

A MODERN APPROACH TO THE FORMATION OF SURFACE AND ELEMENTS OF SORTING SLIDE PROFILES

KHADJIMUHAMETOVA M. A.

Tashkent Institute of Railway Engineers (TIRE)
Uzbekistan, 100167, Tashkent, St Adilhodjaeva,1

ABSTRACT:

The article proposes a unique approach to designing a plan and profile of a sorting slide. To form the subgrade surface in cross section, it is proposed to use single-leaf and double-leaf hyperbolic paraboloids (hypars), as well as a form of hypersurface of the sorting slide, in which the guide line is a curve with negative Gaussian curvature, and the generatrix is a parabola (curve positive curvature).

KEYWORDS: sorting slide, longitudinal profile, curve, Gaussian curvature, wagon, trajectory, transverse slope, and subgrade.

INTRODUCTION:

Status of the issue: On railway transport, various special devices are widely used to perform sorting work, among which the main ones are sorting slides. Currently, the sorting hill is a complex of technical structures, systems and devices that implement modern achievements in the field of technology and management of transport facilities.

Currently, at the sorting stations of JSC "Uzbekistan Railways" where sorting slides operate, the main parameters are calculated according to the norms and rules of the instructions For the design of stations and nodes (IPSU) of 1978, although in 1992 a method was developed and introduced that allows a more detailed approach to calculating the parameters of sorting devices [6]. The experience of operating sorting slides shows that at present the problem of the quality of using the paths of sorting parks is still a

problem that has not been completely solved [3,4,5]. A significant number of detachments do not reach the cars standing on the tracks, forming "Windows". At the same time, there is a fairly large number of cases of collisions with unacceptably high speeds, while often there is damage to cars and cargo. According to official statistics, out of the total number of cars damaged at network stations, about 70% are put out of action on sorting slides [7] and there is a significant increase in the number of cases of damage to cars [3,8].

MATERIALS AND METHODS:

In recent years there have been many works in the field of improvement of hump yards, in particular, S. A. Assonance explored the issues of optimization of basic parameters of a gravity hump [11]; the calculation of the slope of the second brake position on the probability of starting, unhook in the case of stopping when braking [12]; calculating the average speed of uncoupling on the plot of the drain side hump [13]. V. I. Smirnov research in the area of influence of the inertia of rotation of the wheels on the speed of rolling of uncoupling on sorting slides [14]; V. I. Smirnov also investigated the air resistance to the movement of detachments on sorting slides [17], rolling of detachments from the sorting slide at different temperature conditions [18].

Optimization of the values of the slope drain side slides is a very complex task, the solution of which it is necessary to consider features of the dynamics of rolling of uncoupling with various driving

characteristics, as well as to ensure that all structural and technological requirements to the draft hump.

When solving this problem, various criteria for optimal longitudinal profile are used, the choice of which greatly depends on the efficiency of the sorting hill. Thus, in [1] the optimal design of the slide is considered to provide the minimum value of the slide technological interval, although the time of disbandment of the train is one of the main indicators of the sorting process, so there are other important factors taken into account.

In order to intensify the sorting process by increasing the speed of dissolution of trains in a number of works, the profile of the descent part of the slide is recommended to be designed stepwise (see, for example, [2]). However, studies have shown [3], profile speed hump does not pass long cars, leads to a significant additional vertical offset of the axes of automatic couplers and power of their interaction on the drain side slides and therefore cannot be considered to be appropriate based on the conditions of preservation of the rolling stock.

Optimization of the slide parameters based on the criterion of the minimum required power of the decelerators of the descent part [7] when rolling a very good runner (OX) also does not allow you to set the best profile. When solving this problem, it is necessary to take into account the dynamics of rolling down not one car of the engine, but the entire flow of detachments with different running qualities under certain braking modes that ensure reliable separation of detachments on the arrows. At the same time, changing the braking mode may require a significant increase in the required power of the brake positions. Minimizing power Park brake position [12] also not is the best criterion of optimization of the longitudinal profile slides,

since the main energy cost of inhibition of uncoupling does not depend on the magnitude of redeemable power and the number of inclusions of inhibitors [9].

In [10, 11], the possibility of optimizing the profile of the head part of the slide when using the dissolution rate as a criterion is considered: Optimization can be performed under the condition of equality of the calculated speed of dissolution for the limiting dividing elements-the 1st dividing switch (RSP) and the upper brake position decelerators (VTP).

In [17], it is proposed to evaluate the parameters of the slide profile by the degree of its concavity, which depends on the values of slopes and lengths of its individual elements. This characteristic is proposed to be evaluated by the concavity coefficient, which is the ratio of the longitudinal cross-section area and significantly affects the speed of a bad runner at the calculated point. The obtained results should be taken into account when designing new and reconstructing existing sorting slides.

In order to reduce energy costs for disbanding trains

In [19], the profile optimization is proposed to be performed according to the criterion of the minimum energy consumed at the Park brake position (PTP). At the same time,

Reducing the brake on the PTP may lead to the need to increase

The required power of the brake positions on the descent part of the slide.

In a series of works [1-5,10-14,16,19] elements of the longitudinal profile hump taken straight associated vertical curves, at the same time in [12,18], it is shown that the longitudinal profile of the drain side hump from the top to the first brake position should correspond to brachistochrone, i.e. the fastest sliding curve by

limiting output speed maximum allowable input speed of uncoupling on wagon retarders.

Thus, as the analysis shows, the problem of optimizing the slopes of the longitudinal profile of the sorting hill has not yet received a final solution.

MAIN PART:

The longitudinal profile of the sorting hill can be represented as a gravitational device, the profile of the sorting hill, cars, fences and brake devices [5].

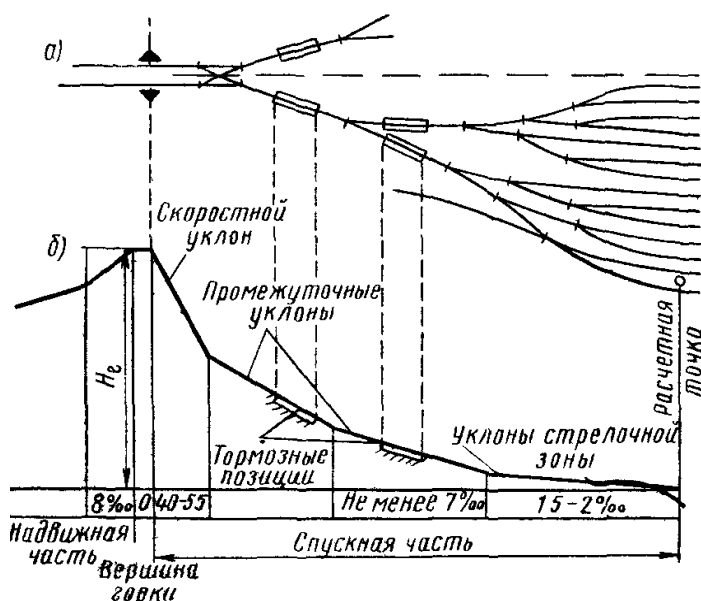


Fig. 1-layout and profile of the sorting hill

The conversion of gravity energy into kinetic energy of motion is performed on a high-speed section, which, in contrast to the straight trajectory of an inclined path, can have any specified trajectory.

In this regard, the interest is the trajectory of the descent of the wagons, in which the elements of the longitudinal profile is designed as a curve of steepest descent of brachistochrone representing an inverted cycloid arc [19, p. 59] (ASV), which is formed by rolling the generating circle of radius r along the guide rail of the straight AEB without slipping when you change the angle of the range of φ from 0 to 2π (Fig. 2).

Brachistochrone is any area of the cycloid from its beginning at point A to its end at point C (C', C'') [22].

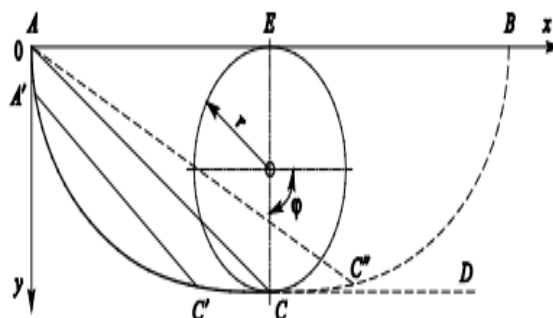


Fig. 2. - Curve of quickest descent

The descent of a car under the influence of gravity along the AC curve or any part of it (for example, A'C') will always be faster than along the corresponding straight line connecting the ends of the curve, since the speed of descent along the brachistochrone is always higher than the speed of descent along the inclined straight line.

Now let's consider the possibility of using shells of negative Gaussian curvature to form a longitudinal profile of the sorting hill paths. Shells of negative Gaussian curvature include shells outlined on the surface of a hyperbolic one with sides $2A$ and $2b$, given by a parabola convex up [16], with a lift arrow f_1 over side $2A$ and a parabola convex down with a SAG arrow f_2 over side $2b$ (see Fig.3). The surface equation in the General form of a hyperbolic parabolic has the form [16]:

$$z = f_1 \left(\frac{x}{a} \right)^2 - f_2 \left(\frac{y}{b} \right)^2 \quad (1)$$

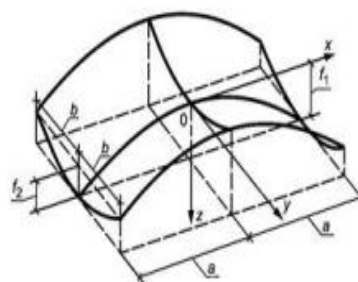


Fig. 3-Hyperbolic paraboloid

The shells are a curved surface. Geometric and static properties of shells depend on their curvature and its continuity. The sign of curvature depends on the location of the centers of the radii of curvature relative to the surface. When the centers are located on one side, K has a positive value, and on both sides – a negative value (Fig. 4).

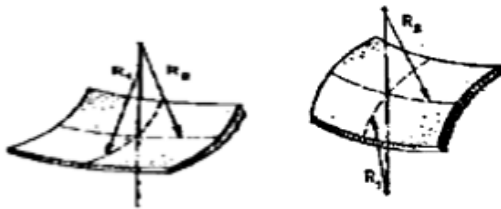


Fig. 4 surfaces of double positive (a) and negative (b) curvature.

A typical example of a surface of negative curvature is a hyperbolic paraboloid formed by moving a parabola with branches up along a parabola with branches down (Fig.5).

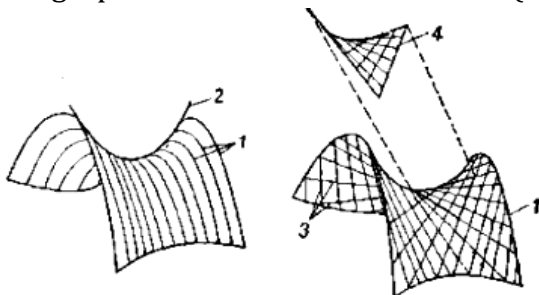


Fig. 5: Hyperbolic paraboloid 1 – parabola with vertex up (forming); 2-parabola with vertex down (directing); 3 – rectilinear generators; 4 – spatial quadrilateral – hyper.

To ensure the rapid rolling of the wagon and unhooked on the surface of the slides we offer in hyperbolic paraboloid, a parabola (Fig.5.2) from the top to the bottom it will be a guide to replace brachistochrone, in the end, for projecting the surface of the hump will get a shell of negative Gaussian curvature (Fig. 6).

To design a sorting hill, select one half of the resulting shell from the saddle point of the brachistochrona (for sorting direction from left

to right-left half, and for sorting from right to left-right).

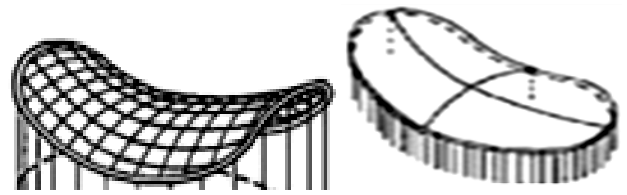


Fig. 6. Shells of negative Gaussian curvature

In accordance with [16], the cross-section of the roadbed in the bundle must be arranged as a single-pitched (or double-pitched) with a slope of 0.02 (Fig.7,a).

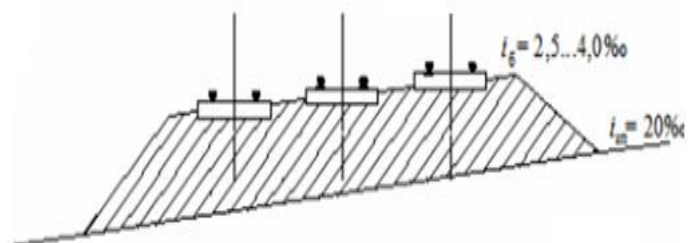


Fig. 7a. - Transverse profile of the sorting fleet beam

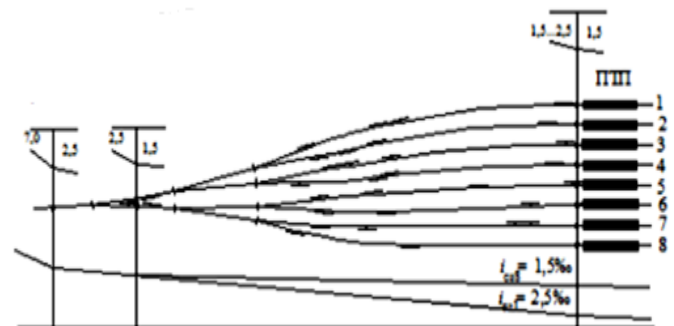


Fig. 7 b-longitudinal profile of the sorting fleet beam

The transverse beam slope is achieved by changing the slopes of the longitudinal profile (by changing the thickness of the ballast prism) after the beam arrow on each sorting path. It is obvious that the maximum transverse slope will be provided that the extreme paths of the beam are designed, respectively, with the maximum and minimum allowable longitudinal slopes, i.e. $ic_{31} = 2.5$ and $ic_{38} = 1.5$ (see Fig. 7, b). At the same time,

as the analysis showed, it is not possible to provide a slope of $\text{in} = 20\%$ along the top of the ballast with the existing restrictions on the slopes of the longitudinal profile. Calculations have shown that the slope along the top of the ballast in front of the Park brake position at 8 paths in the beam does not exceed 2.5...4%, depending on the number of paths in the beam and the distance between the beam arrow and the Park brake position. These differences are caused by the design features of the cross-section of the sorting fleet, which affects the longitudinal profile of the tracks. This can be eliminated by using the negative Gaussian curvature surface to form the profile of the roadbed.

To form the surface of the roadbed, single-petalled and multi-petalled hypars (hyperbolic paraboloids) can be used [21] (Fig.8 a,b). The median surface of a single-petalled hypar is calculated using the formula:

$$z = C_0xy + C_1x + C_2y + C_3, \quad (2)$$

$C_0 \dots C_3$ - constants that are found by known applications of the four corners of the shell.

The surfaces shown in figure 8 can be obtained by moving a straight line (forming) that intersects two intersecting straight lines (guides) shown [16]. During the movement, the generator remains parallel to one of the vertical coordinate planes. The guides can be selected as straight lines that run along any two opposite sides of the plan. Then the initial position of the generator can be assumed to pass along one of the other two sides. In the cross-section of the surface, the vertical planes that are not parallel to the coordinate planes are parabolas. The parabola of one family is convex down, the parabola of another is convex up.

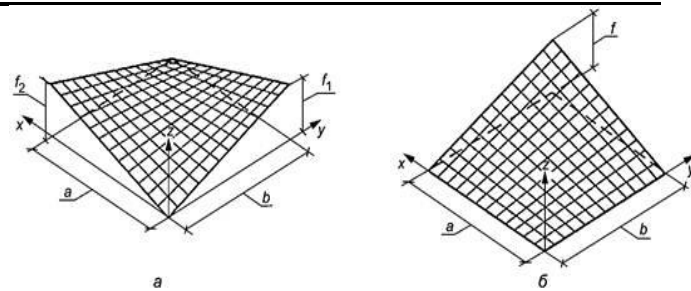


Fig. 8-single-Petalled hyper

The surface shells of negative Gaussian curvature, the curved surfaces of the second order (hyperbolic paraboloid) are of two types: in one case the sides of the contour parallel to the base line of the main curvature of the surface (Fig.8A); the other line of the main curvature of the surface directed along the diagonals of the base (Fig.8 b).

At the same time, the parabolas with the top up can determine the marks of the axes of the paths as they move away from the top of the hill (Fig.9).

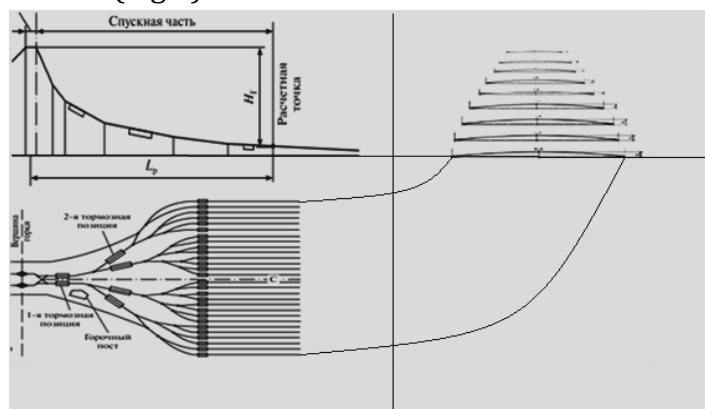


Fig. 9 Cross-sections of sorting fleet track profiles

The result is a hyper surface of the sorting hill, where the guide is a brachistochrona (a curve with negative Gaussian curvature), and the generator is a parabola (a curve with positive curvature).

The analysis showed that the studies on the impact of the longitudinal profile to the working conditions of slides, usually seen only calculated the hard way [16], are not considered features of the dynamics of rolling

on other ways of a car yard, the profiles of which are quite significantly different from each other. It is proposed to determine the height of the slide (N_g) for each track of the sorting fleet in accordance with the energy they repay when rolling cars from the top of the slide to the calculated point according to the formulas [16].

It should be noted that the formula for determining the height of the hill [1.2, 6] implies the movement of cars and detachments in the vertical plane (XOZ), although the resistance from curves and arrows in the horizontal plane (XO) is taken into account. When modeling the movement of cars along the tracks of a sorting hill in space (XYZO), it is necessary to take into account changes in the profile elements of the sorting hill and in the transverse profile. In General, in problems of geometric modeling of complex objects, the projected curves can not be written as an equation $y=f(x)$ using ordinary single-valued functions. Curves of the axes of paths can have vertical tangents, which are closely related to multi-valued functions.

Therefore, the parametric representation of curve sections plays a role in the design of the sorting hill surface [16, 23]. Parameterization is performed by specifying Cartesian coordinates of the curve point as functions of some parameter [23]:

$$x = x(u), y = y(u), z = z(u), a \leq u \leq b$$

To specify a curve using a parametric equation in vector form:

$$r = r(u) = x(u)e_1 + y(u)e_2 + z(u)e_3$$

$r = \{x, y, z\}$ - Radius-vector of a point on a curve;

e_1, e_2, e_3 - The unit vectors of the coordinate axes;

u - Parameter of the point on the curve.

The u parameter is a variable that is convenient for setting the desired functions: arc length, number of node points, polar angle, time parameter, and so on. The parametric method for setting path curves on the formed surface of the slide has the following advantages:

More than a simple calculation of the coordinates of characteristic points;

- simplify calculations when connecting curves and straight elements of paths;
- simplification of calculations related to determining the profile elements of the sorting hill and modeling the movement of cars and detachments on the simulated three-dimensional surface of the sorting hill.

CONCLUSIONS:

Based on this analysis, we can draw the following conclusions:

In the studies devoted to the influence of the longitudinal profile of the conditions of slides considered only the estimated hard way not accounted for by features of the dynamics of rolling on other ways of a car yard, the profiles of which are quite significantly different from each other;

- To form the surface of the roadbed in the cross-section, it is proposed to use one-and two-pedaled hyper (hyperbolic paraboloids);
- a form of hypersurface of a sorting hill is proposed, in which the guide is a brachistochrona (a curve with negative Gaussian curvature), and the generator is a parabola (a curve with positive curvature);
- it is proposed to determine N_g for each track of the sorting fleet in accordance with the energy they repay when rolling cars from the top of the hill to the calculated point.

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