THE STUDY ON INCREASING THE RELIABILITY OF WHEELS AT RAIL VEHICLES WITH DIESEL-ELECTRIC TRACTION

drd. eng. Bianca Silvia ORHEI, Facultatea de Constructii de Masini si Management Industrial Iasi, bercea_silvia@yahoo.com,

dr. eng. Daniel APOSTOL
daniassy@yahoo.com

Abstract: We have presented a study regarding reliability growth of driving wheels at railway vehicles with diesel-electric traction. The study has been done on 060 DA diesel-electric locomotive and it was possible thanks to existing modernization, made in repairing plants at mechanic and electric equipments of the locomotive.

Keywords: diesel-electric locomotive, defects, profile, reliability, modernization

1. Introduction

At present, Romania has a railroad system with a total length of 10818 km, of which 6816 km is unelectrified and 4002 km is electrified. The most important railway operators which activate on this railway have in their own rolling-stock depot railway vehicles as locomotives or railcars. Locomotives are in a greater number than railcars, such as electric and diesel-electric locomotives.

In Romania, the tow of passenger trains and goods trains is made, mostly, using two types of locomotives: 060 DA diesel-electric-used on unelectrified railway and 060 EA electric locomotive, used exclusively on electrified railway. These locomotives are equipped with continuous power electric engines with serial excitation, which are electrically connected series-parallel or parallel only.

The study intends to point out the influence of the type of electric connection at traction engines on the wear of driving wheels of railway vehicles with continuous power electric traction. Thus, we have followed and analysed the appearance of profile defects of the driving wheels in operation of 060 DA diesel-electric locomotives partially modernized and totally modernized.

These types of diesel-electric locomotives were designed by Electroputere Craiova Plant between 1965-1985, after 2000 were modernized, in partial version (MP-partial modernization), without the replacement of group diesel engine-generator and in total version (MT-total modernization) with the replacement of group diesel engine-generator.

General technical features for the diesel-electric locomotives partially and totally modernized:

- axle formula: Co-Co
- gauge: 1435 mm
- length between buffers sides: 17 000 mm
- maximum width: 3000 mm
- wheelbase bogie: 4100 mm
- total wheelbase: 12400 mm
2. Generalities regarding profile defects appearing at the wheels of traction vehicles

The profile defect could be defined as a deviation from the parameters of wheel profile (wear) admitted in operation of traction railway vehicles. The deviations appear due to wear of driving wheels and it is influenced by many factors, but the most important is slip.

Profile defects can appear due to normal wear of the wheel (bandage) at the wheel-rail contact or accidental due to external factors as: improper braking, material defects, slip, etc.

The repair of the driving wheel profile consists in reshaping (readjustment), this operation being made on underground lathes. Any repair of the profile implies the removal of metallic material and thus reducing the wheel diameter. The number of the reshapings is limited, so is intended as these should be as few.

The profiles after that the wheels of traction vehicles in Romania are turned respect STAS 112/3/1990.(fig.1).

![Fig. 1 - Wheelset and external profile of the wheel rims (bandages) processed for locomotives, in accordance to STAS 112/3/1990](image)

The main odds which are measured at a bandage profile and which decide if we have a profile defect due to a normal wear are:
- radial tire wear on rolling circle;
- thick bandage measured on rolling circle;
- flange thickness;
- the distance between internal sides of driving wheel bandages;
- the distance between external sides measured at 10 mm above the rolling circle.

Profile defects which are determined by abnormal wear of the tire (accidental) due to the following: flat appearances (improper brakings, slips), various traces on tire surface (gouges, channels, deformities after impact with hard objects), material peels (material defect).
3. The analysis of profile defects at a traction railway vehicle with diesel-electric traction-060 DA diesel-electric locomotive

The study regarding growth of reliability of driving wheels by optimal electrical connection of continuous current of electric engines with serial excitation was made on traction railway vehicles -060 DA diesel-electric locomotives, partially modernized (MP) and totally modernized (MT), between 2005-2009.

We have chosen this locomotive of the following reasons:
- after locomotive modernization, the whole bogie remained the same;
- wiring diagram connection of traction motors differs at the two versions of locomotives;
- the locomotives have modern equipments from wheel -slide protection
- the locomotives towed trains on the same sectors tow.

We kept in mind the following aspects:
a) At the 060 DA partially modernized locomotive:
- connection of traction motors is series-parallel type (fig.2)
- the wheel tread profile — in accordance to STAS 112/3/190
- the reshapings were made on underground lathe-Hegenscheidt type 106
- we noticed 060 DA MP-060 DA partially modernized locomotive — with top speed 100 km/h and with 060 DA1 MP-060 DA1 partially modernized locomotive with top speed 120 km/h

![Connection of traction motors at 060 DA partially modernized locomotive](image)

Fig. 2 - Connection of traction motors at 060 DA partially modernized locomotive

We can write:

\[ U = E + I \sum R = k_e n \Phi + I \sum R \quad [V] \quad (1) \]

Considering the transmission ratio \( i = \frac{z_{motor}}{z_{roata}} = 69 / 15 \) (used at 060 DA locomotive with top speed 100 km/h)

\[ n_{motor} = 24,41 \quad \nu_{locomotive} / d_{wheel} \quad [\text{rot} / \text{min}] \quad (2) \]

Neglecting internal resistances of electric motors

\[ U = E_1 + E_4 = E_2 + E_5 = E_3 + E_6 \quad [V] \quad (3) \]
U = 20.91 \frac{v_{\text{locomotive}}}{d_{\text{wheel}}} [V] (4)

b) At the 060 DA totally modernized locomotive:
- connection of traction motors is parallel type (fig. 3)
- the wheel tread profile- in accordance to STAS 112/3/190
- the reshapings were made on underground lathe-Hegenscheidt type 106
- we noticed 060 DA MT-060 DA totally modernized locomotive with top speed 100 km/h and 060 DA1 totally modernized locomotive with top speed 120 km/h

![Connection of traction motors at totally modernized locomotive with GM-USA equipment](image)

Now, we can write:

\[
U = E_1 + I_1 \sum R_1 = E_2 + I_2 \sum R_2 = E_3 + I_3 \sum R_3 = E_4 + I_4 \sum R_4 = E_5 + I_5 \sum R_5 = E_6 + I_6 \sum R_6 \ [V] \quad (5)
\]

Neglecting internal resistances of electric motors

\[
U = E_1 = E_2 = E_3 = E_4 = E_5 = E_6 = k_e n_{\text{motor}} \Phi_{\text{motor}} \ [V] \quad (6)
\]

\[
U = 20.91 k_e \Phi_{\text{motor}} \frac{v_{\text{locomotive}}}{d_{\text{wheel}}} [V] \quad (7)
\]

The 060 DA partially modernized locomotive is using a connection series-parallel type, and 060 DA modernized locomotive with General Motors equipment is using a connection parallel type for the traction motors. Thus, we have observed:
- in the case of 060 DA partially modernized locomotive, due to series parallel connection, electrical current that circulates by two traction motors will be always the same, so any increase of revolution of one motor (slip) will lead to the decrease of revolution of the other motor;
- at the 060 DA modernized with General Motors equipment, traction motors work independently one another, the increase of revolution of one motor doesn’t influence the others motors;
- from the equations (4) and (7) we observed that the wheel diameter \(d_{\text{wheel}}\) intervenes in tension equation, thus influencing motor operation. In vehicle operation, the diameter difference between wheels is limited;
- if we consider that traction electric cars aren’t equally perfect as parameters and that the driving wheels diameters are not equal, than all traction engines will have different revolutions, so wiring diagram connection in parallel should be better;
- in tabel 1 and 2, and fig. 3 and 4 are represented the number of kilometers between two profile defects at 060 DA partially and total modernized locomotive.

**Tabel 1** - Mileage between two profile defects at 060 DA modernized locomotive with increased speed (120 km/h)

<table>
<thead>
<tr>
<th>Locomotive</th>
<th>Mileage between two profile defects</th>
</tr>
</thead>
<tbody>
<tr>
<td>060 DA1 MP</td>
<td>112884 156918 332000 405300 510000 658000 726000 853000</td>
</tr>
<tr>
<td>060 DA1 MT</td>
<td>49099 403800 541000 610000 896000 - - -</td>
</tr>
</tbody>
</table>

**Fig. 4** - Wiring diagram connection of traction motors at totally modernized locomotive with GM-USA equipment

**Tabel 2** - Mileage between two wheel profile defects at 060 DA modernized locomotive with top speed 100 km/h

<table>
<thead>
<tr>
<th>Locomotive</th>
<th>Mileage between two profile defects</th>
</tr>
</thead>
<tbody>
<tr>
<td>060 DA MP</td>
<td>98000 230420 447009 519000 708000 770000 787000 -</td>
</tr>
<tr>
<td>060 DA MT</td>
<td>48980 393400 588000 688000 770000 879000 930000 1160000</td>
</tr>
</tbody>
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5. Conclusions
- At present the 060 DA diesel-electric locomotive suffered profound changes, becoming a modern locomotive, equipped with the newest technologies.
- Profile defects of the driving wheel are more numerous at 060 DA locomotive and 060 DA1 than at 060 EGM diesel-electric locomotive and 060 EGM1, thus meaning repair of wheel profile more often at the same mileage. This fact makes us believe that also electric scheme of connection of traction engines has an influence in increase/decrease of driving wheel wear.
- The modernization of a locomotive is more efficient considering that at the electric equipment design is important their influence on mechanical equipments.

6. References
[9] www.remarul.eu