IMPACT OF QUALITY INDICATORS OF ELECTRICAL ENERGY ON METROPOLITAN ROLLING STOCK

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Abstract. *The quality of electrical energy is becoming an increasingly sought-after factor that affects various parameters of electrical equipment, including reliability. In the article, the authors conducted a study of the influence of the quality of electric energy on the performance indicators of the metro rolling stock.*

Keywords: *quality of electric energy, electric discharge, wagon, metro, bearing, rolling stock.*

Introduction

Monitoring the electrical energy quality in the metro power system is uncommon, despite the importance of maintaining the system's performance. The electric motor of the rolling stock is the main consumer, which can deteriorate the quality of electrical energy. While passive filters can suppress harmonic surges, improvement systems are not typically utilized. Diagnosing quality of electrical energy through direct measurements at electrical substations is a promising method for the metro's rolling stock.

Quality parameters of electric energy in the electric transport network

One of the components of low quality electrical energy isthe presence of higher harmonics in the electrical network [1,2]. Supplies s of higher harmonics are traction substations ofelectric transport and other non-linear consumers.

A series of measurements showed that the deterioration ofthe quality of electrical energy in electric transport is a consequence of the operation of the electrical equipment of thesubway and various electrical devices contribute to the deterioration of the quality parameters of electricity. At the same time, it was found that the harmonic components have an influence on the technical elements and nodes of the rollingstock [3, 4].

Therefore, the question of determining the element that leads to the deterioration of the quality of electrical energy onrolling stock is an urgent direction in the development of diagnostic equipment.

The parameters of the quality of electrical energy were determined in various nodes of electrical network schemes. Measurements were performed on the border of the supplier's and consumers' balance sheets.

Electric power quality measurements were performed at the connection of the main network substations of SMES andJSC "Yuzhd" using microprocessor analyzers of voltages andcurrents in electrical networks of the ANTES AK-3F type in accordance with GOST 13109-97.

The total duration of continuous measurements, taking intoaccount the requirements of clause 5.2.1, was at least seven days. The volume of measurements made during NEE monitoring [5] allows us to assume that the values and rangesof changes in the electrical energy parameters in the network, KU and KU(n), are reliably determined. In total, more than 50PKE measurements were carried out at electric power facilities located on the territory connected as consumers to the JSC "Yuzhd" substation located in the city of Kharkiv.

Received detailed protocols of electricity quality measurements for each indicator, which were obtained as a result of measurements at each control point.

Below are some final results of measurements of thequality of electrical energy at the studied facilities, Kharkiv.

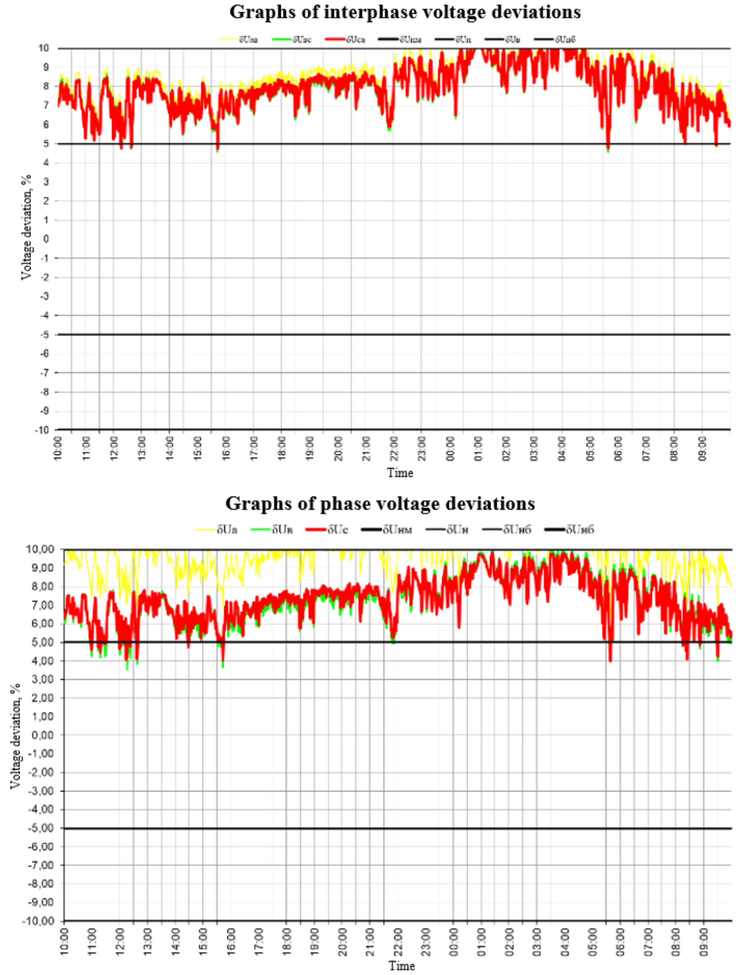

Figure 1. Graphs of interphase and phase voltage deviations.

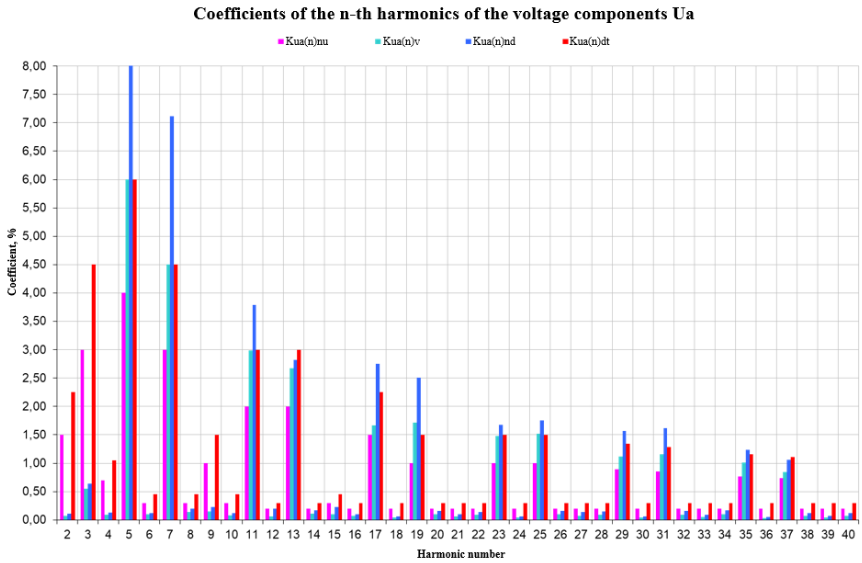

Figure 2. Coefficients of the n-th harmonics of the voltage components Ua

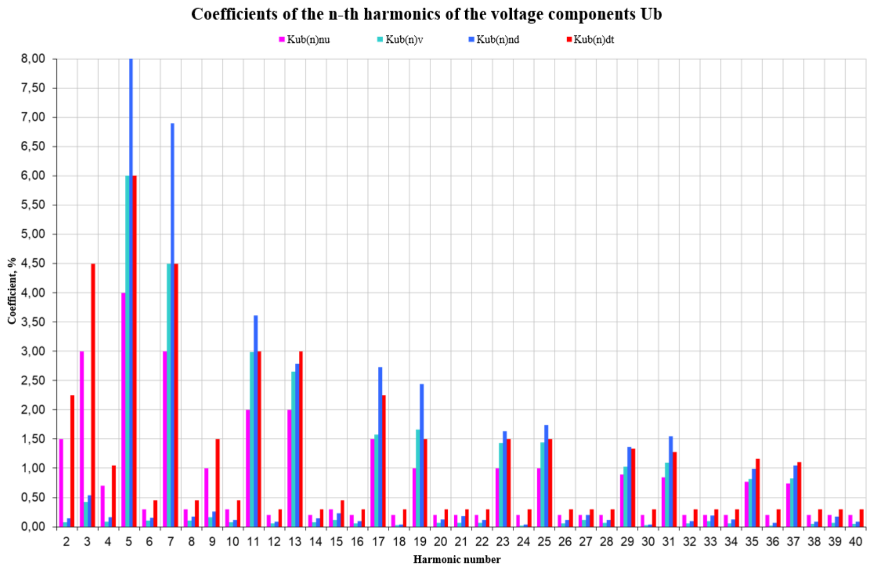

Figure 3. Coefficients of the n-th harmonics of the voltage components Ub

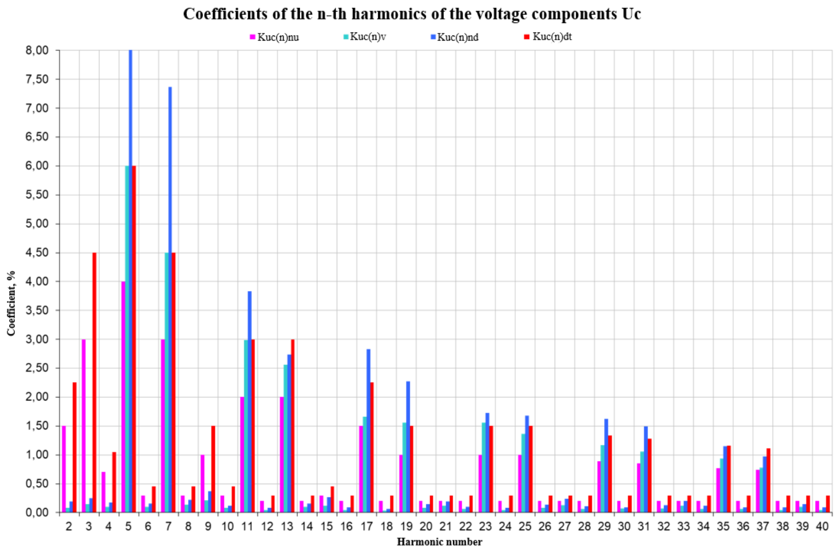

Figure 4. Coefficients of the n-th harmonics of the voltage components Uc

The results of measurements of KU(n) values in the distribution network at the substations where the measurements were made demonstrate a pronounced predominance of the 11th and 13th harmonic components, which significantly exceed the normalized values [6, 7].

The presence of harmonic components in the frequency range of the 11th and 13th harmonic components is due to the influence of the alternating current rectification scheme used in the consumer's power supply system with a non-linear load[8].

In Fig.2-4, it is shown that the 5th and 7th harmonic components prevail in the frequency range, due to the influence of the alternating current rectification scheme used in the traction load power supply system.

Directly determining the spectral components for elements of rolling stock schemes can be difficult due to the movement of rolling stock and the presence of network disturbances, which can lead to unpredictable results. Additionally, such measurements and devices can be expensive. As a result, developers often place technical control sensors directly on the engines or responsible nodes.

The author of the article propose a technique for quickly determining the deterioration of rolling stock by measuring the quality parameters of electrical energy, which involves structuring electrical disturbances from various elements of rolling stock.

General characteristics of the problems of the influence of poor-quality electric energy on metropolitan rolling stock

Electric system of metro wagon:

The body of the wagon is connected by flexible jumpers tothe frames of the trolleys, and the frames of the trolleys are connected by jumpers through the box body to the wheel pair.Grounding nodes are designed to form a power chain: contactnetwork - current collector - traction motors - grounding nodes – wheel.

The grounding node ensures that the current passes through the wheel, bypassing the bearings of the axles. But inthe case of additional grounding of the wagon body, it is connected to the axle box with a copper busbar. Grounding ofthe wagon body is performed by two tires at the beginning andend of the wagon.

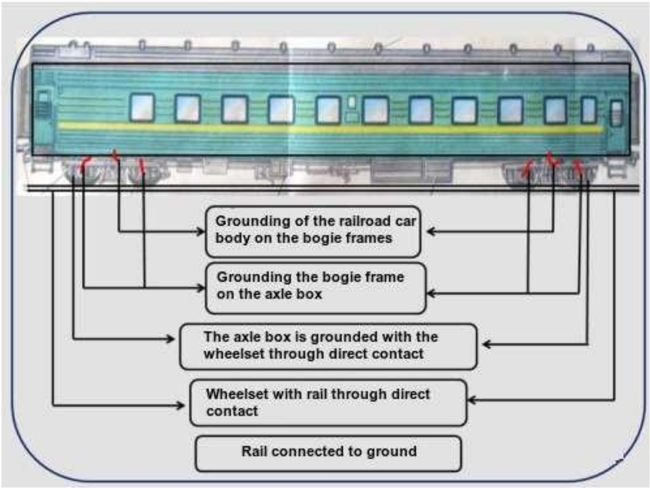

Figure 5. Places of grounding of the wagon body.

Grounding is carried out using shunts located on the bogie:two shunts per wagon on each side of the "body-bogie" and two shunts on each bogie diagonally "bogie-box".

Grounding shunts are installed so that the reverse currentduring the operation of electrical equipment passes through grounding shunts with low resistance, and not through detachable connections, which become non-conductive during the movement of the rolling stock under the influence of vibration.

Rolling bearing defects:

- Fatigue surface failures are associated with lubricationproblems (lubricant mismatch, low viscosity, and oil film breaks).
- Atmospheric corrosion. Corrosion is caused by moisture entering the bearing from the atmosphere. Moist air, getting into the middle of the bearing, condenses when the environment cools, breaking the oil film in the places of contact between the bodies andthe raceways.
- Fretting corrosion. Fretting corrosion is very similar tonormal corrosion. It occurs on the surfaces of the bearing on the shaft, as well as on other adjacent surfaces. It is caused by minor (microscopic) loads.
- During brinelling, regular indentations appear on the surfaces of the rings, one by one. This is a consequenceof plastic deformations of the metal in the places of thedents, which arise as a result of overstressing the metal.Brinelling is a consequence of high static or shock loads, incorrect bearing installation technology, strongmechanical shocks that occur when the machine falls.

Supplies of electrical potential on thewagon body

The body of the wagon is one of the conductors for the passage of current through the electric units of the wagon, which include: traction engine, engine control system, automation, low-voltage systems of the wagon (lighting, communication, telemetry system, etc.). The potential can alsobe induced by air friction during the movement of an electrictrain, or by the influence of electromagnetic waves from power conductors [10].

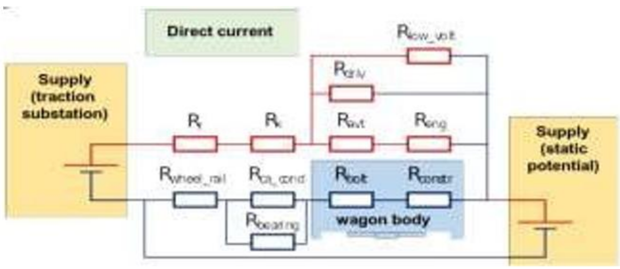

Figure 6. Direct current flow diagram through the wagon body.

The metro's rolling stock is powered by direct current Fig.6. A traction substation is used as a supply of direct current. The supply (traction substation) rectifies the current from the electrical network with an industrial frequency of 50 Hz.

To summarize, the potential on the wagon body during movement is variable and should be calculated for alternating current due to current surges and harmonic components of the current in the power supply network of the rolling stock. Rolling bearings have characteristic frequencies of defects, which can be detected in the spectrum of harmonic bursts in the draining current. The shape of the current at the moment of a surge at the bearing frequency can also provide information about the presence of breakdown or contamination of the bearing lubricant.

Conclusions

The research focused on the impact of current leakage on the support bearing of the metro car. The study revealed that the support bearing undergoes erosion damage due to the purely electric nature of the causes, which are a result of the action of electric discharges: sparking, corona, and arc. Since the bearing is an element of the electric circuit, the surges from the discharges affect other elements of the electric circuit of the metro car, and due to the rough surface of the bearing, its contact receives nonlinear resistance, which also leads to changes in the shape of the current.

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