Rubber Suspension, a Solution of the future for Railway Vehicles

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Rubber is widely used in railway infrastructure and in rolling stock. Rubber pads are used in fastening systems of rail to sleepers and rubber elements are used in the primary suspension of Romanian (and foreign) electric locomotives, in freight and passengers railway cars, metro trains and trams; the trams wheels are built with rubber insertion in order to reduce the vehicle unsprung mass. Also, rubber elastic elements are used in railway vehicles buffers. From these examples it can be seen that the rubber elements are used in the construction of parts which are directly contributing to traffic safety.

Keywords: rubber, railway car, suspension, railway safety

Nowadays, when there is a tendency of using vehicles with high transport capacity and able to run at high speeds, the problem of suspension optimization is of particular importance. During its runtime, a railway vehicle is subject to vibration generating pulses, which have negative effects on the ride quality. The vehicle responds to these pulses generated during the rolling process by its suspension, which has to reduce their effect to acceptable levels.

A source of vibration for railway vehicles is represented by vertical and transversal track irregularities and by rail discontinuities at the joints. The rigid fastening of the wheels to the axle and the reversed conicities of the rolling surfaces of the wheels of the same axle produce the hunting motion of the wheelset, which is transmitted to the sprung mass of the vehicle. Wheel defects such as eccentricity and tread flats are also important sources of vibration. Ensuring passenger vibration comfort, the integrity of the transported freight and of the structure itself of the vehicle depends essentially on the quality of the vehicle suspension. The suspension of the vehicle must ensure stable dynamic behaviour while running in straight line and in curves, in the latter case being required also to ensure low guiding forces. Suspension must contribute to the reduction of mutual forces between vehicle and track, keeping them within the limits determined by traffic safety and by the necessity to ensure the protection of both wheelset and track. The suspension consists of elastic elements (springs), shock absorbers (dampers) and connection elements (links, joints, etc.). These elements are mounted, depending on the vehicle type, between the wheelset and the bogie frame, between the wheelset and the vehicle body, between the bogie frame and the vehicle body.

The suspension elements of the suspension may be metallic (made of steel), of rubber or pneumatic. Their role is to accumulate a part of the vibration energy and then to return it over time, thus contributing to the reduction of the dynamic loads acting on the sprung and unsprung masses of the vehicle.

Rubber emerged as a material with technical application in 1839, when Charles Goodyear discovered and developed the process of vulcanization, by which the plastic rubber can be turned into an elastic material, with proper characteristics to be used in different fields.

The interest for this material, justified by its properties, initiated a series of researches and experiments, which led to the establishment of recipes, mixtures and execution technologies for rubber parts of different shapes and sizes, with characteristics specific to a wide range of applications (rubber resistant within a wide range of temperatures, resistant to oil products, with electrical insulation properties, rubber bonded on metal armatures, etc.). The basic characteristic of rubber is its great elasticity, i.e. the ability to support large deformations under the action of external forces and to recover its original shape when the action of these forces ceases. Rubber elasticity is an intrinsic property, which does not depend on the shape of the part, in contradistinction to steel, which, in order to have an appreciable elasticity, must be manufactured with special shapes (coil springs, leaf springs) i.e. the elasticity is a property of the form. The rubber as a material is incompressible, i.e. a volume of rubber subject to a compressive stress in an enclosed space behaves as an undeformable material so, in order to provide elasticity the rubber part must have the possibility of modify its shape.

The suspension system of many modern railway vehicles uses rubber elastic elements instead of conventional steel springs. In figure 1 is shown schematically a metro train bogie using rubber in both suspension stages.

![Fig. 1. DT type bogie used in metro cars in Hamburg](image)

**Y25 freight bogie**

In Europe, after the first half of the last century, as a result of the enhancement of the unification trends for railway components, the bogie Y25 (fig. 2) has been standardized for freight cars. The structure of this type of bogie is virtually unchanged even nowadays. From the point of view of the suspension, the bogie is fitted with metal coil springs.

As a result of the frame-type construction and of the suspension made of metallic elements (fig. 2), the bogie has a high longitudinal and transversal stiffness, which can be detrimental to the ride quality of freight cars in some operating circumstances.
In order to eliminate the previously presented disadvantages of Y25 bogie with metal coil springs suspension and to meet the requirements of railway operators, the manufacturer Continental has patented the rubber suspension for Y25 freight bogie. In figures 4 – 6 is presented this rubber suspension used in Y25 bogie.

Taking into account the changes made to the bogie by introducing rubber springs, it can be seen that it is not affected the mechanical resistance of the bogie structure and the constructive modifications are minor.

The pictured section of the bogie comprises an axlebox 10 with a rolling bearing 4 mounted in a middle region of the axlebox 10. The rolling bearing 4 supports one end of one of the two axles of the bogie. A base of the axlebox 10 is extended to the left and the right side forming a cup shaped region 12 at each of the sides. Each of the hydraulic springs comprises a spring element 20 which is attached to each of the cup shaped regions 12 of the axlebox 10. A metallic centerpiece 26 is located in the center of each of the spring elements 20. These two centerpieces 26 are attached to one bridging adapter 50. Therefore the centerpieces 26 and the bridging adapter 50 have bores for connecting the centerpieces 26 with the bridging adapter 50 via two bolts 52 pictured uncut in figures 1 and 2. In other embodiments, the bolts 52 can be integral parts of the centerpieces 26 or of the bridging adapter 50 or the centerpieces 26 can be connected to the bridging adapter 50 by any other connecting means. The bridging adapter 50 is attached to a longeron of a frame 6 of the bogie. This longeron extends in a longitudinal direction parallel to the rails and is pictured uncut in figure 1. Preferably the bridging adapter 50 is connected to the bogie frame 6 by welding. In the following description, just the left cup shaped region 12 in connection with the left spring element 20 is described in detail, because the same applies to the right cup shaped region 12 in connection with the right spring element 20. Figure 2 shows a sectional view along the line B-B of figure 1. The spring element 20 comprises sleeve shaped elastomeric elements 22 and intermediate sleeve shaped metallic elements 24 in an alternating succession, whereby the elastomeric and the metallic elements 22 and 24 are connected by way of vulcanization. Also the centerpiece 26 is connected by way of vulcanization to its adjacent elastomeric element 22. The spring element 20 is secured to the respective cup shaped region 12 of the axlebox 10 via a sealing ring 42, which is attached to the axlebox 10 via screws 44. In other embodiments the spring element 20 also can be directly vulcanized to the cup shaped region 12. The spring elements 20 forms together with the respective cup shaped region 12 of the...
axlebox 10 a volume for a fluid 30, particularly a hydraulic fluid. This volume is at least partly filled with the fluid 30. The centerpiece 26 is prolonged into the volume forming a plunger shaped region 28. Thereby at least a disk shaped region at the end of the plunger shaped region 28 is dipped into the fluid 30, so that this arrangement fulfills the function of a damper. The cup shaped region 12 of the axlebox 10 together with the respective spring element 20 and the fluid 30 form together the hydraulic spring [8].

**Bogie DRRS25**

GERMAN Rail (DB) wagon producer DB Waggonbau Niesky has developed a new range of bogies for freight wagons which aim to reduce noise and lower long-term maintenance costs (fig. 7).

The DRRS25 can be fitted with conventional, compact or disc brakes, and all configurations use double rubber rolling springs instead of standard steel springs to help reduce noise resulting from the condition of the track. The disc-braked version reduces noise to 6dB(A) below the TSI Noise standard, and more crucially reduces the perceived noise level by 30% compared with a conventional wagon. Noise-based track access charges will be introduced in Germany by DB Networks from next year and other countries, notably Switzerland, require wagon noise to be managed and reduced. This means the market for quieter bogies could be very large in the future. DB claims disc brakes will reduce maintenance costs by 35% because wheel rims are not worn down by braking, nor is there the risk of wheels overheating due to brakes not releasing properly. DB Schenker has tested the bogies as part of a DB project to develop low-noise freight trains and the bogies meet the relevant TSI standards for freight wagons. The DRRS25 bogie is designed to comply with UIC standard UIC 510-1, meaning it is interchangeable with the standard Y25 type. Swiss intermodal operator Hupac is planning to test the new bogie under its wagons [9].
it should be noted that the shape of the two rolling surfaces, which must not exceed 45°, is under a load is defined by the coefficient of deformation. In figure 11 is shown the influence of rolling surfaces shape on the spring functioning characteristics, namely on the axial stiffness characteristic. Inclination $\alpha$ of the housing and pin inclination $\beta$ are in the range of 10°-30°, so that various combinations can be achieved within these ranges of values. Obviously, high values of inclination result in high stiffness of the spring.

Besides the stiffness in axial direction, the clouth-type springs have also a radial (transversal) elasticity, which is depending on the axial load. This feature increases the field of use of clouth-type springs, as it eliminates the necessity of some guiding systems or links which are required in other systems.

**Conclusions**

Noise is regarded as the “Achilles heel” of European railways. European Commission is aware of this issue and that is why it desires the reduction of noise, without jeopardizing the competitiveness of rail transport. The main goal is to reduce noise inconveniences caused by vehicles to people living near railway tracks. As the renewal of the rolling stock fleet is slow, the European Commission reached the conclusion that further measures are necessary on existing freight wagons. Since metal suspensions are producing and transmitting noise, a solution would be to replace metal suspension of bogies for freight cars with rubber suspension.

Taking into account also the above mentioned characteristics and performances of rubber suspension, it can be stated that it represents an effective and reliable alternative to metal suspension and constitutes a solution of the future for railway vehicles.

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