ANALYSIS OF SPEED CURVES AND TIME INTERVALS OF UNCOUPLING ON SORTING HILL

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Abstract: *This article is devoted to one of the topical issues of improving control devices for automation and telemechanics of a railway sorting slide. Methods of automation and development of a method for determining the speed of uncoupling in the sorting slide, as well as methods of modernization management are proposed. Based on the method of an automated microprocessor control system in the upper part of the railway sorting, the uncoupling is automated by determining the speed and time curves of the uncoupling is reduced by intermediate time intervals. The permissible minimum speeds on the sorting slide were found, as well as calculation points were found to control the speed of uncoupling*

Key words: *A very good runner, a very bad runner, an arrow translation center, an isolated section, a retarder carriage mechanism.*

АНАЛИЗ КРИВЫХ СКОРОСТЕЙ И ИНТЕРВАЛЛОВ ВРЕМЕНИ ОТЦЕПОВ НА СОРТИРОВОЧНОЙ ГОРКИ

Анотация: *Данная статья посвящена одной из главных задач по совершенствованию устройств управления автоматики и телемеханики железнодорожной сортировочной горки.. Предложены методы автоматизации и разработан метод определения скорости отцепа на сортировочной горке, а также методы управления модернизацией. На основе метода автоматизированной микропроцессорной системы управления на вершине горки при определения скорости кривых и времени отцепов сокращаютя интервалы времени отцепа. Были найдены допустимые минимальные значения скорости на сортировочной горке, а также расчетные точки для контроля скорости отцепов.*

Ключевые слова: *Очень хороший бегун, очень плохой бегун, центр для перевода стрелки, изолированный участок, механизм вагон замедлитель.*

САРАЛАШ ТЕПАЛИГИДАГИ УЗИЛМАЛАРНИНГ ТЕЗЛИГИ ВА ОРАЛИҚ ВАҚТ ИНТЕРВАЛЛАРИНИ ТАХЛИЛ ҚИЛИШ

Анотация: *Ушбу мақолада темир йўл саралаш тепалиги автоматика ва телемеханика назорат қурилмаларини такомиллаштириш юзасидаги долзарб муоммолардан бирига қаратилган. Саралаш тепалигидаги узилмаларнинг тезлигини аниқлаш усулини автоматлаштириш ва уни ривожлантириш ҳамда замонавийлаштириш бўйича бошқарув усуллари таклиф этилган. Темир йўл саралаш тепалигида автоматлаштирилган микропроцессорли бошқариш тизими усули асосида узилмаларни тезлиги ва вақт эгриларини аниқлаш орқали автоматлаштирилган тарзда узилмалар оралиқ вақт интерваллари қисқартирилган. Саралаш тепалигидаги рухсат этилган минимум тезликлари ишлаб чиқилган хамда узилмаларнинг тезлигини назорат қилиш учун ҳисобий нуқталар топилган.*

Калит сўзлар: *Жуда яхши югурувчи, жуда ёмон югурувчи, стрелкани ўтказиш маркази, изоляцияланган участка, вагон секинлаштиргич механизми.*

In the proposed method, the disconnections occurring at the classification hump are analyzed based on intermediate time intervals to determine the entry speed into the first turnout, wagon retarder mechanisms, and measurement control points [10,12]. It is essential to note that the high-speed segment of the hump must facilitate the acceleration of the disconnections, while the descending section of the hump must ensure sufficient spacing between railcars to enable the proper operation of turnouts and wagon retarder mechanisms. However, under favorable environmental conditions (i.e., positive ambient temperatures and tailwinds), and with high-running-performance railcars (HRPRs), the entry speed of a 100-ton railcar into the first retarder mechanism must not exceed the permissible speed limit, which is determined by the structural characteristics of the retarder system [15]. Therefore, if the entry speed of an HRPR does not exceed the allowable limit, it can be inferred that the profile of the high-speed section has been correctly engineered [8,13].

Furthermore, the total required braking force must be sufficient to ensure that, under favorable conditions and along the prescribed descent route of the disconnections, the last wagon retarder mechanism can bring a high-running-performance railcar (HRPR) — specifically, a 100-ton four-axle semi-wagon — to a complete stop at the maximum permissible humping speed [6]. Consequently, if the application of all braking devices in the descent section of the hump results in the final wagon retarder mechanism reducing the HRPR's speed to zero, it confirms that the total braking capacity of the wagon retarder mechanisms and their distribution along the descent have been correctly determined and effectively implemented [9,14].

Based on the time curves, the sufficient interval between disconnections is determined to ensure safe passage through retarders and turnouts. Accordingly, it becomes possible to carry out humping operations at the calculated speed V0 under various conditions, including: high-powered humps with very poor-running (VPR) and very high-running (VHR) railcars; medium-powered and low-powered humps with good-running (GR) and VPR railcars alternating in sequence [5].

Therefore, a detailed and high-quality verification of the designed profile of the hump and the descent section of the classification tracks is performed through the analysis of descent time curves top1(L),tVHR(L), and top2(L)based on predefined sequences of consecutively descending railcars with varying running characteristics [1,12]. For this analysis, it is initially necessary to determine the minimum required distances between the centers of gravity of successive railcars at the moment of transition..

– Centralized switch turnout (Figure 1), m:

$l^{стр}=b_{(гб)}+ V_{стр}\cdot t_з+l_{из};$ (1)

– Wagon retarder (Figure 2), m:

$l=b_{у(ох)}+V_{ўт}\cdot(t_{тз}+t_з) +l_{су};$ (2)

– The boundary post (Figure 2), м:

$l_{тз}{}^{су}=l_{у(жся)}+V_с\cdot t_з,$ (3)

here $b_{(гб)}$ – Wheelbase of a four-axle semi-wagon;

$V_{стр}$, $V_{ўт}$, $V_с$ – ЖЯЮ respectively, the average passing speeds through the switch, the retarder, and the boundary post;

$t_з$ – the minimum interval reserve, equal to 1 second, in accordance with the design rules and standards for classification equipment;

$t_{тз}$ – the time required to switch the retarder into the braking mode;

$l_{из}$ – the length of the insulated section with the switch, in meters, m;

$l_{су}$ – the length of the insulated section of the independently controlled retarder, in meters, m;

$l_{y(жcя)}$ – the length of the four-axle semi-wagon along the axle of the gaps, m.

The obtained parameters $l^{cmp}, l^{cy}, l^{uз}$ are represented in the diagram as follows [2].

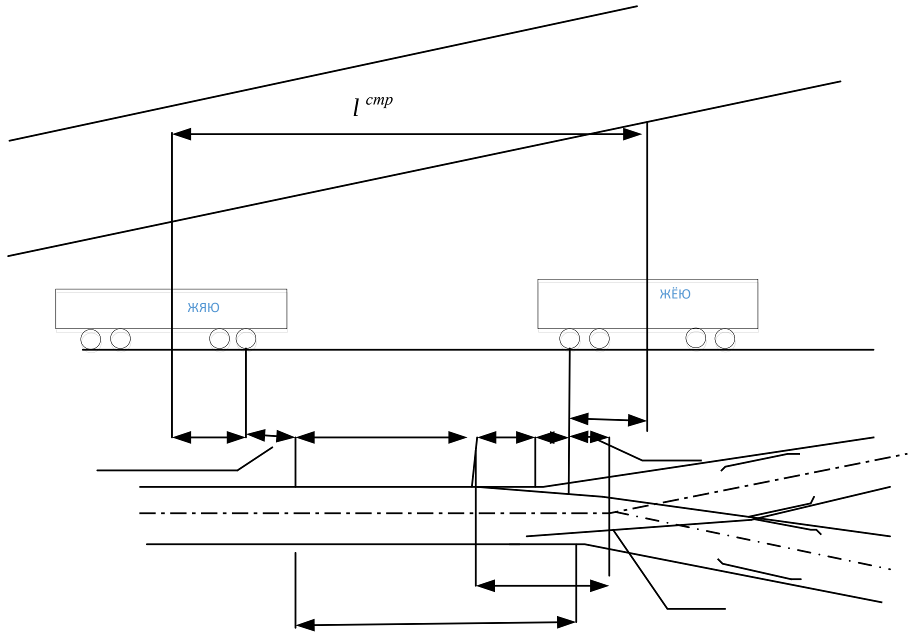

Figure 1. Minimum required distance between the centers of gravity of the running wheels when passing through the insulated switch section:

a_o – the distance from the classification hump to the beginning of the switch points (equal to 6.21 m);

l_y – the length from the insulated joint before the switch to the beginning of the switch points (accepted as 6 m according to standards);

l_{oc} – the length of the switch points (equal to 4.34 m);

k– the distance from the base of the switch point to the nearest insulated joint of the stock rail (equal to 1.04 m);

l_c – the length from the switch points to the insulated joint of the stock rail, equal to 5.38m, calculated as (lc=loc+k);

$l_{cў}$ – the distance from the insulated joint at the end of the stock rail to the center of the switch passage [7].

To represent the segment l^{cmp} on the hump plan from the switch passage center (SPC), a distance equal to the parameter a0 is marked to the left, thereby determining the exact location of the switch points. From this point, moving consecutively to the right, distances equal to the length of the switch points lsp and the additional distance k are added, which allows locating the insulated joint at the end of the stock rail [3].

Furthermore, starting from the switch points, a distance equal to lw is laid to determine the location of the insulated joint at the entry. From this insulated joint, a distance equal to the half-base of the poor runner wagon on the stock rail side is marked to the right [4].

From this point, a perpendicular is drawn to the time curve top1(L) (see Figures 1 and 2). From the obtained point, a segment equal to lstr is marked to the left. Then, from the left end of this segment, a vertical line is drawn up to the curve teg2(L). From the same point, a segment equal to lstr is marked to the right (see Figure 2).

Thus, a "time gate" is constructed, which shows that, without intersecting the curve tjy(L), it is possible for the switch points to be passed between two adjacent wagons [6].

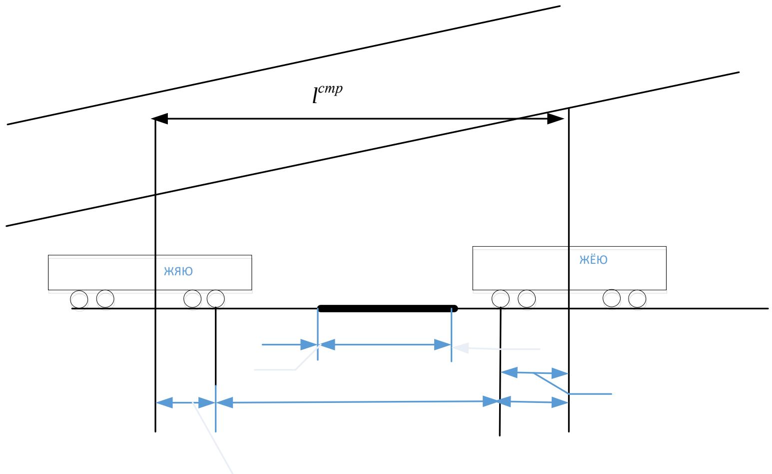

Figure 2. Minimum required distance between the centers of gravity of the running wheels when passing through a single insulated section of the retarder

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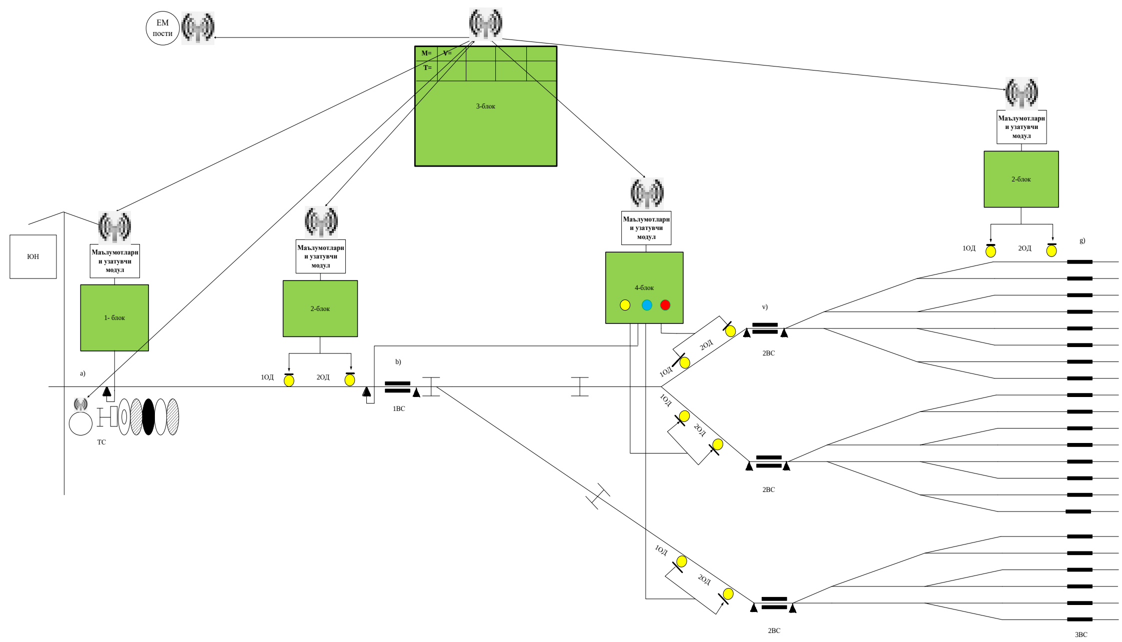

Figure 3. Structural diagram for determining the speed of rolling stock at calculated points on the classification yard hump

In the proposed method, the speed of rolling stock released from the hump is determined using optical sensors, and the wagon retarder mechanisms automatically decelerate the rolling stock while maintaining the time intervals between them. This ensures controlled slowing down, provided that the following conditions are met, under which the following inequalities hold true.

$V_{b.d} \geq V_b$ and $t \geq t_{in}$ deceleration is applied in this case;
$V_{b.d} \geq V_b$ and $t \leq t_{in}$ deceleration is also applied in this case;
$V_{b.d} \leq V_b$ and $t \geq t_{in}$ deceleration is not applied in this case;
$V_{b.d} \leq V_b$ and $t \leq t_{in}$ the hump signal does not turn green in this case;

Here, *V(b.d)* is the actual speed of the rolling stock at the first sensor; *Vb* is the calculated speed of the rolling stock at the sensor; *tin* is the interval between rolling stock; and *t* is the time taken by the wagon retarder to compress the rolling stock.

The increase in kinetic energy results from the decrease in potential energy, which is expended to overcome resistance forces.

$$\frac{mv_b^2 - mv_a^2}{2} = Qh - Qlw10^{-3} \quad (4)$$

$$m = \frac{Q}{g} \quad (5)$$

$$h = li10^{-3} \quad (6)$$

$$\frac{Q(V_b^2 - V_a^2)}{2} = Ql(i - w)10^{-3} \quad (7)$$

here, *m* is the mass of the rolling stock, measured in kilograms (kg); *w* represents the resistance forces, measured in newtons (N); l denotes the distance between points *a* and *b*; *h* is the difference in height between points *a* and *b* (corresponding to the change in potential energy); and *Va* is the initial velocity of the rolling stock.

Scientific research has shown that by automating the operation of the wagon retarder mechanism based on a microprocessor control system, taking into account the speed of rolling stock released from the classification hump, it is possible to significantly reduce train waiting times on the hump and shorten the time intervals between rolling stock. This eliminates the human factor and introduces a fully automated system.

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