ECONOMIC AND MATHEMATICAL MODELING HIDDEN LOSSES IN WAGON PROCESSING AT SORTING STATION

Butunov Dilmurod
PhD, Docent of the Department "Management of railway operations"
Tashkent state transport university (Uzbekistan)
dilmurodpgups@mail.ru
Pulatov Yadgor
Senior lecturer of the Department "Management of railway operations"
Tashkent state transport university (Uzbekistan)
Abdukodirov Sardor
Assistant of Department of "Management of railway operations"
Tashkent State transport University (Uzbekistan)
sardor_abduqodirov@bk.ru
Daminov Shakhriyor
Master's degree of Tashkent State transport University (Uzbekistan)
daminovshakhriyor@mail.com
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ABSTRACT

Purpose: Development of an approach to accounting, analysis and reduction of hidden losses during the processing of wagons at the sorting station. Method: Methods of economic and mathematical modeling are used. Result: The analysis of total losses at the sorting station is carried out. The concept of explicit and hidden losses during the processing of wagons at the sorting station is introduced. The main causes of losses have been identified. The necessity of accounting, analysis and reduction of hidden losses on the basis of their rationing is revealed. The analysis of existing methods of rationing the time spent by wagons and its disadvantage is carried out. An approach to accounting, analysis and reduction of hidden losses based on their rationing has been formed. A method of economic and mathematical modeling of hidden losses in the process of processing transit wagons at a sorting station has been developed. Practical significance: The daily analysis of hidden losses in the process of processing transit wagons, allows you to form statistical patterns of non-compliance with the norms of the time spent by wagons at the sorting station and develop action plans to reduce them to optimize the processing of wagon traffic.

Keywords: Sorting station, hidden losses, time spent by wagons at the station, approach, rationing.

INTRODUCTION

In any real technological process of processing wagons at sorting station, there is a certain level of losses [1, 13-20].

It is very important for a sorting station to be able to calculate losses at all stages of the technological process, keep timely records of them, as well as predict the causes and magnitude of losses in order to eliminate them more effectively.

By its nature, losses during the processing of wagons, according to [1, 2, 13, 18, 19] it can be divided into two groups: explicit and hidden.

Studies show that hidden losses can be attributed to losses resulting from:

– increasing the wagon traffic to a size exceeding the capacity of its processing at the station;

– moving shunting locomotives around the station at a reduced speed;

– irrational shunting movements at the station (due to the busy tracks in the parks, the overlap of the necks of long-composite trains, etc.);

– irrational movements of workers to the place of work;

– recycling of wagons due to staff errors;

– repeated returns for materials during commercial inspections;

– repeated inspections of trains after formation, etc.

In the operation of any station, hidden losses are less noticeable and, as a rule, station workers get used to them, consider them an inevitable part of the wagon recycling process. In this regard, hidden losses cannot be completely excluded in the work. Therefore, the identification and reduction of hidden losses during the processing of wagons is an important problem of the sorting station.

METHODOLOGY

Hidden losses during the processing of wagons at the sorting station arise due to deficiencies in the organization and management of operational work, violations of planning and accounting discipline, and entail an increase in the time spent by wagons at the station [1, 2, 13].

A number of works are devoted to methods for their accounting, analysis and reduction [3-8]. However, most of them disclose individual aspects without offering a general approach.

At the same time, it would be possible to propose an approach to accounting, analysis and reduction of hidden losses based on their rationing. Formally, this approach should correspond to the rationing of the time spent by wagons at the station.

The time spent by wagons, as is known [9-11, etc.] for sorting stations is the main qualitative indicator. Therefore, the correct normalization of its value plays an important role.

The time spent by wagons at the sorting station is normalized according to the methods established by the standard technological process of the sorting station [9]. The time spent by the wagon at each sorting station is normalized, based on the prevailing technological conditions with decomposition into constituent elements.

The norms of the time spent by wagons at the sorting station are calculated taking into account the rational technology of operation separately for transit wagons with and without processing, as well as local wagons [9].

The norms of the time spent by wagons at the station are determined based on the analysis of its performance in the current and previous months and the identical period of last year, and is set before the beginning of each month, depending on the amount of work at a given level of technical development, technology and management [9, 12, 13].

It should be noted, in this case, the value of the norm of the time spent by the wagons is obtained, as if an ideal copy of the actual operation of the station for a certain period of a day. It is obvious that the obvious and hidden losses that took place during that period are reflected in the actual values of the time spent by the wagons at the station.

The time spent by the wagons is most often normalized by building a daily schedule of the station. According to the data of the daily schedule, the costs of wagon hours are determined to calculate the quality indicators of the station. These costs are calculated by

summing up the wagon hours per day, both the total for the station and with the division into elements. Separately, the costs of wagon hours for interoperative expectations are determined. As a result, a set of indicators characterizing the operation of the station is obtained.

Figure 1 shows such a graph of the time spent by a transit wagon with processing.

The time element of the location	Designation	Duration 1 2 3 4 5
Processing in the reception park	t_{rec}	
Waiting for disbandment	t_{wait}^{disb}	
Disbandment	t_{disb}	
Accumulation	t_{accum}	
Waiting for formation	$t_{wait}^{for.proc}$	
Formation and rearrangement	$t_{for.proc}$	
Processing in the departure park	t_{dep}	
Waiting for departure	t_{wait}^{dep}	
Additional operations	$t_{add.oper}$	
Total duration	t_{proc}	

Figure 1. The graph of the dissected time spent by the transit wagon with processing at the sorting station

Establish the norm of the time spent by the transit wagon at the station [9]

$$t_{proc} = t_{rec} + t_{wait}^{disb} + t_{disb} + t_{accum} + t_{wait}^{for.proc} + t_{for.proc.} + t_{dep} + t_{wait}^{dep} + t_{add.oper}, \text{ч}$$

there t_{rec}, t_{dep} – the time when the wagon is in the receiving and departure park, h; t_{wait}^{disb} – waiting time for disbandment, h; t_{disb} – the time of the disbandment of the composition, h; t_{accum} – accumulation time, h; $t_{wait}^{for.proc}$ – waiting time for the formation and rearrangement of the composition, h; $t_{for.proc}$ – formation and permutation time, h; t_{wait}^{dep} – departure waiting time, h; $t_{add.oper}$ – the time spent by wagons under additional operations (cleaning, washing, steaming of wagons, etc.), h.

For each element, the wagon-hours of stay are determined, which are divided by the number of wagons of this category. The accumulation time of wagons is determined separately for each destination. The average accumulation time of wagons at the station is determined by dividing the sum of the wagon-hours of downtime for all purposes by the total number of wagons received per day on the accumulation path.

Let's analyze the structure of the average time spent by a transit wagon with processing (t_{proc}) at the station. Summing up separately the time spent on technological operations ($\sum t_{tech}$) and on interoperative waiting ($\sum t_{wait}$), the following expressions can be obtained.

$$\sum t_{tech} = t_{rec} + t_{disb} + t_{for.proc} + t_{dep}, h$$

$$\sum t_{wait} = t_{wait}^{disb} + t_{wait}^{for.disb} + t_{wait}^{dep}, h$$

Thus, the time of the transit wagon $-t_{proc}$ equally

$$t_{proc} = \sum t_{tech} + \sum t_{wait} + t_{accum} + t_{add.oper}, h$$

In general , this can be represented by a function of four arguments

$$t_{proc} = f\left(\sum t_{tech}, \sum t_{wait}, t_{accum}, t_{add.oper}\right)$$

As is known from the theory and practice of marshalling yards [9-12, etc.], the time spent by transit $-t_{proc}$, wagons is directly dependent on the volume of processing of $-U_{proc}$, wagons, and with an increase in the volume of U_{proc},, the components of t_{proc} change differently (see Fig. 2). So, $\sum t_{tech}$ depends on the level of technical equipment and technology of operation and changes little with the change of U_{proc}. The value of $\sum t_{wait}$ very significantly depends on the value of U_{proc}, since with an increase in the loading of station devices by processing wagons, the waiting time for processing increases. The magnitude of the accumulation process of (t_{accum}) wagons is inversely related to the magnitude of the processed wagon flow (U_{proc}). The value of $t_{add.oper}$ practically does not depend much on the value of U_{proc}. These dependencies are shown in Figure 2.

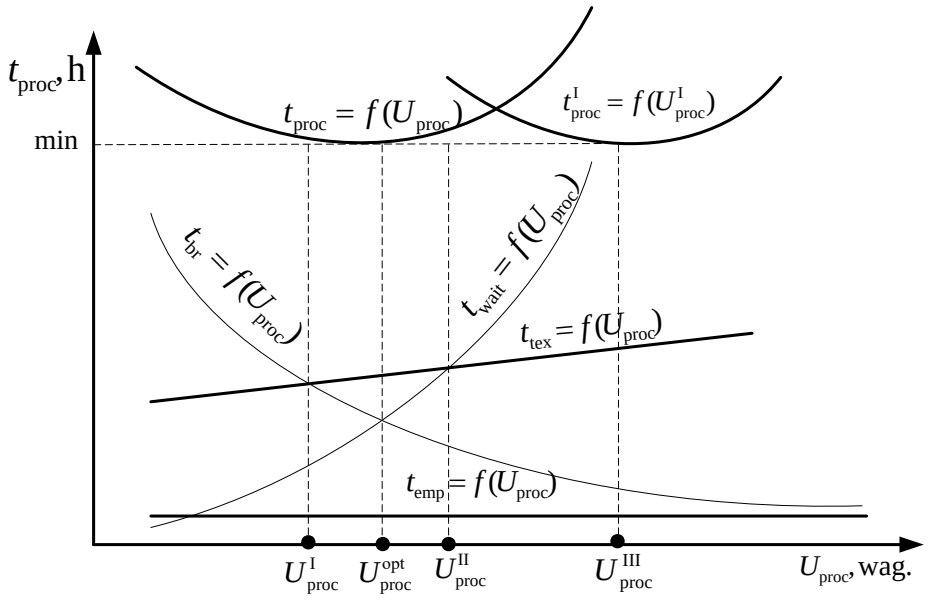

Figure 2. Dependences of the time spent by wagons on the volume of their processing

Thus, when rationing the time spent by wagons at the station, the volume of work of the station and the parameters of technical equipment and technology of operation are taken into account.

This shows that the existing systems of technical rationing of the time spent by wagons at the sorting station do not take into account any reasons for losses in the operation of the station. Consequently, the current calculation method for rationing the time spent by wagons at stations, as well as the order of analysis, need to be changed.

The analysis of robots [3-8] shows the importance and relevance of developing a common approach to accounting, analysis and reduction of hidden losses during the processing of wagons at the sorting station on the basis of their rationing. Therefore, at

present, the development of common approaches to technical rationing of the time spent by wagons at the station remains one of the most urgent tasks.

DISCUSSION AND RESULTS

Losses in the operation of the sorting station are such things that they require more careful consideration.

Therefore, in order to solve the task, it is proposed to consider losses in shifts (Fig. 3) in order to perform daily tasks and monthly technological norms of the time spent by wagons, as well as to study in detail the reasons for not performing and to develop timely and reasonable measures to reduce it in the operation of the station.

To do this, every shift it is necessary to analyze the time spent by wagons during processing and set a daily task for its implementation in accordance with the causes of losses.

Figure 3. Structure of accounting, analysis and reduction of hidden losses in the operation of the station based on their rationing

The presented structure (Fig. 3) allows us to study in more detail the causes of losses, based on their rationing and objectively assess the time spent by wagons at the sorting station.

Therefore, when rationing the time spent by wagons, the planned one should take into account not only the volume and technology of the station and technical equipment, but also the limits of possible deviations, i.e. unproductive time losses (the reasons for obvious and hidden losses obtained in the results) and lay down in the standards.

Unproductive loss of time during the processing of wagons at the sorting station is determined by the formula

$$t_{unp.loss.time} = t_{obv} + t_{hid}, h,$$

there t_{obv}, t_{hid} – time for obvious and hidden losses during the processing of wagons, occurring as a result of the causes of obvious and hidden losses.

Based on this, the total time spent by a transit wagon with processing at a sorting station should be normalized, first of all, according to the following elements:

$$t_{proc} = \sum t_{tech} + \sum t_{wait} + t_{accum} + t_{add.oper} + t_{unp.loss.time}, h.$$

Thus, when rationing the time spent by wagons at the sorting station, taking into account unproductive time losses, it allows you to find out the condition of the time spent by wagons by individual technological operations and determine the possibility of making decisions on adjusting and improving the technology of processing transit wagons.

The correct rationing of the time spent by transit wagons at the sorting station, and the analysis of its implementation determine the quality, efficiency and technology of the station.

As noted above, the planned norm of the time spent by wagons at the sorting station is set for a month, and in turn is the task for the day, i.e. in this case $t_{month}^{plan} = t_{day}^{plan}$. However, in

practice their actual values differ significantly from each other, i.e. $t_{month}^{fact} \neq t_{day}^{fact}$ (see Fig. 5 a, b).

The average daily and average monthly actual time spent during the processing of wagons at the sorting station is determined by the following formulas

$$t_{aver.day}^{fact} = \frac{\sum Ut_{proc}}{U_{proc}}, h \text{ and } t_{aver.month}^{fact} = \frac{\sum Tt_{day}^{fact}}{T}, h$$

there $\sum Ut_{proc}$ – wagon-hours cost amounts; U_{proc} – number of processed wagons; T – the time period, i.e. the number of days.

Rationing of the time spent by wagons per day or month should be based on a reliable qualitative analysis of the work of the sorting station.

Therefore, the paper analyzes the time spent by transit wagons with processing at the sorting station Ch in the daily period for 2021-22. (Fig. 4), in order to study the state of their location and determine the proportion of unproductive time losses.

The division of the transit wagon's stay time with processing into technological operations and interoperative waiting (unproductive loss of time) was performed (Fig. 4). It was revealed that unproductive time losses account for over 45% of the total time spent by wagons. Based on Fig. 4, it can be concluded that the loss of time in the operation of the station has a significant impact on the fulfillment of the norm of the time spent by the transit wagon with processing.

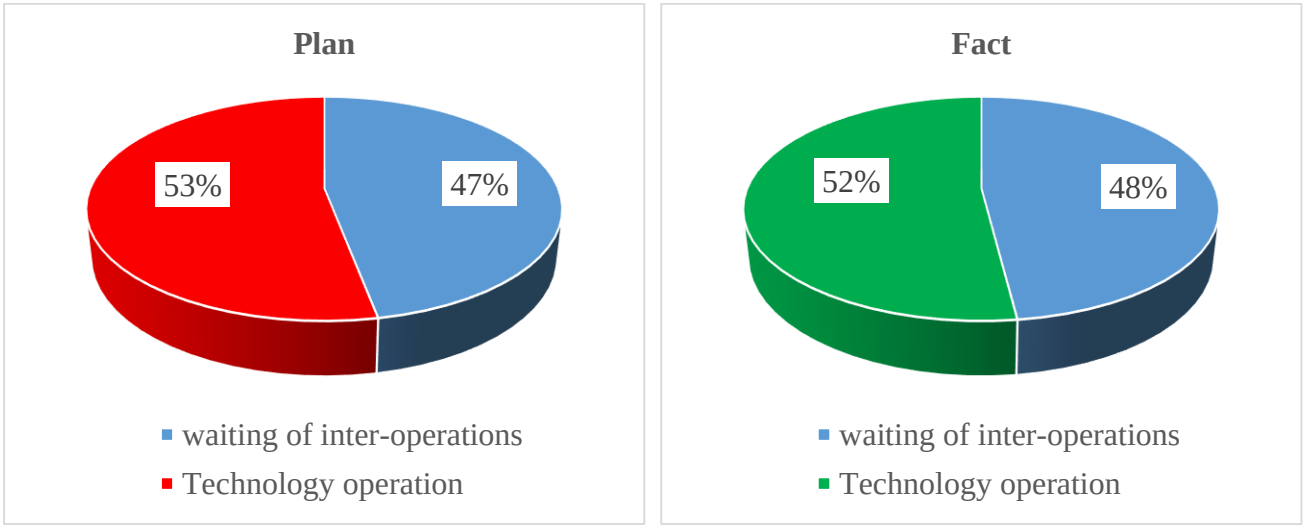

Figure 4. The share of time spent on technological operations and interoperative waiting at the Ch station (excluding accumulation time)

It can be concluded that the time spent by the wagons practically depends on the time period under consideration.

Based on this, it was found in the work that it is advisable to set the norms for the time spent by wagons at the station taking into account seasonal periods in order to correctly assess the effectiveness of the station's technology when processing wagons.

CONCLUSION

The implementation of the proposed model of accounting, analysis and reduction of hidden losses based on their rationing makes it possible to build technological processes for processing wagons that do not have losses, and as a result, this makes it possible to increase the processing capacity of the sorting station, as well as reduce economic losses.

Thus, this approach allows you to objectively assess the time spent by wagons at the sorting station, timely and reasonably develop measures to reduce it, and also makes it possible to carry out shift-daily monitoring and manage the performance of station indicators.

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