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The use of magnetically controlled contacts in the crest lubrication devices of electric rolling stock of industrial railway transport

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ABSTRACT: This article discusses the implementation of a lubrication system for wheel pair flanges and the working face of rails using magnetically controlled contacts.

KEYWORDS: flange, wheel set, electric rolling stock (ERS), reservoir, valve, magnetically controlled contact, reed switch, magnetic circuit.

I.INTRODUCTION

Electric rolling stock (ERS) of industrial railway transport by the type of work performed is divided into the following main groups: career electric locomotives, traction units, shunting, special and mine electric locomotives.

According to the nature of the current, ERS of constant and alternating currents is distinguished.

Depending on the purpose and design, the ERS can consist of the following main parts: the crew, electrical equipment and apparatus, a pneumatic system, an autonomous power source and its cooling systems.

The general layout of the ERS crew is characterized by the formula of its chassis (axial formula) - $3(2_0\text{-}2_0)$, where the number 3 means that the crew consists of three traction units of the same axial formula; the number 2 reflects the number of wheelsets (axles in the trolley); the “-” sign is placed if the carts are not articulated, and the “+” sign - if they are articulated; the letter "0" indicates that the wheelsets are driven by a traction motor; brackets indicate the traction unit or section.

On the roads of the Industrial Railway Administration (IRA) of Almalyk MMC JSC (Uzbekistan), traction units PE2M (U) are operated. Wheel pairs, which are perceived by all vertical and horizontal efforts of the interaction of the EPS crew with the rail track, transmit torque or braking torque from the traction engine through the gears, and traction or braking forces realized in the contact area of the wheel pair with the rails to the axle boxes.

A wheelset consists of the following basic elements: axles, running gears and gears. Depending on the design of the center of the running wheel, wheelsets are classified into spokes, discs (cast or rolled) and all-rolled. Spoke and disk wheels are composite and are formed from the wheel center, the bandage and the fixing (bandage) ring. For seamless-rolled wheels, a rim with a flange and a wheel center with a hub are one.

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On the ERS of industrial railway transport, bandage wheels with disk centers are used, on the elongated hubs of which a gear wheel is mounted. A wheelset of traction units consists of an axle, cast wheel centers with bandages fixed by retaining rings, solid-rolled gears.

II. METHODOLOGY

The working conditions of the individual elements of the wheelset are significantly different; therefore, the choice of materials and the design of each element is made from the conditions of ensuring the required durability, maintainability and high reliability, since wheel sets are the most critical parts of the ERS.

In the zone of contact of the wheelsets with the rails in the elements of the running wheels, stresses arise from vertical static and dynamic loads, from horizontal forces in the modes of traction or braking, as well as from transverse and longitudinal forces acting during twisting motion. Therefore, the material of the bandages experiencing tensile and compressive forces must have high, wear resistance and be sufficiently viscous, withstand shock loads during uneven paths, especially dangerous in winter. In addition, since the bandage is in contact with the rail, the material for the bandages is selected so that it does not cause intense wear of the rails.

When a locomotive implements traction or braking forces, redistribution of loads on the necks of the wheelsets also causes longitudinal and transverse vibrations over the spring structure when the wheels pass uneven paths. These changes in loads in the calculation of wheel sets are taken into account by an increase in $q_{ст}$ by 1.4 times for each axle neck.

The force $q_{ст}$acting on each neck of the axle of the wheelset due to the mass of the sprung parts is equal to half the difference between the static load of the wheelset on the rails q0 and the gravity of the non-sprung parts $q_{нп}$ (the wheelset with axle boxes, half the gravity of the traction motor and spring suspension parts, mounted on axle boxes): $q_{ст}=(q_0 – q_{нп})/2$ overload of one neck of the axis and unloading of the other causes a part of the centrifugal force Pc, unbalanced by the elevation of the outer rail, and wind pressure force .

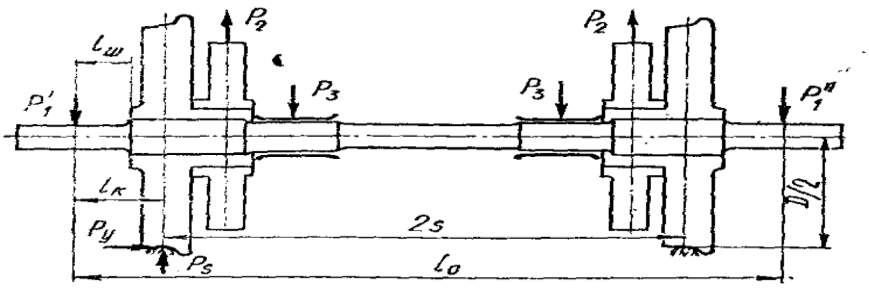

Fig. 1. Wheel pair forces

The total force acting on the neck of the axis of the outer wheel (Fig. 1)
$P_1^{'} =1,4q_{ст}+ \{P_ц(2h_ц-D)+ P_в(2h_в-D)\}/2l_0n_0$,, and at the inner wheel
$P_1^{''} =1,4q_{ст}– \{P_ц(2h_ц-D)+ P_в(2h_в-D)\}/2l_0n_0$,
where$h_ц$and $h_в$ are the distance from the rail head to the center of application of the forces of the $P_ц$and$P_в$;
D is the diameter of the wheels in a circle of riding;
l_0– the distance between the middle of the necks of the axis (or the middle of the working surfaces of the axle box bearings, if they do not coincide with the middle of the necks of the axis);
n_0 is the number of axes perceiving the overturning moment of the forces $P_ц$and$P_в$;
when the traction motor develops the traction force F, the force is transmitted to each gear wheel of a pair of wheels with a two-sided gear transmission:
$P_2 = - 1/2R_{з.к}=FD/4r_{з.к}$,and for each motor-axial bearing - force:
$P_3 = - 1/2R_к+ 1/4q_{т.д}=\{F_кD_к(l_{дв}- 4r_{з.к})\}/4l_{дв}r_{з.к}+ q_{т.д}/4$,
where$q_{т.д}$- traction motor gravity.

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The traction force developed at the wheel bearing points on the rails is perceived by the axis in the planes of the wheel rolling circle and then transferred to the carriage frame, from which the axle is applied to the middle of the necks. Traction force, taking into account the maximum coefficient of adhesion $\psi_{\kappa max}$ (taken equal to 0.4)

$F = q_0\psi_{\kappa\ max}$

The vertical reaction of the outer wheel Ps can be found by adding the moments of all vertical forces relative to the reference point of the inner wheel:

$P_s = P_1' + P_3 - P_2 + [(P_1' - P_1'')l_\kappa]2s$

where l_κ is the distance from the middle of the neck of the axis to the wheel rolling circle;

2s - the distance between the wheels of the wheelset (reference points on the rails).

The horizontal reaction of the outer rail of the P_y is considered the maximum permissible condition for derailment:

$P_y = 0.5$ q

The external rail is affected by the forces of the vertical reaction, the total force acting on the neck of the axis of the outer wheel, and the inner rail and the plane of the tread circle of the inner wheel with the flange are subjected to strong wear, as the radius of the curves is very small. For example, the radius of the curve on the 6th track for loaded trains at Razvyazka stations is 100 m, which has been in operation for 65 years, wearing out the ridges of the wheelsets of technological turntables.

III. EXPERIMENTAL RESULTS

On the tracks of Almalyk MMC JSC (Uzbekistan), to prevent wear of the band crest, the working face of the rails is manually lubricated.

We propose the introduction of a lubrication system for the working face of the rails using magnetically controlled contacts (Fig. 2). When the reverse current flows through the RC, the reed switch switches on the pump motor, and the latter pumps oil in the tank. Oil through the pipeline with pressure lubricates the working face of the rail.

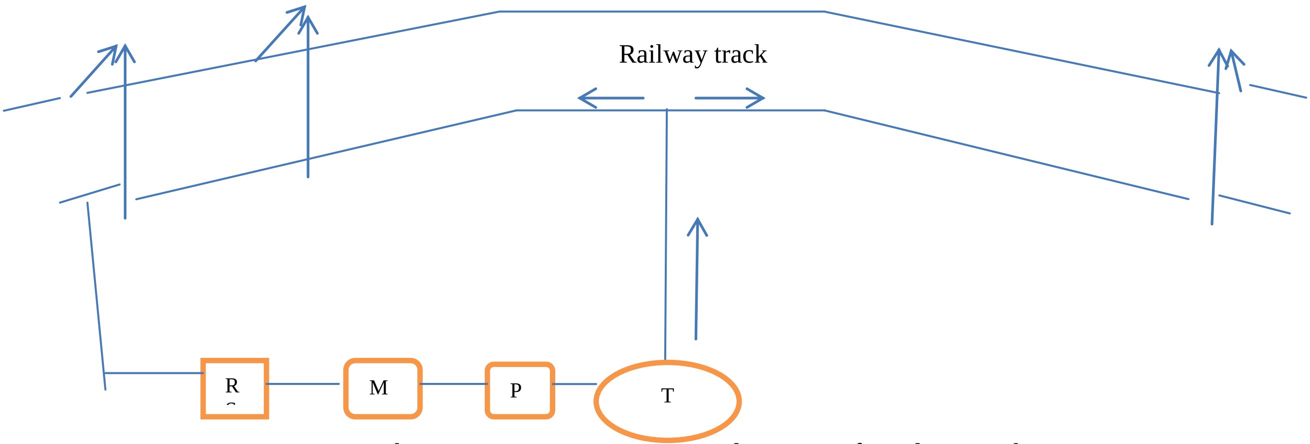

Fig. 2. Lubrication crest system on curved sections of a railway track.
R-reed switch; M-motor to start the pump; P-pump pumping oil;
T-tank for oil

Magnetically controlled contacts are soldered into a glass flask filled with nitrogen or an inert gas, i.e. isolated from the environment (sealed). Therefore, they are often called reed switches, i.e. sealed contacts.

The main elements of the reed switches are (Fig. 3) are perm alloy plates 1, the ends of which are coated with gold, silver or rhodium. Perm alloy plates perform the simultaneous role of the magnetic circuit and contact springs, and their ends 2 - contacts. A control winding 4 is placed on the glass flask 3. When current flows through the winding, a magnetic field appears, which, closing through perm alloy plates, creates an electromagnetic force that attracts contacts to each other. If this force exceeds the mechanical elastic force of the plates, the contacts close (Fig. 3, a).

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In the switching reed switch (Fig. 3, b), when the control current is applied to the left winding, the middle plate closes to the left, and when current flows through the right winding, the middle plate closes to the right.

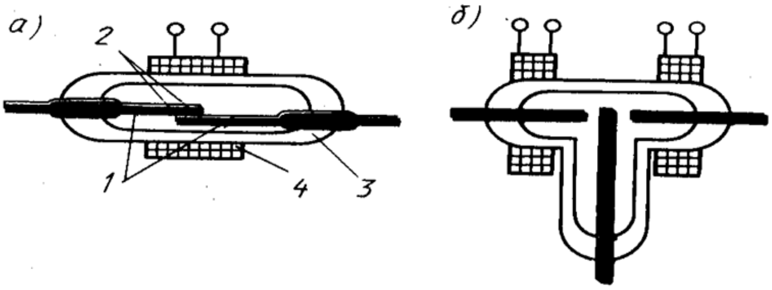

Fig. 3. Reed switches

In the lubrication system of the crest, a switching reed switch is used. When the train passes along a section of the track, the current flowing along the rail circuit is supplied to the left winding of the switching reed switch, the middle plate, closing the left contact, will signal the electro-pneumatic contact of the oil reservoir. The contactor for the release of oil into the oil line is activated. With a vertical load on the sleepers from wheel pairs, oil with pressure will spray the rail from the side of the working face along the perimeter of the curve until the last wheel pair of the technological turntable passes.Reed switches must have a protective housing, since the contacts of the reed switch are sealed.

IV. CONCLUSION

1. The problem of increased wear of the crests of the wheel sets of the rolling stock and the side surface of the rails at industrial enterprises is associated with significant operating costs.
2. The most effective means of reducing the wear of the flanges of the wheel sets and the lateral surface of the rails is to lubricate the flanges using switching reed switches.
3. Lubrication of the crests of the wheel sets and the side surface of the rails significantly increases the service life of the wheel sets and rails, reduces the resistance to movement, increases the safety of movement.
4. Lubrication using magnetically controlled contacts is a reliable and effective means of reducing wear on flanges of rolling stock wheels and rails in industrial vehicles.
5. The use of automatic comb lubricators not only improves driving safety, but also reduces operating costs by reducing the downtime of rolling stock in repairs, reducing the grooves and surfacing of ridges, the need for frequent replacement of wheel ties, reducing fuel consumption and electric power for traction.

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