INTERNATIONAL JOURNAL ON ORANGE TECHNOLOGY

https://journals.researchparks.org/index.php/IJOT e-ISSN: 2615-8140 | p-ISSN: 2615-7071

Volume: 5 Issue: 9 | Sep 2023

The Role of Diagnostics of State of Catenary Poles in the Traffic Safety System

Bayanov I. N., Badretdinov T. N., Muminov S. S.

---***---

Annotation: When operating railways, much attention is paid to the diagnosis of the contact suspension as an unserviceable part of the power supply system. The poles of contact lines are not given due attention, considering them invulnerable. The available means of diagnosing the contact lines do not fully meet the requirements of the operation of power supply devices due to the insufficient number of parameters to be determined, including the determination of the state of the poles. Also, the problematic part in the diagnostic system of the contact lines is the adequacy of the reflection by diagnostic means of the actual quality of the state of contact lines. Improving the quality of diagnostic tools for assessing the condition of the entire contact lines involves identifying potential risk areas, preventing or minimizing the risks of failures, preventing the occurrence of risks based on their systematic forecasting.

Keywords: catenary (contact lines), poles, electrical railways, diagnostic, the load, safety, failures.

In countries operating high-speed railways, the greatest attention is paid to the diagnosis of the contact lines as the most responsible and non-operated part of the train traction power supply system, including through mobile control and computing systems. The most problematic part in the diagnostic system of the contact lines is the adequacy of the reflection by diagnostic means of the actual quality of the state of the contact lines. Improving the quality of diagnostic tools for assessing the state of the contact lines involves identifying potential risk areas, preventing or minimizing the risks of failures, preventing the occurrence of risks based on their systematic forecasting.

At the moment, on electrified railways of the Republic of Uzbekistan, little attention is paid to the detailed monitoring of the diagnosis of the condition of traction power supply facilities, and the available means of diagnosing the contact lines do not fully meet the requirements of the operation of power supply devices due to the insufficient number of determined parameters of the contact lines, which leads to poor quality and accuracy of the forecast of service life and the moment pre-failure status of the catenary devices. Thus, the relevance of the dissertation research is due to the need to improve the diagnostic system of the contact lines and increase the reliability of the quality indicators of the state of the contact lines.

One of the most important indicators for railways is operational reliability and traffic safety. The total number of cases of defects can be reduced by improving the quality of manufacturing of track elements, and maintaining them in working condition due to timely control and detection of defects. This is achieved by introducing effective methods for assessing the condition of railway track elements, introducing new technical controls, and increasing the efficiency of the audit apparatus.

Every year, the pace of functioning of the railway network continues to increase: cargo turnover, passenger turnover are increasing, the speed of cargo delivery and the route speed of passenger trains are increasing. In this regard, the task of ensuring the safety and reliability of railway transport becomes even more urgent and significant.

One of the main elements in the economy of electrification and power supply are reinforced concrete catenary poles, which are involved in the process of transferring electricity from traction substations to electric rolling stock, and for supplying non-traction consumers (lighting of railway stations, crossings, etc.)

https://journals.researchparks.org/index.php/IJOT e-ISSN: 2615-8140 | p-ISSN: 2615-7071
Volume: 5 Issue: 9 | Sep 2023

The peculiarity of Uzbekistan's contact suspension is that reinforced concrete poles with partially stressed reinforcement, 13.6 m long (have a height of 9.6 m from the conditional cut of the foundation and 4.0 m of the underground part) and separate poles 10.8 m long installed on three-beam, I-beam or embedded foundations will be used on high-speed sections.

This decision is due to the fact that each metal poles of the MK type (MCG) costs at least twice as much as reinforced concrete poles of the SS type (SCC) produced by the Binokor plant, due to the lack of the necessary amount of iron ore on the territory of the Republic. Currently, there are about 56,000 poles located on 3,500 km in operation of Uzbek railways the expanded length of the contact lines. Currently, electrification of the Bukhara-Misken-Urgench-Khiva section for high–speed and high-speed traffic with a total length of 573 km and Kashkadarya-Bukhara 145 km is underway. Figure 1 shows the share of the distribution of the number of catenary poles in operation on the railways of the Republic of Uzbekistan. [1].

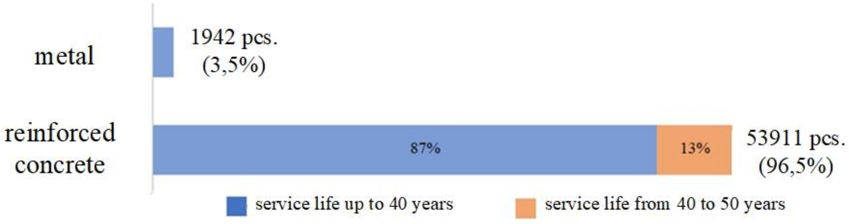

Fig. 1 Statistics of the presence of catenary poles in operation of JSC "Uzbek Railways"

With the development of railway electrification, there is an increasing need for catenary poles. However, they often provide high reliability of structures only in the initial period of operation after their installation. At the same time, each "surge" of failures requires massive work to replace the poles and restore their functioning as soon as possible, which in turn causes huge financial and labor costs.

In the early years of electrification, there was a massive introduction of poles of various types.

Often used wooden poles turned out to be unsuitable in real operating conditions, due to rapid destruction from the effects of atmospheric factors and insects.

Metal poles on reinforced concrete foundations also did not receive further distribution, due to the complexity of the installation technology: a lattice or tubular pole was installed in a pre-dug pit, which was then filled with a concrete mixture. The installation process required significant financial and labor costs, and could not provide the pace of electrification planned in those years.

It is known that it is impossible to implement poles from one concrete, therefore it is necessary to strengthen it with reinforcement, which is laid in an unstressed and prestressed state [2]. Thus, two types of poles have become widespread, differing in the method of compacting concrete: vibrated and centrifuged. But the most widely used are the conical catenary poles, made by centrifugation.

Vibrated I-beam poles are more economical in terms of material consumption, but the manufacturing technology is complex: they did not always manage to properly seal the concrete and withstand the required thickness of the protective layer. A large number of these poles were replaced already in the first years of operation due to rapidly developing damage. Their repair was ineffective, so the poles of this type were discontinued after a short period of manufacture (10-12 years).

Centrifuged conical poles were manufactured with non–stressed fittings in two versions - separate and undivided type. Separate poles were installed on block concrete foundations. They were made of concrete of the M400 brand, with a wall thickness of the poles with an unstressed reinforcement of 50 mm. The diameter of the longitudinal reinforcement, the number of rods and the grade of steel were determined depending on the required power of the poles. Due to the fact that the bending moment is small at the end sections (at the top and the butt part), part of the rods was "torn off" in those sections where it was not required by calculation. In the butt part of the poles with a capacity of 44-79 kN·m, every third rod broke off, and at the poles of 98 kN·m – every fourth at a length of 650 mm from the base. The problems of operation of poles of this type were created precisely by its upper part, in this regard, when the head of the poles was destroyed, its urgent replacement was required.

During operation, the main disadvantages of the pole structures with prestressed reinforcement were identified: increased deformability and a tendency to crack formation. In order to eliminate the likelihood of longitudinal cracks and increase durability, transverse reinforcement has been reinforced in the new design of the poles by reducing the spiral pitch from 75 to 65 mm, which is assumed to be constant along the entire length. In order to reduce the influence of the temperature and humidity difference between the inner and outer surface of the pole, 16 ventilation holes (8 on each side) with a diameter of 24 mm were provided in its lower part. The first hole is located at a distance of 4.5 m from the bottom of pole, the rest – with an interval of 200 mm. Additional openings contribute to ventilation of the internal cavity of the poles, so that the temperature difference between the air outside and inside pole is no more than 5 ° C. And ventilation of the internal cavity of the poles creates a gradual change in temperature along the length of the pole and reduces the temperature difference between the aboveground and underground parts of the poles [4].

Since 1970, string-concrete conical centrifuged poles with prestressed reinforcement in the form of strings (SKU) have been manufactured. The length of the split-type pole has been reduced from 11.2 to 10.8 m, and the wall thickness has been increased to 60 mm for all poles, regardless of the regulatory moment. A rubber gasket was used to isolate the embedded parts from the pole surface.

The practice of using string-concrete poles in conditions of insufficiently reliable protection against leakage currents has revealed the tendency of reinforcing wires to brittle fracture [3].

Currently, standard reinforced concrete centrifuged poles of the SS type contact lines with a length of 10.8 and 13.6 m are used with reinforcement of prestressed reinforcement made of strong wire Vr-2 with a diameter of 5 mm and nonstressed rod reinforcement made of steel AIII with a diameter of 12 and 14 mm. Three-beam TS cup foundations and three-beam TA anchors with lengths of 4.0 and 4.5 m are used [5].

Throughout the entire period of operation, standard projects of reinforced concrete poles and foundations have constantly continued to be improved, increasing the reliability and safety of train traffic.

The main part of maintenance and repair work in the power supply distances of electrified railways is allocated to reinforced concrete catenary poles. Taking this into account, in order to increase the profitability of transportation and ensure traffic safety, it is necessary to exclude sudden failures, which may entail not only the economic costs of eliminating the consequences of the accident (restoration of the track, contact wires), but also cause delays in the movement of trains, thereby incurring even greater costs to the entire economy of the country. Therefore, in order to avoid sudden destruction and collapse of structures, constant monitoring of their condition is required, using modern and effective control methods.

Operational experience has shown that the service life of reinforced concrete poles is less, and maintainability and condition control are more difficult than metal poles. During long-term operation, especially in areas with DC electric traction under the influence of electrical corrosion and aging of concrete, supporting structures wear out faster, and therefore timely replacement is required. Replacement of poles in operational conditions costs 4-6 times more expensive than their installation during construction, and the amount of control work due to the approach of the poles to the service life limit is constantly increasing.

INTERNATIONAL JOURNAL ON ORANGE TECHNOLOGY

https://journals.researchparks.org/index.php/IJOT e-ISSN: 2615-8140 | p-ISSN: 2615-7071

Volume: 5 Issue: 9 | Sep 2023

Indicators of the technical condition of the poles are the presence of cracks in the aboveground and underground parts, the destruction of concrete and reinforcement. Assessment of the technical condition and reduction of the bearing capacity of defective poles is carried out on the basis of commission visual examinations and instrumental non-destructive testing methods.

Some of the existing diagnostic tools in most cases overestimate the condition of the pole, in connection with which they recommend replacing the pole that has not fully exhausted its resource. Many of them have not found proper application due to the complexity of application and insufficient accuracy in measurement.

When implementing a new method, developers face the need to organize a more advanced control system. At the same time, it is necessary to solve the following tasks: maintenance scheme; frequency and completeness of control; processing of the results of diagnostics of poles; the order and form of presentation of control results. In addition, it is necessary to take into account algorithms, data processing time and forms of generalization of statistical data [3].

The sphere of organization of the control system also includes making a decision on the criteria for assessing the condition of the poles. In this regard, the assessment of the technical condition of the poles by a complex generalized indicator is more promising, since it can be used not only to predict the technical condition of the poles, but also to compare their different types.

On the electrified railways of the Republic of Uzbekistan, no attention is paid to the control of the misalignment of catenary poles structures, since there is a judgment that on electrified AC railways in warm regions there is not a high risk of falling of catenary poles pillar or at least exceeding its deviation from the design value, due to which there could be a threat to train safety [2].

A one–time inspection of poles was carried out on the Tashkent- Samarkand section during the reconstruction for the movement of the Afrosiyob high-speed train (Talgo 250). According to the results of the inspection, about 400 acute defective poles were identified, which were decided to be replaced, and the poles with a minor defect were brought into the design position.

The main reasons for the increased defectiveness of the pole racks along the section of the Tashkent and Havast power supply distance is that almost 50% of all poles have been in operation for more than 40 years (with a standard service life of 50 years) and the first 15 years of operation were carried out using a DC traction system subject to increased electrical corrosion.

In the underground part of the reinforced concrete catenary poles, the temperature and humidity conditions in the conditions of ECh-Havast may differ sharply from the above-ground part due to the influence of the salt level and the water level. For the ground part, at a temperature of more than +25 ° C, the concrete dries out so that the resistance of the "armature-clamp", "armature – bolt of the embedded part" of the upper belt increases from 10...50 kOhm to 200...300 kOhm. In spring and autumn, with high humidity and a temperature of - +5 ...+10 ° C, the resistance of the aboveground part decreases to 1...5 kOhm. The precipitation of rain sharply and abruptly reduces the resistance of the "armature - clamp" and "armature - bolt" circuits by 20...30 times to 500...800 kOhm. After the rain, the resistance slowly increases, after 10 ... 15 hours it again reaches 1 ... 5 kOhm.

Separate reinforced concrete pole posts are obtained with a defect in the manufacturing or installation process (the exit of a part of the reinforcing wire into the hole for the embedded part). If a rubber sleeve was installed during installation, then after. after applying mechanical load, the rubber is pressed, then rubbed and a "metallic" touch occurs at the place of the greatest convergence of the bolt and the reinforcement. Since the resistance of the upper belt of reinforced concrete poles decreases sharply, up to 0. with individual grounding to the traction rail and the presence of the "rail - ground" potential, the current value in the "pole rack - grounding" circuit will be limited by the "armature - ground" resistance. The service area of the Havast power supply distance is located in conditions of sulphate aggressiveness of soils. At a high level of groundwater, characteristic of the conditions of the Akaltyn, Bakht, Syrdarya sites, the resistance of the earth is 10 ... 30 ohms. Reduced resistance can trigger the process of electrical corrosion, especially at direct current.

Although the process of electrical corrosion during electrification on alternating current is very poorly expressed, however, under the influence of one half-wave of alternating current, activators-chlorides begin to penetrate into concrete. Some of the molecules remain in the concrete, at the border of concrete with reinforcement, and complex electrochemical processes begin, which gradually destroy the reinforcement of the underground part of reinforced concrete poles.

The largest number of acute defective poles, as it turned out, was in mountainous areas (Junction No. 13, Bogarnaya and lane Jizzakh) distances of ECh – Samarkand. This is due to the fact that in mountainous areas, increased wind loads, high temperature differences and large amounts of precipitation increase the maximum pressure on the pole posts of the contact lines.

In addition to all this, loess loamy soils are common on the territory of the Samarkand depression, which are characterized by subsidence deformation. In such soils, the stability of the foundations of the poles deteriorates during changes in soil moisture and seismic effects [4].

Based on the research, a classification of all possible factors has been compiled, increasing the defect of reinforced concrete poles and their misalignment. During the analysis of the reliability of catenary poles, a number of main problems arising during operation have been identified, which determine priority tasks for activating work to reduce the risks of failure of pole structures.

During operation, various factors affect catenary poles, destroying the integrity of the concrete structure of the pole, forming a grid of cracks on their surface. The degree of their influence characterizes the rate of corrosion of concrete and reinforcement, the number and size of cracks. Therefore, knowledge and consideration of their influence is extremely important in understanding the mechanism of crack formation, establishing the causes and dominant influences affecting their appearance. Knowledge of the factors affecting the destruction of catenary poles will reduce their impact when developing new types of poles and when installing them, as well as for remote territorial areas affected by different factors, to establish optimal diagnostic times.

Conclusions

With the increase in the rate of functioning of the railway networks (cargo and passenger turnover, increasing the speed of movement), there is a need to improve the safety of train traffic and the reliability of the functioning of the elements. This can be achieved only by introducing new, more advanced methods of monitoring and analyzing the condition of railway transport elements.

One of the main elements in the economy of electrification and power supply are reinforced concrete catenary poles. Due to the fact that the first electrification of their installations on the territory of Uzbekistan occurred in the 70s, and the service life is on average 40-50 years, the most acute problem is the timely diagnosis of the condition and timely replacement of defective poles.

The analysis of the operating experience of different types of poles revealed the main disadvantages of reinforced concrete pole structures that affect their further functionality: increased deformability and crack formation.

A comparison of existing methods for assessing the condition of reinforced concrete catenary poles shows that they are sometimes time-consuming and do not provide a qualitative and complete assessment of the condition, and require further improvement.

https://journals.researchparks.org/index.php/IJOT e-ISSN: 2615-8140 | p-ISSN: 2615-7071
Volume: 5 Issue: 9 | Sep 2023

References

1. "Obosnovanie konstruktivno-texnologicheskix resheniy po soorujeniyu opor kontaktnoy seti na zemlyannom polotne iz peschannix gruntov" [Substantiation of structural and technological solutions for the construction of catenary poles on an earthen canvas made of sandy soils according to the project "Electrification of the Bukhara-Urgench-Khiva railway line". The report on the agreement. Director Lesov K.S., executor Bayanov I.N.
2. The electric field of the sliding contact during the interaction of the pantograph and the contact wire I Bayanov, T Badretdinov, S Muminov, I Karimov, S Saydivaliev, E Saliyev/ E3S web of conferences 264. 7 page/
3. T.Badretdinov, I.Bayanov " Analiz sostoyaniya opor kontaktnoy seti jeleznix dorog Respubliki Uzbekistan. [Analysis of the state of catenary poles of railways of the Republic of Uzbekistan]"Transport shyolkovogo puti [Silk Road Transport], №3 (2021). pp. 20-24.
4. Influence of Misalignment of Poles on Arcing During Current Collection. I Bayanov, T Badretdinov, S Saydivaliev, E Saliyev, S Muminov. Safety in Aviation and Space Technologies, pp.181-190
5. I.N.Bayanov, J.M.Saparboev. Uchet klimaticheskix faktorov pri proektirovanii kontaktnoy seti [Consideration of climatic factors in the design of the contact lines] Mejdunarodnaya nauchno-texnicheskaya konferentsiya “Aktualnie problemi sistemi elektrosnabjeniya” [International scientific and technical conference "actual problems of the power supply system.]. 25-26 noyabr, 2021y. – Tashkent, 2021. – pp.66-68.