Considerations on the use of elastic wheels to the urban transport vehicles

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Abstract. To minimize dynamic wheel-rail interaction efforts a condition is that the unassembled mass of the vehicle is as small as possible. The elastic wheel by its construction fulfills these conditions - she has interposed between the crown and the body of the wheel, the elastic rubber elements. In this way, it can be considered that the unsupported mass is represented only by the mass of the wheel crown. Additionally, this elasticity also has a reduction effect on rolling noise. This feature makes it suitable for use on urban transport vehicles.

1. Need and constructive type of the elastic wheels

The idea of breaking the metal chain that conveys shocks, vibrations and rolling noise from the wheel to the vehicle body by interposing an elastic element as close to the exciting source has been backed by the special benefits it offers.

Reduce the weight of the vehicle as much as possible which does not have an elastic suspension, make it as the perturbing influence of the irregularities of the path feel to feel only on these small masses and to be transmitted attenuated to the rest of the vehicle construction.

In fig. 1, is shown the wheel constructions that are more widely used to both in the light rolling stock (tram and metro), as well as the actual railroad. On these types of wheels, the rubber it as use are request at compression and shear or only at compression.

The wheel of fig. 1a has two rubber rings with metal reinforcements, which are pressed to the mounting by bending the metal wings of the wheel center.

On the wheel of fig. 1b also uses two rubber rings, but without metal reinforcements.

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For this purpose, the inner clamping flange is two halves.

The wheels of fig. 1c and 1d, patents of the German company Krupp-Bochum, have a very large spread and are called wheels with a rubber elastic ring.

In some constructive variants, the rubber ring is profiled in V, for greater safety towards transversal efforts. It is generally used for trams (fig. 1c).

The variant of fig. 1d has support collars on both the band and the center of the wheel which come in contact with larger axial deformations, limiting them to a maximum of 4 mm according to the traffic safety rules.
Figure 1. Elastic rolling wheels with the rubber requested mainly at compression.

In fig. 2 are some of the usual types of elastic wheels to which the rubber is only required for shear. It is the type of American conveyor wheel with very large distribution in North America and Canada where it is estimated that about 100,000 such wheels are in operation. And in Europe, companies that have taken US licenses use wheels of this type (Italy, Belgium, etc.).

Figure 2. Elastic rolling wheels with the rubber requested mainly at shearing.

In principle, the special band or wheel center has the shape of a disc that presses between two rubber discs. Pressing is done between metal flanges fixed to the wheel hub. In fig. 2a the bandage also acts as...
a center of the wheel and as a result, outside the section and the tread profile, it is executed as a disk in the central part. The piece is more expensive, but eliminates banding / deburring operations requiring special machines. If the thickness of the outer part in the form of bandage is higher, it is also possible to apply to these wheels after reaching the wear limit and machining as a wheel center as in fig. 2d. Rubber discs can be made in one piece or in sectors, but in all cases they are provided with vulcanized metal fittings.

The tightening of the rubber disc is made under the press and the maintenance in this position is made with screws (fig. 2a) or with a central nut (fig. 2b) for wheels with a lower diameter and lower radial loads.

In general, these wheels, called wheels with two rubber discs, are removable for replacing the wheel-tire center or rubber discs.

There are also wheels of this type, such as a patent of German company Klöckner (fig. 2d). On these wheels the rubber discs are vulcanized on the center of the wheel, and the press flanges are welded and hardened to the workpieces, also welded to the assembly.

It is worth noting the elastic wheel of fig. 2c, a patent of the Swedish SAB, in which the elastic ring consists of a number (generally 8 ... 10) of disk-shaped discs, the free space between these discs permitting air circulation which cools the rubber.

In fig. 2e shows the elastic wheel of Pirelli, to which the packing of the wheel is made with two bolted flanges, centered on the wheel band, which has a special machining. The radial and axial deformations of the wheel are limited between the clamping flanges and the wheel hub.

The centering of the component elements to all these types of wheels is made by the cylindrical projections of the metal fittings of the elastic members, protrusions which penetrate into the corresponding holes of the clamping flanges.

The centering is very good, the bandage or the center of the wheel-bandage, formerly turned, no longer requires, after the assembly of the wheel, than a small correction, which is generally done only by polishing the running surface.

Elastic wheels with two rubber discs generally have a lower stiffness in the radial direction (they are more elastic than the ones with a rubber ring described above but have the disadvantage of the tire-loaded tires) of a more labor-intensive technology maintenance.

For wheels with two rubber discs, according to SAB, the bearing capacity of the elastic wheels produced by this company (fig. 3) is presented.
2. Rigidity of elastic wheels

The elastic wheels provide elasticity in three directions, namely: in the vertical direction (Z axis) in the transverse direction (Y-axis) and in the tangential direction, the acceleration or deceleration of the wheel rotation.

In fig. 4, the rigidity characteristics, as average values, for these three directions are indicated for the tires with a rubber ring (Bochum) and for the two wheels of rubber (Presidents Conference Committee).

![Diagram of wheel rigidity](image)

**Figure 4.** Rigidity of elastic rolling wheels (mean values)

Radically, wheels with two rubber discs are more elastic and, as such, better dampen shocks and vibrations taken from the track in that direction.

In the axial-transversal sense, the Bochum wheel may have two characteristics, as the rubber ring is profiled (see fig. 1c) or with a rectangular section (see fig. 1d). In the first case, the axial stiffness is higher than the wheels with two rubber discs.

If axial stresses (enrollment or curve guidance) are large and can cause axial deformations of the wheel(s) which endanger the safety of the movement or the correct entry on the trackside devices, the axial deformation is limited by the intervention of the shoulder and the center of the wheel (fig. 1d). According to the German rules, the maximum admissible value for the axial deformation $f_a$ is 4 mm.

In the tangential sense, the wheels with a rubber ring are more rigid, as is the case with the other two directions.

The effect of tread rolling elasticity is manifested by the attenuation of shocks and vibrations transmitted to the suspended mass.

In fig. 5 indicate the vertical accelerations measured on the axle bearing housing in the case of standard (metallic) and elastic (Bochum) wheels on subway and railway vehicles. The higher the shock received from the tread of the wheel band, the higher the shock absorption factor transmitted to the center of the wheel and the wheel train, as well as the other vehicle organs (transmissions, motors ...).
3. Conclusions

The quality of the running of the railway vehicles is dependent on both the elasticity and the resonant effect of the elastic wheels. Related to these aspects, the paper presented the theoretical considerations and the results of experimental determinations carried out by the authors with elastic wheels used in subway vehicles. For constructions used in light vehicles, the superiority of the elastic wheels results in the comparison of the entirely metal wheels. The high elasticity of these wheels also contributes to the reduction of the inertial forces with the rolling path.

Acknowledgments

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4. References

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Figure 5. Elastic rolling wheel damping effect - Acceleration measured on the axle bearing (az) on elastic wheels and metal wheels.