International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 12, Issue 3 [March. 2023] PP: 39-41

Structural analysis of train speeds

Pavel V. Kovtun, TatsianaA.Dubrouskaya
Design, construction and operation of transport facilities, Belarusian State University of Transport, Gomel, Republic of Belarus

Eugen V. Nikitin, NatalyaN. Kravchenko
Belarusian Railways, Republic of Belaru
Pavel V. Kovtun,TatsianaA.Dubrouskaya, Eugen V. Nikitin, Natalya N. Kravchenko

ABSTRACT:*In today's economic realities, new, higher demands are placed on the quality of the transport process in all modes of transport, including railways. The customers' wishes for shorter travel times and more comfortable journey with unconditional compliance with train safety come to the fore. In the course of a study of individual Belarusian railway routes, the main reasons for speed reductions have been analysed..*

Date of Submission: 01-03-2023 Date of acceptance: 12-03-2023

I. INTRODUCTION

The position of the Republic of Belarus in the centre of the European continent between its largest trading partners, China and Europe, forms a major challenge for the development of transit corridors. The most important trans-European corridors, designated by the international classification number 2 (West-East) and number 9 (North-South) with branch 9b, converge on the territory of Belarus.

Transport corridor No. 9 connects Finland, Lithuania, Russia, Belarus, Ukraine, Moldova, Romania, Bulgaria and Greece and crosses the country from north to south, bypassing the major industrial centres of Vitebsk, Mogilev and Gomel. The length of railway lines of Transport Corridor No. 9: the direction from Teryukha to Gomel to Vitebsk to Ezerishche is 489 km, and the direction from Gudogai to Molodechno to Minsk to Zhlobin is 372 km.

Transport corridor No. 2 Berlin-Warsaw-Minsk-Moscow-Nizhny Novgorod connecting Germany, Poland, Belarus and Russia has been identified by the European Union as a priority among the Cretan corridors due to the importance of the trade flows passing through it in the West-East direction. Within Belarus the railway line runs in the Brest-Minsk-Orsha-Osinovka direction.

Transport corridor section No. 2 (Krasnoe (Russia)/Osinovka (Belarus)-Brest) is a double-track, fully electrified line equipped with automatic interlocking and electric and dispatcher interlocking devices. The operational length of the corridor on the territory of Belarus is 611 km. Permissible speeds: goods trains - 80-90 km/h, passenger trains - 140 km/h.

II. PROBLEM STATEMENT

The desire to meet the new quality of the transportation process leads to a sharp increase in the requirements to the railway infrastructure, aimed at increasing the capacity of stations and track sections, as well as increasing the speed of traffic.

The long-term foreign experience in the design and operation of railway transport, in spite of differences in socio-economic, geological, topographical and demographic conditions in different countries, has proved the expediency of two ways to solve the problem of speed increase:

- organisation of high-speed traffic on existing lines;
- construction and commissioning of dedicated high-speed lines.

The Belarusian Railways has pursued the first option as a less costly one. At the same time, the increase in throughput capacity can be achieved by implementing such organisational measures as:

- increasing the size of traction shoulders;
- reduction of station and train intervals;
- reduction of time for technological operations;
- operation with combined trains.

The task of increasing the throughput capacity can also be solved by implementing technical measures, such as:

- application of advanced railway track designs and elements;

- track development of stations, development of station entrance-exit throats;
- laying of the second and the third track on the line for crossing and overtaking of trains;
- use of double-track inserts on the line for non-stop crossing of trains;
- adoption of microprocessor-based interlocking;
- modernisation of communication facilities;
- strengthening the capacity of traction power supply and traction substations;
- commissioning of modern rolling stock.

Development of railway transport in terms of the use of advanced track structure has been ongoing throughout the history of transportation. In order to increase the speed of trains and increase the axle load of the rolling stock, the design of rails was strengthened and improved. So, rails R38, R43, R50 were used in the main way, nowadays - R65 and in some cases - R75. The same situation is with switches. Earlier - switches P43, P50 of 1/9 type, and currently - switches P65 of 1/11 and 1/18 types. Everywhere in the main line, the point base is changed from wooden switch beam to the reinforced-concrete beam.

The plan and profile of the railway line is being reviewed with the increase in speed. With high-speed traffic, more stringent requirements are imposed on the line layout for passenger comfort: small radius curves, lengths of straight sections and transition curves, which are increased to stabilise the rolling stock. Crossings with highways are made at different levels, switches are replaced, and passenger platforms are rebuilt. In addition, central interlocking and communication systems are being modernised, the contact network and traction substations are being reinforced, and environmental protection measures are being taken.

The introduction of high-speed passenger trains is carried out in most cases on existing railway lines. These lines have been built to a maximum speed of 100-120 km/h. Therefore, in order to realize high-speed traffic (200-250 km/h), a number of permanent facilities need to be rebuilt. Among others, the railway line is to be reconstructed, the parameters of its layout being more demanding in the context of high-speed traffic for the comfort of the passengers. The use of tilting cars makes it possible to achieve higher travel speeds with the existing layout and to reduce the volume of track realignment. The maximum speed of trains with active tilting systems on the German (DB), Austrian (OBB) and Czech (CD) railways is limited to 160 km/h - 200 km/h. However, this restriction is not imposed by the tilting system, but by the requirement in these countries to equip lines where trains are allowed to run at speeds above 160 km/h with continuous automatic locomotive signalling.

III REASONS FOR SPEED LIMITS

Analyzing the Order of the Head of the Belarusian Railway No. 231H dated July 02, 2013 "On establishing the permitted speeds of trains on the Belarusian Railway" it was found that almost every direction has sections with reduced speeds (the so-called "barrier places": curves, bridges, station necks). Such locations are present practically in all divisions of Belarussian railway.

When analyzing the list of switches installed at stations, it is generally seen that ordinary switches are operated in the main course, the speed of which is 50 km/h on the side track according to the technical specifications and the current order. In our opinion, a possible technical measure in order to eliminate these "bottlenecks" is the use of a single ordinary 1/18 type track switch (with an appropriate technical and economic feasibility study). The use of such switches would increase the speed of trains to 80 km/h.

In the course of monitoring the technical characteristics of the track structure on the example of one of the directions of the Belorussian railway were identified the causes of trains speed reduction up to 40 km / h, which has a negative impact on the time of the train on the road. To determine the causes of the increase in the train stays on the route, used Ishikawa diagram, aka "fishbone", aka "cause-effect diagram", which helps categorize and visualize the potential causes of the problem.

An Ishikawa diagram is a graphical way of examining and identifying the most significant cause-effect relationships between factors and effects in a given situation or problem. The diagram is named after one of Japan's greatest management theorists, Professor Kaoru Ishikawa, who proposed it in 1952 (according to other sources in 1943) as a supplement to existing methods for logical analysis and process improvement in Japanese industry.

Ishikawa is one of the developers of a new concept of production organisation, implemented at Toyota. Professor Ishikawa's scheme clearly shows how to work towards improving the quality of production processes. Like most quality tools, it is a visualisation and knowledge organisation tool which facilitates the understanding and final diagnosis of a particular problem in a systematic way.

It helps to identify key relationships between different factors and to understand the process in question more precisely. It helps to identify the main factors that have the greatest impact on the development of the problem in question, as well as preventing or eliminating those factors.

It is used extensively in new product development, to identify potential factors that cause an overall effect.

The view of the diagram when looking at the field of the problem in question does resemble a fish skeleton (the eyes usually move from left to right, as when reading a line of text). The problem is indicated by the main arrow. Factors that aggravate the problem are indicated by arrows sloping to the right to the main arrow, and those that neutralise the problem are sloping to the left. If the level of analysis is increased, arrows of second-order influencing factors can be added to the factor arrows, and so on. The figure shows such an example with two levels of dice: red colour stands for 1st level - the main (primary): a, b, c, d, and blue for the 2nd level - deepening (detailing) causes (factors) of the studied influence on the result (among factors of the 2nd level are both those that strengthen effect of the 1st level - e, f, g, h, i, l, m, o, p, and those that weaken it - k, n).

The factors detected are further subdivided according to their increasing specificity, until the branches of the problem are further subdivided (the true causes, not the symptoms, must be identified).

An example diagram is shown in Figure 1.

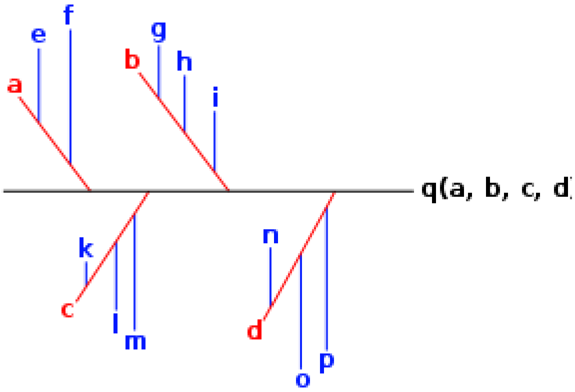

Fig. 1. Ishikawa diagram

The main reasons for the increase in speed are the use of railway infrastructure elements which do not fully comply with the current speed regime of trains on the Belarusian Railway.

IV CONCLUSION

It is necessary to use modern track elements (facilities) of railway infrastructure to increase train speeds, as train speeds are mutually related to the time of freight delivery, reduction in the passenger journey time, attraction of passenger traffic to rail transport and, consequently, reduction of losses in passenger traffic.

Thus, increasing train speeds will increase the competitiveness of railway services not only in the domestic market, but also in the international transport market and create mutually beneficial conditions for intensifying cooperation with partners.

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