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CONTRIBUTIONS TO CALCULATION OF THE FORCES THAT OCCUR ON THE BUFFING GEAR AND DRAW GEAR DURRING RUNNING ON THE CURVES, DEPENDING ON THE TIGHTENING OF THE SCREW COUPLING FROM THE RAILWAY VEHICLES

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Abstract: *The paper presents the calculation of the forces that occur on the buffing gear and draw gear during running on the curves depending on the tightening of the screw coupling. The choice of the buffing gear and draw gear for railway vehicles is done according to the provision from UIC leaflet no. 527-1 and 527-2, respectively to the report of the Commission of experts ORE B36/RP32.*

Key words: *buffing gear and draw gear, screw coupling, forces, UIC leaflets.*

SECTION 1 (INTRODUCTION)

Choosing of the buffing gear and draw gear for railway vehicles is done according to the provision from UIC leaflet no. 527-1 and 527-2, respectively to the report of the Commission of experts ORE B36/RP32. The buffers of the railway vehicles must be checked at the forces defined in the UIC leaflet no. 526-1.

SECTION 2

The calculation of the forces that occur on the buffing gear and draw gear during running on the curves is done depending on the tightening of the screw coupling.

Through the method presented in the report of the Commission of experts ORE B36/RP32 is based on two simplifying hypothesis:

- *the calculation is done for two identical railway vehicles running on the track curve of a radius R;*
- buffing gear and draw gear is new.

The characteristics that we take into account to make the calculus are:

- length over the buffers L [m];
- the axle base of the coach 2a [m];
- type of the elastic elements of the draw gear utilized;
- type of the elastic elements of the buffing gear utilized;
- clearance of the lateral gauge J=(1465-d)/2+q+w [mm], where:
  - d – minimal value of the wheel set gauge, at the highest wearing [mm];
  - q – lateral movement of the wheel set from the median axis of the vehicle, at the wearing limit of the running gear [mm];
  - w – lateral movement in the pivot bearing (w=0 in the case of the two axle vehicles) [mm];
- tightening of the screw coupling: $2S^M$ [mm],
- length of the half couple draw gear in alignment, with buffers in contact [mm]:
- length of the half couple draw gear in alignment, with the screw coupling completely tightened [mm]:
- radius of the buffer taller PB [mm];
- distance between the axles of the draw gear and the buffing gear BG [mm];

- C_A – compression of the draw gear [mm];
- C_T – compression of the buffing gear [mm];
- radius of the track curve R [m].

In order to make the calculation, we take into account three cases, depending on the initial tightening of the screw coupling:

a) with maximum initial tighten of the screw coupling: $C_A+C_T=L_D-D_1G$;
b) with the screw coupling half tightened: $C_A+C_T=L_D-D_1G-\frac{S_M}{2}$;
c) with no screw coupling tighten: $C_A+C_T=L_D-D_1G-S_M$.

The calculation is done for the minimum radius of the track curve that we want the vehicles to circulate.

The compression forces from the buffing gear and the relaxing forces from the draw gear (compression forces in the elastic elements of the draw gear) are established later, based on the force-deformation diagram of the buffing gear, respectively of the draw gear.

Thus, the compressions sum of the elastic elements of the draw gear and buffing gear C_A+C_T, are applied on the horizontal bar between the two curves of the force-deformation diagram of the buffing gear, respectively of the draw gear. Those curves express the characteristics of the buffing gear, respectively of the draw gear. This way we obtain the exact values of the deformations C_A, respectively C_T. After that we obtain also from the diagram the value of the compression forces that occur in the draw gear and buffing gear, at the intersection with the compression forces axle.

According to the provisions of the UIC leaflet no. 620, the value of the compression forces that occur in the draw gear and buffing gear are limited to 250 kN.

After the calculation is done, we are able to know if the vehicle (two identical vehicles coupled) can or cannot safely circulate in track curves with the imposed radius. In case that the limit value of the forces are exceed, is recommended to utilize different types of buffing gears (buffers with a bigger course), to limitate the minimum value of radius track curve, or else it is recommended to impose that the vehicles to circulate only isolated on that track curve.

Doing the calculations through that method has the advantage of relatively simplicity.

This method is based on a simplifying hypothesis to determine the deformations and forces (the two coupled vehicles to be identical), and that don't allow us to made studies for different characteristics vehicles, with axle base of coaches, consoles, draw gears, buffing gears, etc., that are different.

Therefore, we propose a method that allow us to make the calculations taking account of different railway vehicles. That method allow us, for example in case the forces exceed the limit value, that the vehicle could however run on that radius track curve, with the condition to circulate between two low axle base of coach and console, as it is the two axle platform coach.

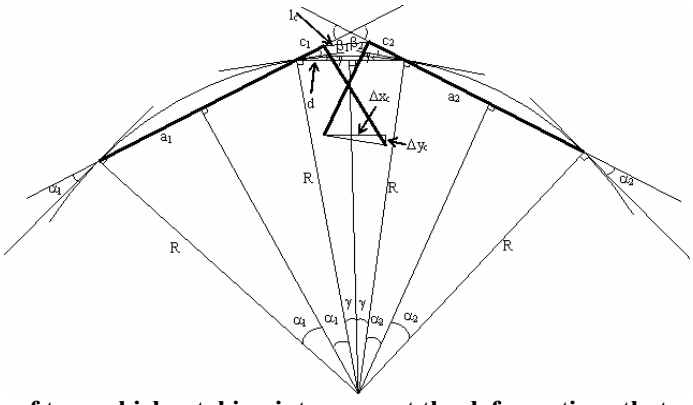

Fig. 1: Curve position of two vehicles, taking into account the deformations that occur in the draw gear and buffing gear.

The characteristics that we take into account to make the calculus are:

- the axle base of the coach a_1, a_2 [m];
- the consoles of the vehicles c_1, c_2 [mm];
- type of the elastic elements of the draw gear utilized;

- type of the elastic elements of the buffing gear utilized;
- clearance of the lateral gauge J=(1465-d)/2+q+w [mm], where:
  - e_{min} – minimal value of the wheel set gauge, at the highest wearing [mm];
  - q – lateral movement of the wheel set from the median axis of the vehicle, at the wearing limit of the running gear [mm];
  - w – lateral movement in the pivot bearing (w=0 in the case of the two axle vehicles) [mm];
- tightening of the screw coupling: $2S^M$ [mm],
- length of the half couple draw gear in alignment, with buffers in contact l_c [mm];
- radius of the buffer taller PB [mm];
- distance between the axles of the draw gear and the buffing gear BG [mm];
- C_A – compression of the draw gear [mm];
- C_T – compression of the buffing gear [mm];
- radius of the track curve R [m].

The angles made by the vehicles axle with the tangent to the track curve:

$$\sin\alpha_{1,2}=\frac{\frac{a_{1,2}}{2}}{R}\Rightarrow\alpha_{1,2}=\arcsin\frac{a_{1,2}}{2R};$$

The angles caused by the clearances:

$$J=(1465-e_{min})/2+q+w;$$

$$\sin\theta j_{1,2}=\frac{J}{a_{1,2}}\Rightarrow\theta j_{1,2}=\arcsin\frac{J}{a_{1,2}};$$

$$\beta_{1,2}=\alpha_{1,2}+\theta j_{1,2};$$

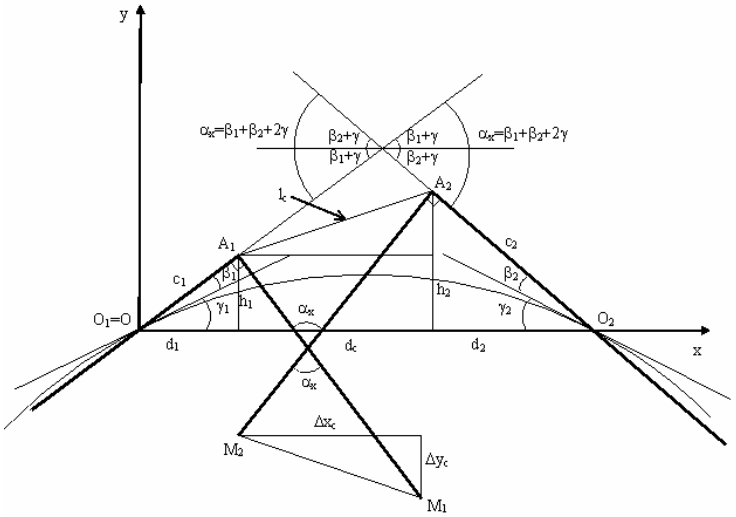

Fig. 2: Detail for curve position of two vehicles, taking into account the deformations that occur in the draw gear and buffing gear.

$$\cos(\beta_{1,2}+\gamma)=\frac{d_{1,2}}{c_{1,2}}\Rightarrow d_{1,2}=c_{1,2}\cos(\beta_{1,2}+\gamma);$$

$$\sin(\beta_{1,2}+\gamma)=\frac{h_{1,2}}{c_{1,2}}\Rightarrow h_{1,2}=c_{1,2}\sin(\beta_{1,2}+\gamma);$$

$$|h_2-h_1|=|c_2\sin(\beta_{1,2}+\gamma)-c_1\sin(\beta_{1,2}+\gamma)|;$$

$$d_c^{\,2}=l_c^{\,2}-(h_2-h_1)^2\Rightarrow$$

$$d_c=\sqrt{l_c^{\,2}-[c_2\sin(\beta_{1,2}+\gamma)-c_1\sin(\beta_{1,2}+\gamma)]^2}$$

$$\sin\gamma=\frac{\frac{d}{2}}{R}\Rightarrow d=2R\sin\gamma;$$

$$d=d_1+d_2+d_c\Rightarrow$$

$$2R\sin\gamma=c_1\cos(\beta_1+\gamma)+c_2\cos(\beta_2+\gamma)+\sqrt{l_c^{\,2}-[c_2\sin(\beta_{1,2}+\gamma)-c_1\sin(\beta_{1,2}+\gamma)]^2}\Rightarrow$$

$$c_1\cos(\beta_1+\gamma)+c_2\cos(\beta_2+\gamma)-2R\sin\gamma+\sqrt{l_c^{\,2}-[c_2\sin(\beta_{1,2}+\gamma)-c_1\sin(\beta_{1,2}+\gamma)]^2}=0$$

This trigonometric equation has the unknown parameter γ. Solving of this trigonometric equation can be done using successive approximations (iterations), using the bisection method (by reducing at half the period). This way we can obtain the value of the angle γ.

After that, knowing the value of the angle γ, will determine the movements Δx_c, respectively Δy_c, which represents the sum of deformations of the buffers in contact $C_{T_1} + C_{T_2}$.

Thus, depending on the elastic characteristics of the two buffers in contact, by utilizing the diagrams, we will obtain the exact values of the deformations C_{T_1}, C_{T_2}, respectively of the compressions forces from the buffers.

In order to solve the problem, will proceed as follows:

- we start from the value of length of the half couple draw gear in alignment, with buffers in contact l_c and we add a distance (deformation) that means a known force in the draw gear; this deformation is the ratio of the iteration and we will choose it;
- we make the calculations as we described above and we obtain the value of angle γ;
- after that we will determine the movements Δx_c, respectively Δy_c, which represents the sum of the deformations of the two buffers in contact $C_{T_1} + C_{T_2}$.
- taking account of the elastic characteristics of the two buffers in contact, by utilizing the diagrams we will obtain the exact values of the deformations C_{T_1}, C_{T_2}, respectively of the compressions forces from the buffers;
- finally, we make comparison with the lengthening force from the draw gear, resulted from the length of the half couple draw gear in alignment, with buffers in contact l_c added with a distance (deformation) add we will do iterations until we obtain the two forces to be equals, with an error ΔF established.

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ПРИНОСИ КЪМ ИЗЧИСЛЯВАНЕ НА СИЛИТЕ, КОИТО ВЪЗНИКВАТ В БУФЕРНИЯ И ТЕГЛИТЕЛЕН МЕХАНИЗЪМ ПРИ ДВИЖЕНИЕ В КРИВИ В ЗАВИСИМОСТ ОТ ЗАТЯГАНЕТО НА ВИНТОВОТО СВЪРЗВАНЕ ПРИ ЖЕЛЕЗОПЪТНИ ВОЗИЛА

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РУМЪНИЯ

Резюме: *Докладът представя изчисление на силите, които възникват в буферния и теглителен механизъм по време на движение в крива в зависимост от затягането на винтовото свързване. Изборът на буферния и теглителен механизъм е направен в съответствие с фишове 527-1 и 527-2 на UIC и съответно на доклада на Експертната комисия ORE B36/RP32.*

Ключови думи: *буферен и теглителен механизъм, винтово свързване, сили, фишове на UIC.*