The Use of Rubber as Elastic and Damping Element at Buffers Equipping Railway Vehicles

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Rubber is increasingly used in the industry of railway rolling stock, as elastic and damping element for the suspension of the vehicle or buffer and draw-gear devices. The simplicity of design, the lack of some special maintenance operations for the rubber elements and the high degree of shock and longitudinal oscillations absorption led to its increasingly use to shock isolators in order to equip railway vehicles.

Keywords: rubber, railway vehicle, buffer, hysteretic loops

Railway vehicles, regardless of the type of construction, motor vehicles or hauled vehicles, are equipped with buffer and draw-gear devices, commonly named buffers and binding couplers. The use of buffers, known in the literature as shock isolators [1, 2] has as main purpose the protection of the structure of railway vehicles when they interact during braking, pushing of the train or forming by individual launching of the vehicle from the shunting humps. Also, the buffer and draw-gear device affects longitudinal dynamic phenomena that develop in the body of the train, with implications on the running stability [3].

Each vehicle consists of four buffers installed on the head bar of the chassis, two on each side. In addition, on each front, there is a buffer with flat plate and one with curved plate, so it will always be contact between a buffer with flat plate and one curved. Thus, it is avoided the breaking of buffer plungers during the movement in a curved line or the tendency of lifting in the case of the curved buffers, when there are level differences, respectively the change slope – downhill, slope – alignment or downhill-alignment.

The design and construction of buffers have evolved over time and have mainly focused on increasing the storage capacity and dissipation of the deformation potential energy due to: the increase of railway velocity, hauled tonnages and the number of vehicles from a train [4]. The main requirements that buffers must meet are:

-protection of the vehicle against the number and intensity of repeated shocks that occur in using;

-safety of the link bogie – chassis;

-safety during circulation and stabilizing role particularly during the movement in curves;

-dabbing speeds at values that provide an optimal duration and acceptable conditions for the implementation of sorting and train formation process;

-the reducing of longitudinal acceleration to values that provide security and integrity to the transported goods, passenger comfort and the quality of driving.

During the railway operating, the emergence and development of the compression forces and, respectively, tensile forces to the coupling devices and shock protection are mainly due to the successive entry into action of the brakes for every vehicle in the train body, aspect that cannot be avoided as long as the vehicles present UIC brake. These forces lead to oscillatory movements along the train that, under certain conditions, are dangerous in terms of road safety. The extinction of these oscillations depends on the capacity to absorb the kinetic energy of the collision devices [5].

To determine the dynamic longitudinal forces during train braking, it is necessary to determine the characteristics of the collision devices, but also those of traction and binding. Therefore, to enhance the simulation programs on the evolution of longitudinal forces in the trains body, it is necessary to establish calculation formulas that portray elastic and damping characteristics of the buffers and draw gear devices.

The construction of buffers with rubber elastic elements

From the construction point of view, there is a great variety of buffers, especially due to technical solutions used in order to store and dissipate convenient values of the potential energy of deformation in the elastic and damping elements. Related to this, there are differences due to vehicle operating schemes, meaning that passenger coaches and locomotives present better operating conditions than flat wagons.

The buffers of the railway vehicles have a simple structure, consisting mainly of (fig. 1): 1 represents buffer body, 2 is subassembly which comprises the plate and 3 its elastic element.

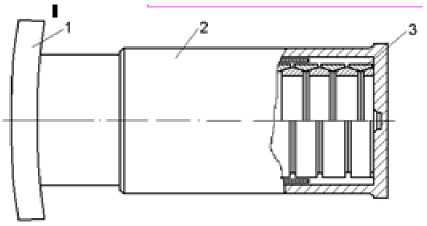

Fig. 1. General construction of buffers

Depending on the elastic element used, there are buffers with metal springs (coil springs or ring springs), rubber springs, steel and rubber combined springs or hydraulic buffers. The buffers with ring springs are the most common type used in the construction of flat wagons. For the locomotives, buffers present coiled springs or friction ring springs.

Wagons and locomotives used for passenger trains, due to easier operating conditions than flat wagons, can be equipped with buffers that have the elastic element from rubber or combined from steel and rubber. Also, to these types of vehicles, hydraulic buffers may be used.

The use of rubber in the railway industry was made possible with the development of the vulcanization

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Table 1
THE HARDNESS OF THE RUBBER USED TO RAILWAY VEHICLES

Type of the rubber	Hardness (°Sh)
Soft rubber	35 ... 50
Medium rubber	50 ... 60
Hard rubber	60 ... 85

technology that allowed its transformation from a plastic material to an elastic one. Vulcanization offers the possibility to modify the functional characteristics of a piece of rubber without changing its form but only by changing the rubber hardness.

According to Shore hardness, the rubber used for the railway vehicles is divided into (table 1): soft rubber, medium and hard [6].

In order to use rubber as an elastic element in the construction of buffers, this being used in compression, it must be made in the form of packets inserted between two metal plates. Thus, the friction that occurs between the metal plate and the rubber prevents the free deformation in the contact area. Usually, it is used as a solution to stick the rubber on a metal surface on which the load is applied, thus eliminating the possibility of relative movement between the rubber and the metal.

In figure 2 it is presented the elastic and damping element of a buffer with elastic element from type I AIC-495-OM rubber, and figure 3 shows the type SE-821-0, both using rubber packages vulcanized on metal plates. As components of such a buffer, we can distinguish the pre-compression rod 1, outside of which there are large rubber disks 3 vulcanized on the metal plates 2 forming the first pack of rubber springs [7].

On top of this, it is found a package of small springs, consisting of small rubber disks 6 vulcanized on the spacers sheet 7, which are fixed to each other by the screw 8, the screw holding in contact the pressure plates 5 with the outer disk 4 (fig. 2) .

Figure 4 presents the buffer used to railway vehicles for passengers in the CFR yard, buffer equipped with rubber elastic elements (fig. 5).

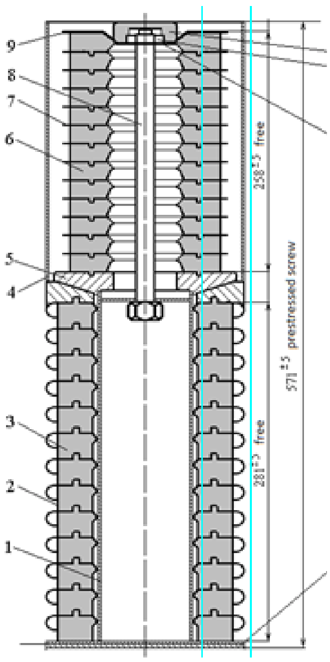

Fig. 2. Buffer with rubber elements type I AIC-495-OM.

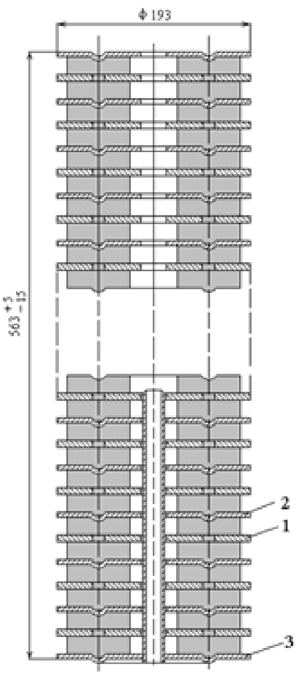

Fig. 3. Buffer with rubber elements type SE-821-0


Fig. 4. Buffer with rubber element


Fig. 5. Rubber elements of the buffer.

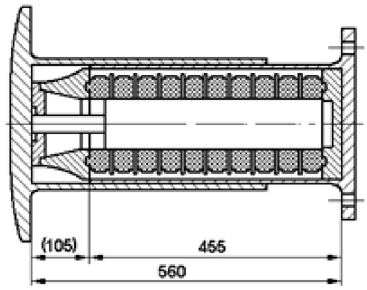

Fig. 6. Buffer with the stroke of 105 mm, C category, type MINER – SUA [3]

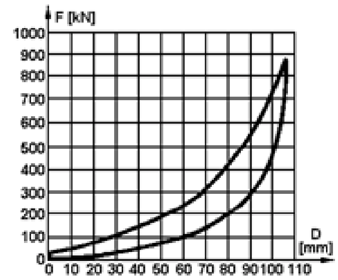

Fig. 7. The static characteristic of the buffer with the stroke of 105 mm, C category, type MINER – SUA [3]

Another type of buffer uses as elastic and damping element a hydraulic shock absorber connected in parallel with an elastic element consisting of 10 elements made of rubber vulcanized on metal plates (fig. 6).

The static characteristic is shown in figure 7 and Figure 8 features the dynamic one. The static characteristic shows the hysteretic allure of the compression and expansion curve of the elastic elements from the buffer due to the rubber. This is determined on the test benches by static tests and it is usually used in the calculation of longitudinal dynamic forces developed in the train body.

The dynamic characteristics are determined experimentally, by the collision of two vehicles equipped with buffers for testing, at various collision speeds. These features are necessary for assessing the impact forces during the frontal collision of two vehicles.

During the buffer testing and experimentation program for approval, a series of determinations of the elastic assembly with rubber elements are performed, aiming mainly:

-residual deformations after a compression of 25% of the maximum force over a temperature range between + 70 and - 30°C;
-static compression strength on elastic assembly;
-strength to dynamic loads on elastic assembly;
-static elastic characteristics on the assembled buffer;
-temperature influence on the assembled buffer;
-dynamic characteristics of the buffer.

For an A category buffer, with 105 mm stroke, which meets the requirements of Fiche UIC 526-1 [8], it was determined, experimentally, on the testing stand, the static characteristic shown in figure 9.

The Math modelling to trace the buffer feature must take into account the compression release stroke. For

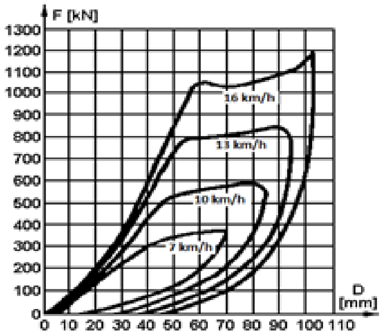

Fig. 8. Dynamic characteristics of the buffer with the stroke of 105 mm, C category [3]

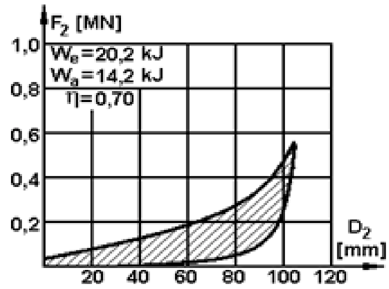

Fig. 10. The static ıracteristic of the buffer at + 50 °C [3].

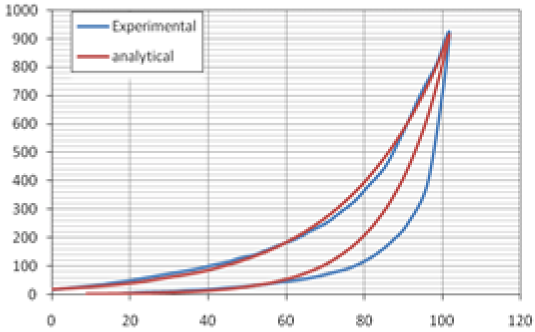

Fig. 9. Static characteristics for the A buffer

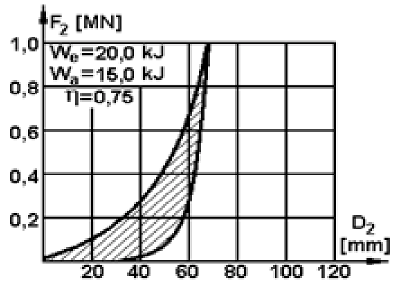

Fig. 11. The static racteristic of the buffer at – 40 °C [3]

calculations of the dynamic longitudinal forces in trains body, modelling must take into account when changing direction by the change in the force value acting on the buffer. To calculate the longitudinal forces there are used, usually, empirical formulas determined on static characteristics for different buffers. In figure 9 it is presented the static characteristic of the buffer (with red line) obtained with an empirical formula of the form:

$$F_b = \begin{cases} \alpha \cdot e^{\beta \cdot x} & \text{for compression} \\ \gamma \cdot e^{\delta \cdot x} & \text{for release} \end{cases}$$

where α, β, γ, δ are coefficients that depends on the type of the rubber used and its answer to compression, respectively to release, and *x* represents the displacement or the buffer stroke.

An important aspect observed during the experiments reported in [2, 3], refers to the modification of the characteristics of the buffers with rubber elements due to the variation of ambient temperature. If the temperature rises above 40 ... 50 ° C, the buffer will have a more elastic soft stroke. As shown in figure 10, the buffer stroke increases slightly, while the maximum force decreases. At temperatures of -30 ... -40 ° C, the buffer becomes rigid and substantially changes its course, decreasing by almost 33%, while the maximum recorded force increases of nearly four times compared to the value recorded for the temperature of +50°C. Therefore, in areas where temperatures do not vary greatly from one season to another, the use of buffers with rubber elements does not bring problems, but where temperatures vary in the range mentioned above, the case of our country, it is recommended to use synthetic rubbers which have a quasi-steady characteristic in the temperature range specified or elastic elements combined, rubber and ring springs.

Conclusions

For railway vehicles, rubber is often used as elastic and damping element in the suspension of the vehicle or in manufacturing buffer and draw-gear devices. Buffers with rubber elements have the advantage of ensuring a high degree of shock absorption and longitudinal oscillations by their ability to stock a large amount of energy, hence the name of high capacity buffers. Using rubber elements in building the buffers leads to the simplification of constructive methods, the lack of special maintenance operations and of additional damping systems, all this leading to the decrease of operating costs.

A major disadvantage of the rubber elastic elements is the influence of ambient temperature variation on the characteristic of the buffer. The values below -30 ° C hardening occurs, while at values of 40 ... 50 ° C increases elasticity, leading to a substantial change of the feature of the entire ensemble.

To exploit the advantages offered by the rubber, as elastic and damping element in the railway vehicles buffers it is recommended to be used with metal ring springs to mitigate the effects of temperature on the buffer feature.

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