

Development of an automated sand supply system for places of technical inspection of locomotives

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Abstract. To increase labor productivity is one of the most important tasks of the branch strategic document of JSC "Russian Railways". The article describes the existing system of sand supply to the locomotive at the places of technical inspection of locomotives (PTIL), its shortcomings are revealed. At present, this system has been outdated and it does not meet the requirements of the modern logistics and the organization of railway operation. To solve this problem, an automated system of sand supply to the locomotive based on a rotary level gauge and a slide gate with a pneumatic drive has been developed, which will eliminate the disadvantages of the typical system, which will increase labor productivity.

1 Introduction

For many decades, the railway has been one of the socially significant and labor-intensive sectors of the country's economy, whose activities cover a whole range of transport services and require the employees of a transport company to apply a wide range of technical skills and qualifications in various fields. The specifics of the work of the railway transport enterprises presuppose a round-the-clock mode of operation aimed at obtaining maximum results in the process of fulfilling the production, corporate and strategic tasks. Thus, the efficiency of the JSC "Russian Railways" company depends on labor productivity largely [1]. In this regard, to increase labor productivity is one of the tasks of the Long-term Development Program of JSC "Russian Railways" until 2025, approved by the Government of the Russian Federation No. 466 dated 19.03.2019 [2]. To achieve this task, it is necessary to update and modernize production mode, to introduce new technologies and to improve labor organization [3-5].

2 Disadvantages of the existing sand supply system in the places of technical inspection of locomotives

In most places of technical inspection of locomotives, there is the sand supply system, the project of which was developed back in 1968 by the Locomotive Engineering Bureau [5]. To

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supply locomotives with sand, there are warehouses of raw sand near the PTIL, sand dryers with sand drying furnaces, compressor and fuel facilities are located, after which the sand enters the dry sand warehouse, from where it flows through the sand-feeding sleeve into the sand bunkers of the locomotive (Fig.1).

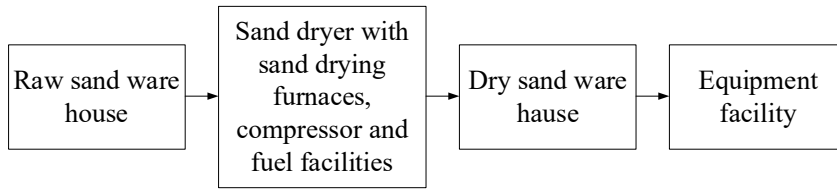


Fig. 1. Technological complex of equipment facilities.

The locomotive is filled with sand by the outfitter, who alternately directs the sand-feeding sleeve to each hopper.

The total volume of sand for one section of an electric locomotive is shown in Fig. 2.

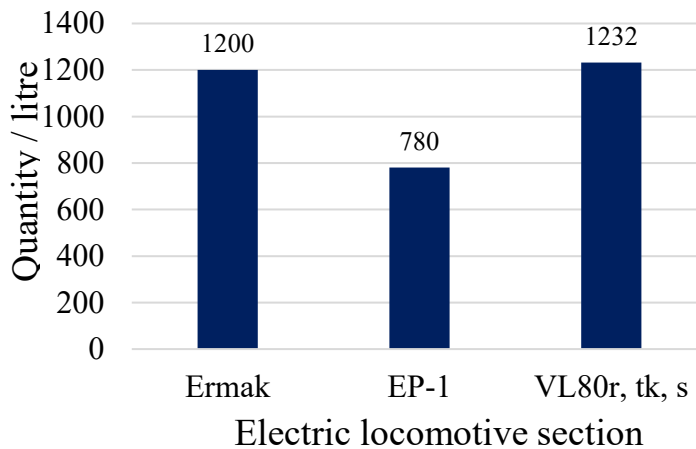


Fig. 2. The volume of electric locomotive sandboxes (one section).

Sand bunkers on locomotives are made in the form of welded tanks and installed on the side walls inside the body. The location of the sandboxes on the modern domestic AC electric locomotive 2ES5K is shown in Fig. 3.

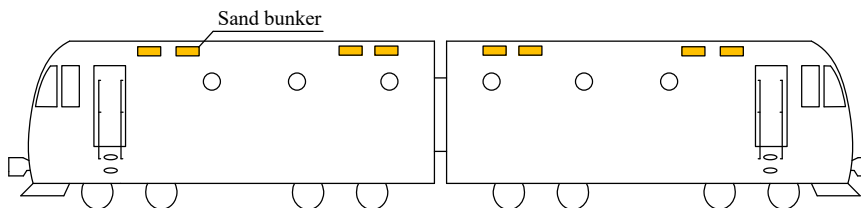


Fig. 3. The location of the sandboxes on the 2ES5K electric locomotive.

Filling with sand is carried out according to the given time standards for one person, taking into account the complete absence of sand in the sand bunkers of the locomotive, according to the technological process for equipping the locomotive for TO-2 with dry sand in the PTIL at the workshop of the Taishet service locomotive depot (Table 1).

Table 1. The norm of time for one person to fill an electric locomotive.

Name of the work	Normalized time (person-hour)
To equip locomotive VL85 with sand	0.97
To equip locomotive VL80r,t,s,m with sand	1.22
To equip locomotive E5K with sand	0.51
To equip locomotive 2ES5K with sand	0.97
To equip locomotive 3ES5K with sand	1.22
To equip locomotive EP1, EP1P with sand	0.51

But, the existing sand supply system for the locomotive has a number of serious technical and technological disadvantages:

- there is no automated system for controlling the amount of sand when filling it into the hopper;
- due to the inefficient technology of filling sand into the locomotive, about 25% of the fraction goes to losses in the placer [6];
- high labor costs due to the large proportion of manual labor.

Thus, this system of sand delivery to the locomotive has been outdated and does not meet the requirements of modern logistics and the organization of railway operation. In this regard, it is necessary to improve the organization and technology of sand supply of locomotives in the PTIL of JSC "Russian Railways".

3 The proposed automated system of sand delivery to the locomotive

Currently, the automatic filling with bulk materials has found wide application in construction and agriculture, which can also be used on the railway. In this regard, an automated hose for supplying sand into the hopper has been developed to control the sand supply to the locomotive. To select a suitable level gauge that controls the level of sand in the locomotive bunkers and an automatic valve that is responsible for stopping the supply of sand at the signal of the level gauge, all the existing types of level gauges and valves with their advantages and disadvantages have been studied [7]. Thus, for an automated sand-feeding sleeve, it is proposed to use a rotary type level gauge and a slide gate with a pneumatic actuator (Fig. 4, a, b).

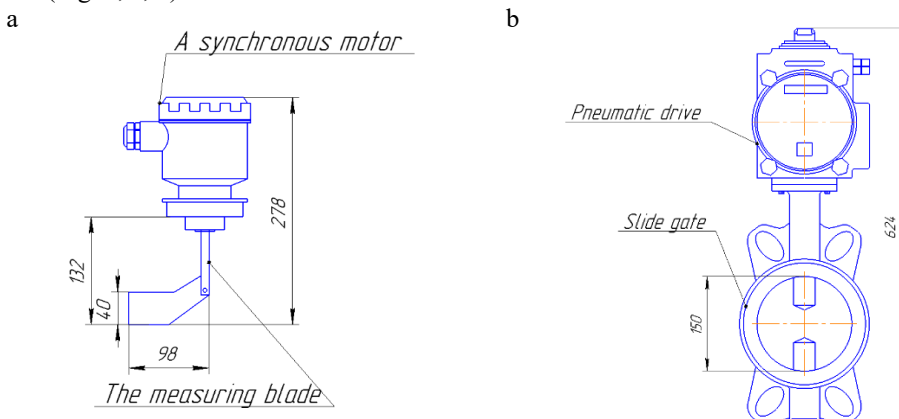


Fig. 4. Selected equipment for automated sand-feeding hose, a – rotary level gauge; b – slide gate with pneumatic drive.

The rotary level gauge is used to measure the level of bulk products and is based on the rotational resistance of the blade driven by the motor. The measuring blade is driven by a synchronous motor.

Advantages of the selected rotary level gauge:

- simplicity and reliability of the design;
- absence of constant maintenance required;
- a wide range of models provides application with a wide variety of bulk materials;
- high stability of operation;
- the ability to install the sensor at different heights;
- easy installation;
- resistance to the presence of dust in the air and avoidance of sticking;
- availability of high-temperature versions.

The main advantage of the selected slide gate is that when opening the sand–feeding sleeve, the slide is completely retracted into the housing, leaving the passage section free, which is especially important when working with abrasive materials as sand.

Figure 5 shows the scheme of operation of the proposed automated system of sand delivery to the locomotive. The principle of operation of this system is as follows: when lowering the sand-feeding sleeve into the hopper, the outfitter must turn on the level gauge, which is installed at the end of the sleeve, the measuring blade of the level gauge begins to revolve, as soon as the sand level rises and creates resistance to the movement of the blade, the rotary level gauge will signal the filling of the locomotive hopper to the pneumatic drive, which will push the gate, and the sand supply it will stop. To notify the outfitter about filling the locomotive bunker with sand, a reader is offered, which receives signals from a pneumatic actuator with a slide valve. As soon as the gate valve assumes a closed state, the number of the sand-feeding sleeve lights up on the outfitter's reader, which signals to the outfitter that the hopper is full.

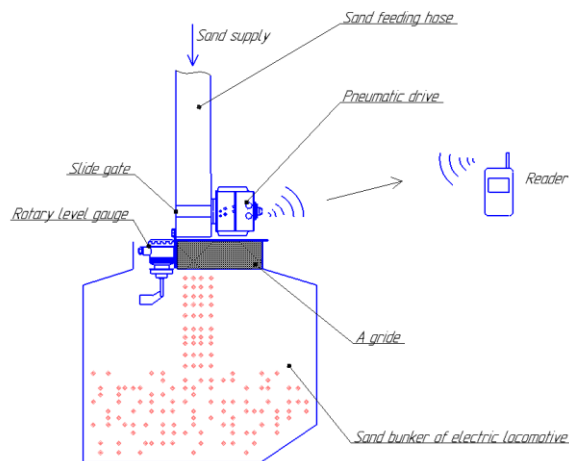


Fig. 5. The scheme of operation of the proposed automatic sand feeding system to the locomotive.

In order to prevent large sand particles from entering the hopper of the electric locomotive, a grid is installed at the end of the sand-feeding sleeve through which the sand will pass. This grid is attached to the edges of the hopper neck, which ensures the fixation of the sleeve.

4 Advantages of an automated sand delivery system for a locomotive

The proposed automated system of sand delivery to the locomotive will eliminate alternate filling of the locomotive bunkers, which will reduce the time limit of the outfitter for filling the electric locomotive with sand. Using the example of an electric locomotive 2ES5K, it is possible to calculate how much time will be the norm for its filling after the implementation of the proposed technical solution. At the moment, it takes 0.97 people-h to fill eight sandboxes on an electric locomotive, since the outfitter starts filling the next sandbox only after filling the previous one, then the filling time of one sandbox is on average 0.12 people-h. Consequently, with a mobile sleeve, the norm of time for filling an electric locomotive 2ES5K on average will be 0.12 people-h. Table 2 shows the norms of time per person for filling an electric locomotive with sand using the proposed sand supply system.

Table 2. The norm of time for filling an electric locomotive with sand per person using the proposed sand supply system.

Name of the work	Normalized time (person-hour)
To equip locomotive VL85 with sand	0.2
To equip locomotive VL80r,t,s,m with sand	0.25
To equip locomotive E5K with sand	0.17
To equip locomotive 2ES5K with sand	0.2
To equip locomotive 3ES5K with sand	0.25
To equip locomotive EP1, EP1P with sand	0.17

Decreasing the norm of time per person for filling the locomotive with sand will reduce the time of TO-2, and, therefore, will improve the quality performance of the locomotive. The full turnaround of the locomotive, which is expressed by the time spent by the locomotive of one pair of trains on the traction arm, includes also the time for maintenance of the TO-2, therefore, with the reduction of the time of the TO-2, the total turnover of the locomotive will decrease, and, consequently, the coefficient of its demand and the number of operated fleet will decrease. This will increase the time in the movement, the time of useful work and the average daily mileage of the locomotive (Fig. 6).

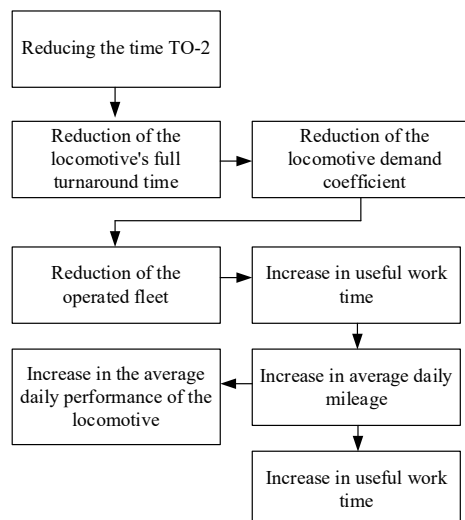


Fig. 6. The effect of reducing the time of TO-2 on the quality indicators of locomotive use.

Another advantage of the proposed technical solution is that by automating the process of filling the locomotive with sand, its spillage will be eliminated.

5 Conclusion

1 The disadvantages of the typical locomotive filling system with sand have been considered, which showed that this system has been outdated and requires improvement.

2 The automated system of sand supply to the locomotive based on a rotary level gauge and a slide gate with a pneumatic drive has been developed, which allows reducing the share of manual labor while speeding up the filling process, which will lead to the exclusion of sand spillage and increase labor productivity in PTIL.

3 The proposed automated system of sand delivery to the locomotive will reduce the norm of time for filling the locomotive with sand (for example, an electric locomotive of the 2ES5K series from 0.97 to 0.12 person-hours), and, consequently, reduce the time for maintenance in the volume of TO-2, which will increase the quality indicators of the locomotive.

4 The annual cash savings from the implementation of the proposed technical solution on the example of the Taishet PTIL station will amount to 4,051,664.51 rubles, and the payback period will not exceed 1.01 years.

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