Study about wear of wheel's bandage for C.F.R. 060 - EA 5100kW electric locomotive at circulation in curve with R = 300 m radius

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Abstract. In this paper we study wear of lead wheels bandage for C.F.R. 060-EA 5100 kW at dynamic circulation in curve with 300 m radius. This study show how variation of wear factor is for lead wheels towards its admitted value on speed domain from 0 km/h until maximum speed of this locomotive in curve with articulated bogies. Among this it is also determined maximum admitted speed in curve impose by Technical Exploitation Regulation.

1. General considerations

Utilization of electric engine CFR 060-EA de 5100 kW, by buying the license from ASEA (1965), a Swedish Company, at towing freight and passengers trains evidenced many negative aspects from which we mention the exaggerate frazzle of wheel's bandage lip especially at guiding axles 1 and 4 of locomotive on rail track portions with curves. The consequence is introducing the locomotive before planned date for repairs [1].

On this aspect it couldn't be found any cause and due to this there were introduced oil cups at each wheel, and it function continuously to reduce the frazzle.

From the practice of railway exploitation, we know about this aspect that on a railway with certain bumps at action of dynamic forces and not only at a vehicle with high frazzle of bandage's lip can appear the derailment of the vehicle.

So at circulation of C.F.R. 060-EA of 5100 kW electric locomotive with articulated bogies using elastic inclinated couple in R = 300 m rays, constant speed in contact wheel – track points appear cvasistatic interaction forces which influence railway safety, produces frazzle of surfaces being in contact and overloads of rolling treadmill and of bogie's frame. The value of frazzle increases once the circulation speed increase.

Elastic inclinated couple as a bond between bogies has benefic effects on locomotive's circulation in curve as [2-5]:

- reduces the directive forces especially on small ray's curve circulation that leads to increasing of railway safety;
- maintaining the attack angle and frazzle of bandage's lip in certain limits;
- reduces the oscillations of drafts of the bogies;

To determine the positions of bogies and following calculus, knowing all functional and constructive parameters of locomotive from its technic book, we take the usual simplifying hypothesis

and friction coefficient between wheel and rail track and it is considered variable depending on pseudo – slipping after Müller.

2. The frazzle of wheel – rail track contact points

The calculus of contact surfaces is done considering of frictions between these surfaces. The frazzle of surfaces in contact is considered generally proportional with mechanical work of friction forces between wheel and rail track, the intensity of lateral frazzle (lip - track) expressing for directive wheel „i" with relation[2-5]:

$$\varphi_i = \mu_b P_i v_{r_i}, \tag{1}$$

where: μ_b is friction coefficient between rail track and bandage's lip;

P_i - conductive force at „i" wheel;

v_{ri} – relative slipping speed after perpendicular direction on railway as corresponding to „i" wheel, expressed through relation:

$$v_{r_i} = \frac{w_{y_i}}{v},$$

w_{yi} – slipping speed after ax y,

v – moving speed.

As $v_{yi} = p_i\omega_z$ şi $v = R\omega_z$ results:

$$v_{r_i} = \frac{p_i}{R} \cong \sin \alpha_i \approx tg\alpha_i \approx \alpha_i \quad [rad].$$

For the calculus of attack angle, we can write:

$$\sin \alpha = {}^{p}/_{R}. \tag{2}$$

For comparing calculus in a conventional way, it is considered $\mu_b = 1$ and results the practical expression of frazzle indicator:

$$\varphi_i = P_i tg\alpha_i \approx P_i\alpha_i \quad [Nrad]. \tag{3}$$

The frazzle admitable factor is calculated with:

$$\varphi_{adm} = 4 \cdot 10^5 \cdot \frac{r}{R},$$

where: r is wheel's ray;

R – curve's ray,

Relation experimental determinated.

If ϕ_i exceeds certain limits the frazzle became very intense and to reduce it is necessary to grease bandage's lip.

After the specific calculus for dynamic circulation in curve with R = 300 m ray were determined the values of polar distances of the two articulated bogies depending of its successive positions in curve and the values of guiding forces P_1 and P_3 for front bogie and P_4 and P_6 for back bogie of locomotive on speed interval $v \in [0, 120]$ km/h. In Figures 1, 2 and 3 is represented its variation according to speed o chosen interval [6].

With the help of relation 2 it is determined the attack angle of guiding axles from both articulated bogies for polar distances above and their variation according to speed is represented in Figure 4 [6].

Finally, with relation 3 it is determined the frazzle factor φ_1 and φ_2 for guiding wheels of the two bogies and heir dependency according to speed is represented in Figure 5 [6].

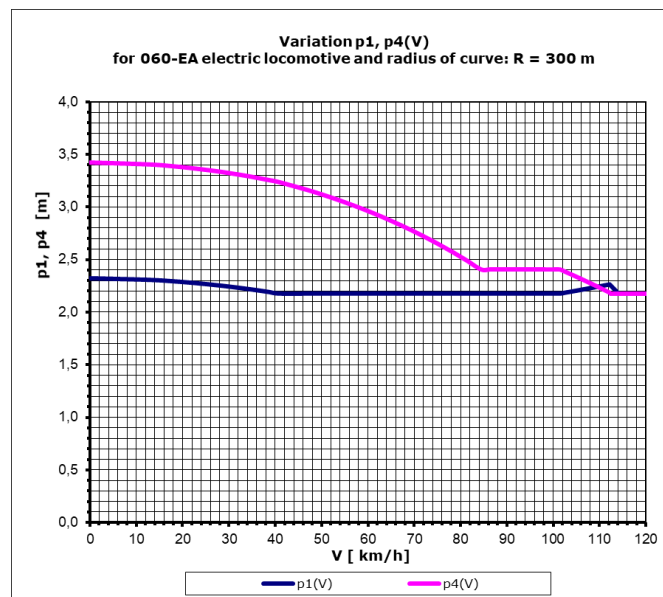All the calculus has been done with Mathcad and the figures were designed in Microsoft Excel.
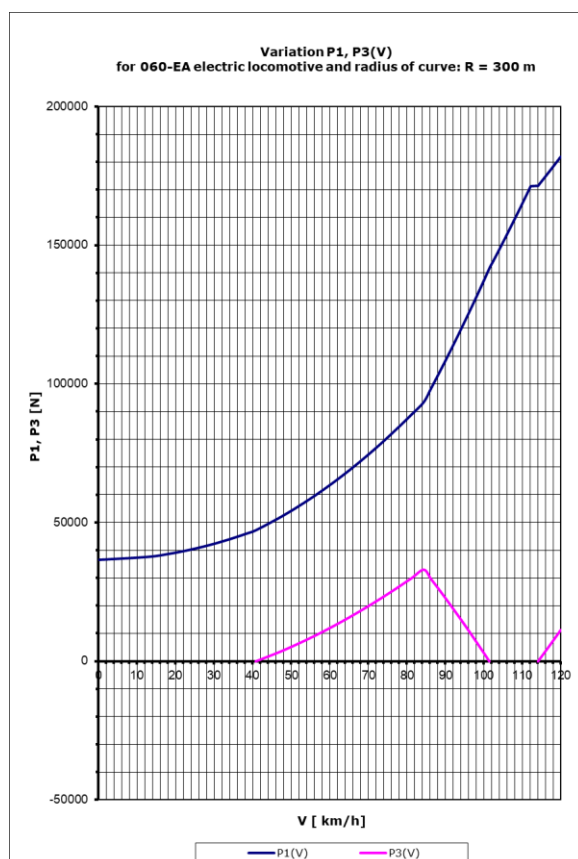
Figure 1. Polar distances

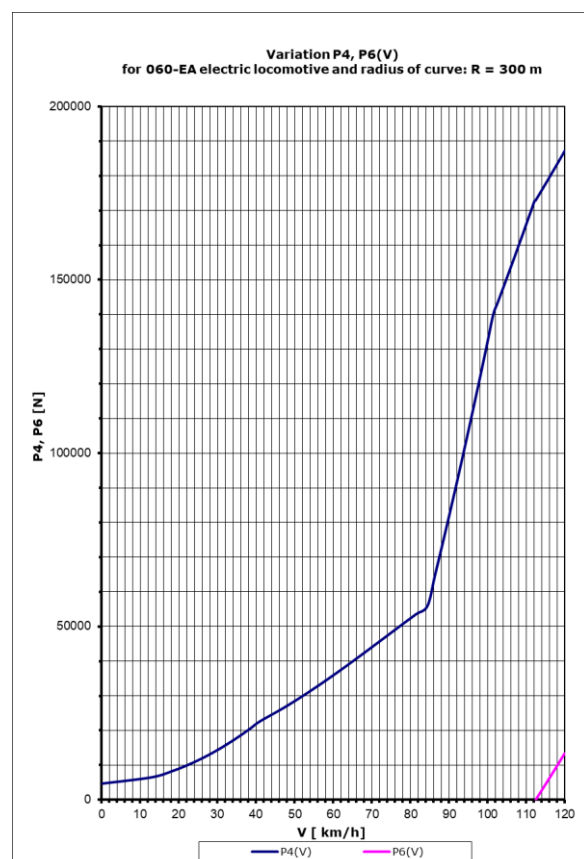

Figure 2. Guiding forces bogie 1

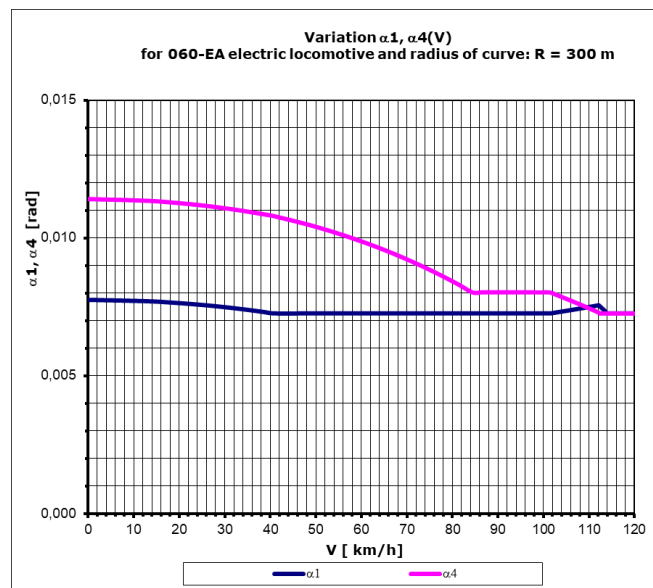
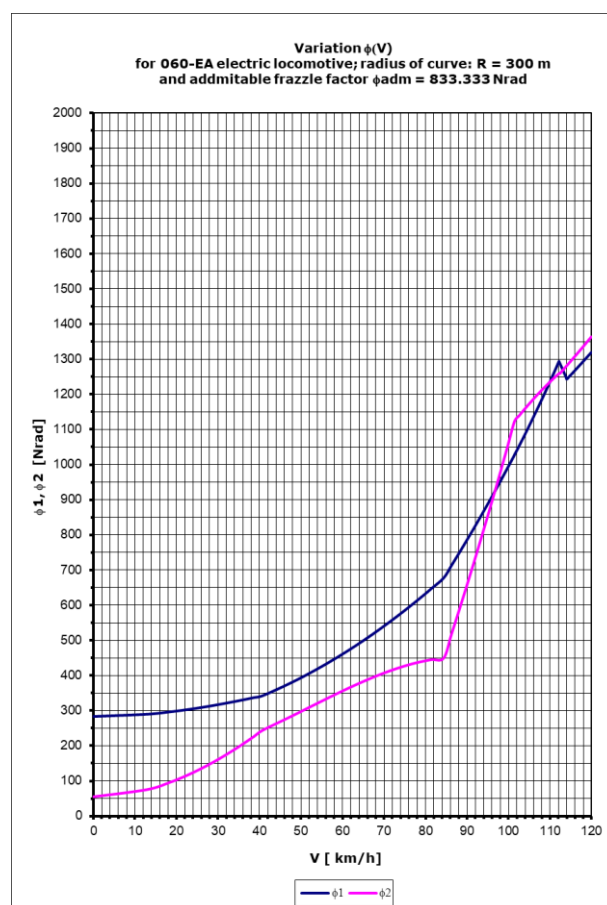**Figure 3.** Guiding forces bogie 2

Figure 4. Attack angle

Figure 5. Frazzle factor

For rolling wheels' ray, r = 0,625 m, and curve's ray, R = 300 m, the value of addmitable frazzle factor according to relation above is [6]:

$$\varphi_{adm} = 833,333 \text{ [Nrad]}$$

And limit speed resulted through interpolation in graphic from Figure 5 for guiding wheels of both bogies are [6]:

$$V_{1.lim} = 92,91 \text{ km/h and } V_{2.lim} = 95,04 \text{ km/h.}$$

3. Maximum speeds admitted in curves

Maximum speeds admitted by circulation in curve of rail vehicles cannot exceed certain values which depend of:
  - R is curve's ray,
  - h – effective overhighting,
  - l – the length of the overhight ramp,
  - fillets presence etc.

On C.F.R. network the admitted speeds are given for normal gauge and effective overhight according to admitted overhighting insufficiencies (practically lateral admitted accelerations – see Table 1):

Table 1. Overhighting insufficiencies

I [mm]	70	80	90	100	120
a_l [m/s^2]	0,46	0,52	0,59	0,65	0,78

and it is determined with relation [2-5]:
  - for curves with fillets:

$$V_{max} = \sqrt{\frac{R}{11,8} \cdot (h + I)} \quad \text{[km/h],}$$

and for h = 120 mm and I = 90 mm results:

$$V_{max} = 4,25 \cdot \sqrt{R} \quad \text{[km/h];}$$

  - for curves without fillets:

$$V_{max} = 3 \cdot \sqrt{R} \quad \text{[km/h].}$$

In both cases it is limited speed at $V_{max} \leq 140$ km/h.
  - for curves without overhight:

$$V_{max} = 2,8 \cdot \sqrt{R} \quad \text{la R} \geq 300 \text{ m,}$$

$$V_{max} = 2,8 \cdot \sqrt{\frac{R}{90}\left(40 + \frac{R}{6}\right)} \quad \text{la R} < 300 \text{ m.}$$

If from horizonal dynamic passport results $v_{lim} > v_{max}$, the vehicle satisfies the safety circulation conditions on railway.

The values for V_{max} according to R and h are given in RET resulting V_{RET}.

Following the calculus results [6]:

$$V_{lim} = 73,612 \text{ km/h,}$$

But the Technical Exploitation Rules for curve with de R = 300 m impose the maximum circulation speed at curve's ray at value of V = 70 km/h.

4. Conclusions

Based on calculus made we conclude:

- In Figure 5 bit is observed a substantial increase of frazzle factor on chosen speed interval due to forced circulation of the two bogies because of too high pretension force and arc's rigidity from the couple.
- The speed resulted for both bogies according to addmitable frazzle factor are $V_{1.lim}$ şi $V_{2.lim} >$ VRET and results the fact that it is not necessary a greasing device for bandage's lip to reduce the frazzles.

References

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