COMPOSITE ROLLERS FOR ARMATURE OF THE CONTACT NETWORK

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ABSTRACT

Development of contact networks feeding electrified railways has a trend to use the devices, structures and elements that can be maintained with less efforts and as rarely as possible. The article considers an alternative to application of rollers KS-084 regarding the Russian practices but also suggests approaches and useful tools that can be used on the whole while assessing different operation aspects of power supply systems. Theoretical studies of the permissible normative load on the wire fastening assembly, as well as the experimental verification, including the evaluation of the mechanical strength of GRP rollers for failure in accordance with OST 32.204–2002, showed the complete availability of the composite products offered for operation in the construction of overhead contact systems.

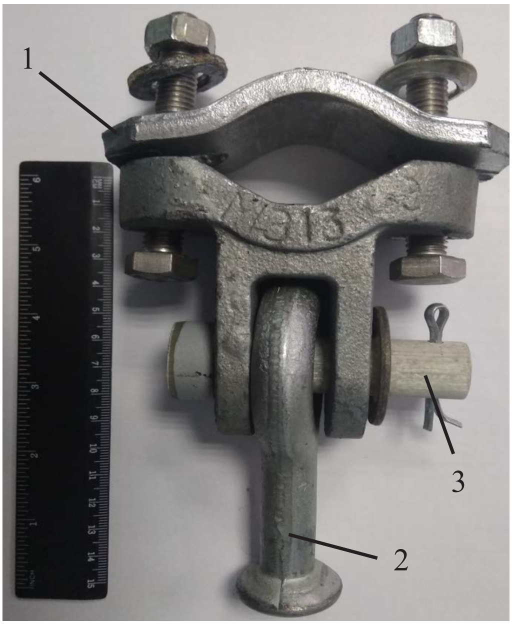
Keywords: *railway, contact network, catenary, armature, roller, fiberglass, composite, shear, load.*

Background. *To begin with, let's clarify: the catenary of electrified railways is a complex system with a large number of nodes and elements. Many of these elements can be combined into the concept of «armature of the contact network» and described as products and fittings intended for hanging, fixing in a given position, docking, anchoring, mechanical and electrical connection of wires suspended on the contact network supports [1].*

Both in Russia and abroad, the armature of the railway contact network is divided according to the material of manufacture:

- *of metals (by casting);*
- *of non-ferrous metals;*
- *of steel.*

With advancement of self-supporting insulated wires, the production of components and fitting elements for wires made of polymer composite materials has been developed. Siemens AG, Pfisterer, Ribe group, Ensto, Niled, Sicame, Tyco Electronics Simel, MZVA, and TESK are among the leading companies in this field [2]. Despite the positive effect, such nodes are used when using protected wires.



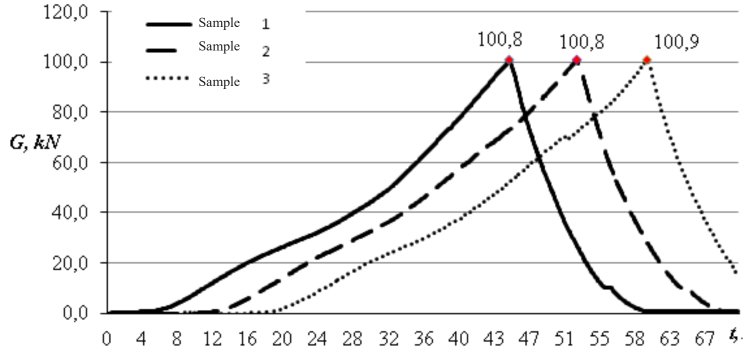
Pic. 1. An assembly of the contact network armature with a composite roller: 1 – string node LEZ 41.1066; 2 – connecting link KS-075; 3 – composite roller 19 × 70.

Objective. *The objective of the authors is to consider composite rollers for armature of the contact network.*

Methods. *The authors use general scientific and engineering methods, comparative analysis, evaluation approach, graph construction, mathematical calculations, electrical engineering methods.*

Results. *To date, there has been an active trend in development of railway transport facilities using polymer composite materials (PCM). In addition to bridges and cars, PCM are used for construction of supports, consoles of the contact network and brackets for power transmission lines for longitudinal power supply, which are smooth-rod designs [3–6]. From the point of view of increasing their electrical strength, the question arose about the possible use of fiberglass plastic as a material for rollers in the fittings of the catenary instead of steel rollers KS-084. This part is planned to be used within the connection between the string node LEZ 41.1066 and the*

Pic. 2. Scheme of tests for a single cut: 1 – blades; 2 – the sample.



Pic. 3. Tension diagrams.

connecting link KS-075 (Pic. 1), providing for future replacement of the metal connecting link with a composite one.

The first stage of the analysis is the study of OST 32.204–2002 [technical specifications] and comparison of the required norms with regard to a new design of rollers.

Since the roller is intended to resist to stalling (the load applied to the product of the armature is perpendicular to the plane passing through the axis of the wire and the axis of symmetry of the armature), it is necessary to estimate the maximum breaking load across the fibers of fiberglass plastic. Critical mechnaical load that causes stalling is the lowest value of the load applied to the product of the armature or the connection of wires, causing their destruction, deformation or other irreversible changes. Product performance is determined by the safety factor of the mechanical strength (the ratio of the destructive load to the permissible load) [1].

At the same time, the main parameters to be determined by the composite rollers are defined:

- *they should ensure the possibility of free movement of the mating products relative to each other and exclude the possibility of their spontaneous disengagement under operating conditions;*
- *parameters regarding accidental shearing must comply with the requirements of OST 1.90148–74 [7];*
- *rollers must be made of an anti-corrosion material or have a corrosion-resistant coating;*
- *for armature products that do not subject to the load from wires, the load that causes a shearing and a stall must be at least three times the permissible value;*
- *the service life of the armature products with a fitting product made of corrosion-resistant material must be of 50 years.*

To accomplish the task, the tensile/compression stand «Universal Testing Machine Testometric FS100 AT» (maximum load 100 kN) was used. The stand was installed in the testing center of railway technics of Ural State University of Railway Transport. The Center

Pic. 4. Samples of composite rollers after testing.

Pic. 5. Appearances of the composite roller KS-S-084.

is one of the leading testing centers in the Urals region, where a wide range of scientific research is being conducted, including research on the properties of polymer composites and products made of them.

Three samples of composite rollers manufactured at the research and production enterprise Elektromash (Yekaterinburg) were provided for testing. The rollers are rods of diameter d = 19 mm, length l = 70 mm, having a head on one side, and on the other a hole for the cotter pin, i. e. the appearance completely repeats the design of the traditional roller KS-084.

Failure tests were carried out under normal climatic conditions and in accordance with the requirements of [7, 8]. Pic. 2 shows a single-shear test scheme. The sample is inserted into the technological hole of blades, without interference, the gap between the specimen and blades is not more than 0,1 mm. The speed of movement of blades does not exceed 10 mm/min during the working stroke of the testing machine. The tests for each sample were identical, during the experiments the loading diagrams shown in Pic. 3 were recorded.

Using the formula (1) [7], the shear resistance for 19 × 70 composite rollers was determined:

$$\tau_{sh} = \frac{4 \cdot P}{\pi \cdot d^2}. \qquad (1)$$

The resistance is τ_{sh} = 50 kgf/mm².

Proceeding from [9], for the structural steel St3kp2, of which the metal rollers KS-084 are made, with the diameter of the rod up to 20 mm, the shear resistance is 24 kgf/mm², for St3ps2 – 25 kgf/mm². It can be seen that the calculated shear resistance for steel is half that of composite rollers.

Pic. 4 shows samples of rollers that have been tested. On the surface of the samples, at the point where the load is applied, there are marks from the blades, but the damage obtained did not reduce the mechanical strength of the rollers. They were used in further mechanical testing of polymer support structures designed for overhead contact network in devices for electrification and power supply of railways.

To ensure a service life of up to 50 years composite rods are used, in which a UV stabilizer is added during production, and dielectric enamel is applied to the surface. This enamel has a high resistance to ultraviolet radiation, thermal aging, abrasion, prevents penetration of moisture, and has resistance to temperature changes.

Pic. 5 shows a sample of a composite roller ready for use.

Conclusions. *According to the theoretical studies, the permissible normative load on the wire fastening unit (when using the AS-70 wire in the conditions of the third level of wind and ice conditions) is 1738 N [10], taking into account the safety factor k_s = 3, the breaking load should be at least 5214 N.*

From the experimental studies it was determined that the breaking mechanical load of 19 × 70 composite rollers exceeds 100 kN, which is 95 % more than the normative allowable value.

Thus, the composite rollers meet the requirements [1, 7] regarding stall and can be used in the fittings of the contact network.

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