communication protocols such as DNP3, IEC 61850 and Modbus, to list a few, are used to allow multiple intelligent electronic devices to communicate with each other and supervisory control centers. Distributed automatic control at substations is one element of the so-called smart grid.

Borshev, Ye.S.

Voltage control in the electrical network

National Research Tomsk Polytechnic University.

The current flow through the elements of the electrical network is attended with losses of voltage. It causes voltage reduction with increasing distance from the power supply. However voltage supplied to the electric consumer can vary slightly from the nominal voltage and should be within acceptable limits. In accordance with State Standard 13109-97 voltage deviation from the nominal value shall not exceed ± 5% for most consumers. In the post-emergency conditions, the duration of which is relatively small, voltage tolerance is increased by 5%. There are also acceptable voltage limit in the high voltage network. In particular, peak working voltage makes from 105 to 120% of nominal value and is determined by conditions of reliable operation of isolation for the high-voltage devices. In the electric power system voltage reductions are determined by the stability conditions of parallel operation of power station generators and load node. In supply networks lower voltage deviations reaches 10-15%. When we assess voltage levels, we should bear in mind that the load are continually changing during the day, therefore voltage losses and voltage levels of power consumers also change.

The electricity transmission scheme (fig. 14.1) demonstrates that it is impossible to ensure compliance the requirements for voltage deviations in modern power system without using special measures and devices. If we assume that on the path from the power generators to the receiver we have four transformation of electric energy. The voltage losses is 5 % at each transformation and 10 % in each of the networks. So the total voltage losses may reach 60%.

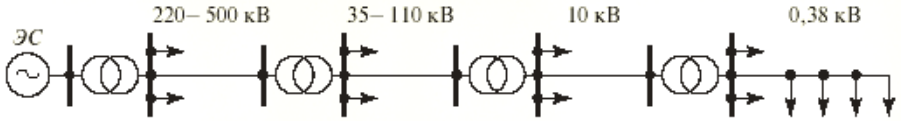

Рис. 14.1. Схема передачи электроэнергии в сети

For ensure acceptable voltage levels in the EPS we use special equipment – regulation devices. Their appointment is the reduction or compensation losses of voltage.

For the analysis of opportunities to reduce voltage losses in elements (lines, transformers), we use the expression.

$$\Delta U = \frac{PR + QX}{U}$$

P,Q – active and reactive powers in the network element;
R,X – resistance and reactance element;
U – the voltage at the end of the element, where we set the powers.

Expression shows that the voltage losses decreases with increasing mains voltage. At operation the change in the nominal mains voltage requires reconstruction of this network. Furthermore, increasing the nominal voltage allows to reduce voltage losses, but it can not be considered as a means of voltage regulation. Decision about the level of nominal voltage

is made based on information about transmitted power and the distance at which this power is transmitted.

Another possibility is the change of power. The active power is reduced due to undersupply of energy customers, and therefore it cannot be used. We can decrease flows of reactive power by installing reactive power sources at consumers. Zero flow of reactive power can be achieved at full RPC, although it is not economically feasible to do.

Another way to have an impact on voltage losses consists in the change of line resistance. Decrease in resistance due to the increase in the cross section of HV line wires or with the inclusion parallel operating elements. However the effectiveness of such measures for supply main is not as high inasmuch as active resistance of elements is substantially less reactance. The reactance of a transmission line can be reduced by incorporating the direct compensation plant (DCP). The direct compensation plant represents capacitance with the reactance X_c (fig.14.2). As a result, the total line resistance decreases and becomes equal to $X_{л\Sigma} = X_L - X_C$, here X_L – inductance of the line. But the use of the DCP only to reduce voltage losses also not economically justified. DCP are used to increase the network capability and steady-state stability of EPS.

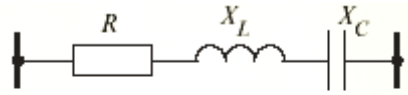

Рис. 14.2. Использование установки продольной компенсации в линии

Nevertheless, the main means of voltage regulation is the use of special technical equipment, which are explained below.

- The synchronous generators.

The power generators not only are sources of reactive power in the power system, but at the same time are the most important means of voltage regulation. The terminal voltage Ug of most generators can vary from $0{,}95U_{\text{ном}} \le U_{\text{г}} \le 1{,}05U_{\text{ном}}$.

The set point voltage can be supported by automatic excitation control (AEC). The voltage at the generator tires can be maintained at a predetermined level only if the reactive power Qg (which is generated by them) is within acceptable limits $Q_{\min} \le Q_{\text{г}} \le Q_{\max}$

When reactive power reaches a limiting value, it is fixed at that value. In this case, the voltage of the generator will be changed as follows: when it reaches the lower limit of the power – to rise, when the upper limit – lower. Nominal reactive power of generator is determined by nominal power factor cosφg. If you need to use a reactive power on the generator by more than nominal, it is possible within certain limits by reducing its active power. In this instance the increase in reactive power will restricted by means of currents in the stator and rotor of the machine.

- The synchronous compensators.

Synchronous compensators allow to support and regulate the voltage within ± 5% at the point of connection by changing the excitation current. As with generators, voltage regulation can be carried out by changing the reactive power within an acceptable range.

- Synchronous thyristor compensators.

Regulation is carried out almost instantly due to the thyristor control system. This is especially important for the stabilization of transient phenomenon in EPS.

- Transformers, autotransformers.

The following devices allow you to change the parameters of the branch of a network: double-wound transformers, autotransformers and three-winding transformers for communication networks of different nominal voltage, linear regulators, working in alliance with autotransformers are all linear controls.

In these devices, one of the windings has a multiple taps, with which you can change the number of active coils of winding. Thereby you can change the transformation ratio. Changing the transformation ratio leads to a change of load voltage at the same voltage supplied to the transformer.

Electricity is distributed from main substation (MS) in distribution networks of urban, rural, industrial consumers. Main substations usually are constructed in the immediate vicinity or within the separate area of electricity consumption. Distribution of electricity inside the area is firstly produced at the voltage of 6-20 kV. Lines 6-20 to (air and cable), are constructed from the MS to the substations, which feed a group of closely spaced small consumers. Their power is supplied through the network of 220-380V. Transformation of electricity from stage 6-20 kV to stage 220-380 V is carried out by means distribution transformers (DT).

In such networks, due to their mass we provide the most simpler and cheaper control devices: distribution transformers with voltage regulation without power, uncontrolled capacitor banks.

In electrical networks with voltage Un ≥ 110 kV regulation of voltage has its own characteristics. These networks are hard-closed structure. They are equipped supervisory control devices, which let you transmit the information about regime parameters at different points of the network to the control centre.

When we consider networks with Un ≥ 330 kV, we must take into account the loss of active power to the crown in the power lines.

The main objective in the design and reconstruction of EPS is complex solution of ensure the balance reactive power and definition of the conditions of voltage regulation in the networks. Also, developers should ensure manageability EPS voltage and reactive power. By this we mean the possibility of providing allowable voltage at all points in the EPS and In the post-emergency conditions of operation. Control is achieved due to right choice of placement, accurate control ranges of the control system.

References:

1. Mohamed A. El-Sharkawi Electric Energy: An Introduction, Third Edition.
2. Electrical Engineering Books And Guides.
3. Leonard L Grigsby Electric Power Generation Transmission and Distribution.
4. H. Bevrani Robust Power System.

Charkov, D.

On the Economic Ground for Introducing Bioenergetics

National Research Tomsk Polytechnic University.

Russia has large reserves of natural resources, giving the possibility to be one of the main exporters of hydrocarbon energy . To reduce the dependence on fossil resources, to strengthen the country's position as an energy power one improves the ecological environment and to conserve resources for the future generations, it is necessary to raise the questions about the possibility of expanding the use of alternative energy sources.