http://www.moderntechno.de/index.php/meit/article/view/meit21-01-012
DOI: 10.30890/2567-5273.2022-21-01-012

UDC 656.21

THE CONCEPT OF THE TRAINS' SPEED INCREASING
КОНЦЕПЦИЯ ПОВЫШЕНИЯ СКОРОСТИ ДВИЖЕНИЯ ПОЕЗДОВ

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Annotation. *Currently, high-speed railways provide not only high speed of movement, but also a higher level of reliability and safety, and comfort, and economy. New trains built based on innovative technologies develop a speed of 300-350 km/h and successfully compete with all types of transport. In the modern sense, high-speed overland transport is railway transport, which guarantees the movement of trains at a speed of more than 200 km/h. Its movement is carried out either by wheeled rolling stock along the rail track, or by rolling stock on a magnetic cushion.*

The problem of the trains' technical speed increasing is an important task facing the railway. Reconstruction actions to increase the speed of movement by the railway should be designed in such a way as to guarantee the safety and uninterrupted movement of trains and reduce the time of passengers on the road while ensuring the required dimension of traffic and the lowest construction and operating costs.

Keywords: *railway, reconstruction, speed increase, criteria, rolling stock.*

Introduction.

Railways are ideal for providing comparatively cheap and fast, and convenient, and low environmental impact mass transportation. Many railway enterprises and operating companies are already using the opportunities provided in this regard [1].

Analysis of recent research.

An analysis of recent researches conducted by the authors showed that the issue of the trains' speed increasing is very popular in the modern world.

Most European countries are successfully solving the problem of the trains' speeds increasing through actions that are carried out both on existing railways through their modernization, and on specially built lines [2-4].

By the example of Chinese railways, a complete assessment of speeds during operation was implemented [6, 7]. The article presents indicators and an integrated framework for the comprehensive assessment of operating speed on a high-speed railway.

Article [8] is devoted to the analysis of the high-speed railways accessibility in Korea. The variance analysis test (ANOVA) and cartographic audit based on geographic information systems (GIS) are used as assessment tools.

The main ways to increase the trains' speeds. When solving the problems of developing high-speed traffic along existing railway lines, the road is considered as an integral system consisting of devices and structures that, due to the imperfection of the technical condition, can limit the trains' speed on each specific section. Therefore, it is necessary to know the permissible speed of trains on each railway section, as well as the parameters of the devices, according to which the railway must be rebuilt to implement these speeds.

According to the research [1], there are four types of trains' speed increase currently in operation around the world and their relationship to conventional rail systems.

The model of the first type differs completely from the traditional services and it used in Japan (the use of magnetic levitation trains).

The second operating model is a mixed high-speed model, in which a high-speed train can run both on a purpose-built new line and on upgraded sections of conventional lines. This leads to lower construction costs as a result. This model corresponds to the French TGV (Train à Grande Vitesse) system.

The third operating model is the mixed traditional model adopted by the Spanish railway system. It allows driving some conventional trains on high-speed railways.

The fourth model is a fully mixed model. This involves the use of both high-speed and conventional trains by the same infrastructure. This model is used for the German ICE system, where high-speed trains use upgraded conventional lines and freight trains use the high-speed lines' spare capacity at night.

Thus, authors stand the main goal of this article as further study the main technical solutions for the trains' speed increasing based on researching the experiences of various countries.

Figure 1 shows schematically the main technical solutions for the trains' speed increasing.

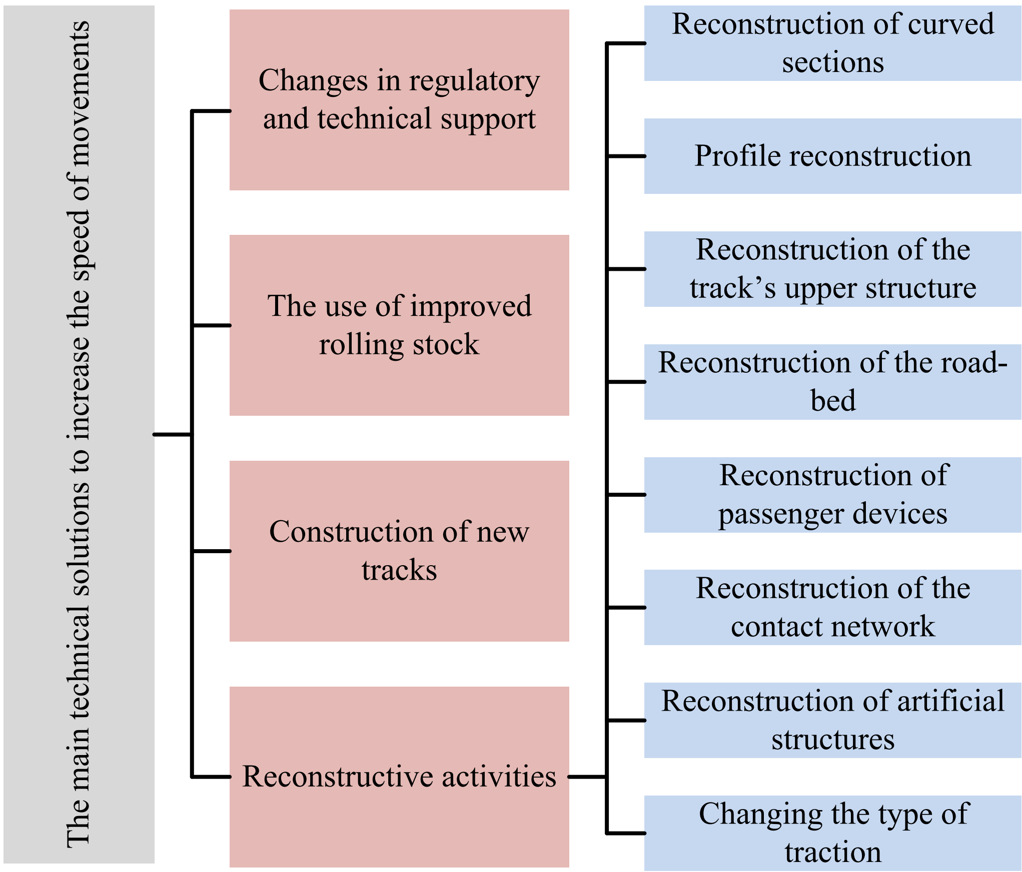

Figure 1 – The main technical solutions to increase the speed of movements

The increasing of trains' speeds at the change in regulatory and technical documentation expense is associated with various justified "simplifications" of tolerances for the maintenance and operation of the railway track. So, for example, the increase of the standard of un-extinguished acceleration value from 0.7 m/s2 to 0.9 m/s2 (for example, the rolling stock "Lastochka" ("Swallow")) allows to more quickly pass the existing curved sections at a higher speed.

It is also possible to increase the speed of trains on existing railway lines through the use of improved rolling stock. For example, since 2010, modern rolling stock Stadler has been produced in Belarus, which can be operated on 1520 mm gauge railways with an operating speed of up to 160 km/h.

The Strizh (Swift) rolling stock runs between Moscow and Berlin and transits through the territory of the Republic. Its feature is the ability to change the gauge from 1520 mm to 1435 mm and back moving with a speed of up to 15 km/h.

The Lastochka (Swallow) rolling stock runs along the section of the second transport corridor and connects the two capitals Moscow and Minsk. It develops speed up to 140/160 km/h and can go through curved sections of the track faster due to the increased value of the permissible un-extinguished acceleration.

The increasing of speeds associated with the construction high-speed railway (HSR) is characterized by high costs and as a rule they are one of the largest infrastructure projects in the countries which implement them. Such projects have a significant long-term impact on the national transport system and its development. As world experience shows the creation of the HSR network can cause significant socio-economic effects that justify the costs of their construction. However, often the construction of new HSR is associated with limitation of space (especially for the second and the third tracks) and the presence of existing infrastructure that does not allow the construction of additional tracks.

The reconstruction of the railway track is focused on increasing the bearing capacity, strength, durability and other reliability characteristics of both the railway track as a whole and its components. These characteristics provides an extension of the life cycle, reducing labour costs and the cost of maintenance of the track and obtaining an economic effect during its operation, in including by the trains' speeds increasing.

The reconstruction of the railway track includes works that lead to a change of the track category, as well as to increasing the bearing capacity of artificial installations, to the ability of the track and artificial installations to carry increased axle and linear loads, to the change in spatial characteristics (plan and profile of the track, geometry of the ballast prism and road-bed, and oversized places), to the change in the design of the track with the construction of new drainage, protective and fortifying installations. As a result of the reconstruction the railway track has the ability to be transferred to the higher category depending on the operational criteria.

When developing a project for the reconstruction of an existing railway, the following tasks are solved: optimization of the plan and profile of the existing railway line; such improvements of the track's upper structure condition as are allowing to pass high-speed trains; modernization of station devices, etc.

The reconstruction of the line plan consists of increasing the radii of the curved sections of the track, because curves of small radii restrain the speed of trains. However, it is not always possible to do this, because existing tracks and developed infrastructure hinder this measure in this case.

Permissible slope difference (Δi), on a section with train speeds of 160 km/h, should not exceed 6 % ($\Delta i \leq 6$ %). If the slope difference exceeds the standard value, this slope is straightened and a check carried out by traction calculation. After that, the reconstruction of the track will be carried out in this section in order to increase the speed of movement.

Contact suspension in cooperation with current collectors of electric rolling stock should ensure uninterrupted current collection when trains move at a set speed and the calculated climatic conditions of the area with the optimal service life of both the contact wire and the contact inserts (plates) of the current collectors. When the trains' speeds increase there is a need to reorganize the contact network due to a change in the position of the turnout centres for increasing of the inserts between them and the tracks' axes to expand the passenger platforms, which will require the transfer of supports, as well as the modernization of the construction of the contact suspension in accordance with the requirements of high-speed traffic.

In many cases, the use of polymeric materials on electrified railways allows to find completely new simple ways to solve complex technical problems related to increasing the speed of trains; increasing the reliability of devices; reducing the cost of manufacturing structures and installation and operation; increasing the safety of work on the contact network under voltage; saving scarce non-ferrous metals; extending the service life; improving the appearance of contact network structures.

When placing intermediate stations on straight lines, it is necessary, first of all, to eliminate the reverse curves arranged on the approaches to increase the distance between the main tracks' axes (from 4.10 m to 5.30 m). For this purpose, one of the main tracks is shifted to provide between them the same distance between the tracks at both of the station and the adjacent hauls. When the movement speeds are increasing, passenger platforms placed between the main tracks are removed. Those platforms located close to the main tracks are brought up to 8 m wide with transitions at different levels, and the track junction is reorganized to meet these requirements, since turnouts for high-speed traffic have a length greater than regular turnouts.

When the trains' speeds are increasing, the upper structure of the track must meet all the requirements for the implementation of high speeds on it. Turnouts on the main tracks need to be replaced with high-speed ones with a continuous rolling surface and straight inserts between them are increased up to 25 m, and up to 12.5 m in difficult conditions, the reconstruction of the electrical interlocking of turnouts and signals is being carried out, since high-speed turnouts have movable cores of the cross requiring additional electric drives.

Changing the type of traction, in particular, the electrification of railways ensures the availability, high quality and safety of transport services; development of its infrastructure; renewal of rolling stock of railway transport; increasing the speed of goods delivery and passengers transportation; increase in the length of electrified railway sections in the main directions of international transportation; acquisition of a new generation of rolling stock that ensures high speeds for passenger and freight trains; improving the efficiency of the transport complex.

The efficiency of increasing the speed of trains on the territory of the Republic of Belarus is quite justified, since the distance and character of transportation corresponds to the factors that determine the scope of its rational application, in particular:

- the length of the directions on which the greatest intensity of traffic is observed corresponds to an equal amount of time in comparison with air transport;
- service by high-speed trains of a number of large settlements located relatively close to each other, providing a sufficiently large number of passengers;
- transportation of a lot of passengers making business trips, etc.
- transfer of freight trains to a parallel track.

On the Belarusian Railway, the introduction of high-speed passenger trains on railways is possible in the following options [3]:

- construction of new lines;
- reconstruction of existing lines, including changing the geometric parameters of the line (plan and longitudinal profile) will requiring significant capital investments;
- the introduction of an improved rolling stock with the possibility of realizing outstanding un-extinguished acceleration $a_{\text{np}} = 0.9$ m/s^2 while ensuring the level of passenger comfort (including a change in traction).

The strategy for the development of railway transport ensures an increase in traffic and its qualitative change in order not only to maintain, but also to expand the positions of railways in the transport services market.

To develop a speed of up to 160 km/h, you need the appropriate rolling stock. First of all, such trains are launched between Brest and Minsk, as well as between Gomel and Minsk.

Findings.

The choice of possible options for increasing the speed of trains in any case is a technical and economic task of a high level of complexity. Both individual reconstructive measures and their various combinations are possible. The decision depends on the factors considered in each case.

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Аннотация. *В настоящее время высокоскоростные железные дороги обеспечивают не только высокую скорость передвижения, но и более высокий уровень надежности и безопасности, комфорта, экономичности. Новые поезда, построенные на основе инновационных технологий, формируют скорость в 300-350 км/ч, благополучно соперничают с абсолютно всеми типами транспорта. Высокоскоростной наземный транспорт в современном представлении – это железнодорожный транспорт, гарантирующий движение поездов со скоростью более 200 км/ч. Его движение осуществляется либо колесным подвижным составом по рельсовому пути, либо подвижным составом на магнитной подушке.*

Проблема повышения технической скорости движения поездов является важной задачей, стоящей перед железной дорогой. Реконструктивные мероприятия для повышения скоростей движения на железной дороге должны проектироваться так, чтобы были гарантированы безопасность и бесперебойность движения поездов, сократилось время пассажиров в пути при обеспечении потребных размеров перевозок и наименьших строительно-эксплуатационных затратах.

Ключевые слова: *железная дорога, реконструкция, повышение скорости, критерии, подвижной состав.*

Article submitted: 28.05.2022 г.