Saidburhan DJABBAROV
Tashkent Institute of Railway Engineering
Adilhodzhaev, 1, 100167 Tashkent, Uzbekistan
Corresponding author. E-mail: saidhon@inbox.ru

PROSPECTS FOR RAISING PASSENGER TRAIN SPEED ON THE RECONSTRUCTED SECTION OF THE UZBEKISTAN RAILWAYS

Annotation. Analysis of the state of technical equipment and railway infrastructure in the example section of the Tashkent-Andijan shows the possibility of increasing the speed of passenger trains. The results can be used in the reconstruction of railways operating under similar conditions, in order to increase train speed.

ПЕРСПЕКТИВЫ ПОВЫШЕНИЯ СКОРОСТИ ДВИЖЕНИЯ ПАССАЖИРСКИХ ПОЕЗДОВ НА РЕКОНСТРУИРУЕМЫХ УЧАСТКАХ ЖЕЛЕЗНЫХ ДОРОГ УЗБЕКИСТАНА

Аннотация. В результате анализа технического состояния и оснащенности инфраструктуры железной дороги на примере участка Ташкент-Андижан показаны возможности повышения скорости движения пассажирских поездов. Результаты могут быть использованы при реконструкции железных дорог, эксплуатируемых в аналогичных условиях, с целью повышения скорости поездов.

1. INTRODUCTION

High-speed railway lines represent an integral system of a specialized rolling stock; and a railway track on which the speed of movement of trains, and safety requirement is higher than on the traditional railroads [2].

In post-war Japan, similar integrated system was put into operation in 1964. The network of national high-speed, and high-speed railroads connecting large cities has been created in majority of the countries of Western Europe, Scandinavia, Southeast Asia, as well as in some countries of the Middle East and North America.

The high-speed movement of passenger trains is carried out since 2011 on lines with the general extent about 463 km. Uzbekistan, since 2011, has a high-speed railway line from Tashkent – Samarkand - Karshi. On sites where large-scale reconstruction of infrastructure are carried out, the train gathers speed to 150-180 km/h, and between settlements such as Yangiyer and Dashtobod, the maximum speed of the train reaches 250 km/h.

Completion of large-scale reconstruction, as well as construction of high-speed sites on the Samarkand – Bukhara railway line, and its electrification will allow room to organize high-speed movement of passenger trains on this site, with speed of 200-250 km/h. This brings the total length of the high-speed and high-speed railroads in Uzbekistan to excess of 700 km.

2. FORMULATION OF THE PROBLEM

With input in 2016, in operation of the new electrified railway line Angren-Pap in Uzbekistan will be created the uniform network of the railroads. There is the reality of organization of high-speed, and in the long-term of high-speed movement of passenger trains the use of the newly electrified railway line Angren-Pap, along Tashkent-Andijan route between Tashkent and Fergana Valley with of population more than 11 million people. The site of the Tashkent-Andijan railroad, according to experts, becomes an element of the high-speed land connection between Europe and Asia, along the international transport corridor of Southeast Asia - Western Europe [3, 8].

High-speed movement of passenger trains from Tashkent to Andijan can be organized along two routes (Fig. 1): inside of the Tashkent area and the Kamchik pass along a uniform route of Tashkent-Angren-Pap; in Fergana Valley, from Pap station to Andijan station, by Pap-Namangan-Andijan or Pap-Kakand-Andijan, which can conditionally be designated as "northern" and "southern" options. Thus, the length of "northern" option is 43 km shorter than the "southern" option.
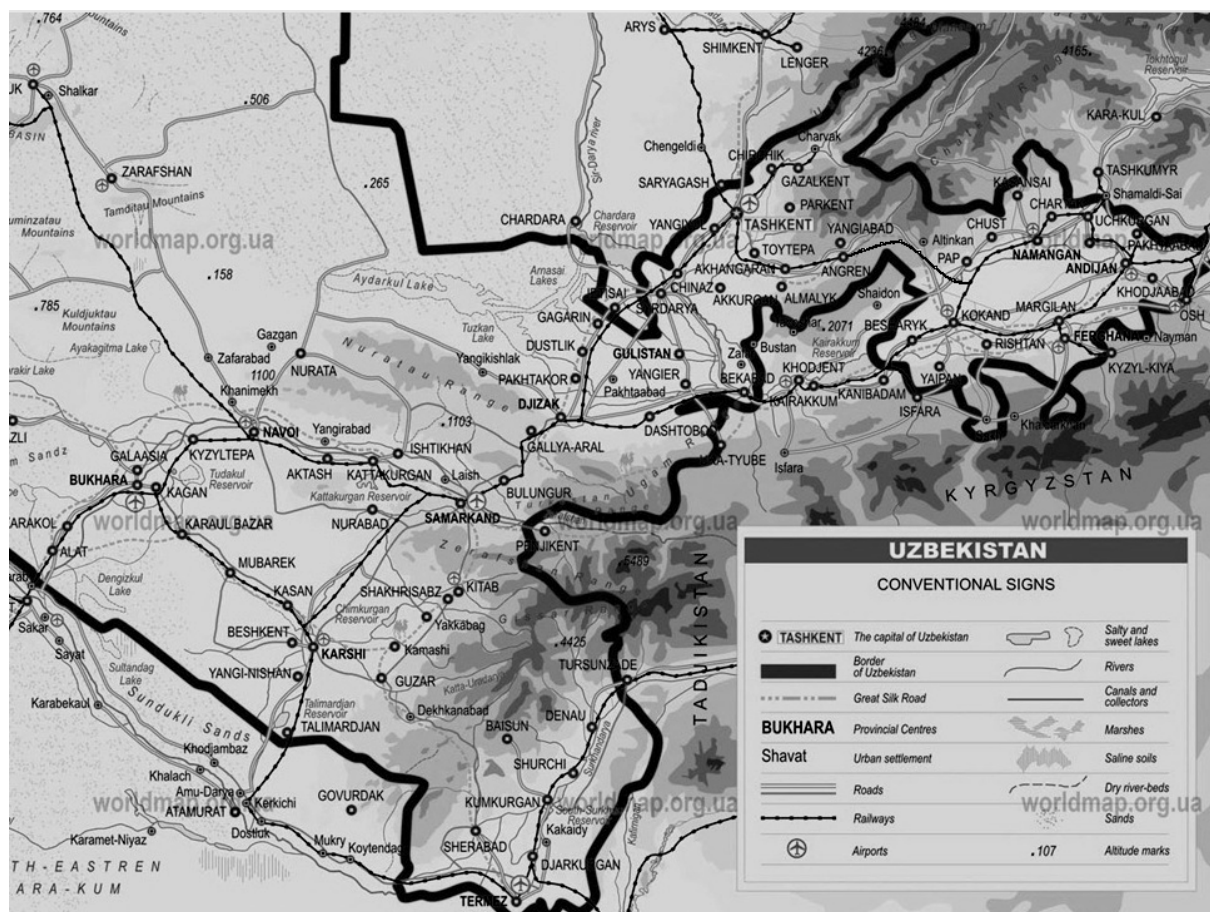

Fig. 1. Scheme of the railroad Tashkent - Andijan
Рис. 1. Схема железной дороги Ташкент-Андижан

For an assessment of options for the organization of the high-speed movement, is carried out the analysis of parameters of technical equipment and devices, construction of infrastructure, elements of longitudinal profile, and the site plan of the railroad.

Parameters of technical equipment assessment of the railroad site from Andijan station can be divided into four components:
  - Tashkent-Angren (T-A);

- Angren-Pap (A-P);
- Pap-Namangan-Andijan (P-N-A) and Pap-Kakand-Andijan (P-K-A).

The key technical parameters and equipment of sites of northern and southern option of the movement on the Fergana ring are identical.

3. ANALYSIS OF OPTIONS

For the analysis of parameters of elements of a longitudinal profile, the size of longitudinal biases is arranged in increasing order and distributed in side - altars of biases of 0.1‰ – 6 ‰, 6.1‰ – 9‰, 9.1‰ – 12‰, 12.1‰ – 18‰, 18.1‰ – 21‰, 21.1‰- 24‰, 24.1‰, and more. Thus, the total length of the elements corresponding to a certain range of size of longitudinal biases, and the share percentage of the total length of the railroad is determined. The graphic representation of distribution of the size of preferences of longitudinal profile in the specified ranges, and a share of total length of elements in them on separate sites is shown in fig. 2.

The longitudinal profile analysis of the railroads shows that on the Angren-Pap site, the total length of the elements of longitudinal profile designed by biases more than 12 ‰ of 5.3%, including 29.7% of slopes greater than 24‰. On sites Tashkent - Angren, Pap Namangan - Andijan, Pap – Kakand – Andijan, the maximum longitudinal biases do not exceed 12‰ -15‰Thus, only on a site Angren Pap, can the speed of the movement of passenger trains be limited to a profile of a way. But for modern locomotives and electric trains such as "Uzbekistan" (made in China), or Talgo – 250, this factor is not restricts and in subsequent calculations, it cannot be considered.

In the same way, on increasing parameters of elements of the plan, i.e. length of direct sites of a way (including direct inserts between adjacent curves) and radii of circular curves are ranged, their quantity and a share from total elements of the plan is defined.

The graphic representation of distribution of quantity of direct inserts and direct sites of a way, and also radii of circular curves on separate sites is shown in Fig. 3 and Fig. 4.
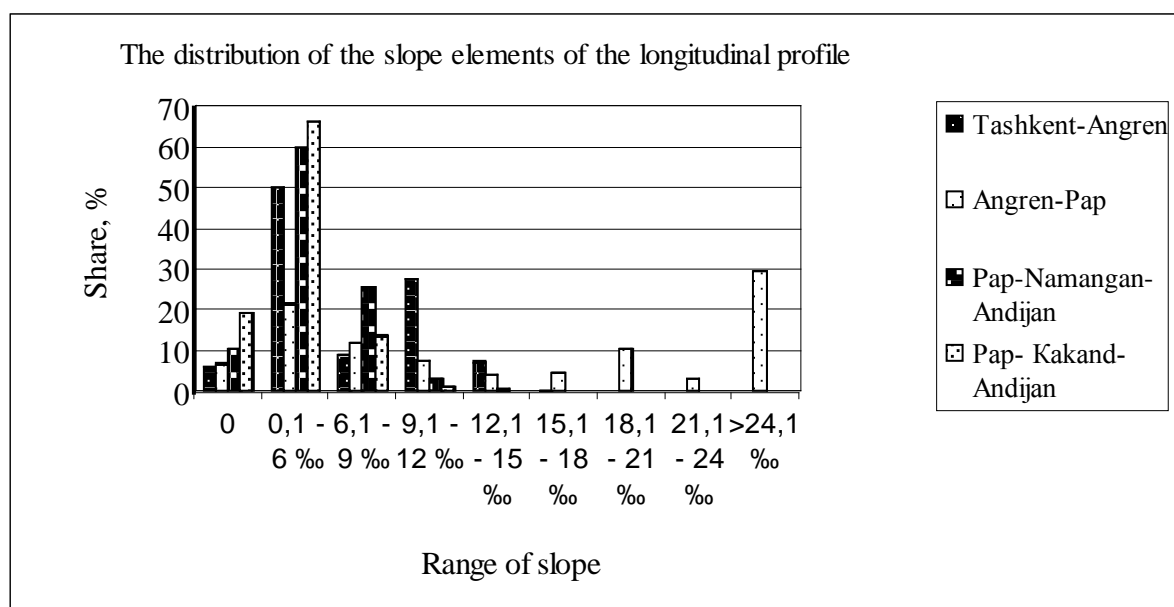

Fig. 2. Distribution of biases of elements of a longitudinal profile
Рис. 2. Распределение уклонов элементов продольного профиля

The number of sites with a length of direct inserts and direct sites of a way less than 300 m long on Angren - Pap site is 62%. On other three sites this indicator less in two and more times.

While analyzing the data characterizing parameters of elements of the plan, it is possible to make the following conclusion: on the existing railroad Tashkent – Andijan, parameters of elements of the plan of a way. And, first of all, radii of circular curves and the length of direct inserts between adjacent curves on Angren – Pap site are the main constraining reason for increase in speed of the movement of passenger trains.

Insufficient length of direct inserts does not allow placement of transitional curves of longer length, will disperse to the train to higher speed. Thus smoothness of the course of the train on curves, as a result, comfort of passengers is also broken.

On Tashkent - Angren, Pap-Namangan - Andijan, Pap-Kokand – Andijan sites, more than a half of direct sites of a way allow to place transitional curves of settlement length and to lift an external rail to the calculated value.

Nearly half (46%) of curves on Angren – Pap site are designed with a radius of 300 m and less. On the Tashkent – Angren site, 22% of curves have the radius of 301 m-400 m. On sites such as Tashkent - Angren, Pap-Namangan - Andijan, Pap-Kokand - Andijan curves with a radius within 501 m - 800 m respectively, are 28%, 36%, 25%.

Introduction of the high-speed movement on the existing railroads sharply differ from the organization of the high-speed movement [1]. The experience of Japan, France, Germany, Spain, China and other countries shows that if the high-speed movement of passenger trains can be organized on the existing railroads, it is expedient to organize the high-speed movement of passenger trains on specially-built highways [4-6].
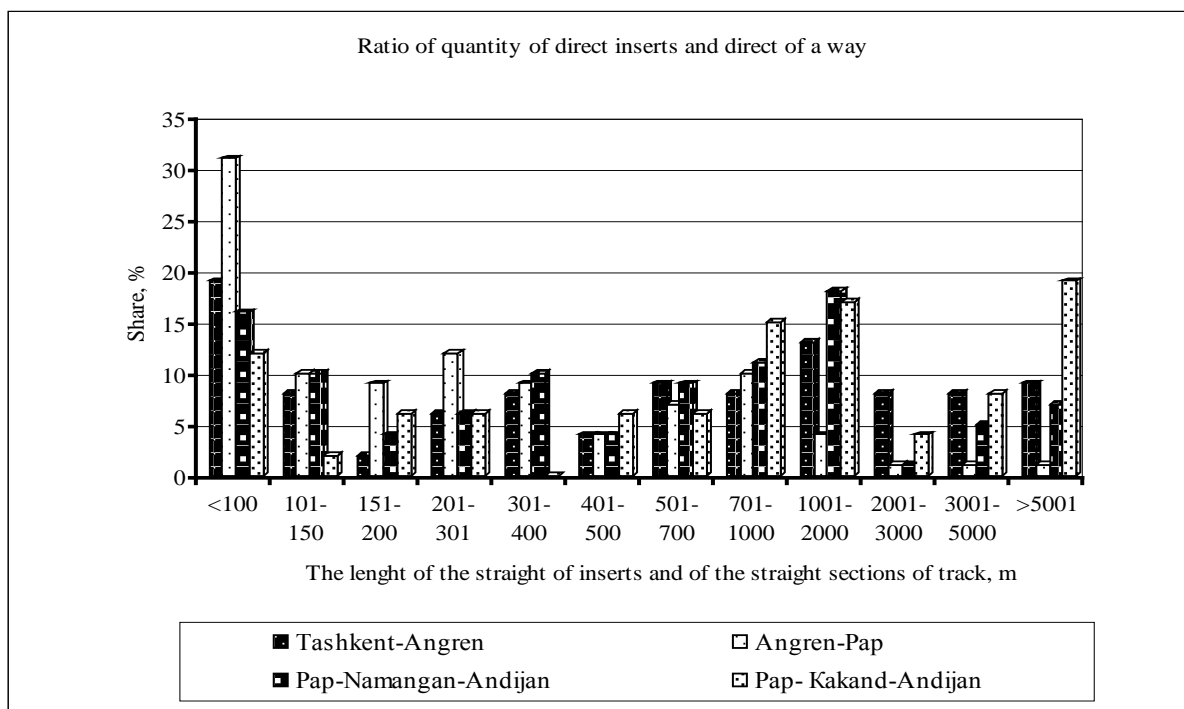

Fig. 3. Ratio of quantity of direct inserts and direct sites of a way
Рис. 3. Соотношение количества прямых вставок и прямых участков пути

For an assessment of possibility of increase in speed of the movement of passenger trains on the existing sites of the railroad Tashkent - Angren, Pap-Namangan-Andijan, Pap-Kokand-Andijan and a site under construction at Angren – Pap, the corresponding calculations [1] proceeding from the following conditions and assumptions were carried out:
1. Rolling stock
   - for passenger trains electric locomotives of 'Uzbekistan' (made in China) and 4-axis cars;
   - for high-speed trains of an electric train of Talgo - 250.

2. The most admissible speed
    -   at an initial condition of 70 km/h,
    -   after modernization 90, 120, 140, 160, 180, 200 km/h.
3. Maximum speed of the movement
    -   passenger trains to 140 km/h,
    -   high-speed passenger trains of 141-200 km/h.
4. Mass of structures
    -   passenger trains of 1200 t,
    -   high-speed passenger trains of 400 t.
5. The maximum speed of cargo trains at the combined movement of 70 km/h - 90 km/h.
6. The greatest size of outstanding acceleration according to the standard of 0,7 m/c^2.
7. Maximum eminences of an outside rail of 150 mm.
8. Speed of increase of outstanding acceleration cargo and passenger train in transitional curves ($a_{out.c \arg o}$, $a_{out.pass}$), not more than 0.5 m/c^3 and 0.7 m/c^3.
9. Speed of passing of railroad switches coincides with the most allowed speed, established on this site.
10. Throughout a site, Tashkent - Andijan is electrified.
11. For an increase in the maximum speed of the movement of passenger trains, carrying out modernization of constant devices, and construction of infrastructure of the railroad is recommended. Thus, at this stage of calculations of investment on carrying out modernization of constant devices and construction of infrastructure on sites of the railroad were not considered.
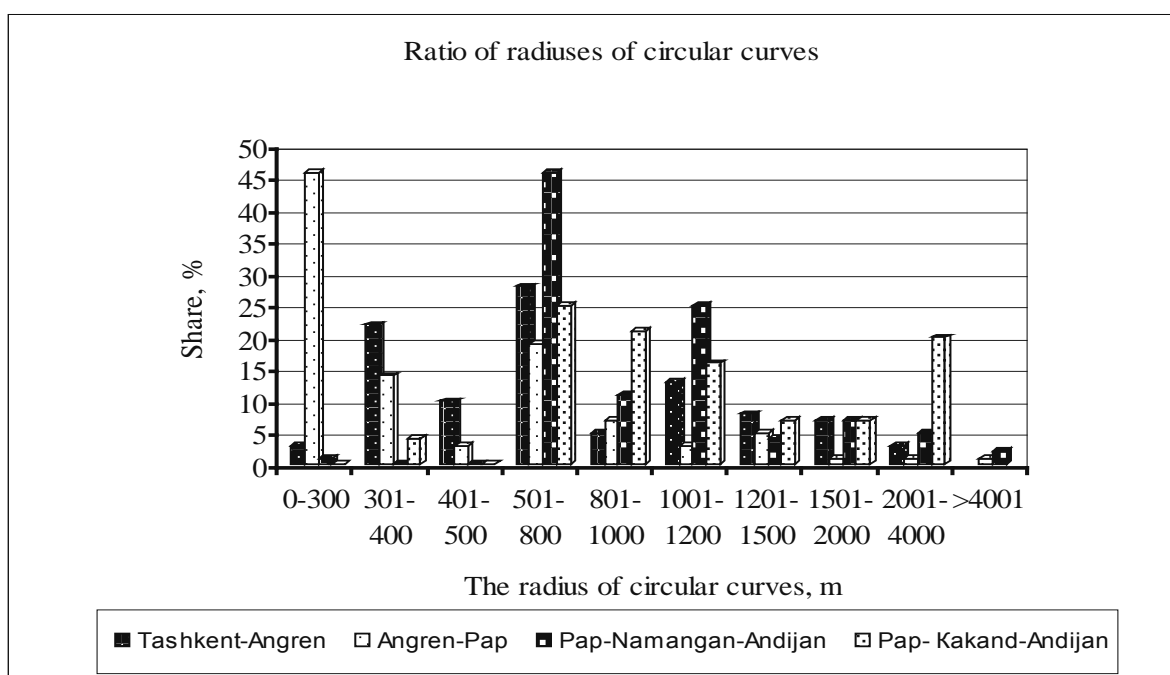

Fig. 4. Ratio of radiuses of circular curves
Рис. 4. Соотношение радиусов круговых кривых

Distinctive features of the Tashkent-Andijan railroad site is that on this single-line site, there is a combined train service for all categories. Therefore, restrictions on the maximum speed of train service on curves is established taking into account safety and smoothness of the movement of all categories of the trains handled on this site, including a high-speed electric train of Talgo - 250, with a car body inclination. The calculation of parameters of a curve equally meeting conditions of movement of trains with the maximum speed is made in the sequence given in [7].

Electric trains Talgo-250 has opportunity to realize a body inclination to 4z, which is equivalent to the device of an additional eminence of an external rail in curves at a size determined by the formula:

$$h_{add.} = \varphi \cdot S_{d.c.}, \tag{1}$$

where: $S_{d.c.}$ - distance between circles of driving of wheels of a rolling stock, for a track of 1520 mm is accepted equal 1600 mm; φ - the body inclination size measured in radians.

The additional eminence of an external rail determined by the formula (1), for a car body inclination on 2,7° (or 4°) to make 78 mm (112 mm).

Minimum values of an eminence of an external rail $h_{min.cargo}$, providing the maximum speed of cargo trains $V_{max.cargo}$, when passing i - oh by a curve radius R_i, it is determined from the following expression:

$$h_{min.cargo.i} = \left(\frac{V^2_{max.cargo}}{3,6^2 \cdot R_i} + a_{out.cargo} \right) \frac{S_{d.c.}}{g} \tag{2}$$

The maximum speed of the movement of the passenger train with traditional cars ($V_{max.pass.}$), and cars with a body inclination ($V_{max.h.sp.}$) on i -oh a curve are, respectively, determined by the following expressions:

$$V_{max.pass.} = 3,6 \sqrt{R_i \cdot \left(\frac{h_{min.cargo.i} \cdot g}{S_{d.c.}} + a_{out.pass.} \right)} \tag{3}$$

$$V_{max.h.sp.} = 3,6 \sqrt{R_i \cdot \left(\frac{h_{min.cargo.i} \cdot g}{S_{d.c.}} + g \cdot \varphi + a_{out.pass.} \right)} \tag{4}$$

Thus, for everyone i -oh the circular curve with a radius R_i located on a site of the Tashkent – Andijan railroad, using expressions (3) and (4), the maximum speed of the movement of the passenger train with traditional cars ($V_{max.pass.}$), and cars with a body inclination ($V_{max.h.sp.}$), which are used when carrying out traction calculations (tab. 1) are calculated.

4. THE DISCUSSION OF THE RESULTS

On the basis of the analysis of parameters of elements of the plan (a longitudinal profile), results of the traction calculations carried out were established as follows:
1. The reasons for restriction of speed at the level of 90, 120, 140, 160, 180 and 200 km/h.
2. Separate sites, curves or adjacent curves on which the maximum speed of the movement of passenger trains at the available parameters of a way have to be limited to speeds 90, 120 km/h.

Calculations show that lifting speed restriction for the movement of passenger trains on all sites, except for Angren-Pap site allow to reach the average speed of trains of 110 km/h -150 km/h. This reduce the time spent by passengers on the way by 3.9 hours (40% reduction).

The most intensive reduction of time of the course of the train and respectively increase, on average, speed to happen within the maximum speed of 70 km/h -160 km/h (Fig. 5). In the followingt range of the speed of 160 km/h -200 km/h, increase in average speed and reduction of time of the course of the train to occur less intensively.

Dependence of change of reduction of time of the course of the train on the level of the maximum speed for Tashkent – Namangan – Andijan, and Tashkent-Kokand – Andijan routes, can be described by equations (5) and (6):

$$y = 41,527 + 33,934x - 3,8122x^2 + 0,1475x^3, \tag{5}$$
$$y = 68,71 + 23,963x - 2,6811x^2 + 20,1015x^3, \tag{6}$$

Table 1

Time of the course and speed of the movement of the train on sites

No.	Indicators	Maximum speed of passenger and high-speed trains, km/h	Sites of the railroad				Total along a route	
			T-A	A-P	P-H-A	P- К-A	T-H-A	T-К-A
1	Length of a site, km		114.1	122.3	141.1	180.1	377.5	416.5
2	Train course time on a site, min.	70	109.9	119.3	146.4	154.9	375.5	384.0
			108.7	119.7	146.8	155.4	375.2	383.8
		90	79.5	111.9	94.5	121.2	285.9	312.6
			79.3	112.3	94.5	121.5	286.1	313.1
		120	66.5	108.8	79.3	94.5	254.6	269.8
			65.8	109.6	79.3	94.7	254.7	270.1
		140	62.7	103.0	77.4	84.8	243.1	250.5
			61.5	103.4	77.0	85.2	241.9	250.1
		160	61.3	102.7	71.4	77.9	235.4	241.9
			59.4	102.9	71.2	78.0	233.5	240.3
		180	60.7	102.4	70.5	74.1	233.6	237.2
			58.4	102.5	70.2	74.2	231.1	235.1
		200	60.4	102.3	70.1	71.9	232.8	234.6
			58.0	102.4	69.9	71.9	230.3	232.3
3	Average speed on a site, km/h	70	62.0	61.0	57.0	70.0	60.3	65.1
			63.0	61.0	56.0	70.0	60.4	65.1
		90	86.0	65.0	88.0	89.0	79.2	79.9
			86.0	65.0	88.0	89.0	79.2	79.8
		120	103.0	67.0	104.0	114.0	89.0	92.6
			104.0	67.0	104.0	114.0	88.9	92.5
		140	109.0	71.0	107.0	127.0	93.2	99.8
			111.0	71.0	108.0	127.0	93.6	99.9
		160	112.0	71.0	116.0	139.0	96.2	103.3
			115.0	71.0	116.0	139.0	97.0	104.0
		180	113.0	71.0	117.0	146.0	97.0	105.4
			117.0	71.0	118.0	146.0	98.0	106.3
		200	113.0	72.0	118.0	150.0	97.3	106.5
			118.0	72.0	118.0	150.0	98.3	107.6

5. CONCLUSION

This stage of the research has allowed us to draw the following general conclusions:
1. In the Tashkent – Andijan area, increasing the maximum speed of passenger trains to 200 km/h will reduce the time spent passengers in transit, by 2.5 hours and 3.1 hours in the northern and southern variants.
2. The maximum speed of passenger trains is 160 km/h (except for the section of Angren-Pap).
3. High-speed movement of passenger trains on the section can also be organized on the basis of existing Ozbekiston locomotives and 4-axle passenger cars.

The research results can be used to assess the possibility of deploying high-speed passenger trains on existing routes of Uzbekistan, and other countries with similar conditions of operation of the railways.
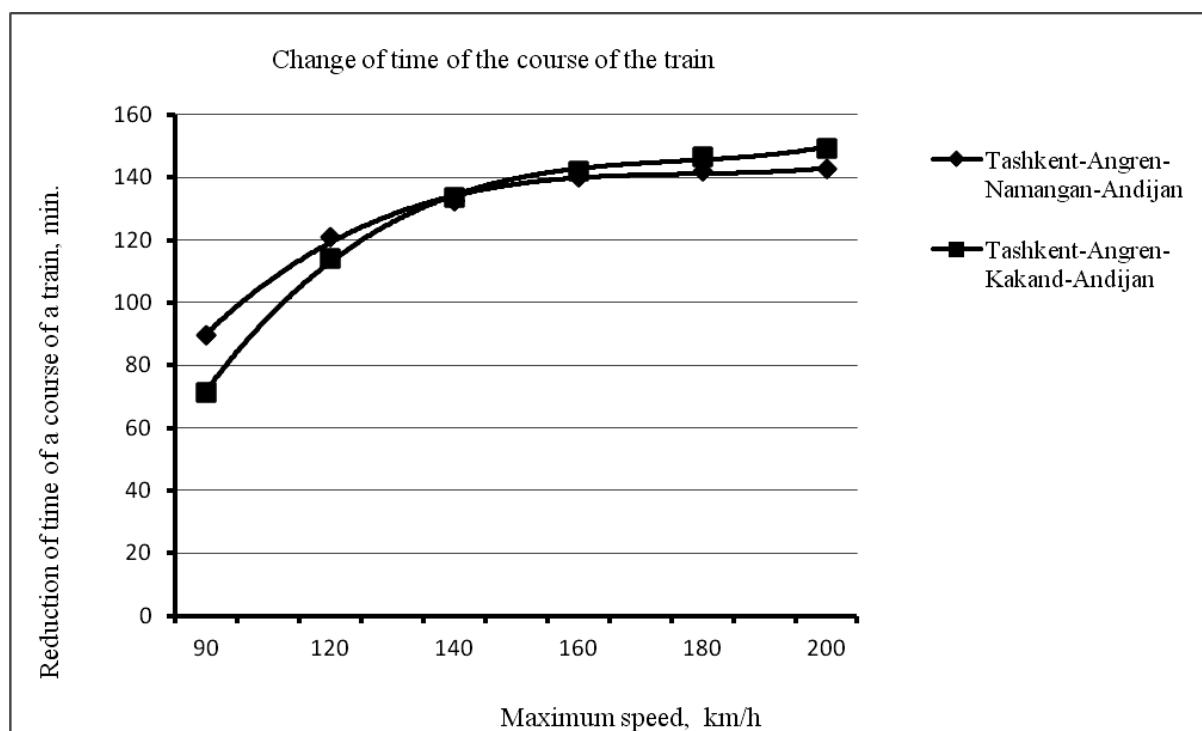
Fig. 5. Change of time of the course of the train
Рис. 5. Изменение времени хода поезда

References

1. *Првила тяговых расчетов для поездной работы*. Moscow: Транспорт, 1985. 287 p. [In Russian: *Rules of traction calculations for train work*. Moscow: Transport].
2. *General definitions of high-speed*. International Union of Railways. Retrieved. 13 May 2009.
3. Винокуров, Б.Ю. *Международные коридоры ЕврАз ЭС*: быстрее, дешевле, больше: отраслевое обозрение. Алма-Аты. 2009. [In Russian: Vinokurov, B.Yu. *International corridors Evraz of ES*: *quicker, cheaper, it is more: branch review*. Alma-Ata].
4. Beijing - Guangzhou high speed line completed. *Railway Gazette International*. Retrieved 31 December 2012.
5. World Speed Survey 2013: China sprints out in front. *Railway Gazette International*. Retrieved 11 September 2013.
6. *High Speed lines in the World*. UIC High Speed Department. 1 July 2013. Retrieved 21 July 2013.
7. Гусцов, Г.В. & Шраменко, В.П. Возвышение наружного рельса в кривых при скоростном движении поездов с активным наклоном кузова. *Транспортное строительство*. 2006. Vol. 5, P. 20-21. [In Russian: Gustsov, G.V. & Shramenko, V.P. The elevation of an external rail in curves at high-speed train service with an active inclination of a body. *Transport construction*].
8. *Formation of uniform transport space of the Euroasian economic community*. Available at: http://www.rostransport.com/transportrf/pdf/32/4-7.