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Increasing the speed of transportation on the railway section

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ABSTRACT:*The priority direction in increasing the speed and efficiency of rail transportation is the weakening of the stress state during the interaction of elements in the mechanical system "wheelset – rail grating". The figure shows that the speed of the locomotive is significantly reduced. Due to the constant ascent of the guiding slope, there is a protracted ascent throughout the site. There are several ways to increase the speed of movement on such sections and improve the interaction of the wheel-rail system.*

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I. INTRODUCTION

The priority direction in improving the efficiency of rail transportation is the weakening of the stress state during the interaction of elements in the mechanical system "wheelset – rail grating". In reality, there are always two reasons for a malfunction: excessive stress and insufficient physical properties (for example, strength, wear and corrosion resistance). The world experience of railway operation shows that the process of dynamic interaction of rolling stock and track is key in solving railway traffic problems and an integrated approach is needed to them[1]. Therefore, technical solutions, technologies, methods of diagnostics of system parameters aimed at reducing the dynamic interaction and tension of the elements of the mechanical system "wheelset – rail grating" should be used along with traditional methods of increasing reliability and durability parameters. Such approaches are more effective and less costly.

II. PROBLEM STATEMENT

Let's consider the possibility of solving the problem of wheel-rail interaction using the example of a railway section.The Volkovysk - Zelva railway line is single-track, not electrified, the length of the section under consideration is 27.651 km. There are problematic areas: small radius curves, compound curves, insufficient straight inserts, constant use of a guiding slope, there is a protracted rise for the cargo direction throughout the section. Due to these features of the site, the interaction of rolling stock and rail track is significantly deteriorating. Due to the presence of a guiding slope and a protracted climb, the speed of cargo movement in the right direction is reduced to 25-20 km/h. This leads to more intensive wear of the rail head. To solve this task, it is necessary to conduct a comprehensive study of the site and assign measures to improve the "problem" places.

Figure 1 shows that the speed of the locomotive is significantly reduced. Due to the constant ascent of the guiding slope, there is a protracted ascent throughout the site. So the speed of the train from 80 km/ h is reduced to 28 km/h. The complex of theoretical studies conducted at the Volkovysk-Zelva section revealed that in order to improve the interaction in the "wheelset – rail track" system, it is necessary to develop new technical solutions aimed at improving traffic safety, improving operational properties and increasing the reliability of rolling stock.

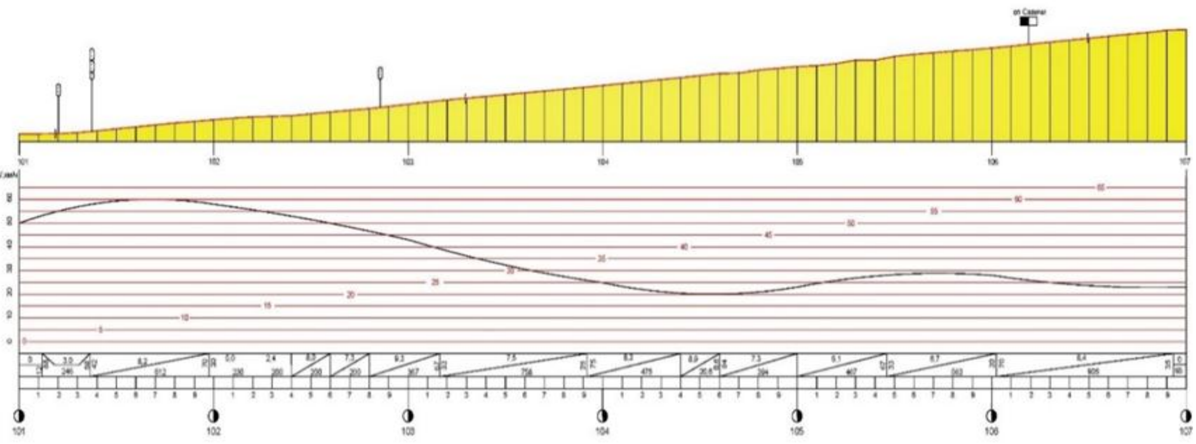

Fig. 1 The speed curve on the site

III SOLUTIONS TO THE PROBLEM

To eliminate the "problem areas" on the Volkovysk-Zelva section, the following technical solutions are proposed:

- reconstruction of the longitudinal profile in order to straighten the section of the route to improve the traction characteristics of the rolling stock[2];
- removal of the Volkovysk-Zelva section to a new axis, which allows to increase the speed of passage of the section;
- the use of double traction, due to which the traction of the freight train in the direction of lifting is improved;
- electrification of the Volkovysk-Zelva section.

Any of these measures will improve the operational characteristics of the rolling stock in the cargo side. Which of these activities to choose is the task that falls on the decision–maker. Let's consider each of them separately.

1) The use of double traction. One of the solutions to this problem is the use of dual traction on the Zelva – Volkovysk section. Multiple traction is a type of traction of trains using two or more locomotives (double, triple traction) placed in the head of the train. The advantage is that the maximum weight of the load that can be loaded into the train increases, as traction characteristics increase. In addition, the number of individual locomotives can be increased to achieve a greater braking effect when driving trains on long descents. Even multiple traction can be used where it is impossible to allow the train to stop due to a malfunction of the locomotive, for example, if it concerns the transportation of dangerous goods. Later, sectional locomotives and the ability to use a system of many units appeared.

The main disadvantage of multiple traction is the increase in the number of locomotive crews and locomotives, respectively. In our case, to attach the second locomotive, it is required to involve a traffic worker (compiler), as well as an employee of the carriage economy. Which will lead to a lot of time, a lot of people and a change in the train schedule.

2) Reconstruction of the longitudinal profile in order to straighten the section of the route to improve the traction characteristics of the rolling stock. One of the most important and difficult issues in the reconstruction of railways is the design of the line plan. Due to a number of reasons (the dynamic impact of passing trains, changes in air temperature, precipitation, etc.), the railway track in the plan has an incorrect outline, different from the one it should have according to the original design. During the reconstruction process, in order to ensure normal operating conditions, the line plan must be brought into the correct geometric position, as well as in accordance with the requirements of design standards. The work on the design of the line plan during reconstruction should be divided into the following main types[3-5]:

- calculations of the reconstruction of the curves of the existing path with their reduction to the correct geometric position;
- calculations of reconstruction of the existing track plan;
- design of the plan of straightening sections of the route and detours.

The most important sections of the plan are curves. During the passage of trains in curves, lateral forces arise, acting on the track and the crews. These dynamic forces should not disrupt the stability of the track and the smoothness of train movement. When designing the reconstruction of the plan, it is necessary to obtain a geometrically correct curve with an accurate calculation of all its elements. As a result of the curve reconstruction calculation, the speed increases by about 15%.

3) Moving the line to a new axis will allow you to design the line as needed. But it should be taken into account the presence of residential development throughout the site.

4) The use of modern types of locomotive and electrification of the site. Electrification of railways ensures accessibility, high quality and safety of transport services; development of its infrastructure; renewal of railway rolling stock; increasing the speed of cargo delivery and passenger transportation; increasing the length of electrified railway sections in the main directions of international transportation; acquisition of a new generation of rolling stock providing high speeds of passenger and freight trains; improving the efficiency of the transport complex[6, 7].

The Republic of Belarus, due to its geographical location, is an integral link in cargo transportation on the China–Europe–China route. In recent years, the Belarusian Railway has been making great efforts to modernize the railway and upgrade traction rolling stock, thereby increasing the level of organization of transportation, their efficiency, which contributes to a significant increase in the volume of transit traffic.

A significant step towards updating the fleet of freight locomotives is the acquisition by the Belarusian Railway of AC electric locomotives BKG1 and BKG2, manufactured by CRRC Datong Co., Ltd. (China). These electric locomotives were developed taking into account the peculiarities of operation on the territory of the Republic of Belarus. In March 2013, a certificate of the National Conformity Assessment System of the Republic of Belarus was obtained for the BKG1 electric locomotive, and in June 2017, a certificate of the Eurasian Economic Union EAC was obtained for the BKG2 electric locomotive. In electric locomotives BKG1 and BKG2, 75% of the equipment is interchangeable, which significantly reduces the cost of their maintenance and repair. Based on the experience of operation and maintenance of electric locomotives, as well as materials provided by the Chinese side, we present a brief description of these electric locomotives.

Let's consider the feasibility of introducing electric traction on the single-track section of the Volkovysk-Zelva Belarusian Railway, which takes into account the most significant factors affecting the amount of initial and subsequent capital investments during electrification (reconstruction) of the line and the influence of these factors on the dynamics of changes in operating costs.

The road section consists of 11 stages with different lengths, where the traction arm, respectively, has a length of 183.9 km. It is planned to electrify the section from the Baranovichi station through the stations of Volkovysk, Svisloch state border with the Republic of Poland.

When analyzing the geographical location and the longitudinal profile of the railway section, it was found that the stage has a protracted guiding bias. Since the electrified section of Volkovysk-Zelva assumes a large cargo flow with access to the pan-European gauge, it would be necessary to consider the operation of a Chinese-made freight electric locomotive BKG-2, which is capable of transporting trains weighing up to 9,000 tons. However, it is necessary to reduce the weight of such a train at border stations. It requires studying the condition of the roadbed and the plan of the railway line for large weight loads. With this in mind, the operation of one of the most common electric locomotives used in Belarus - VL80k is considered. For comparison, 2M62 and 2TE10M diesel locomotives already in operation at this site are accepted. The weight of the freight train composition is assumed to be 4700 tons in the freight direction and 2810 tons in the opposite direction. When electrifying a railway section, such indicators of traction calculations as the running time of the train, the mechanical operation of the locomotive and the work of resistance forces, fuel or electricity consumption are calculated to determine operating costs. Operating costs are determined to assess the efficiency of electric traction train operation compared to diesel locomotive. Traction calculations are performed for diesel and electric traction with different locomotives and train weights, as well as speed limits.

Having analyzed the train traffic conditions for various profile elements, the VL80k electric locomotive and the 2M62 and 2TE10M diesel locomotives in operation on the Volkovysk-Zelva section in the freight and reverse directions have significant differences in the train running time. This is due to the difficult terrain, which has a protracted guiding ascent in the cargo direction.

Let's determine an economically feasible cargo turnover, in which the cost of transportation with electric traction becomes less than with diesel. It is obvious that it directly depends on the ratio of the cost of electricity and fuel for train traction, the maintenance of infrastructure, and the operating costs of all organizations engaged in transportation. By calculating the operating costs using the expense rates method, including the costs of moving freight trains; the costs of stopping trains, including acceleration and deceleration of trains; expenses for the maintenance of permanent railway infrastructure (linear structures and devices, contact network, traction substations, separate points, snow removal of tracks); depreciation charges for the maintenance of permanent road devices (roadbed, upper structure of the railway track, pipes, bridges, power supply devices) with the existing infrastructure and electrification of the railway, a schedule is constructed the dependence of operating costs on the load load for the Volkovysk-Zelva section at different costs of 1 kg of fuel and 1 kWh of electricity.

From the calculations, we can say that there is a fairly wide range of values of economically feasible transportation sizes for the transition to electric traction, below which the cost of electrification infrastructure is overestimated (with small transportation values), and above that it is compensated by higher technical and economic indicators of electric traction (with large transportation sizes). For the Volkovysk-Zelva section, the range of values for the transition to electric traction is in the range from 10 to 14 million tons. Currently, the load capacity of this section is 11.5 million tons, i.e. electrification of the site is advisable.

Taking into account the cost of electricity from the Belarusian NPP, as a regular consumer, it is advisable to electrify the single-track section of the Volkovysk-Zelva railway. The reserve for reducing fuel costs for train traction is to improve the quality of operational work, improve technological processes and improve the quality indicators of the use of rolling stock.

IV CONCLUSION

Comparing the approximate economic costs of various measures to improve the operational characteristics of the Volkovysk-Zelva section, it can be concluded that the most expensive, but also the most effective and promising option is the electrification of the Volkovysk-Zelva section with subsequent access to the Svisloch station and the state border.

The feasibility of electrification is explained by taking into account the cost of electricity from the Belarusian NPP, as a regular consumer of the Belarusian railway, and the reserve for reducing fuel costs for pulling trains, as well as improving the quality of operational work, improving technological processes and improving the quality indicators of the use of rolling stock.

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