Analysis of the Quality of Aluminium Overhead Conductors After 30 Years of Operation

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Abstract

Overhead power conductors (OHL) are designed for the service life of min. 50 years. During this time, the OHL conductors should work without failure. The article concerns aluminium conductors tested after 30 years of operation. The mechanical properties, electrical properties and structure were tested. The analysis of the quality of the supplied wire samples carried out on a scanning microscope allowed to distinguish three types of wire damage, namely: corrosion on the surface of the outer layer wires, local melting and loss of cross-section and wire breakage. Based on a detailed analysis of places (areas) of damage to the wires from the tested OHL conductors, it can be stated that the main cause of their breakage is melts caused by an electric arc. Under the influence of high temperature, the material was subject to local melting, which led to significant losses in the cross-section and a decrease in their strength properties, and as a consequence, loss of the carrying capacity of the conductor and its breakage. It follows that during operation the phase conductors had to be subjected to frequent live contacts caused by changing weather conditions (short circuits). On the other hand, the analysis of the strength properties of the wires showed that the UTS values are lower than those required by the standard. The greatest degradation of the strength properties occurring on the wires of the outer layer. The center wires show a negligible reduction in tensile strength. The electrical properties of central wires show lower resistivities than the standard ones, which correlates with the strength properties.

Introduction

One of the main technical issues is the transmission of electricity to customers in real time. Traditionally, this is done by overhead power lines, which are divided into categories according to the rated voltage. Various operational exposures (climate, topography and environmental factors, as well as current flow) lead to the degradation of properties and quality of conductors. They are often the cause of energy crises caused by “blackouts” - cascade shutdowns of power transmission. These factors should be taken into account in the design, construction and operation of overhead lines. The basic element in spans of overhead lines is the conductor, arranged as a stranded structure, which is required to meet an entire array of properties, including: high electrical conductivity of the material, it was made of and low resistance, high ratio of tensile strength to mass density, high fatigue, rheological, tribological, thermal and corrosion resistance, along with corresponding operational properties and the ability to recycle easily. These properties depend not only on the type of material used and the wire manufacturing technology, but also on the assumed geometry of the conductor and the manner of its production.

Goal and Research Results

Overhead conductors are multi-wire, with a regular multilayer structure, and the number of layers largely depends on the electrically active cross-section of a conductor. Traditional ACSR conductors (Aluminium Conductors Steel Reinforced), due to the whole range of operational problems (corrosion at Al-Fe contact point, high specific gravity, installation problems, poor electric conductivity of the steel core, etc.), are being replaced with modern homogeneous structures constructed of aluminium and aluminium alloys (the so-called AAAC or AAC).

The aim of the research was to identify the condition of the AAAC conductor after 30 years of operation, in particular the quality of the surface and structure. The main object of research were wires from the cable after operation. In order to assess the type and mechanisms of wire damage, the scanning electron microscopy technique was used.

The analysis of the obtained results of quality tests and structural properties of aluminium conductors allows to conclude that the tested conductors have numerous discontinuities of the outer layer wires, losses in cross-sections, and as a result their geometric structure, incompatible with the standard, strength and electrical properties. The analysis of the obtained results shows that the main cause of discontinuities (breaks) of the wires are burned out or melted wires, mainly of the outer layer of the conductors, which resulted in a significant reduction in the static breaking strength of the conductor. Figures 4-6 show selected photos of the damaged areas of the tested wires as a result of melting.

Summary

The analysis carried out on a scanning microscope allowed to distinguish three types of wire damage, namely: a) corrosion on the surface of the outer layer wires, b) local melting and loss of section, c) broken wires. On the basis of a detailed analysis of the areas failures wire, it can be concluded that the main cause of their breaks are melts caused by an electric arc. Under the influence of high temperature, the material was subject to local melting, which led to significant losses in the cross-section and a decrease in their strength properties, and as a consequence, loss of the carrying capacity of the conductor and its breakage. It follows that during operation the phase conductors had to be subjected to frequent live contacts caused by changing weather conditions (short circuits).