Analysis of the movement of an empty railcar on the longitudinal profile of the sorting slide

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Abstract. The article uses analytical formulas derived from the application of the basic law of dynamics for non-ideal connections (the Dalembert principle), the calculation of the kinematic parameters of the rail carriage movement (acceleration, time, braking path) in the braking zone on the site of the first braking position of the sorting slide is performed. All over the world, it is becoming increasingly important to design and build modern sorting stations, as well as to choose the right height for sorting slides. The main function of the sorting slide at railway stations is the disbanding of trains, as well as the formation of new trains. Sorting will depend on how rationally the profile of the descending part of the slide is designed. Calculation of the height of the descending part of the slide and design work is carried out according to the existing method, according to which the movement of the railcar on the slope of the sorting slide, the speed is determined by the expression of the rate of fall of the railcar vertically, taking into account the inertia of the rotating masses. This, in turn, creates several problems. In developed countries, including the US, Germany, Sweden, China, India, and Russia much attention is paid to the development of methods, such as mechanization and automation of sorting ways of stations that affect haul transport and local rail network [1-7].

1 Introduction

The analysis of several works devoted to the study of the problems of calculating and designing the descent of the sorting slide shows that the mathematical model and calculation schemes for the movement of a single railcar on the slope of the slide have not been developed. In particular, the method of determining the time, path, and speed of braking of the railcar on the site of the braking positions has not yet been considered on a scientific basis. In this case, one of the actual practical issues of railway transport is the improvement of the method of calculation and design of the descent part of the sorting slide under the action of a small longitudinal wind, based on the construction of a mathematical model of the movement of railcar in braking areas [10-17].

Measures are being implemented in the republic to develop transport systems, including the development of technologies that optimize and control the organization and management of processes for processing railcar flows at railway marshaling yards. Decree

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of the President of the Republic of Uzbekistan dated December 2, 2017 Resolution "On measures to diversify and develop foreign trade areas and improve transport infrastructure" where "... in the field of railway transport in general -improving the quality and safety of railway transport services, the construction of new railway lines, increasing the level of electrification of railways, ... creating the necessary conditions for the accelerated development of the railway network of the Republic of Uzbekistan". When performing these tasks, it is necessary to choose the optimal heights of the tops of marshaling yards, the development of a way to ensure a given norm of shock frequencies for standing groups of wagons is one of the important tasks.

2 Main part

The development and improvement of the work of marshaling yards are carried out in scientific centers, universities, and research institutes of leading countries, including the University of Baltimore (USA), Technical University of Berlin (Germany), Swedish National Railway Administration (Sweden), St. Petersburg State Railway University (Russia), Russian Transport University (Russia), Ukrainian State University of Railway Transport (Ukraine), Tashkent State Transport University (Uzbekistan) [1,3,5,7,9,11,13-17].

New and reconstructed sorting facilities should be designed on the basis of calculation periods, taking into account the directions of railway networks and the location of industrial centers [1].

Sorting devices at stations are divided into two groups based on local conditions: main and auxiliary.

The main sorting devices are designed to sort and organize one-group contents at sorting stations, and to organize multi-group contents at section and freight stations, to bring wagons into and out of general and non-general use loading points (points).

Auxiliary sorting devices are designed at stations for multi-group formation, transfer of wagons to freight stations and the above-mentioned cargo areas, as well as train formations at stations where the main sorting devices are available.

The following types of main and auxiliary sorting devices are designed at stations for sorting wagons:

• sorting hill - super large, large, medium and small power hills. In this case, the weight of the wagons is used to roll them down the hill;

• without hills - traction roads consisting of an arrow throat on a slope. In this, the traction power of the locomotive and the weight of the wagon are used; traction tracks, as well as arrow throats in the horizontal field, in which only the traction power of the locomotive is used.

The types and capacity of the main and auxiliary sorting devices are set depending on the planned volume and structure of the flow of processed wagons. The calculation forecast amount of the wagon flow should be calculated for the tenth year usage amounts in the sorting stations, and for the fifth year usage amounts in the rest of the maintenance stations.

An analysis of well-known scientific works on the dynamics of rotation of a wheelset of a wagon on the slope of a sorting slide allowed us to establish that, by the existing method, the same acceleration of gravity acts on the body both during vertical descent and when moving along an inclined plane.

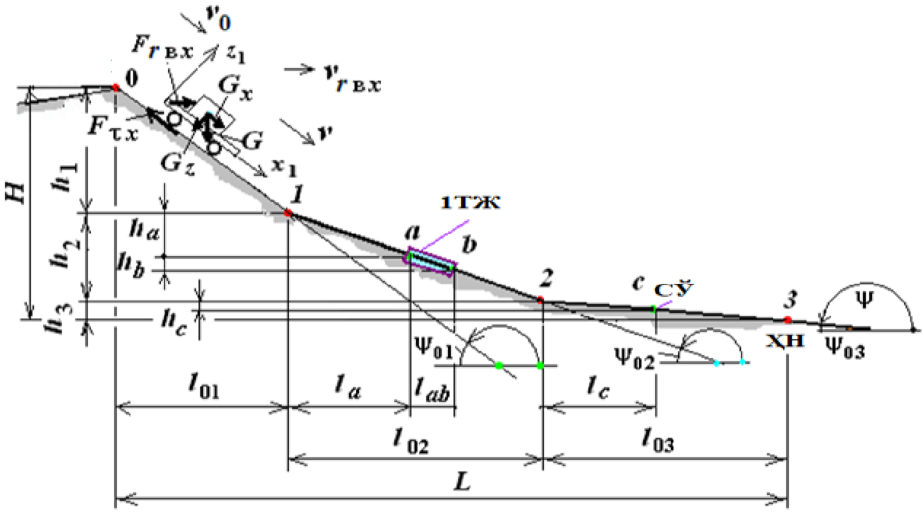

Fig. 1. Calculation drawing of the descent of the vertex.

In Figure 1.1, the sorting vertex is considered as consisting of 3 sections 0-1, 1-2, and 2-3 connected by two fault points 1 and 2. At the same time, in the second section 1-2 a and b, the first stop is located at (1TP), and in sections 2-3, there is a switching zone (NW) [2,4,6,8,10,12,14-17]. Also:

PM - the top of the hill;

N is the difference between the calculated point and the top of the slide on the sub-assembly paths, the most difficult in terms of rotation, m;

L is the estimated length of the slide (the distance from the top of the slide to the calculated point), m;

h1, h2, h3, ha, hb, hc and l01, l02, l03, la, lb, lc - height and length of the legs arranged according to the sections of the slide, m;

lab – length of the first braking position (1TP), m;

ψ_{01}, ψ_{02}, and ψ_{03} - the angle of inclination of the sections on the slide by, rad.;

G and G_x, G_z - gravity and its projection on the coordinate axis, N;

F_a is the friction force and as an active force, the aerodynamic drag force in the longitudinal wind;

v_0 is the highest initial rotation speed of a very good runner (PB), m/s;

v_{yx} is the projection of the wind speed horizontally (33 m/s, which is less than the speed of the storm wind), m/s.

An analysis of the work in this direction shows that when mathematically writing a dynamic model of the descent of a car from the top of the sorting, there are shortcomings in the interpretation of typical rules of theoretical mechanics.

The planned (planned) structure of the road branching of the sorting hill is designed based on the capacity of the hill, as well as the technological process and work intensity corresponding to the structure of the wagon flow given to the hill. First of all, connection of uphill and downhill roads, sorting park roads and road links; connection of bypass roads; layout drawings of brake positions are developed.

Along with the design of the hill roads, the park in front of the hill and the roads leading to the hill should also be designed.

The gap of the hill tracks should allow the following requirements to be met: the hill locomotive can pass to the next train, push it up the hill and distribute it to the sorting tracks (in the case of parallel distribution of two trains); parallel execution of operations such as derailment of train locomotives arriving at the park, acceptance of trains coming to the park

 https://doi.org/10.1051/e3sconf/202337604036

from the direction opposite to the direction of sorting (at one-way sorting stations, trains are received from the opposite side to the train being pushed from the hill to the parking lot); in addition, provision of the necessary number of technological systems for the processing of wagons in the next stages of the hill development, etc.

In justified cases, it is allowed to use 2/9 intersections and blunt intersections in order to reduce traffic congestion in front of the hill of the reception park and ensure parallel routes.

It is recommended to design a 350-400 m long push road for newly built high-capacity hills (for the possibility of extending the roads). During the reconstruction of hills, it is allowed to reduce the length of push roads to 150 m, in difficult conditions to 100 m.

Hill push roads and hill traction roads are planned along a straight line, 1200 m radius curve in difficult conditions, 600 m radius curve in extremely difficult conditions, and 500 m curve in mountainous conditions. can be projected along the line.

In order to increase the processing capacity of the hill (at the expense of reducing the duration of distribution of contents), to reduce the construction and operating costs (at the expense of reducing the height of the hill and the necessary power of the braking means), the following should be ensured when designing the arrow neck of the hill descent part:

• the length of the throat with the arrow to be laid is short;

• that the sum of the resistance forces applied to the wagon when going down any track of the sorting park is as uniform as possible.

To fulfill the first condition, the following should be followed:

1) Laying 1/6 grade symmetrical arrow conductors, in some justified cases laying 1/9 grade one-sided arrow conductors;

2) use radii of 200 m on the road curves of the downhill part, use radii of not less than 180 m on the curves after the last dividing arrow switch, the number of roads of the downhill sorting park is more than 32 use curves of 150 m, length no more than 20 m, in justified cases;

3) reduction of the distance between their centers when laying 1/6 symmetrical sided arrow conductors in a row (when laying R65 type rail arrow conductors, the distance between them is at least 23.85 m);

4) when laying the curves of the road, it is necessary to start from the end of the crossing.

To fulfill the second condition, it is better to group the roads of the sorting park into four- to eight-way links.

The distance between the road axes in the park under the hill is 5.30 m; between links - 7.50 m, 6.5 m can be taken at existing operational stations; 6.50 m is accepted between push tracks.

At the initial stage of the design of the grading hill, in order to calculate the height of the hill, it is necessary to leave room for the placement of brake retarders by positions on the descent.

For this, a straight section of the road is allocated for the placement of each position on the downhill section. Brake position retarders in the qualifying fleet can be placed on the turning curve. The main technical and operational characteristics of retarders are presented in Table 2.4 of Section 2.6.

It is not recommended to reduce the length of the distance from the top of the hill to the first dividing arrow and the beginning of the first brake position. These distances affect the intensity of throwing the contents and they should not be shorter than the established standards.

In addition, a 1/6 grade arrow switch should be installed to exit the sorting park's 2-4 edge roads, and a road around the hill should be laid. Transfer of wagons that cannot be dropped from these exits from the hill from the reception park to the sorting park; sending some trains directly from the peripheral tracks of the sorting park; backtracking after

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shunting on the tracks of the hill locomotive's sorting park; it is intended to take some groups of wagons out of the sorting park roads through a roundabout.

For the convenience and safety of construction crews, the ballast layer is extended to 1 m from the edge of the sleepers in the pushing part of the hill, in the distance from the place of separation of wagons to the peak.

Mathematical recording of a dynamic model of the rotation of a wagon from a sorting slide, let's consider a visual example.

Winter temperatures are -100 degrees Celsius, the headwind speed is 5 m/s, and the weight of an empty covered wagon is 22 tons. According to the results of the calculation work using existing formulas for determining the height of the sorting slide Ht = 3.5 m. the number of paths of the sorting park is 22 paths.

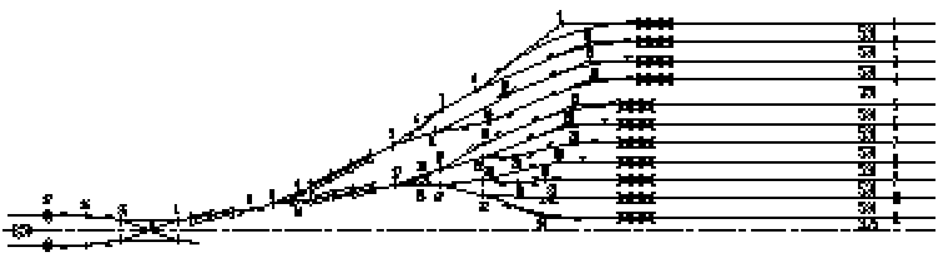

Fig. 2. The number of tracks in the sorting park is 22 tracks.

We design a 3.5-meter-high slide profile for the necks, where the sorting fleet consists of 22 tracks, based on the requirements of the norms and rules of railway construction. From the designed profile of the sorting slide, we build the height of the energy that will be lost for all tracks, dropping a bad runner (empty covered wagon) for each track.

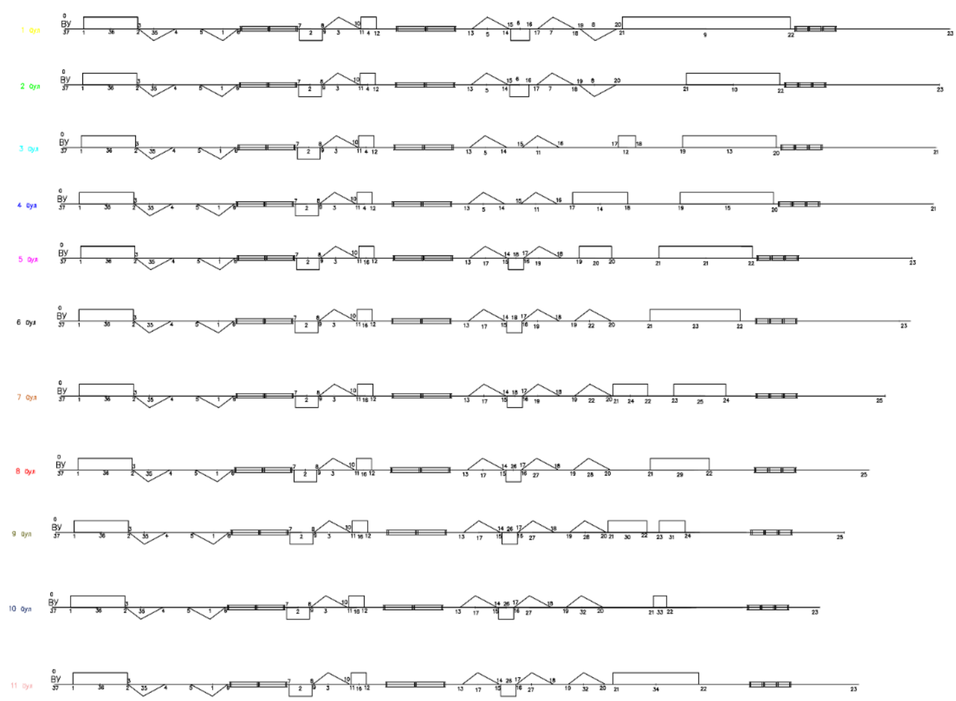

Fig. 3. Schemes of sorting paths.

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The path diagram in Figure 1.3 includes the distances from the top of the slide (TS) to the calculated point (CP).

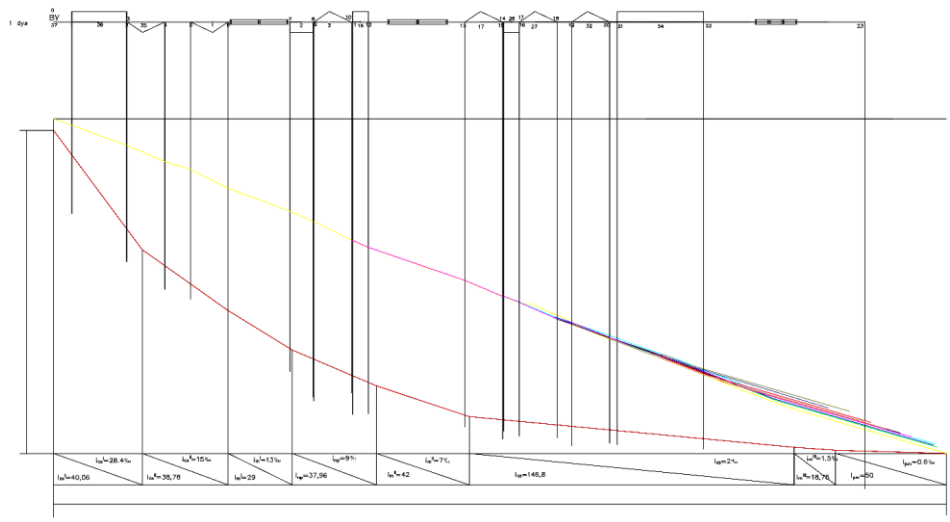

Fig. 4. Heights of energy loss descending cars from the sorting hill (on each segment of the way).

As can be seen in Figure 1.4. it can be seen that the height of the sorting slide, chosen for a difficult path, is high for the rest of the paths of the sorting park. The speed of descent from the reception park to the sorting slide depends on the power of the sorting slide, it is accepted as for small power V0 = 1.2 m/s; for medium power, V0 = 1.4 m/s; for large power, V0 = 1.7 m/s. It is assumed that the requirement for cars with poor running when descending from the sorting slide must reach the minimum design point. It was recommended not to apply braking concerning this car at a time when the car with a bad move is moving from the top of the sorting hill.

3 Conclusion

Sorting devices are an important element that ensures smooth operation of the processing capacity of the station. In order to organize the work of the technical station well, it is necessary to know the use and description of each type of sorting devices, their place in the production process.

At the modern stage, great importance is attached to the modernization of sorting hills. The main factor of this problem is the complex approach in the design and calculation of sorting devices. In this methodical literature, insufficient attention is paid to the technological calculations that allow to check the working capacity of the designed hill. In this work, materials for checking the intervals between breaks in the descending part of the sorting hill are presented.

Analysis of the movement of an empty wagon in the profile of the sorting slide allows us to conclude that empty wagons dumped from the sorting slide on each track should be carried out by adjusting the speed of dissolution to the slide.

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