that arise during the processing of wagons.

The results of the analysis show that the authors separately studied the factors affecting the time spent by wagons at the station, but did not pay attention to the degree of their interaction with the elements that make up this indicator.

In this regard, the aim of the study was to develop a factorial model using the example of qualitative indicators of sorting stations - the time spent by transit wagons with processing (hereinafter referred to as the time spent by transit wagons). To achieve this goal, it was necessary to solve the following tasks:

-determination of random factors in the work of a sorting station and their mathematical expression;

-creation of a methodology for the development of a factorial model.

Determination of random factors in the operation of a sorting station

Losses at the sorting station include an overestimation of the established norms for the time spent by transit wagons in anticipation of technological operations, due to various random factors [5, 6, 14].

To identify random factors affecting the non-fulfillment of the time limits for the stay of transit wagons, an analysis was made of the operation of sorting stations of the Uzbek railway (Fig. 2 and 3).

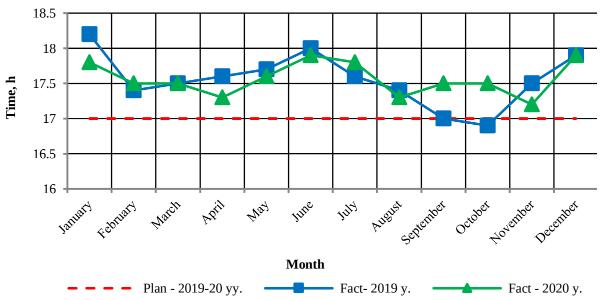

Fig. 2. Schedule of time spent by transit wagons at the sorting station “Ch”

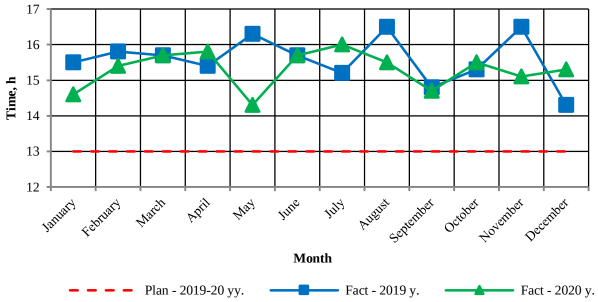

Fig. 3. Schedule of time spent by transit wagons at the sorting station “K”

As a result, a detailed analysis (Fig. 2 and 3) and research work [2, 5-15] made it possible to identify and formulate a list of random factors that affect the overestimation of the norms for the time spent by transit wagons, and for the convenience of developing a model, they are presented in mathematical terms s_k, k – index of random factors):

- accidents,defects and failures in the operation of technical devices – s_1;
- damage to wagons (for example, when disbanding from a hill) – s_2;
- damage or malfunction of devices and infrastructure – s_3;
- damage or faulty operation of objects station technology center (STC) – s_4;
- exceeding the time limit for technological maintenance of trains (wagons)– s_5;

- exceeding the time limit for commercial inspection and customs inspection – s_6;
- interruption in the supply of electricity or voltage drop in the contact network – s_7;
- contact wire burnout due to malfunctions of the shunting locomotive – s_8;
- malfunction of technical devices – s_9;
- malfunction of the shunting and train locomotive, as well as locomotive safety devices – s_{10};
- train radio failure due to locomotive malfunction – s_{11};
- untimely delivery of locomotives – s_{12};
- unavailability of brigades and sending locomotives under the formed trains with their timely issuance from the depot – s_{13};
- non-appearance of locomotive crews by the set time of train departure – s_{14};
- incorrect regulation of train traffic by a train dispatcher – s_{15};
- reprocessing of wagons due to personnel errors – s_{16};
- repeated returns during inspections – s_{17};
- repeated inspections of trains after formation – s_{18};
- acceptance of a train with a length exceeding the useful length of the station's receiving and departing tracks – s_{19};
- tying a train locomotive to a train with a valid ban on departure from the station – s_{20};
- shunting locomotives moving around the station at a reduced speed – s_{21};
- pressure drop in the brake line during testing of train brakes due to a malfunction of a freight wagons after undergoing technological maintenance – s_{22};
- overexposure of "windows" for track repair, contact network devices and technical devices – s_{23};
- self-uncoupling of automatic couplers between the locomotive and the first wagon during shunting operations – s_{24};
- irrational shunting movement (due to busy tracks in the parks, overlapping of the necks with long trains, etc.)– s_{25};
- irrational movement of workers to workplaces – s_{26};
- violation of the norms and procedures for securing a mobile unit on the tracks of the park by braking devices – s_{27};
- violation of the procedure for issuing train warnings – s_{28};
- violation of the plan for the formation of trains along the length of the trains – s_{29};
- improper use of technical means, including power supply devices, alarms, centralization and blocking, communications and anothers – s_{30};
- untimely or incorrect execution of transportation documents by employees STC – s_{31};
- incorrect tying of locomotives to trains in the system of the “Automated system for the operational management of transportation” – s_{32};
- incorrect actions of locomotive crews – s_{33};
- irrational use of working time by locomotive crews – s_{34};
- untimely cleaning of paths, parks, snow, liquidation of the consequences of floods, arrows from pollution – s_{35};
- failure to eliminate the mismatch of automatic coupler centers in the train, including between the locomotive and the wagon due to a malfunction of the wagon – s_{36};
- non-reception of trains by neighboring stations – s_{37};
- non-reception of trains by neighboring railways – s_{38};
- lack of order in the workplace (for example, non-observance of the order of the brake shoes)– s_{39};
- lack of information during the processing of wagons – s_{40};
- cancellation of the prepared route, due to violation of the procedure for preparing shunting and train routes – s_{41};
- uncoupling of a freight wagon due to a commercial failure after the formation of the train – s_{42};
- uncoupling of a freight wagon due to a technical malfunction after the formation of the train – s_{43};
- disruption of the departure of the train to the point with the transfer of the departure to a later time – s_{44};
- reduced traffic speed due to the poor condition of the pavement of the tracks, lack of lighting at night – s_{45};
- technical malfunction of the carriage upon arrival – s_{46};
- commercial malfunction of the wagon and violation of the conditions for securing cargo upon arrival – s_{47};
- increase in wagon traffic to a size exceeding the capacity of its processing at the station – s_{48};
- repair and track work not provided for in the station work plan – s_{49}.

Such random factors in the operation of a sorting station arise due to shortcomings in planning at the level of the dispatching apparatus, organization and management of operational work (including automation), violations of planning and accounting discipline, weak interactions with related departments involved in the same technological process. It should be noted that in order to improve the rationing of the indicator “time spent in transit wagons”, it is advisable to expand the scope of the factor space, taking into account random factors and include them in the factor model.

Development of a factor model

As applied to any indicator of plant performance, using a variety of methods. Let us build models of the factorial system of the indicator of the time spent by transit wagons (t_{proc}), based on a combination of the information-logical approach to the analysis of the loss of time.

According to the existing theoretical approach of the main model of the factor system, t_{proc} is a dependence used as parameters of conditionally constant factors, i.e. the parameters of the base model are the daily plan of the plant operation schedule (DPS).

Formal description of the factorial model [16], the indicator t_{proc} consists of three sets

$$\{H;P;L\}$$

where $H=\{h_i, i\in I\}-$ a set of conditionally constant factors, i.e. parameters DPS, i = [1,…, I]; $P=\{s_k, k\in K\}-$ many random factors – events, violations of the plant operation technology, k = [1,…, K]; $L=\{l_j,\ j\in J\}-$ many interconnections, j = [1,…, J].

To build a factorial model of indicators, we use the econometric method for determining schemes of parametric relationships.

At the first stage, the info-logical scheme t_{proc} can be built according to their parameters (Fig. 4). When constructing the info-logical scheme, the parameters of the reporting form were used DO-24 VTs [5, 17].

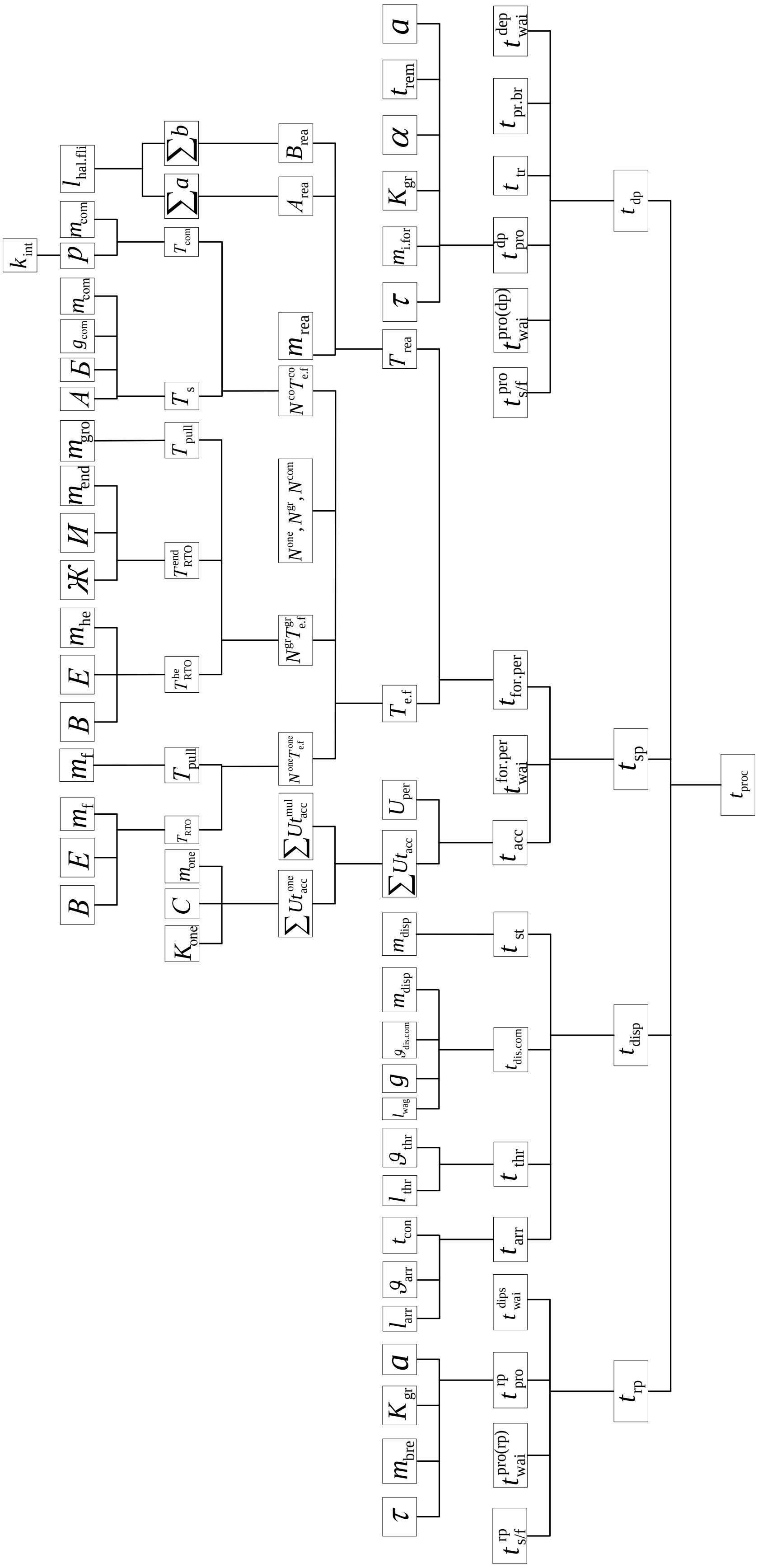

Fig. 4. Info-logical diagram of the indicator “time spent in transit wagons” at the sorting station

On the picture 4:

$t_{disb}-$ disbanding time, h; $t_{sp}-$ the time spent by the wagon in the sorting park, h; $t_{dp}-$ the time spent by the wagon in the departure park from the end of the formation of the train or its rearrangement in the departure park until the train departs, h; $t_{s/f}^{rp}, t_{s/f}^{dp}-$ respectively, the time for securing and fencing the train in the reception and departure park, h; $t_{wai}^{pro(rp)}, t_{wai}^{pro(dp)}-$ respectively, the waiting time for the processing of the train in the park of reception and departure, h; $t_{arr}-$ arrival time of the hump locomotive in the train reception park, h; $t_{thr}-$ time of thrust of the train to the hump of the hill, h; $t_{dis.com}-$ the time of the dissolution of the composition from the sorting hill, h; $t_{st}-$ time for wagons to stop on sorting ways per train, h; $t_{wai}^{for.per}-$ waiting time for the formation and permutation of the composition, h; $t_{for.per}-$ time of formation and permutation, h; $t_{tr}-$ train traction time, h; $t_{pr.br}-$ the time of providing the train with brakes, h; $t_{wai}^{dep}-$ departure waiting time, h; $\tau-$ time of inspection of one wagon, h; $m_{bre}-$ number of wagons in the breakdown train; $K_{gr}-$ number of groups of workers "Point of technical service" in one brigade; $a-$ time for preparatory and final operations, h; $l_{arr}-$ distance traveled by a locomotive on arrival, km; $\vartheta_{arr}-$ average speed on arrival, km/h; $t_{ext}-$ extra time to change direction, h; $l_{thr}-$ thrust distance, h; $\vartheta_{thr}-$ average thrust speed, km/h; $l_{wag}-$ wagon length, m; $\vartheta_{dis.com}-$ average speed of the dissolution of the composition from the hill, km/h; $g-$ number of disassemblings; $m_{disb}-$ the number of wagons in the trains being disbanded; $\sum Ut_{acc}-$ total wagon-hours of accumulation; $U_{acc}-$ the number of wagons participating in the accumulation; $\sum Ut_{acc}^{one}, \sum Ut_{acc}^{mul}-$ total wagon-hours of accumulation, respectively, of one-group and multi-group trains; $K_{one}-$ number of appointments of one-group trains; $C-$ accumulation parameter of one-group trains, h; $m_{one}-$ number of wagons in one-group trains; $T_{e.f}-$ time for the end of the formation of trains; $T_{e.f}^{one}, T_{e.f}^{gr}, T_{e.f}^{com}-$ respectively, the average time the end the formation of one-group, group and combined trains on a given hood; $N^{one}, N^{gr}, N^{com}-$ accordingly, the number of one-group, group and combined trains formed on a given hood; $T_{RTO}-$ technological time for performing operations related to the arrangement of wagons in accordance with the requirements of the "Rules for technical operation" (RTO); $T_{pull}-$ time for pulling up wagons from the side of the exhaust tracks to eliminate "windows" on the sorting ways; $B, E-$ normative coefficients depending on the average number of operations for uncoupling wagons attributable to one wagon of the formed train; $m_{for}-$ the number of wagons in the formed one-group train; $T_{RTO}^{he}, T_{RTO}^{end}-$ time for the arrangement of wagons according to the PTE, respectively, in the head and end of groups of the train; $m_{he}, m_{end}-$ number of wagons in head and end of groups; $Ж, И-$ normative coefficients depending on the number of operations for uncoupling wagons and the time spent on rearranging end of section to the assembly line; $T_{s}-$ technological time for sorting the composition on the hood, h; $T_{ass}-$ time to assemble groups of wagons on one track, h; $g_{com}-$ the number of cuts when sorting the stock of a combined train accumulated on one track; $A, Б-$ normative coefficients depending on the sorting method (shocks, upsetting) and the reduced slope; $m_{com}-$ average number of wagons in a combined train; $p-$ number of tracks from which wagons are transferred to the assembly track; $k_{int}-$ the number of train groups in the composition of the combined train, an equal number of intermediate stations of the section at which work is carried out on uncoupling and hitching wagons; $m_{ass}-$ the number of wagons moved to the assembly line of the formed train; $A_{rea}, B_{rea}-$ normative coefficients determined by summing the norms a and b for all half-flights when rearranging; $a, b-$ the norm of time for moving a shunting locomotive and one wagon, respectively; $m_{rea}-$ average number of wagons in the rearranged train; $\alpha-$ share of trains requiring labor-intensive uncoupled repair of wagons in the train; $m_{i.for}-$ the number of wagons in its formed train; $l_{hal.fli.}-$ half-flight length, m; $t_{rep}-$ the average duration of labor-intensive uncoupled repair of wagons in the train, h.

The developed infological scheme (Fig. 4) shows the restriction of the factor space of the indicator t_{proc} of the set by conditionally constant factors $H=\{h_i\}$, listed above.

At the second stage, we will introduce random factors (s_k) into the info-logical scheme that have a significant impact on the indicator t_{proc} during the performance of operational work, but are not taken into account when normalizing the time spent by transit wagons at the sorting station.

At the third stage of building a model of the factor system of the indicator, in order to balance the forecasts of deviations, we will form a combined model by searching for common conditionally constant factors.

As a result, a factorial model of the indicator t has been developed (Fig. 5), the structure of which is represented by eight hierarchical levels. Note that if it is necessary to deepen the analysis, the number of levels can be increased. In Figure 1…7th levels of the hierarchy there are conditionally constant factors h_i, the value of which is determined either by the DPS parameters or by other regulatory documents for the sorting station operation. At the 8th level of the hierarchy, there are random factors (s_k) associated with wagon expectations.

The developed factorial model of the indicator t_{proc} allows you to explore their changes depending on the action of factors s_k.

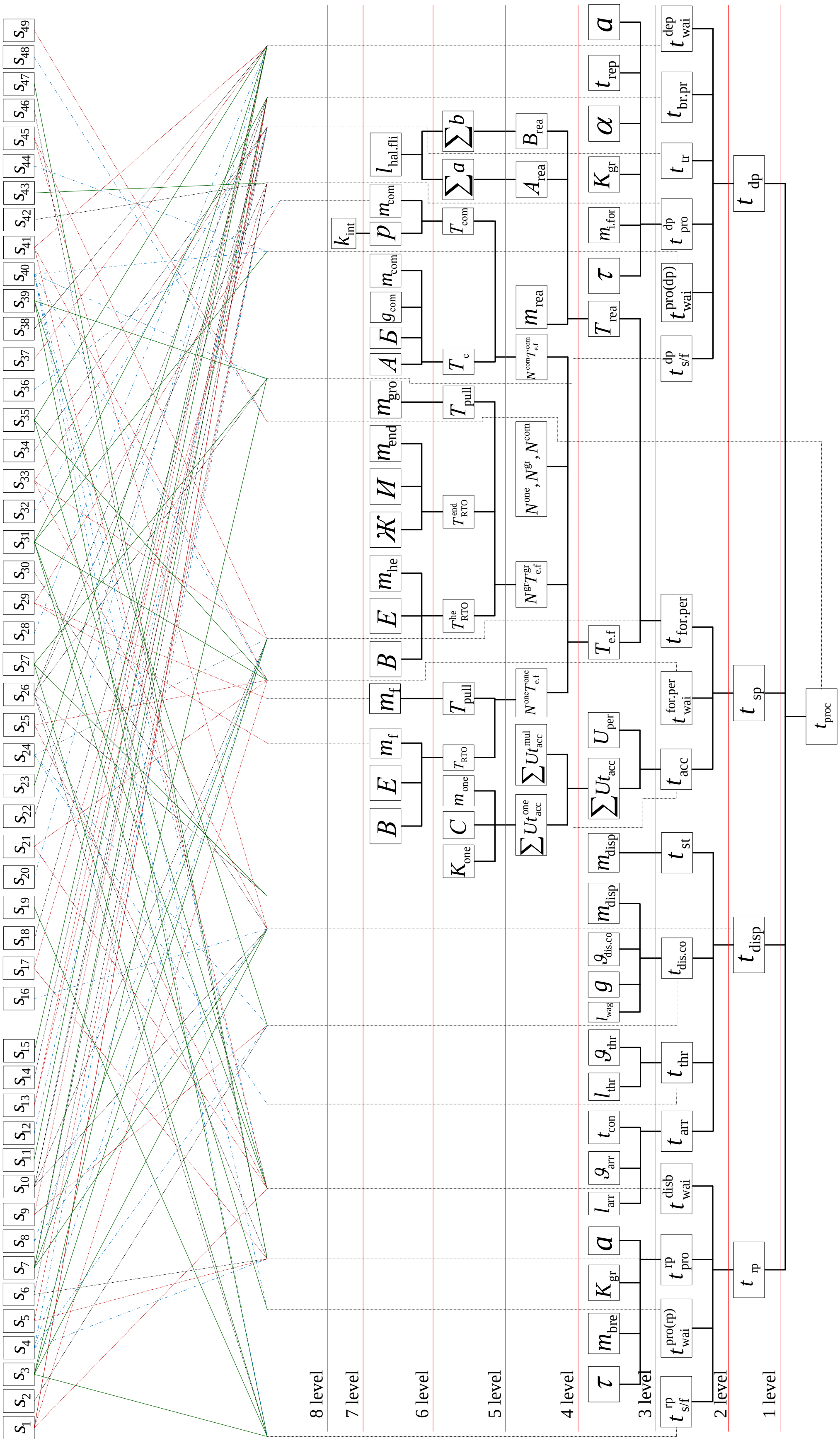

Fig. 5. Factor model of the indicator “time spent in transit wagons” at the sorting station

2. Conclusion

One of the main qualitative indicators of the sorting station is the time spent by transit wagons with processing.

Many scientists have been involved in factor modeling of the time spent by wagons at sorting stations and their development, but the sets of parameters used by them differ significantly from each other. In addition, the issues of the relationship between the elements of the time spent by wagons and the influencing random factors of their non-fulfillment have been little studied. Therefore, when developing the model, the parameters of the reporting form DO-24 VTs,currently used on the railways of the CIS countries, were used.

A list of conditionally constant and random factors influencing the fulfillment of the norm of the time spent by transit wagons at the sorting station is formulated.

The developed factorial model allows solving the problem of overcoming the information deficit in the analysis of random factors in the operation of a sorting station, and also makes it possible to accurately assess the work of the station staff. It also expands the boundaries of the factorial system of indicators by adding to the set of conditionally constant factors a set of random factors-technological events attributed by industry documents to technological violations and recorded by existing accounting systems.

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