EURASIAN JOURNAL OF ACADEMIC RESEARCH
Innovative Academy Research Support Center
UIF = 8.1 | SJIF = 5.685 www.in-academy.uz

CALCULATION OF DYNAMIC STRENGTH AND DURABILITY OF RUBBER-METAL SPRINGS OF "MEGI" TYPE FOR LOCOMOTIVES

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https://www.doi.org/10.5281/zenodo.10046960

ARTICLE INFO

Received: 18th October 2023
Accepted: 26th October 2023
Online: 27th October 2023

KEY WORDS

Rubber-metal springs of "MEGI" type for locomotives, rubber-metal elements, the rational dimensions of parts of rubber-metal elements at increased speeds, improved method for calculating of dynamic strength and durability of rubber-metal springs of "MEGI" type for locomotives.

ABSTRACT

The article presents the method of calculation of dynamic strength and durability of rubber-metal springs of "MEGI" type for locomotives.

The use of rubber-metal elements and parts in many units and interfaces of locomotive equipment makes it possible to significantly improve the cushioning of dynamic forces arising in them. In the context of continuous growth in movement speeds and increasing loads on the locomotive axle, this becomes especially important, as it improves the general dynamic characteristics of locomotives and helps to reduce harmful dynamic interactions between locomotives and the track [1,2].

In addition to improving dynamic performance, the use of rubber in locomotive shock absorbers reduces the wear of parts, increases their service life, reduces, and often completely eliminates noise and dampens vibration. Since 1968, the entire electric and diesel rolling stock of the French railways has been equipped with secondary suspension with rubber-metal elements [1].

Tests carried out over several decades have established some principles necessary to reduce the wear of rails by locomotives. It is noted that for this, especially at high speeds, it is necessary as a mandatory event to create a pendulum suspension system for the crew of locomotives. Its mass shall be concentrated as close as possible to the center of the trolley, and the ratio $\frac{M\rho^2}{a^2}$ shall be reduced as much as possible, where M - is the weight of the trolley; ρ - radius of inertia; a - trolley base. Adherence to these principles led to modern French

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Railways locomotives at 250 km/h having less impact on the track than the effects that were exerted by locomotives of earlier editions, such as the 202 series locomotives at 130 km/h.

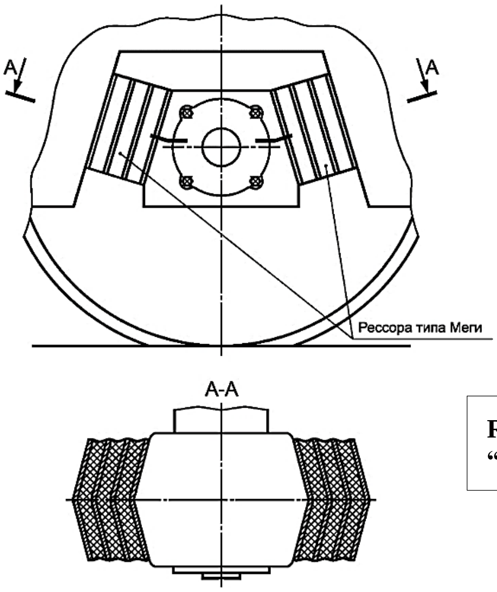
Rubber-metal elements are widely used as elastic elements and movable joints on rolling stock in axle-box spring suspension of locomotives [2,3]. Their use is associated with high internal friction and significant energy consumption, which allows absorbing high-frequency oscillations. Disadvantages of rubber elements include high rigidity and influence of temperature on its physical and mechanical properties.

Rubber elements used in spring suspension work on shear, compression and simultaneously on shear and compression. Due to the relatively high allowable relative deformations and the presence of internal friction, it is possible to create compact elastic elements that also realize energy dissipation, which, for example, makes it possible to do without vibration dampers in the axle box suspension stage when using them. Internal friction in rubber is particularly effective in suppressing high-frequency vibrations - noise.

The different compression and shear properties of rubber are used very well to produce different structural flexibilities in different directions. Figure 1 shows axle-box suspension with rubber springs of bell type using rubber-metal spring of MEGI type in locomotives.

Rubber insert *2* is enclosed in steel cup *1* and touches its walls with upper and lower thickened parts, and inside rubber insert spinton *3* passes with lower shape in the form of cone. Under load, the spinton *3* enters the bell, first causing only a shift of the inner layers of the bell relative to the outer ones, with a further increase in load, the bell begins to press stronger than its upper part to the glass and a compression voltage is added to the shear voltage.

Each set of these springs consists of two identical packages of metal shaped sheets and rubber gaskets symmetrically located on both sides of the axle box. The metal sheets *1* of the spring bags are coated with vulcanization or rubber layers *3* are glued. Rubber is divided by inner metal sheets arranged parallel to two outer sheets. Outer and intermediate metal sheets with rubber layers between them form an angle.



Rubber-metal spring of “MEGI” type

Figure 1. Rubber-metal spring of “MEGI” type (three-layer rubber-metal shock absorber with V-shape of rubber layers in cross section):

1-metal sheets; 2.5-mounting ledges on the axle box and on the bogie frame;
3-layers of rubber; 4-angled consoles.

Packages of metal springs [4] with rubber gaskets are installed somewhat obliquely to vertical plane perpendicular to direction of motion. As a result of this arrangement, the rubber gasket is simultaneously subjected to compression and shear stress under vertical load on the axle box.

The intermediate metal sheets increase the resistance to compressive forces without affecting the shear resistance in any way. The axle box is shaped to correspond to the inclined arrangement of the spring packs. To install the spring there are ledges *2* on the axle box and the same ledges *5* on the frame. Bogie frame forms inclined cantilevers *4* tightened by string from below. In the lateral direction, the springs, due to their V-shaped shape, are 3-5 times more rigid than in vertical. Even more rigid springs of the "MEGI" type in the longitudinal direction, since in this case compressive forces act on them. Their stiffness in the longitudinal direction is 10-30 times greater than in the vertical direction, which is especially important in the rectilinear direction of the axes and for good perception of forces during braking. According to [3,4,5], the disadvantage of such suspension is the dependence of elastic and mechanical characteristics on the ambient temperature and a possible increase in stiffness by 2-3 times at negative temperatures - 40°C - 50°C. This kind of rubber springs are used on the rolling stock of various states; including Finland, Sweden, Canada. They were experimentally tested on the Moscow Metro.

Deflection of springs under load of 0,5 P_{STAT} is specified in the design documentation of springs of specific versions [5,6]. The compression deformation factor of each rubber layer of the spring ε under the spring load equal to 0.65 P_{STAT} shall not exceed 0.10, where P_{STAT} is the design static load, kN [5,6,7].

According to the design studies carried out in [8,9], the shear strain coefficient of the spring γ under spring load equal to 0.65 P_{STAT} should not be more than 0.30. Residual radial deformation of the $\varepsilon_{R\,res}$ spring shall not exceed 10%.

Durability of rubber-metal springs of "MEGI" type shall ensure absence of their failures during assigned service life and assigned service life [4,5,6]. Failure of the spring is considered the appearance of cracks in rubber layers with a length of more than 20 mm and a depth of more than 3 mm, which are detected during visual inspection, as well as their destruction.

To test the durability of springs, a stand is used that ensures: testing four springs simultaneously; cyclic loading of two pairs of springs with maximum cycle amplitude corresponding to 1.3 P_{STAT}; dynamic calibration of each pair of springs in the range of loads up to 1.3 P_{STAT} inclusive. For dynamic calibration, the test bench shall be equipped with a force gauge with the limits of the permissible basic relative measurement error ± 1.0% with a load value for each pair of springs of 1.3 P_{STAT} or more accurate [7,8,9].

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