



## MATHEMATICAL MODEL FOR QUASI-STATIC CALCULATION OF CONICAL RUBBER-METAL ELEMENTS OF HIGH-SPEED ELECTRIC TRAINS

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### ABSTRACT

*The article presents a mathematical model for quasi-static calculation of conical rubber-metal elements of a high-speed electric rolling stock, as well as an experimentally obtained relationship between the deflection of conical shock absorbers of electric trains from various grades of rubber.*

When creating chassis for high-speed electric rolling stock, it is necessary to set and solve the tasks of ensuring safety, smoothness, and reducing vibrations at high speeds in a new way [1].

The solution to these problems is a properly designed suspension of vehicles using various types of dampers based on rubber-metal elements, a pneumatic spring and hydraulic vibration dampers, which leads to an increase in the smoothness of the rolling stock and an improvement in the strength and elastic-dissipative properties of the suspension in order to reduce dynamic effects on the track and transported goods [1,2,3]. The main reliability requirement for rubber-metal elements is that their durability should ensure the absence of failures during the assigned service life and assigned life [1,4,5].

In spring suspension of electric locomotives and electric trains, most often used are not cylindrical, but conical rubber-metal shock absorbers that experience torsion twisting during operation [3]. These shock absorbers have rectangular sections enclosed between two support surfaces and experience simultaneous compression and shear deformations (Figure 1). The rigidity of such a shock absorber depends on the angle of inclination of the base plates  $\beta$ .

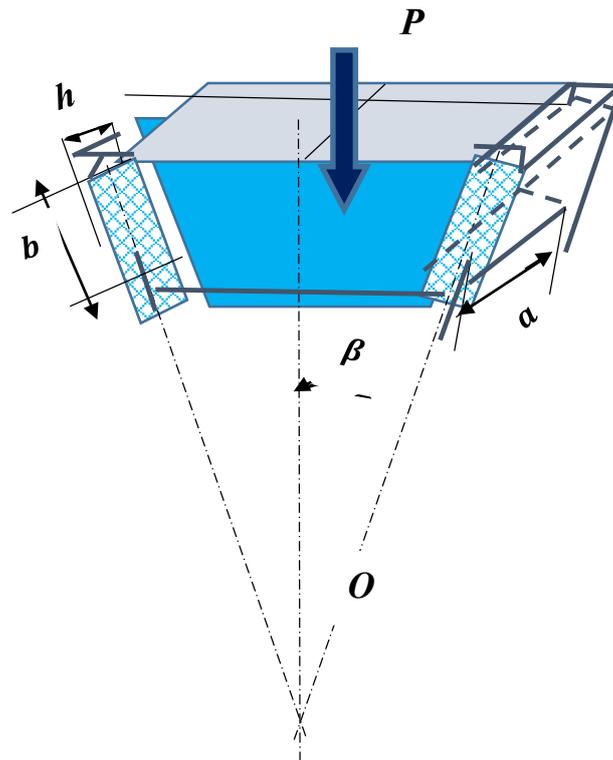


Figure 1. Design scheme for rectangular shock absorbers enclosed between two inclined support surfaces.

The stiffness of the conical shock absorber can be determined by the formula in accordance with scientific articles [4,5]

$$G_{KA} = \frac{2F \cdot (E_p \sin^2 \beta + G \cdot \cos^2 \beta)}{h} \quad (1)$$

The calculated modulus of elasticity of the  $E_p$  depending on the shape factor is determined in the same way as in uniaxial compression. The factor  $n$  is taken equal to 1, and  $f$ ,  $mm$  - according to the graphs shown in Figures 2 and 3, depending on the rubber grade and the load value  $P$ ,  $kN$ .

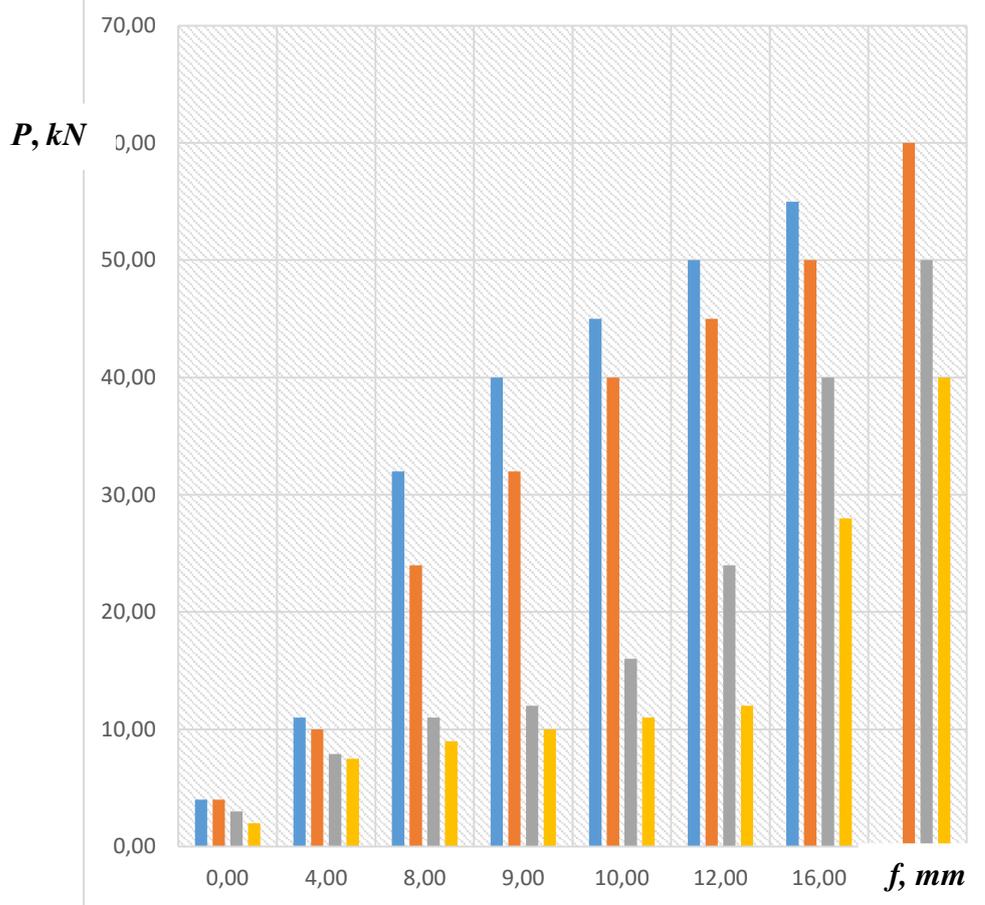


Figure 2. Dependence of deflection of conical shock absorbers of electric trains from different rubber grades  $f, mm$  on load  $P, kN$ :

- Row 1 - rubber grade 2959 B; - Row 2 - rubber grade 2959;
- Row 3 - rubber grade 3068 H; - Row 3 - rubber grade 8075 H.

The form factor in this case is determined by the formula

$$FF = \frac{F_{op}}{F_b} = \frac{a \cdot b}{2(a+b) \cdot h} \quad (2)$$

Cone shock absorbers (Figure 3) under the action of the force  $P$  in the direction of the  $Z$  axis also experience joint deformation of shear and compression and can be calculated by formula (1). Here, the form factor for determining the calculated modulus of elasticity can be approximately found by formulas (2) and (3) in accordance with scientific articles [4,5]

$$FF = \frac{\pi \ell (R_c + r_c)}{2\pi (R_c + r_c) \cdot \delta} \quad (3)$$

where  $R_c, r_c$  are the average radii of the larger and smaller bases of the cone, respectively.

$P, kN$

$P, kN$

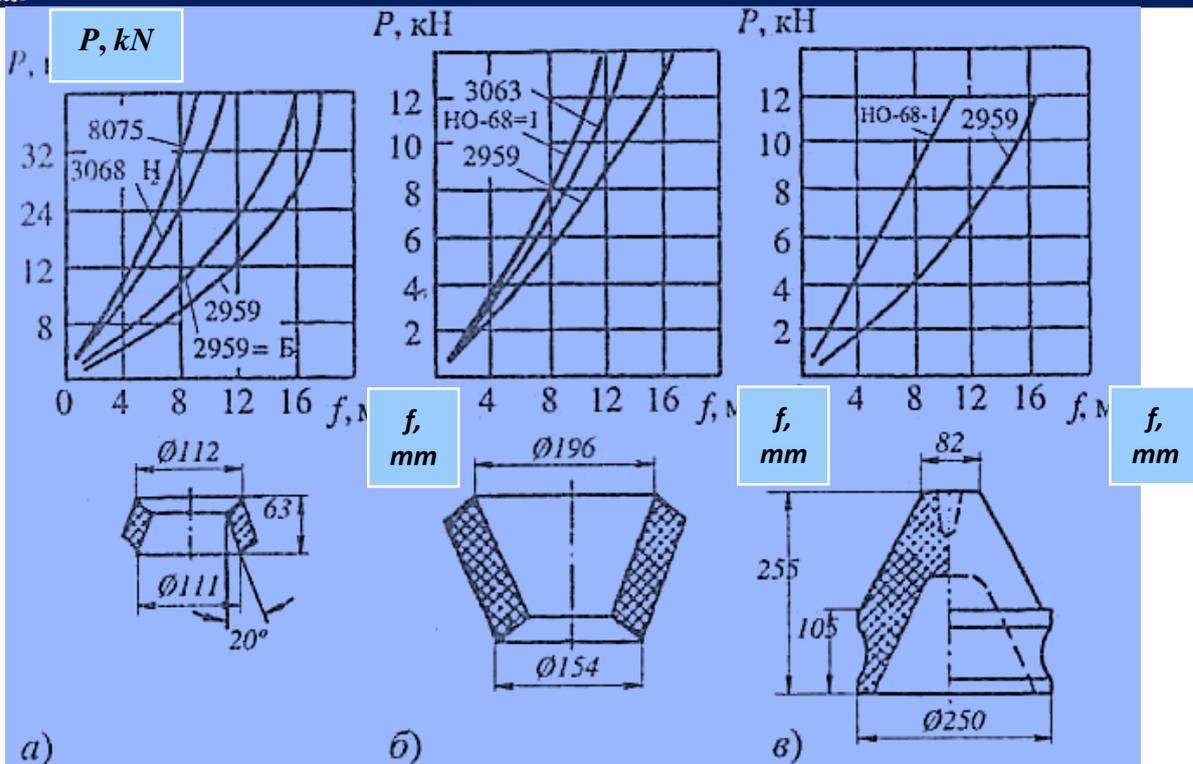


Figure 3. Dependence of deflection of conical shock absorbers of electric trains from different rubber grades on load and shape.

A rubber-metal element is considered to be designed correctly if it meets the following requirements: deformation stiffness corresponds to the design one, stresses are evenly distributed throughout the element, thermal stress, taking into account dissipative heating, is below the permissible level for this rubber grade, residual deformations after full unloading of the element are minimal and durability under certain operating conditions of the element is within the specified limits [4,5,8,9,10].

A prerequisite for the correct design of elastic elements is knowledge of the specific conditions of their operation, which allows you to choose rubber with the necessary properties. In addition, the designer must have a clear understanding of the technology of manufacturing rubber elements, the effect on their properties of rubber components, vulcanization mode, mold design, geometric dimensions of the rubber part, etc. [4 ÷ 10].

**References:**

1. Simon Iwnicki. Handbook of Railway Vehicle Dynamics.2006. Taylor & Francis Group. - 527 p.
2. Резиновые амортизаторы в локомотивах. / И.П. Ситковский, В.И.Маевский, <https://lokomotiv.ru/podvizhnoy-sostav/polimernye-materialy-na-zarubezhnyh-zhd/Page-34.html>
3. Кононов В.Е. Резиновые амортизаторы в экипажной части локомотивов: Учебное пособие. - М.РГОТУПС, 2002.-147 с.



4. Khromova G., Makhamadalieva M. Разработка математической модели по обоснованию рациональных параметров рессорного подвешивания высокоскоростного электропоезда Afrosiab. // Universum: Technical sciences, 2022, № 10 (103), октябрь 2022, часть 2, С. 62–66. DOI: [10.32743/unitech.2022.103.10.14404](https://doi.org/10.32743/unitech.2022.103.10.14404). Available at: [https://7universum.com/ru/tech/10\(103\)/10\(103\\_2\).pdf](https://7universum.com/ru/tech/10(103)/10(103_2).pdf) (02.00.00; № 2).
5. Хромова Г.А., Худайкулиев Р.Р., Вершков С.А. Численно-аналитический метод прогнозирования ресурса деталей пространственной конфигурации. // Журнал «Доклады АН РУз», № 1, 2006, С.11-14.
6. Khromova G.A., Makhmadaliev M.A., Khromov S.A. Generalized dynamic model of hydrodynamic vibration dampener subject to viscous damping. //E3S Web of Conferences. – EDP Sciences, 2021. – Т. 264. – С. 05029. <https://doi.org/10.1051/e3sconf/202126405029>
7. Khromova G.A., Kamalov I.S., Makhmadaliev M.A. Improved method of calculating the rational dimensions of parts of hydraulic vibrations dampers of electric trains at high speeds // «Eurasian Journal of Academic Research»: International scientific journal (ISSN: 2181-2020), Volume 2 Issue 12, November 2022, p. 1096-1100. <https://doi.org/10.5281/zenodo.7386499>
8. Khromova G.A., Tukhtaev B.U. Calculation of stiffness of a rubber -metallic elements of electric trains at torsion twisting. // Eurasian Journal of Academic Research»: International scientific journal (ISSN: 2181-2020), 2023, Volume 3, Issue 9, September 2023, pp.12–15. ISSN 2881-2020. <https://doi.org/10.5281/zenodo.8321796>
9. Khromova G.A., Tukhtaev B.U. Calculation of dynamic strength and durability of rubber-metal springs of “MEGI” type for locomotives. // Eurasian Journal of Academic Research»: International scientific journal (ISSN: 2181-2020), Volume 3 Issue 10, October 2023, pp.251-254. <https://doi.org/10.5281/zenodo.10046960>
10. Хромова Г.А., Тухтаев Б.У. Основные конструктивные требования для резинометаллических элементов высокоскоростного электроподвижного состава. // Международный научно-образовательный электронный журнал «Образование и наука в XXI веке». выпуск № 42, том 2, сентябрь, 2023. С. 33-38.