1)Wire vibration and ways to prevent it

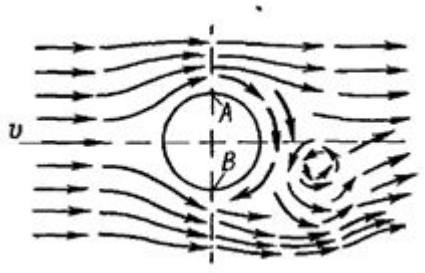
2)CONNECTION OF WIRES IN ELECTRICAL TRANSMISSION LINES

Vibration of wires on overhead power lines

- Wire vibration

  When the flow of air around the wires, directed across the axis of the line or at a certain angle to this axis, turbulence occurs on the leeward side of the wire. Wind breaks from the wire and the formation of vortices of the opposite direction periodically occur.

  The separation of the vortex in the lower part causes a circular flow on the leeward side, and the flow velocity v at point A becomes larger than at point B. As a result, the vertical component of wind pressure appears. When the frequency of formation of vortices coincides with one of the frequencies of natural oscillations of the tensioned wire, the latter begins to oscillate in a vertical plane. In this case, some points deviate most of all from the equilibrium position, forming an antinode of the wave, while others remain in place, forming the so-called nodes. In nodes only angular displacements of the wire occur. Such oscillations of a wire with an amplitude not exceeding 0.005 of the half-wave length or two wire diameters are called vibration.



- Wire vibration occurs at wind speeds of 0.6–0.8 m / s; when the wind speed increases, the vibration frequency and the number of waves in the span increase, and when the wind speed exceeds 5-8 m / s, the vibration amplitudes are so small that they are not dangerous for the wire.

  Operating experience shows that the vibration of wires is observed most often on lines running through open and level terrain. On sections of lines in forest and rough terrain, the duration and intensity of vibrations are much less. Vibration of wires is observed, as a rule, in spans longer than 120 m and increases with increasing spans. Vibration is especially dangerous at crossings over rivers and bodies of water with spans of more than 500 m in length.

Preventing ways

- According to PUE, single aluminum and steel-aluminum wires with a cross section of up to 95 mm2 in spans over 80 m long, with a cross section of 120 - 240 mm2 in spans of more than 100 m, with a cross section of 300 mm2 and more in spans of more than 120 m, steel wires and cables of all sections in spans more than 120 m should be protected from vibration if the voltage at an average annual temperature exceeds: 3.5 daN / mm2 (kgf / mm2) in aluminum wires, 4.0 daN / mm2 in steel-aluminum wires, 18.0 daN / mm2 in steel wires and cables .
- In spans less than the above, vibration protection is not required. Protection against vibration is also not needed on lines with phase splitting into two wires, if the voltage at the average annual temperature does not exceed 4.0 daN / mm2 in aluminum and, 4.5 daN / mm2 in steel-aluminum wires. Phase with splitting into three and four wires, as a rule, does not require protection from vibration. The sections of any lines protected from transverse winds are not subject to protection from vibration. At large crossings of rivers and water spaces protection is necessary regardless of the voltage in the wires.
- As a rule, reducing the voltage in the wires of the lines to values at which protection against vibration is not required is economically unprofitable. Therefore, on lines of 35-330 kV, vibration dampers are usually installed, made in the form of two weights suspended on a steel cable.

overhead line galloping

- The wire galloping, as well as the vibration, is excited by the wind, but differs from the vibration by a large amplitude reaching 12–14 m and a long wavelength. On lines with single wires, dancing with one wave, i.e., with two half-waves in a span (Fig. 4), is most often observed, on lines with split wires - with one half-wave in a span. In the plane perpendicular to the axis of the line, the wire moves when dancing along an elongated ellipse, the major axis of which is vertical or inclined at a small angle (up to 10 - 20 °) from the vertical. The diameters of an ellipse depend on the sag: when dancing with one half-wave in a span, a large diameter of the ellipse can reach 60 - 90% of the sag, and when dancing with two half-waves - 30 - 45% of the sag. The small diameter of the ellipse is usually 10 to 50% of the length of a large diameter.

  As a rule, wire dancing is observed during icy conditions. The ice is deposited on the wires mainly on the leeward side, as a result of which the wire gets an irregular shape. When exposed to wind on a wire with one-sided ice, the speed of the air flow in the upper part increases and the pressure decreases. The result is a lift Vy, causing the wire to dance.

  The danger of dancing is that the oscillations of the wires of individual phases, as well as wires and cables occur asynchronously; there are often cases when the wires move in opposite directions and come closer or even clasp. When this occurs, electrical discharges, causing the melting of individual wires, and sometimes wire breaks. There were also cases where the wires of the 500 kV lines rose to the level of the cables and clashed with them.

Types of wire connections.

- Connections of wires and cables in the span of power lines are allowed to be performed only with the help of special clamps, while in each span during the installation of the line there should be no more than one connection per wire or cable. Connections of wires of overhead lines are carried out either with the help of oval connectors - by means of crimping or twisting, or by shaped connectors - by means of crimping. Connections of wires and cables with the help of bolt clamps in the span lines do not apply. Single-wire steel wires are allowed to be joined by welding overlap, and the length of the weld should be at least 10 wire diameters. The place of welding after its execution should be reliably protected from corrosion by thorough cleaning and coating with moisture-resistant paint or ZES grease.

Wire connection with oval connectors.

- The most common way to connect wires in span lines is to connect using oval connectors. When connecting wires with oval connectors, electrical contact is obtained as a result of the direct contact of the surface of the individual wires of the outer layers of the ends of the connected wires inserted into the connector overlap, and through the connector body due to the contact of the wires of the outer layers of the wire ends with the inner surface of the connector body. When connecting steel-aluminum wires, an aluminum strut is installed between them to equalize the compression forces, and the contact surfaces of the connected ends of the wires occur through the strut. Thus, in the connections of wires made with oval connectors, the current flows mainly from the wire to the wire and only partially through the connector body and the spacer, if installed. The oval connector is an oval tube made of aluminum or steel. The tube from both ends has flaring.
  The following brands of oval connectors are available for connecting different types of wires:
  SOAS - for connecting aluminum-steel wires;
  SOA - for connecting aluminum wires;
  SOS - for connecting steel wires.
  At the case of each connector, a mark is applied at the factory, indicating for which wire the connector is intended, for example: SOAS-70 - the oval connector for the steel-aluminum wire AC-70. Oval connectors are used to connect steel-aluminum and aluminum wires with a cross-section of up to 185 mm2, copper wires with a cross-section of up to 150 mm2 and stranded steel wires with a cross-section of up to 95 mm2.

Preparation of wires and connectors for installation.

- The first technological operation performed when connecting wires in any way is the preparation of wires and connectors. Before installing the connector, the necessary materials and tools should be prepared, namely: steel brushes, steel card brushes, pliers, a three-sided file, a hacksaw or cable hook, binding wire, ZES lubricant or technical petroleum jelly, gasoline and clean rags or rags. The operational reliability of the connection depends to a very large extent on how carefully the necessary processing and cleaning of the connected ends of the wires and the contact surfaces of the connector are made. The connectors should be cleaned of dirt and grease, their inner surface should be cleaned with a cloth dipped in gasoline, and then lubricated with ZES grease or technical petroleum jelly. After lubrication, the inner surface of the connector is treated with a steel brush to shine to remove the oxide layer, then wipe with a clean, dry cloth and again smeared with a thin layer of lubricant. The ends of the wires to be connected must be mounted so that they can be inserted freely into the connector. Then the ends of the wires are cleaned of dirt with a rag dipped in gasoline, lubricated with ZES grease or technical petroleum jelly, cleaned with a wire brush to shine, wiped with a dry, clean cloth and still smeared with a thin layer of grease. This concludes the preparation for connecting the ends of the wires and the connector. It should be noted that ZES grease protects the compound against corrosion for a very long time, since it has a dropping point above 105 ° C and very weak oxidation, while the protective effect of technical petroleum jelly is limited to a few hours or days depending on the time of year and the temperature of the compound.
  The above procedure for processing wires and connectors must be strictly followed, especially for aluminum connectors and aluminum and steel-aluminum wires, since an aluminum oxide film imperceptible to the eye has a very high electrical resistance and its presence in the connection can make it difficult to obtain the desired electrical characteristics of the contact. The process of oxidation of aluminum in the air proceeds very quickly, so the stripping of connectors and wires is carried out under a layer of lubricant to obtain luster on their surfaces.
  Not only external but also internal layers of aluminum wires are cleared of the oxide film, although they do not directly come into contact with the metal of the connector, but when crimped, crimped or twisted, they are connected with a large number of contact points. Preparation of wires and connectors for installation should be done immediately before performing work on the connection.