Formation of a Mechanism for Minimizing Risk and Economic Losses when Optimizing the Working Hours of Locomotive Crews

Shkurina Lidiya Vladimirovna[1], Struchkova Evgeniya Vladimirovna[2]
Russian University of Transport, 127994, GSP-4, Moscow, Obraztsova str ., 9, building 9
shkurinalv@mail.ru, evstruchkova@yandex.ru

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Abstract: The article considers the issues of increasing the efficiency of the use of human resources in the traction directorate by reducing the unproductive costs of working time of locomotive crews. The paper analyses the current state of information systems that reflect the accounting of working hours of employees of locomotive crews (a report on the use of working time and rest time of locomotive crews, a report on compliance with the work and rest regime of locomotive crews, a report on the fulfilment by locomotive crews of working time standards in freight traffic). The study of the working time of employees of locomotive crews allowed the authors to establish its unproductive costs, as well as to differentiate it into traction dependent on employees of the directorate and independent of them. Based on the analysis of working hours, the main factors influencing the excess of the established norms for the trip of the locomotive crew in freight traffic, the following by the employees of the locomotive crew by the passenger and the overtime hours of the locomotive crews were established. Based on a systematic study of risk factors for unproductive work of locomotive crews, mechanisms have been developed to reduce economic losses and increase labor productivity of employees of the traction directorate.

1 INTRODUCTION

Global trends in economic development require increased efficiency of transport, including the most productive use of all types of resources, including labor, which is becoming one of the priority areas of strategic development. As early as the mid- 19th century, K. Marx, while preparing one of his most important works, pointed out that: “All savings ultimately come down to saving time” (Marx, 2018). In this regard, studying the use of working time by employees of the main production groups of railway transport and developing proposals for its rationalization is of scientific and practical interest. Currently, the country's transport complex faces the problems of solving technological, organizational and managerial tasks of reducing costs in all business processes.

Historically, Russian railway transport has significant development features that differ from the evolution of foreign railways: Russian railways chose their own path and followed it strictly. This aspect characterizes significant differences in approaches to organizing the work of locomotive crews - on Russian railways of the main production group. This is explained by organizational, technological, legal and economic differences.

In accordance with the Order of the Ministry of Transport of Russia dated March 9, 2016 No. 44, the working hours of locomotive crews are limited to two reference points: the moment of arrival and the moment of release from work. Between these two points, locomotive crew workers perform a number of mandatory actions before the start of the trip and after its completion. In addition, the use of locomotive crews in time has a number of significant regulatory restrictions. Therefore, each element of the working time of these workers must be considered through the prism of all influencing factors (both internal and external) to assess the possibilities of its rational use.

[1] https://orcid.org/0000-0001-7848-8542
[2] https://orcid.org/0000-0003-2115-6365

The solution of these problems is within the competence of transport scientists and various railway specialists, since the working time of locomotive crews is the area of responsibility of representatives of almost all railway transport enterprises. The dynamic development of railway transport dictates its requirements and sets the vectors for searching for reserves to increase the efficiency of using the working time of locomotive crews, reduce unproductive costs of their working time and, as a result, directions for increasing labor productivity. In the last decade, there has been an increased interest in this issue, which is characterized by an increase in publications on this topic.

A great contribution to improving the efficiency of locomotive crew management was made by V.N. Morozov, who for many years held key positions in the central office of Russian Railways (Moscow, Russia) (hereinafter referred to as JSC Russian Railways). Thus, in his monograph (Morozov, Shapkin, 2019), Vadim Nikolaevich substantiated the need to introduce fixed "threads" of the train schedule, primarily for the purpose of forming personal schedules of locomotive crews, which as a result ensures a reduction in mileage standards, and also contributes to the rational use of locomotive crews in time and, as a consequence, the optimization of their numbers.

The authors Yu.S. Kozhevnikova and T.A. Bulokhova (Kozhevnikova, Bulokhova, 2021) from the Irkutsk State University of Railway Engineering studied the reserves for optimizing the working time of locomotive crews in terms of travel time by organizing the work of crews on extended shoulders without changing locomotive crews. However, it should be noted that there are risk factors here, such as failure to comply with the train schedule (for reasons that require an independent study), the consequences of which will lead to exceeding the established maximum working time norm.

Vlasensky A.A. (Vlasensky, 2014) investigated the problems of using locomotive crews on long-distance routes, but this author, in our opinion , look , there was not enough formalization of their results.

A significant study was conducted by V.N. Kovalev and V.L. Salchenko in 2008 (Kovalev, Salchenko, 2008) regarding the calculation of the optimal number of locomotive crew workers in conditions of ensuring solid schedule "threads" and developing personalized schedules for their work based on the linear programming method, namely the multi-extremal integer programming problem ("traveling salesman problem"). The models proposed by these authors make it possible to practically evaluate the stability of train schedules and ensure the transportation process with the optimal number of crews. But in the context of this publication, it would be interesting to provide an assessment of the effectiveness of this proposal from an economic point of view.

In this regard, it should be noted that the technical, technological and regulatory aspects of the organization of working time of locomotive crews are changing quite dynamically, so the subject of scientific interest is transforming and developing. In their study, the authors of the article focused their attention exclusively on one part of the working time of locomotive crews (preparatory-final and auxiliary time), the formation of which occurs in operational locomotive depots and is completely managed by their managers.

2 MATERIALS AND METHODS

The main objective of this study is to find internal production sources and reserves for increasing the efficiency of using the working time of locomotive crews in the context of investment restrictions to ensure sustainable growth in the productivity of railway workers and, in particular, locomotive crews when improving the business process "Provision of locomotive traction services". To achieve this goal, it is necessary to solve the following tasks:

1) to study the peculiarities of the organization of work of locomotive crews using the example of a specific operational locomotive depot;
2) conduct an analysis of unproductive costs of working time of locomotive crews;
3) identify risk factors for unproductive work of locomotive crews;
4) to assess the economic losses arising in the locomotive operating depot and the Traction Directorate.

In order to identify unproductive expenditures of working time, it is necessary to analyze the entire complex of production operations of the business process "Provision of locomotive traction services". It should be noted that the time costs for the implementation of this business process depend both on the locomotive crew workers themselves and on

the organization of effective interaction between workers of other regional directorates participating in this business process: the Traffic Management Directorate, the Infrastructure Directorate, etc.

When assessing the efficiency of using the working time of performers of production operations, standard methods are used, including those approved by JSC Russian Railways for railway transport workers. The coefficient of possible growth in labor productivity with a reduction in the risk of unproductive losses of working time is used as the main indicator in the analysis of working time. The following information systems are used to analyze the use of working time of locomotive crews and risk factors for unproductive losses:

- The automated system for centralized processing of driver routes (TSOMM) allows monitoring the work of locomotive crews and the performance indicators of locomotives;
- The Unified Corporate Human Resources Management System (UCHRMS) performs functions for organizing, paying, motivating and regulating labor, allows for recording and analyzing the working hours of locomotive crews, and identifying the causes of overtime work.

Based on the data from the information systems, a number of reports are generated that reflect the working conditions of locomotive crews and indicators characterizing the volume of work and time characteristics of the production process. Thus, the "Report on the use of working time and rest time of locomotive crews" includes data from the driver's routes and diesel fuel and electricity accounting statements on locomotives as primary information. The report contains the following indicators:

- number of driver routes accepted for accounting;
- working hours of locomotive crew workers, including those working “as one person”, broken down by work elements and types of movement, total hours;
- number of hours and cases of travel by the passenger;
- hours worked on non-working holidays within and in excess of the standard working hours;
- hours worked overtime;
- the number of hours of absence of locomotive crew members, broken down by reason (annual basic (additional) leave, absence due to illness, study leave, advanced training, absence for periodic medical examinations, leave without pay, replacement of locomotive crew driver-instructors).

The internal statistical reporting form “Report on compliance with the work and rest regime of locomotive crews” is also used as an analytical basis for identifying risk factors for unproductive work of locomotive crews. This report reflects data on violations of the work and rest regime, use of working time based on the results of processed routes of drivers according to the following indicators:

- working more than two nights in a row;
- work of teams less than 3 hours;
- work of teams over 12 hours;
- cases of rest at the point of turnover;
- cases of departure by train while being at work for more than 2 hours;
- cases of passengers following for a change on the line.

Data on unproductive losses of working time from exceeding the standards for the turnover of locomotive crews in freight traffic can be obtained on the basis of the "Report on the fulfillment of working time standards by locomotive crews in freight traffic", which is generated by the Main Computing Center of JSC Russian Railways in the Unified Corporate Automated System for Managing Labor Resources based on the processed routes of the driver. To generate the indicators in this report, all working time from reporting for work until the end of work is analyzed for each section, locomotive operating depot and the Traction Directorate.

3 RESULTS

The risk of unproductive work of locomotive crews and associated economic losses usually arises as a result of the following factors:

- non-pairing of freight trains according to the schedule;
- exceeding the established standards for the turnover of the locomotive crew;
- setting speed limits after major track repairs, etc.

To determine the time of unproductive work of locomotive crews, it is necessary to compare the actual time spent on the trip and its standard value. But for more correct management decisions, it is necessary to consider this time element by element, since the structure of unproductive costs of

locomotive crews' working time determines the horizon for finding optimal solutions. The structure of unproductive losses of working time in the regional Traction Directorate for 2020 is shown in Fig. 1.

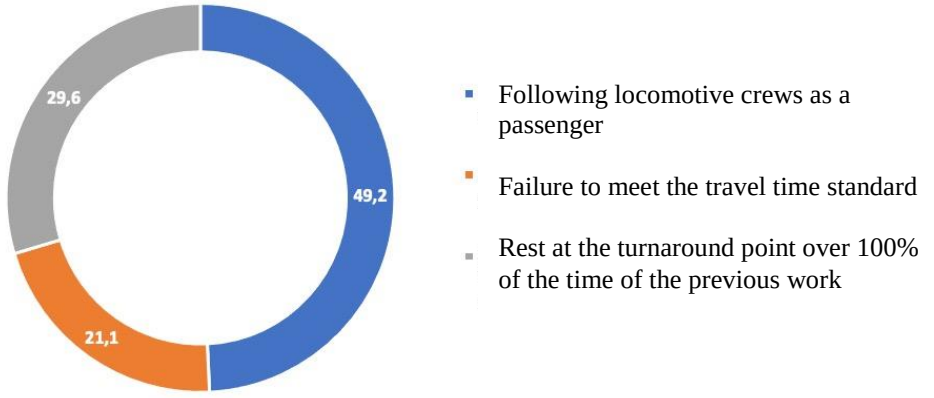

Figure 1: Structure of unproductive losses of working time of locomotive crews in the regional Traction Directorate for 2020, %. *Compiled by the authors.*

The organization of technical processes and the fulfillment of preparatory and final time standards depend on the employees of the Traction Directorate:

- from arrival to passing the checkpoint when accepting a locomotive at the operational locomotive depot;
- from arrival to the end of acceptance of the locomotive at the station;
- from passing the checkpoint until the end of work upon delivery of the locomotive at the operational locomotive depot;
- from the start of the locomotive delivery until the end of work upon delivery of the locomotive at the station.

Elements of auxiliary time, the performance of which depends on related services:

- from passing the checkpoint to departure by train;
- from the end of acceptance of the locomotive at the station until departure;
- from arrival to passing the checkpoint;
- from arrival to the start of delivery of the locomotive at the station;
- stops that are not included in the train schedule.

The differentiation of elements of locomotive crews' working time costs into those dependent and independent of the Traction Directorate employees is presented in Fig. 2.

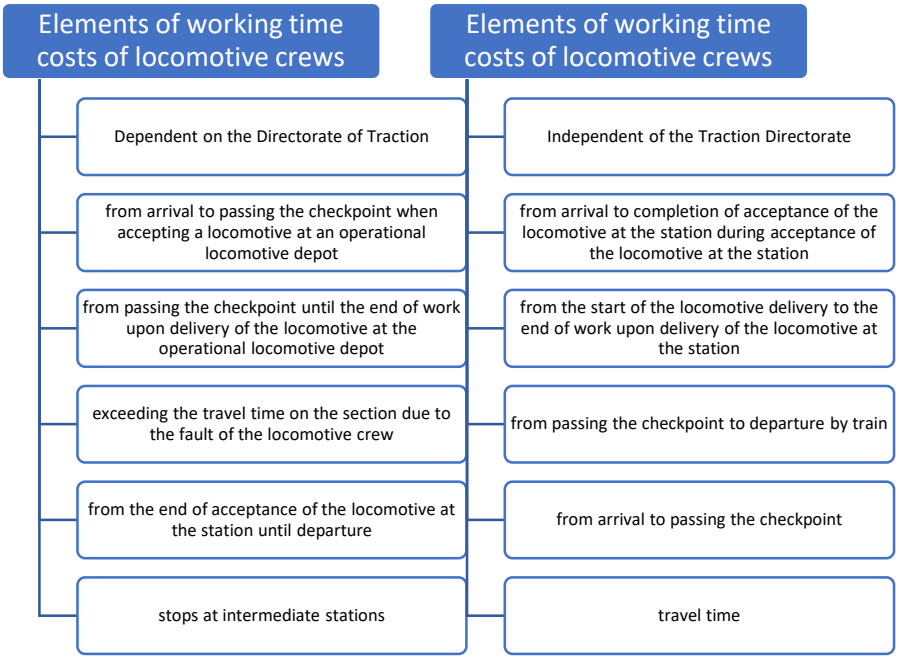

Figure 2: Differentiation of elements of working time expenditure of locomotive crew workers into those dependent and independent of the Traction Directorate workers. *Compiled by the authors.*

In order to reduce unproductive losses of working time of locomotive crew workers in each operational locomotive depot, it is first necessary to analyze those elements that depend on the employees of the Traction Directorate, and having eliminated the identified losses, it is necessary to ensure coordinated interaction with other participants in the transportation process.

The analysis of unproductive labor time expenditures in the regional Traction Directorate under the element "Exceeding turnover rates" showed that in 2019, 79.6 thousand hours were lost, which required the involvement of an additional 49 workers, and in 2020, the loss of working time amounted to 166.4 thousand hours and the involvement of an additional 103 people.

As a result of conducting a photograph of the working day, it was established that time standards were not met for the following elements:

- from the acceptance of the locomotive to the departure of the train for the following reasons: unreadiness of the train, waiting for departure due to the station duty officer's adjustment, overestimation of the time for testing the automatic brakes, repeated testing of the automatic brakes during a long wait for departure. As a result of taking photographs of the working day, an excess of the time standard from 0.3 hours to 0.5 hours was established;
- time spent in motion on sections due to failure to meet travel time due to issued warnings to reduce speed due to the state of the infrastructure, the norm is exceeded by 0.4-0.7 hours;
- stops at intermediate stations due to stops at red lights, stops due to brakes being applied, when there is a risk of a violation of train traffic safety, stops due to the regulation of a train dispatcher.

The analysis of the results of observations and processing of photographs of the production process showed an excess of time standards from 0.2 hours to 1 hour. Systematic analysis of all production operations performed during the transportation of goods allows eliminating unnecessary operations and minimizing the time of their implementation. For these purposes, a functional project was considered to preserve the preparatory and final time of locomotive crews when transferring the point of appearance to the place of work from the railway station St. Oskol (Belgorod region, Russia) to the railway station Stoilenskaya (Belgorod region, Russia).

Currently, all locomotive crews of the Stary Oskol

operational locomotive depot, which service the Stoilenskaya-Chugun-2 section, have undergone a pre-trip medical examination (5 min.), a pre-trip briefing (3 min.) in the building of the Stary Oskol operational locomotive depot. Then they walk to the car (5 min.) and travel 35 minutes to Stoilenskaya station (9 km within the city with traffic jams and traffic lights, speed limits) (Fig. 3).

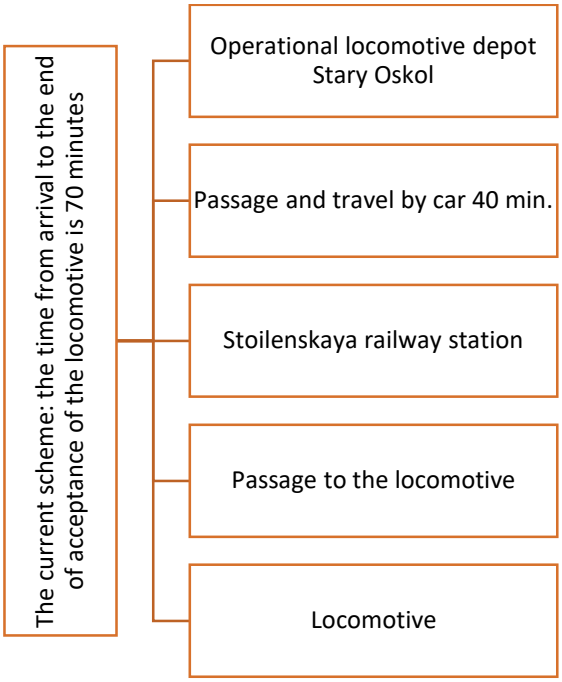

Figure 3: The existing scheme of organization of pre-trip medical examination and instruction in the building of the operational locomotive depot. Compiled by the authors.

The total working time of locomotive crews from arrival to the start of locomotive acceptance is 48 minutes. The process from the moment of locomotive delivery to the closure of the route is similar, its duration is also 48 minutes.

The Stary Oskol operational locomotive depot services 8 scheduled lines on the Stoilenskaya-Chugun-2 section daily. Trains on these lines are formed at the Stoilenskaya station. The locomotive is stationed at the departure station, which is located 9 km from the Stoilenskaya station within the city limits.

In order to reduce the standard time from arrival to departure, it is proposed to move the arrival point of locomotive crews directly to the departure station, thereby optimizing the costs of vehicle travel and vehicle operation.

After the implementation of this event, the locomotive crews will appear at the Stoilenskaya railway station. The process from the moment of delivery of the locomotive until the end of work is similar. Thus, the working time of the locomotive crew is reduced by 40 minutes upon arrival at work and by 40 minutes upon delivery of the locomotive. At the same time, no additional costs or investments are required (Fig. 4).

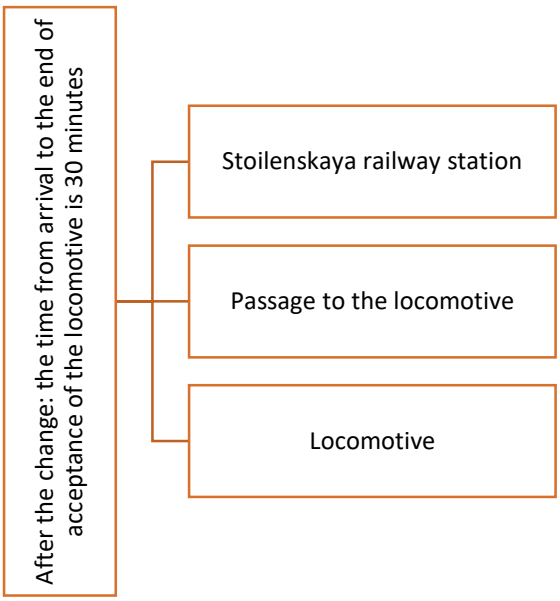

Figure 4: Proposed scheme for moving the locomotive crew reporting point to the Stoilenskaya railway station . Compiled by the authors.

In forming the effect, the decisive influence is exerted by the reduction of labor costs only for one attendance point by 7767 hours per year (the result was obtained in the process of processing photographs of the working day of the TNU-2 form) and the reduction of expenses for transportation types of activity by more than 9 million rubles (the savings are determined based on the average network rate of the locomotive brigade -hour of 888.61 rubles, taking into account deductions for social needs in the amount of 30.4%).

The issues of increasing labor productivity and the efficiency of using labor resources are always high on the agenda and the interest of scientists is associated with various industry characteristics and conditions for performing production processes.

The features of the organization of production processes in railway transport in terms of reducing the risk of unproductive use of locomotive crews' working time are not fully reflected in the scientific studies under consideration. To carry out the calculations in this article, current methods were used, including taking photographs of the working day and timekeeping observations.

4 DISCUSSION

Rational use of working time of locomotive crews has historically been of scientific and practical interest, since the desire to clearly regulate this indicator has encountered a number of significant complex restrictions, such as: failure to comply with the train schedule, the requirements of labor legislation and regulatory acts of JSC Russian Railways, the track development of stations where locomotive crews are changed, geographical and climatic features, etc., in connection with which the most ineffective "call-out" system of organizing the work of these workers has been and is currently used in Russian railway transport.

The risk of inefficient organization of locomotive crews' work leads to loss of working time and, as a consequence, the emergence of overtime hours, growth of expenses for transportation activities and the standard number of employees. Identification of the causes of irrational use of labor resources with subsequent development of measures to increase labor productivity will improve the business process "Provision of locomotive traction services" and

ensure a reduction in labor costs of locomotive crew employees.

The results of the conducted study indicate that there are internal production reserves at railway transport enterprises to increase the efficiency of using locomotive crews' working time and labor productivity, due to organizational factors. It would be interesting, if possible, to try to further scale this approach to all structural divisions of the Traction Directorate - a branch of JSC Russian Railways, since there are limitations in this aspect and each enterprise has its own "local" features, such studies should be integrated into the locomotive crew management system, this is a subject for discussion and subsequent adaptation of this proposal for specific organizational and technical conditions of operation of operational locomotive depots.

It should be noted that these issues have been repeatedly considered in the community of transport scientists since the formation of the transport economic school. We will cite only a few publications as an example (Morozov, Shapkin, 2019; Kozhevnikova, Bulokhova, 2021; Kovalev, Salchenko, 2008), but each of them considers different aspects of managing the working hours of locomotive crews, which allowed the authors to make their small contribution to the industry economic thought by considering the possibilities of increasing the efficiency of using working hours only in terms of preparatory-final and auxiliary time of an organizational nature. Technical and technological factors, travel time, etc. were beyond the scope of this study. But each contribution is invaluable, since it is the result of painstaking work and work with large arrays of information. Since the work and rest regime of locomotive crews is multifaceted, depends on many factors, including each participant in the transportation process, the process of effective management of the working hours of the main production group of rail transport should in the future acquire the form of an economic and mathematical model with a certain set of criteria and a sufficient information platform.

Based on the above and the obtained research results, we can talk about the advisability of further research in terms of identifying risk factors for unproductive work of locomotive crews not only from the position of the Traction Directorate, but also other participants in the transportation process. I would also like to note that such research should be conducted using a modern scientific and methodological apparatus, since static and dynamic factors of influence must be taken into account when modeling processes in the field of organizing the work of locomotive crews and rely on the automation of calculations when handling large arrays of data.

5 CONCLUSION

Based on the study of the organization of work of locomotive crews, the assessment of preparatory-final and auxiliary time, including all mandatory elements of the working time of locomotive crews from the moment of arrival to the start of the trip and from the end of the trip to release from work, as well as the analysis of the running standards of locomotive crews based on data from photographs of the working day, timekeeping studies and reporting data of corporate automated systems of JSC Russian Railways, the main reasons for the emergence of unproductive costs and losses of working time of this production group of railway workers have been formulated.

The results of the conducted study indicate the need for continuous monitoring of technological processes in operational locomotive depots, existing options for organizing the working time of locomotive crews and its improvement in order to reduce or eliminate unproductive losses of the leading production group of railway workers, which can amount to 5 to 35% of the actual working time fund of these workers.

The economic effect of the implementation of just one measure to optimize the placement of a locomotive crew changeover point on the scale of one operational locomotive depot is about 9 million rubles . When replicating this experience of reducing unproductive losses of locomotive crews' working time across the entire railway network on a company-wide scale, this will allow JSC Russian Railways to use its available labor resources more rationally and efficiently, effectively manage costs, which will ultimately contribute to increasing its operational efficiency.

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