

RESOURCES OF GROWTH IN LABOUR PRODUCTIVITY: ENERGY FOR SYNERGY

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ABSTRACT

The market economy stimulated the emergence of new principles of cooperation in the production field based on capitalization and predetermined the priorities for development of railways. It is a holding structure of management with a lot of subsidiaries, vertical management of economic structures within the company. The article shows the importance of

optimizing various interrelated operational processes in modern production conditions, as well as the influence of managerial and modernization factors on the nature of provision of external services, internal efficiency of labor. The chosen direction for improving technological processes through obtaining synergies is most significant see limited economic and human resources.

Keywords: railway transport, personnel, labor productivity, efficiency, time, infrastructure, synergetic effect.

Background. The main tasks solved by railway companies are satisfaction of consumers through the amount of work performed and quality of services.

On Far Eastern Railway, a branch of Russian Railways, the freight turnover since 1988 – the maximum before the collapse of the USSR – has increased more than fourfold, reaching 251 billion t·km gross in 2017 and has a steady growth trend (Pic. 1).

In the course of implementation of the program of stage-by-stage reforming on railway transport, one of the main problems that required its solution is connected with the change in existing processes in transportation of passengers and cargo, with an increase in the volume of transportation, creation of landfill technologies in the organization of use of:

- traction rolling stock;
- infrastructure maintenance;
- lengthening of railway hauls of warranty run of cars.

Therefore, when developing programs for reconstruction, modernization, predictive and preventive maintenance activities on infrastructure objects and network polygons, it is necessary to take into account not only throughput opportunities, but also losses in operational work, as well as highly efficient use of all types of resources [1].

Objective. The objective of the authors is to consider the issues of labour productivity.

Methods. The authors use general scientific methods, comparative analysis, evaluation approach, scientific description.

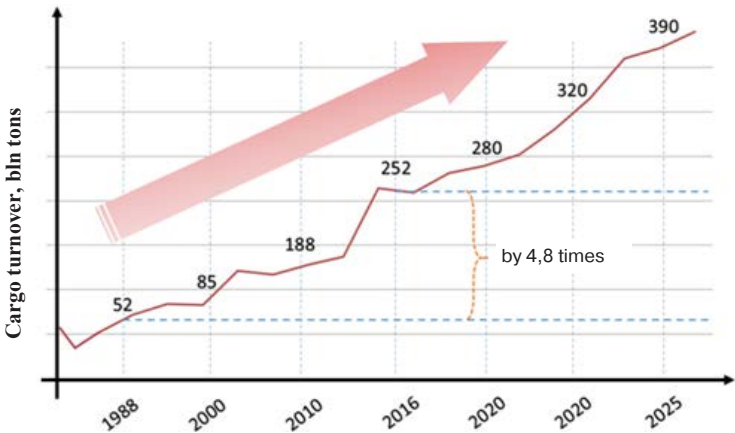
Results.

I. Circumstances. The strategic task facing our country is to increase labor productivity, which is the basis for sustainable economic growth and the welfare of workers. At present, labor productivity in Russia, despite the positive dynamics, is still low. On average, it is about 26 % of the US level [4, p. 26–27].

Modernization of railway transport, carried out on the basis of electrification, development of digital technologies, range management models, markedly changed the transportation process. During construction and repair, high-precision machines and mechanisms with the use of reference positioning systems are now widely used, and automation and mechanization of work and technological processes have become widespread. As a result, the organization and working conditions of locomotive, track crews, automatics and telemechanics service employees, and the energy supply directorate have become different. This posed new challenges for railway science and company management. Their complexity increases due to the further development of digital technologies in railway transport and the almost complete loading of its infrastructure in separate areas. And such an uneasy objective reality when assessing the total labor productivity of JSC Russian Railways cannot be ignored.

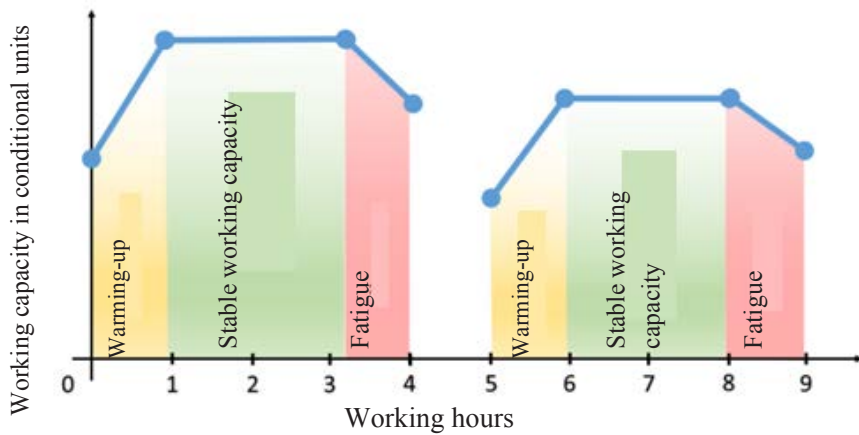
II. Physiology (ϕ). New approaches to the technology of production processes on the basis of scientific organization of labor are introduced in railway transport. Inseparable part of them are:

- ensuring optimal hygienic conditions;
- compliance with the requirements of labor physiology;



Pic. 1. Growth of transportation volumes.





Pic. 2. Levels of working capacity.

– creation of a favorable psychological environment in the workplace [2, p. 3–4, 23].

The modern transport process is a unified system of work involving millions of people, various machines and mechanisms, continuous in nature, stretched in space and time, requiring a high degree of coordination of labor, accurate accounting of the physiological and psychological patterns of the human body, the impact of external and internal factors on it. Under the conditions of production, factors of a very different nature are systematically manifested, which strengthen the tension of a person in the process of work.

External influences include:

- adverse and harmful conditions of the production environment;
- cooling or heating microclimate;
- poor lighting;
- unacceptably high concentration of dust, gas, toxic substances;
- excessive noise and vibration.

These are negative effects, that most often occur in modern production, and reduce the effectiveness of personnel [2].

III. Working capacity (r). In fact, it is an opportunity for a person to manifest himself in an active activity, characterized by the volume of products produced and the functional state of the organism in the process of work. It rather refers primarily to the intra-factor zone and is variable – it changes with age, training, during acquisition of new skills and bringing to the automatism of the former. The working capacity is also shorter in shorter periods of time.

Maintaining the efficiency at the optimal level is the main goal of the rational mode of work and rest of the personnel. The specificity of labor conditions at infrastructural facilities invariably remains the absence of a certain stable labor regime. This is

caused by frequent changes in order, volume and impact of emergency work.

The phase of stable high working capacity. This is the state of high labor performance. Depending on the severity of labor, this kind of phase lasts from 2 to 4 hours (Pic. 2).

In practice, technological time intervals in traffic for maintenance works («windows») along the Eastern range of railways are provided in 20 % of cases at night, 10 % – between 08:00 and 12:00 local time. Wages losses – more than 150 million rubles. on Far Eastern Railway.

$\Sigma = Npr.w \cdot Knight \cdot Npers \cdot Zday \cdot Ksup.pay,$

where Npr.w – number of process windows (50000 per year); Knight – coefficient of process windows at the night (0,2); Npers – number of personnel (≈ 22); Zday – daily wages (1800 rub.); Ksup.pay. – coefficient of supplemental payment for night work (0,4).

From the point of view of planning work in process windows, the highest efficiency can be achieved between 9:00 and 12:00 am local time. The preparatory stages of the work must be done during the period of warming-up, then the main activity will fall on the phase of stable working capacity. At the same time, it is the maximum consumption of electrical energy in regional systems and, accordingly, the highest tariffs.

IV. Electric energy (E). The purchase of it is about 9 % of the costs of JSC Russian Railways.

Optimizing energy costs, it is possible to improve significantly the company's financial performance, including by mediating the results through the combined performance.

When purchasing electricity for facilities of 670 kW or more, the calculation is made at a three-part tariff. It includes three main components:

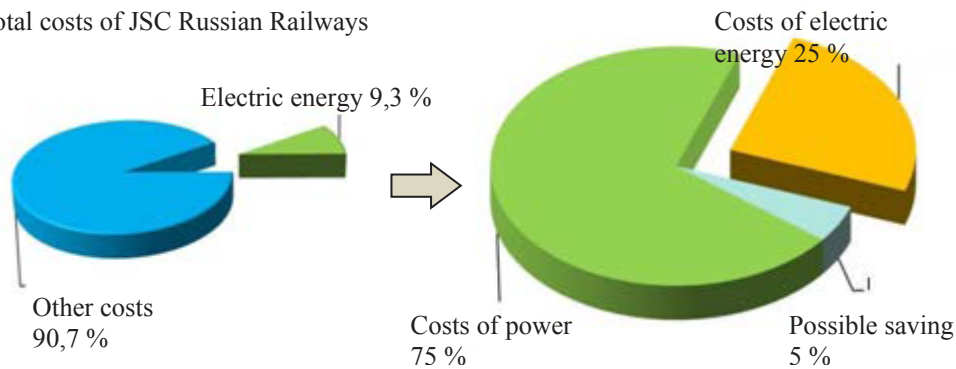
- rate for the amount of electricity actually consumed (rub./kW·h);

Table 1

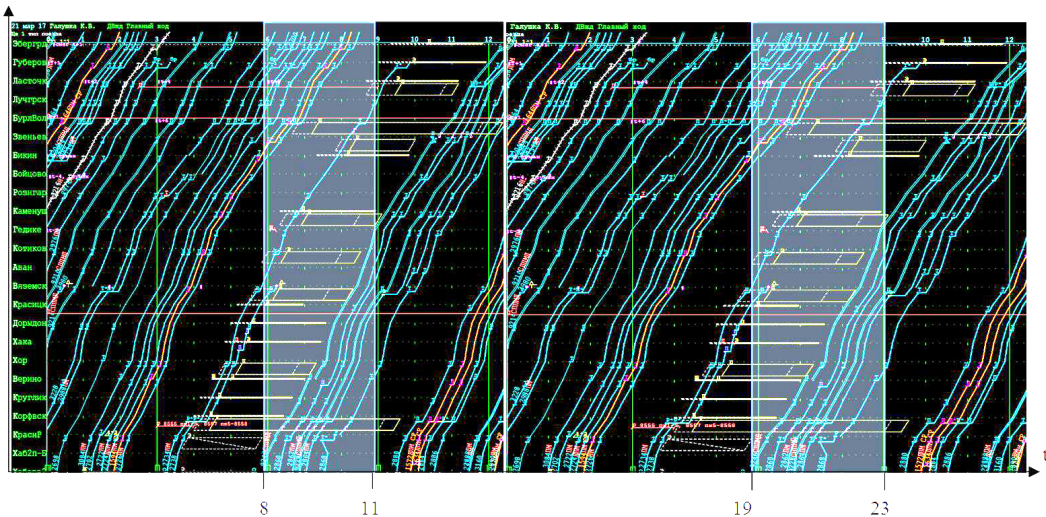
Calculation of economic effect based on 2016 data

Indicator	Amur region	Jewish autonomous region	Khabarovsk region	Primorsky region	Total
Power of SO, MW	71,8	77,5	12,2	100,3	
Tariff, rub./MW month	1192	1077	631	1423	
Effect, mln rub./year	85,6	83,5	7,7	142,8	319,5

Total costs of JSC Russian Railways



Pic. 3. The ratio of the cost of electric energy and power consumption.



Pic. 4. Movement of trains with the maximum load of the system operator.

– rate for the amount of power actually consumed during the peak load hour (rub./MW month) (power of a commercial operator);

– rate for maintenance of electrical networks (rub./MW month) (power of a system operator).

The last two components of the tariff have a very significant effect on the total cost of buying electricity.

Pic. 3 shows graphically the ratio of the cost of electric energy and power consumption, the payment for power is more than 70 % of the total cost of electric energy. When implementing an optimized train schedule and providing process windows at the

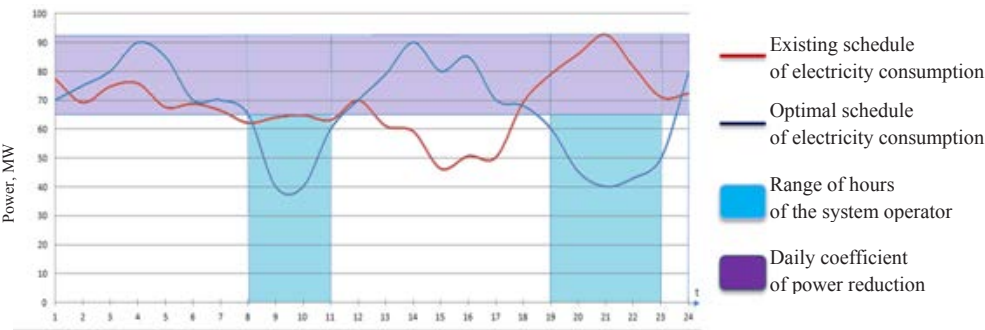
optimal time for the highest labor productivity of workers, a possible cost saving is 5 % of the total amount of electricity costs.

For the Far East, the maximum power period falls on two bands: 08:30–11:30 and from 19:00 to 21:00 local time.

The daily power of the system operator is determined by the maximum value within the specified hours.

V. Optimal motion.

Its meaning is clear from the very beginning. Pic. 4 shows the schedule for movement of trains



Pic. 5. The effect of power reduction (local time).

Table 2

No.	Name of a fault	Average length, m	Note
Retreat of rail threads in the plan:			
1	Alignment – A	24	
2	Track drawdown – Dr	4,8	
3	Distortions – D	11,7	
4	Breach of track width – W	43,6	

Table 3

	Laying of leveling shims up to 10 mm	Adjusting track width	Alignment of the track in the plan	Alignment of the track in the profile (drawdown, distortion, elr.)
Time for completion of preparatory and final operations	7,3	58,7	1,3	13,4
Basic	29,9	148,3	21,6	70,9
Final operations, performed once	5,7	16,8	5,8	38,7
% ratio t_p, t_b, t_f	17 % 70 % 13 %	26 %, 66 %, 8 %	8 %, 75 %, 17 %	11 %, 58 %, 31 %
% and weight norm in hours b. f. repeat.	17	26	8	11
% and weight norm in hours basic	70	66	75	58
% and weight norm in hours final	13	8	17	31
Time to eliminate one averaged fault	0,53 hours drawdown; 1,3 hours distortion	5,2 hours	1,8 hours by alignment; 2,6 hours by respiking	1 hour drawdown; 2,4 hours distortion

at the «optimal» day and during the provided «windows».

The range of hours of the system operator is highlighted in color, this is the most optimal schedule, in which there is a coincidence of process «windows» with maximum power of the power system and the maximum working capacity. With this traffic schedule and «window» technology, the power saving mode is maintained in the hours of the system operator and the maximum productivity of labor.

Pic. 5 shows the overlap of two graphs with the existing power consumption for traction of trains on the section Khabarovsk–Guberoovo and the proposed (optimal) power consumption schedule. At the same time, the power consumption in two cases is equal, and the daily power involved in the calculations is reduced by more than 20 mW.

Based on the «new» schedule of operational work, the economic effect was calculated under the conditions of 2017 under «optimal» train schedules (Table 1).

The amount of power consumption remained unchanged. Only hourly values were redistributed in the accounting period, which allowed to reduce the average tariff when buying electricity from 10 to 15 kopeks per kW.

With such traffic schedule and «window» technologies, a power saving mode is observed in the hours of the system operator.

VI. Efficiency of time use. During the works the degree of effectiveness depends on the number of trains moving on the section in both directions and the interval between trains. The most productive use of working time is under the condition $t_{int.} > t_{tec.op.}$,

where $t_{tec.op.}$ – time of a technological operation;

$t_{int.}$ – interval between trains taking into account time for receipt and handling of a train.

The time of a technological cycle to eliminate track failures consists of:

- preparatory works designed to prepare a track way to carry out basic works;
- basic works, when movement of trains is impossible and is intended to align a track;
- final works designed to bring a track to serviceable condition for handling trains.

With inverse dependence, work is possible only if the preparatory and final operations for trains are repeatedly performed.

The analysis carried out by the center for monitoring and diagnostics of the directorate of infrastructure on the passages of track-measuring cars TsNII-2 and KVLP showed that the average length of malfunctions is from 3 meters of track drawdown to 24 meters in alignment of rails, and the faults in widening and narrowing of the track width in some cases reach hundreds of meters (data in Tables 2 and 3).

Technological processes, according to which work is carried out to eliminate track malfunctions, according to the parameters of operations:

- t_p – preparatory-final;
- t_b – basic;
- t_f – final ones.

After the calculations, the data are summarized in Table 3.

The calculations carried out for each type of work allowed to obtain the following results:

$$t_{op.} = \frac{l \cdot 2 \cdot (t_p + t_b + t_f)}{N},$$

where l – length of track faults, taken from Table 2; 2 – number of sleepers per 1 km of track (in thous. pcs); N – output per unit time (hour); t_{op} – time spent for elimination of one fault.

To determine the number of preparatory and final multiple repetitive operations in case of elimination of one fault, let us calculate:

$$N_{p.f.} = \frac{t_{op}}{t_{int.}} \text{ (with increasing up to an integer).}$$

Let's consider losses in case of production of works:

$$t_{losses\ hour.} = (N_{p.f.} - 1) \cdot (t_p + t_f).$$

Having losses in hours, we will calculate the economic losses per shift

$$t_{losses\ hour.} \cdot n_{faults} \cdot T_{av.t.} = P,$$

where n_{faults} – number of faults in the period of time under consideration; $T_{av.t.}$ – average tariff rate.

Applying the organizational system of complex current maintenance of the infrastructure by the local method, concentrating the estimated number of personnel in the areas of «windows» with division of work into preparatory, basic, final period and performing the basic work in the «window», it is possible to increase labor productivity without losses in train work: $t_{win.} = t_{bas.}$

Output per shift is reduced by (at $t_{bas.} > t_{win.}$):

$$(t_f + t_p) \cdot k,$$

where k – number of handled trains per place of work per shift.

Based on these conditions, it is possible:

- to determine an optimal «window» when eliminating infrastructure malfunctions;
- to organize them in the period of the greatest possible development on physical and psychological factors;
- to determine the minimum expense for payment to the network operator;
- to maximize the effect of the integrated use of the «window» by all infrastructure economies;
- to use the optimal number of machines ($N_{mach. opt.}$).

In general, all reasoning can be represented as a function:

$$F = f(\phi, r, E, t_{win.}, t_{opt.}, N_{mach. opt.}).$$

Conclusions. In the conditions of maximum infrastructure loading, restriction of tariffs for bulk goods, high price components of purchased goods and services to enhance the internal efficiency of production processes, it is necessary to carry out optimization procedures. Each resource component becomes, in this case, a direct or indirect element of labor productivity, personified in a separate workplace and in the aggregate corporate results. That is, the same synergistic effect is achieved, which exceeds the energy costs and the performance potential of individual performers or personnel.

The authors of the article express their gratitude to the heads of Far Eastern Directorate for Energy Supply (Head of the Directorate – K. G. Plesovskikh, First Deputy Head – V. V. Zhuravlev) for the information provided.

REFERENCES

1. Nachigin, V. A., Stepanets, S. E. New approaches to optimization of repair and track works using the example of railways of the Eastern range [Novye podhody k optimizatsii remontno-putevykh rabot na primere zheleznykh dorog Vostochnogo poligona]. Transport Aziatsko-Tihookeanskogo regiona, 2017, Iss. 1 (10), pp. 6–8.
2. Hygiene and physiology of labor in railway transport [Gigiena i fiziologiya truda na zheleznodorozhniy transport]. Ed. by A. A. Prokhorov. Moscow, Transport publ., 1973, 264 p.
3. GOST 12.4.061–88. Occupational safety standards system. Method of determining the working capacity of a person in personal protective equipment [GOST 12.4.061–88. Sistema standartov bezopasnosti truda. Metod opredeleniya rabotosposobnosti cheloveka v sredstvakh individualnoi zashchity].
4. Duvieusart, J.-P. [et al]. Effective Russia: productivity as the foundation of growth [Effektivnaya Rossiya: proizvoditelnost' kak fundament rosta]. McKinsey Global Institute, MGI, 2009, 46 p.
5. Krushelnitskaya, Ya. V. Physiology and Psychology of Labor: A Textbook [Fiziologiya i psikhologiya truda: Uchebnik]. Moscow, Finance and Statistics, 2003, 367 p.
6. Nikonorov, A. G. TNK No. T857C-16 // Leveling up the level by up to 10 mm by laying the adjusting pads / CDI 26.05.2016 [TNK No. T857Ts-16 // Vypravka puti po urovnyu na valichinu do 10 mm ukladkoi regulirovochnykh prokladok / TsDI 26.05.2016].
7. Nikonorov, A. G. TNK No. T859C-16 // Adjustment of the track width with a tie-down device on the combined rails and sleepers of the link track / CDI 14.10.2016 [TNK No. T859Ts-16 // Regulirovka shiriny relsovoi koei styazhnyy priborom na kombinirovannoi relsohpalnoi reshetke zvenievogo puti / TsDI 14.10.2016].
8. Nikonorov, A. G. TNK No. T860C-16 // Adjusting the rail track width with separate fastening using a coupling device / CDI 02.08.2016 [TNK No. T860Ts-16 // Regulirovka shiriny relsovoi kolei pri razdelnom skreplenii s primeneniem styazhnogo pribora / TsDI 02.08.2016].
9. Nikonorov, A. G. TNK No. T875C-16 // Track leveling by up to 10 mm by replacing adjusting pads / CDI 24.11.2016 [TNK No. T875Ts-16 // Vypravka puti po urovnyu na velichinu do 10 mm zamenoi regulirovochnykh podkladok / TsDI 24.11.2016].
10. Order of the Ministry of Transport of Russia of December 21, 2010 No. 286 (as amended on 01.09.2016) «On approval of the Rules for Technical Operation of Railways of the Russian Federation» [Prikaz Mintransa Rossii ot 21.12.2010 No. 286 (red. ot 01.09.2016) «Ob utverzhenii Pravil tekhnicheskoi ekspluatatsii zheleznykh dorog Rossiiskoi Federatsii»].
11. Krakovsky, Yu. M., Nachigin, V. A. Influence of polygon technologies on organization of repair works in the infrastructure directorate [Vliyaniye poligonnykh tekhnologii na organizatsiyu remontnykh rabot v direktsii infrastruktury]. Transport infrastructure of the Siberian region: Proceedings of the Eighth international scientific-practical conference. Irkutsk, IrGUPS publ., 2017, Vol. 1, pp. 8–11. ●

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Article received 09.01.2018, revised 29.03.2018, accepted 31.03.2018.

