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Transmission Capacity of Overhead Power Lines and Ways of their Improvement

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Due to the significant increase in the cost of building new high-voltage power lines, the role of increasing the capacity of existing and newly constructed overhead . Is economically advantageous to increase the transmit power through until limit heat through various devices.

The task of the article is to show what determines the capacity of the transmission line and in what ways it can be improved.

The urgency of the problem is obvious, because we live in a huge country, the power which is the largest in the world. It is therefore very important that the capacity of the transmission line was as much as energy is transmitted over long distances.

Just increasing the capacity – an important technical and economic challenge, as it eliminates the construction of additional transmission lines and provide the necessary power to the consumer . It is important not only to increase the capacity of constructed lines, but also to prevent accidental reduce it.

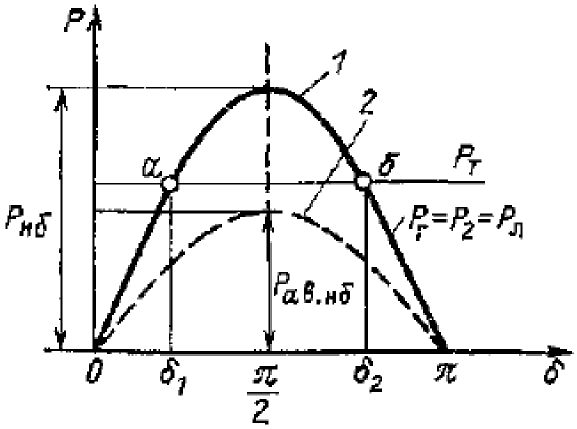


Figure 1 - The relationship between the transmit power of the angle δ.

The capacity of power lines

The capacity of power – this is the highest active power, which, taking into account all technical restrictions can be passed down the line. Technical constraints are defined : stable parallel operation of generators, heat transfer of individual elements, the value of long-term allowable voltage loss on the crown on the line, and other factors.

If you do not take into account the technical constraints, the bandwidth is equal to the MFN amplitude sine wave in Fig. 1: $P_{нб} = \frac{E_q U_2}{x_\Sigma}$

The greater the capacity of the power NLR, the more power can be transmitted over the line. But we can not allow an emergency reduce it. For example, if the result of an accident throughput drops to Rab.nb (see the dashed sinusoidal curve 2 in Fig. 1), then it would reduce the power transmitted on the line, and canceling the consumer. Mode corresponding to a stable point (Fig. 1), there is no reduction in the capacity to Rab.nb.

Measures to improve the capacity

Measures to improve the capacity of existing and newly built power include, inter alia, the effect on the EMF generator (Eq), the total resistance (hΣ) and the substation busbar voltage at the end of line (U2).

EMF generator Eq regulated current of the generator. In accidents it is important to maintain the excitation of the generator, ie prevent conditions RPB <pm, where it is necessary to reduce the transmit power through . In the Soviet Union for the first time in the world have developed a strong excitation controls the actions that kept constant during accidents not only the EMF generator Eq, but even on the tires of the generator voltage Ur (see Fig. 2). Regulators strong actions are widely used for high-power plants.

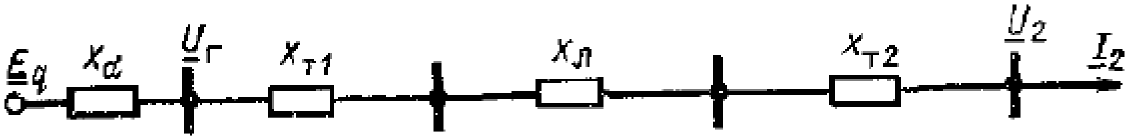
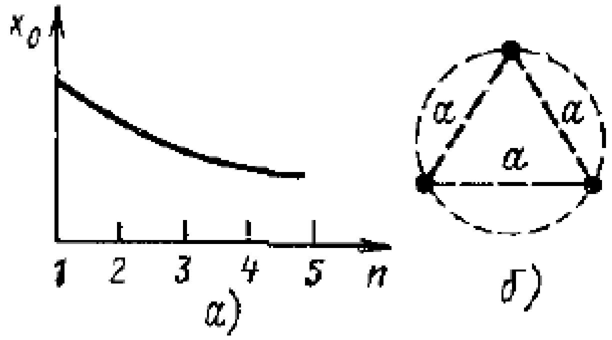


Figure 2 – Equivalent circuit of power.



The total resistance $x\Sigma$ and its components appropriate to reduce it. Resistance generators and transformers is reduced by the use of special steels and special design solutions. The inductive reactance of lines of 330 kV and higher voltage lower by splitting phase – phase perform not one, but several parallel wires (Fig. 3).

Figure 3 – Cleavage of wires in phase: A – x0 decrease depending on the number of wires in the phase b, the location of phase conductors 500kV line.

In lines with Un = 330 kV cable splits into two, ie, n = 2, to 500 kV n = 3, wherein a = 40 cm.

Figure 4 (left) – Longitudinal compensation lines.

Application of series compensation (Figure 4) is a viable and popular means of increasing the capacity of long-distance power lines. CPC capacitors connected in series in the line, reduces the resultant reactance line.

With a moderate amount of series compensation are limited to one of the CPC on the line. If the resistance of the capacitors of the CPC is that offset 50% or more resistance line, it is necessary to perform the CPC is not less than two substations. Focusing too much compensating resistance in one place leads to an increase in the multiplicity of internal overvoltage and causes difficulty in ensuring correct operation currently in use protective relays.

The voltage U2 on the buses at the end of the substation EHV line must be adjusted so that it is not reduced in the normal mode and the post-fault and that, in turn, reduces the capacity of the line. Effective use of managed devices shunt compensation: synchronous compensator (SC) and static reactive power compensators (Statkom).

FACTS technology

Next, consider the FACTS technology. In our country and abroad are working to create a managed (flexible) electrical connections, the load which can be set regardless of the load of any other links in the electrical network and controlled automatically or manually by a given law.

Devices based on the modern power electronics started to control the operation of power, able to simultaneously work on three of the above parameters (U, $h\Sigma$, δ), which improves efficiency and provides flexible control modes of power systems. Such technology abroad called FACTS (flexible alternating current transmission systems).

Function of FACTS:

- increasing the capacity of transmission lines;
- ensure stable operation of the power system under different perturbations ;

- ensuring a given (forced) power distribution in networks, in accordance with the requirements of the supervisor;
- Increased reliability of energy consumers;
- Reduction of losses in electric networks ;
- the task of turning the mains of a "passive" device transport electricity in the "active" control modes.

Wires high power and durability.

Currently, an increase in transmit power network requires a large investment. Since power consumption is growing, network companies have to reconstruct the existing network with increasing wire size, and thus increases its mass. Ultimately, companies are faced with the replacement of the existing power grid supports the new, designed for higher loads, or the construction of new transmission lines. The latter can be difficult especially when proleganiya VL in a densely populated area, and in sparsely populated areas of private land, such as national parks, nature reserves and other areas with a ban on construction. Thus, the recent attempts to develop a wire combine high mechanical strength and low weight without compromising throughput attracted the interest of various companies.

We consider a number of existing developments.

Aluminum Conductor Composite Core wire. Standard iron cores can overheat in peak electrical loads, which leads to stretching of the wire and below the permissible sag rate. In contrast, the core wire of the composites has a lower thermal expansion coefficient and are therefore less susceptible to thermal expansion than the steel core conductors. Replacing the wire with a steel core wire for composite materials can increase the capacity of the lines. Manufacturers wire say can double the amount of current in the line without the risk of sagging and wire fracture.

Properties of composite material – high strength to weight ratio and the low slack value, which leads to an increase in span between supports, reducing the number of poles in line at 16%.

ACCC cable system can operate continuously at 180^0C and can withstand short-term jumps up to 200^0C, with sagging only 10% of the slack cable with steel core.

Although the value of the product ACCC per km is about 3 times higher than conventional wires, the economic effect of their use ensures high return on investment.

Conductive Composite Reinforced Aluminum wire (Aluminum Conductor Composite Reinforced (ACCR)). Composite fiber core consists of high purity alumina ceramic. Each core consists of more than 25,000 heavy-duty fiber Al_2O_3. The cores have diameters from 1.9 mm to 2.9 mm. Ceramic fibers are continuous, axial orientation, and placed completely in the aluminum matrix. The wire is a standard twisted wire with a wrap consisting of a continuous strand Al-Zr. The outer strands of Al-Zr are heat-resistant alloy that can operate continuously at 210^0C, with peak loads up to 240^0C. Conductor composite core is about 9 times stronger than aluminum and is 3 times tougher. Core being half lighter than corresponding iron core has a higher electrical conductivity and has a coefficient of thermal expansion in the same half of the values for steel.

The use of composite-cored wires can not only increase the capacity of transmission lines and reduce the costs of reconstruction, but also due to the higher conductivity of the composite core to reduce electrical losses in overhead.

Wires, called Aero-Z ® (110 – 1150 kV) are fully interconnected conductors, which consist of one or several concentric layers of round wires (inner layers), and the wires in the form of the letter "Z" (outer layers) . Moreover, one or more conductors may be hollow and contain within the optical fiber. External layers of the same wires are made of aluminum wire having a shape of the letter "Z", where the conductors are very closely adjacent to each other.

It is thus possible to use thinner and lighter wires. This in turn reduces the power losses in the conductors 10-15%, including the loss of the crown, and increasing the mechanical strength of the structure . Through tight twisting virtually eliminated penetration into the inner layers of water and impurities, thus decreasing corrosion of the inner layers of wires . Wire Aero-Z ®, having a higher torsional rigidity practically does not rotate, which leads to excessive snow self relief under the action of gravity.

Due to a more smooth outer conductor structure Aero-Z ® are about 30 – ¬ 35% minimal aerodynamic wind load resistance as compared with the conventional wire. This fact leads to a dramatic reduction conductor galloping.

GTACSR («Gapped» TAL alloy Aluminium Conductor Steel Reinforced) – is carried out with a gap made of aluminum alloy resistant to high temperaturam.Alyuminievye conductors of the inner layer closest to the core, and have a trapezoidal cross section. The inner layer is made in such a way that between them a gap iron core is filled with grease resistant to temperature. This design provides a sliding aluminum layers relative to the steel core, thereby GTACSR wire can be pulled, just fixing a steel core. This solution guarantees: the small sagging wires due to the increase in temperature. The maximum operating temperature is 150 GTACSR wires 0C. At this temperature, the transmit power can be increased by 2 times.

In the future, questions about transmission of electric power is still to be decided on the basis of overhead transmission lines, since they are much cheaper than cable, despite their serious shortcomings. Of course, the prospects for the use of ¬ overhead transmission lines will largely be determined by how much will be able to eliminate their shortcomings, improve performance and enhance the technical and economic performance.

At the same time, thanks to advances in modern power electronics there is an alternative that allows you to delay the strengthening of existing lines and new gasket . It is to improve the use of existing grid infrastructure by increasing its flexibility and manageability. This is possible by setting the transmission system managed by special devices called devices FACTS.

Currently considered international projects interconnection of the countries concerned, which will implement the most cost-effective electricity surpluses each member association, as well as to mutual assistance in emergency situations, such as in post-emergency conditions of individual power systems.

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