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THE APPLICATION REVIEW ON THE ROLLING STOCK OF DEVICES FOR TURN OF WHEEL PAIRS IN THE HORIZONTAL PLANE

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Summary. The application review on a rolling stock of devices for turn of wheel pairs in the horizontal plane is presented in this article. Parameters of movement of single wheel pair in a direct way and radius of curvature of a way, in which radial self-installation usual colpar is possible, are defined. The expediency of use of each kind of rotary devices is shown.

Key words: roller bench, experimental carriage, wheel pair, measuring, wheel-rail contact.

INTRODUCTION

For the purpose of the systematised review of the big variety of devices for turn of wheel pairs in the plan, we will divide into three kinds:

1. The device for turn of wheel pairs usual type with a rotating axis, but with various conical shape of bandages and a profile outline (are considered above).
2. The device for turn of wheel pairs of usual type, but with application of special directing and rotary in respect of devices [Kokorev, 1993].
3. The device for turn of wheel pairs with an unrotative axis (with a free nozzle of the right and left wheels on pins of an axial beam) and with directing and rotary devices in the plan.

Wheel pair of usual type, i.e. with a rotating axis and bandages of the conic form, possesses property to move on a twisting trajectory concerning average position in a rail track. [Vol'pert, 1990]. Therefore usual wheel pair can be considered as the elementary rotary device providing self-installation in the plan in the event that movement of colpar it is not constrained by other communications in system of rail crew, and preventing constant contact to rails and intensive deterioration of crests of bandages [Bogdanov, 1992, Byinosov, 1995, Byinosov, 1994].

THE FORMULATION OT THE TASK

The increase in diameter of wheels leads to improvement of characteristics of fluctuations of wagging in a direct way (the length of a wave "L" grows and frequency of fluctuations f decreases), conditions of passage of curve sites (the radius of curvature $R_{кр}$ increases, see tab. 1) however worsen.

Usual wheel pair has a bias of bandages i = 1/20, high-speed electric trains on railway road "New - Tokaido" in Japan have a working profile with twice smaller bias i = 1/40 for a high-speed domestic electric train “Neva express train” with constructional speed of 200 km/h a bias of a working profile of wheels is accepted still smaller i = 1/100 [Works ,1978]. It is made that frequency of fluctuations at speed of movement V = 200 km/h would be less, than at V = 100 ÷120 km/h at usual locomotives and cars.

The biaxial cart with crosswise cross-section communications (Sheffelja cart [Priests, 1979]) addressing on sites with a considerable quantity of curves, is equipped by bandages with conical shape 0,2, i.e. with the big bias i=1/10.

According to the researches conducted by Golubenko’s school [Golubenko, 1999] (see tab. 1), at i=1:10 wheel steams can self-center in a radial direction in curves R≥280 m and more that corresponds to all often meeting curve sites R. The constructive scheme of Sheffelja cart however worsens characteristics of twisting movement in a direct way (the length of a wave decreases, frequency of fluctuations grows).

Table 1. **Parameters of movement of single wheel pair in a direct way and radius of curvature of a way in which radial self-installation of usual colpar is possible**

№№ п/п	Initial data			Movement parametres in a direct way					At what value of radius of curvature of a way radial installation колпары is possible	
	D, м	*i*	y_0, *м*	*L, м*	*f [Гц]*	β_{max}	Δ	*R*	y_{max}	*Rкр≥R [м]*
1	*1,05*	*1:20*	*0,007*	*18,1*	*1,53*	*±0,00244 (8,4’)*	*±2.6*	*1190*	*0.007*	$R_{кр}$≥*1190*
2	*1,25*	*1:20*	*0,007*	*19,8*	*1,4*	*±0,00222 (7.6’)*	*±2,37*	*1420*	*0,007*	$R_{кр}$≥*1420*
3	*1,05*	*1:10*	*0,007*	*12,8*	*2,16*	*±0,00343 (11.8’)*	*±3.65*	*800*	*0.015*	$R_{кр}$≥*280*
4	*1,25*	*1:10*	*0,007*	*13,95*	*1,99*	*±0,00244 (10.8’)*	*±3.36*	*710*	*0.015*	$R_{кр}$≥*330*

where: D - diameter of wheels; i – a bias; L - length of a wave;
y_0 - the greatest displacement of colpar in a direct way
β_{max} - the greatest corner of a deviation of colpar in the plan;
Δ - longitudinal moving of axle boxes at l δ = 2134 mm;
R - curvature of a trajectory; R = (r*lk)/2yi
$y_{max}=y0 + \delta$ with the account of widening

A lot of attention was given and is given nowadays to researches for choice an optimum profile of a bandage [Golutvina, 1978, Gus'kova, 2000, Ivanov, 1974, Pan'kin, 1991, Kurasov, 1981, Stacenko, 2003], however this way of improvement of horizontal dynamics and reduction of deterioration of crests and as a whole bandages is not always effective, how in process of deterioration of bandages the initial (new) profile is deformed: dynamic qualities and obsolete characteristics, as a rule, worsen. To keep under operating conditions invariable a profile of a bandage at the expense of more frequent turnings not always expediently as it leads to price increase of repair of running gears. Deterioration of rails and as consequence the distortion of profile of rail heads leads also to instability of dynamic characteristics of a rolling stock [Byinosov, Stacenko 2002, Byinosov, Stacenko 2003].

Deep theoretical researches of system movement of crew with a rigid frame or bogie taking into account the elastic sliding of wheel pairs and limiting backlashes in axle equipment show that as a whole this system is unstable [Golubenko, 1999]. Operating experience shows that at speed of movement to 70 km/h in a direct way and in curves $R \geq 1500$ m bandages with a bias of a surface of driving 1:20 practically provide contactless movement of crests of bandages and their minimum deterioration; it does not occur at speeds above 70 km/h and in a curve way of [Golytvina, 1978]. It is almost impossible to fulfil requirements of good self-installation of usual wheel pairs in a direct way and in operational curves.

In conclusion of consideration of the elementary of "the rotary device", i.e. usual wheel pairs, it is necessary to tell what to counteract it and to carry out other direction of movement of usual wheel pair not so easily: for this purpose it is necessary to overcome a twisting moment created by forces of a friction between wheels and rails on a shoulder, equal to distance between planes of circles of driving of wheel pair $l_к$ = 1,58m:

Thus, the device of radial installation of wheel pairs of usual type, at all its simplicity, absence of feedback is automatic, creating twisting periodic movement in a rail track, but not steady and rather powerful.

Passing to consideration of rotary devices of the second kind we will tell that they are systems, in which simultaneously operate (and two independent rotary devices confront): wheel pair of usual type and the directing device which should overcome action of the first.

In this sense application of wheel pairs with an unrotative axis in the presence of a directing rail is the most radical decision of questions of horizontal dynamics as in this case the trajectory of movement of wheel pair does not depend neither on a bandage profile, nor from a difference of diameters of wheels of wheel pair. Therefore lateral static pressure upon a directing rail in curve sites of a way can be received equal to zero; it can arise only in transitive curves from inertial forces, the gyroscopic moment and damping efforts at turn of wheel pair in an input and an exit from curve sites of a way.

Passing to consideration of rotary directing devices of the third kind, i.e. with wheel steams with an unrotative axis, it is necessary to tell that they on a rolling stock of railway transport are not applied, however they are the basis for engines of all modern cars and other wheel transport cars [Boronenko, Orlova ,2006, Kaley, Semyuels, 2003].

Operational tests within a year of eight-whelled electrosection with skilled biaxial cart of type K - 68 with differential on a driving axis and an unrotative axis on a supporting axis have shown the following:

a) The Car has been less subject to cross-section fluctuations at low and high speeds of movement; amplitudes of fluctuations of wagging have decreased on 60 - 80 %, lateral pressure upon rails – for 50 %.

b) Sinusoidal fluctuations of wagging of wheel pair have been completely eliminated, the tendency to preservation of constant contact is observed between one of crests and a lateral surface of a rail.

c) It has not been noted the essential reduction of intensity of deterioration of wheel pairs bandages of new design in comparison with the usual.

d) The size of resistance to movement in curves has decreased on 20 % the electric power expense in curves has decreased on 10÷15 %.

Results of researches of the cart K - 68 in Japan show that advantages from application of wheel pairs with independent rotation of the right and left wheels (with an unrotative axis) can be received considerably more if we will apply directing device to 1st wheel pair of the cart and to provide contactless movement of bandages crests [Kobayashi, 2000]. Besides, differential, as the knot that is not peculiar for locomotive building factories, it is expedient to replace with a separate drive of the right and left wheels of wheel pair from two feasibility reports through two traction reducers. In this case each wheel with the drive rotates irrespective of other wheel.

THE DECISION OF THE TASK

Recently in patent materials appear more often the messages on patents for rotary devices separate wheel gift in carts and as a whole carts concerning a body in the plan with application of systems of automatic stabilisation of position wheel gift or frames of the cart concerning a rail track.

The considerable quantity of patents is protected by constructive schemes for realisation of turn in respect of wheel pairs of railway crew; however does not make a reservation thus, what type of wheel pairs is expedient for using. At the same time, as it follows from the aforesaid, the type of wheel pairs has the most direct relation to the scheme of the rotary device.

CONCLUSIONS

In conclusion of the review of rotary devices we will consider properties, best of them (3 kinds (fig. 1,2,3)):

a) The Minimum twisting moment for overcoming of forces of a friction, inertial and returning forces is required for turn in a horizontal plane (in the plan) wheel pair with an unrotative axis, therefore rotary devices of the third kind are the most expedient for using on a rolling stock of railways.

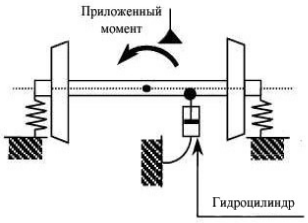

Fig. 1 Use of hydrocylinders for turn wheel parf

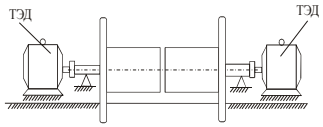

Fig. 2 Application of feasibility reports on each wheel

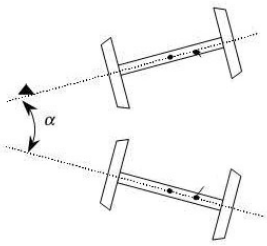

Fig. 3 Mechanical self-installation

b) Wheel steams with unrotative axes cannot be used without directing rotary devices or a compulsory steering with a drive from watching system (depending on size of a lateral backlash of wheel pair in a rail track).

c) Application for a rolling stock of railways of wheel pairs with an unrotative axis and with the rotary device is the complex action allowing considerably to improve horizontal dynamics in a direct way and in curve sites to receive economy traction and energy expenses at the expense of reduction of resistance to movement of rail crews in a direct way and especially in curves, to provide economy of metal and means at the expense of considerable decrease of intensity of bandages and rails deterioration, to raise durability of all elements of a design of wheel-motor blocks at the expense of division of a drive of the right and left wheels of wheel pair and realization thus statically - the definable scheme of a traction drive on locomotives.

d) The directing complete set consisting of wheel pair with an unrotative axis also drove with a directing roller, in the dynamic relation the deviation of a directing roller “Δ” - an entrance signal is nonperiodic link in which the cross-section deviation “y” wheel pair in a rail track from average position is in target parameter. Therefore the deviation of wheel pair at absolutely rigid rails and drive cannot be on size more = 1,5 ÷ 2 mm, and transient of cross-section moving of wheel pair in a track after moving of a directing roller is nonperiodic, i.e. is made without hesitation. The constant of time of this link is equal to the relation of length drove to linear speed of movement. This directing device is recommended to be used for cargo locomotives.

e) The ideal rotary device for wheel pairs with unrotative axes is the contactless system of automatic control of turn in respect of directing wheels of the cart (fig. 4). In this case the electric drive of the rotary device operates from the strengthened electric signal proportional to the sum of signals: a cross-section deviation of wheel pair in a rail track, “y” its the first and the second derivatives. At all advantages of this system, its lack consists in necessity of application of the difficult electronic equipment. This system of automatic stabilization of a lateral backlash of wheel pairs in a rail track is recommended for use on high-speed passenger transport with constructional speed more than 200 km/h.

$$R = \frac{rl_k}{2yi} \tag{1}$$

where: r - nominal radius of right and left wheels of wheelpair;; l_k - distance between the planes of circles of rolling; y - current transversal displacement of wheelpair is in railway track; i – slope of working surface of bracer.

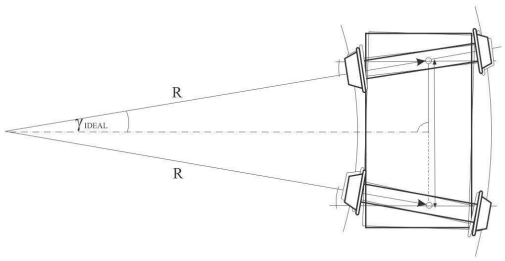

Fig. 4. Contactless system of automatic control of wheel pairs turn

In conclusion of the review of rotary devices of wheel pairs it is necessary to note the greatest expediency on railway transport of the devices of the third kind, with the automatic electric drive of turn which can be used on a rolling stock of high-speed service.

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АНАЛИЗ УСТРОЙСТВ ПОВОРОТА КОЛЕСНЫХ ПАР В ГОРИЗОНТАЛЬНОЙ ПЛОСКОСТИ

Александр Голубенко, Андрей Малохатко, Сергей Клюев, Александр Клюев

Аннотация. В статье приведен анализ устройств поворота колесных пар в горизонтальной плоскости и выбор конструктивной схемы. Определены параметры движения одиночной колесной пары в прямом пути и радиус кривизны пути, в котором возможна радиальная самоустановка обычной колесной пары. Показана целесообразность использования каждого вида поворотных устройств.

Ключевые слова: поворотное устройство, колесная пара, бандаж, невращающаяся ось, износ, рельсовое транспортное средство.