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SELECTION OF CONSUMER REACTIVE POWER COMPENSATION DEVICES

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The main goal of power supply systems is the uninterrupted supply of consumers with electrical energy of required quality. In steady state operation, the network parameters must comply with the requirements of regulatory documents, and the equality of produced and consumed energy must be continued. Nonobservance these requirements may lead to emergency situations.

Energy saving is the cheapest and safest way to increase energy generating capacity while maintaining electricity production at the same level. The cost of saving 1 kW of power is 4-5 times cheaper than the cost of newly introduced power of 1 kW [1].

The increase in the cost of electricity and elements of power supply networks leads to the fact that it is getting harder these days, when developing and implementing measures aimed at reducing electricity losses, to find such network parameters that would take into account the required characteristics and would be economically feasible. Considering the complexity of power supply systems, as well as the variety of options when choosing methods for optimizing their parameters, often the quality and efficiency of the project mainly depend on the experience and intuition of the designer.

Thus, the goal has been set to develop an algorithm for determining rational, from a cost point of view, parameters of elements of power supply systems.

The main consumers of reactive power (70% of power consumption) are alternating current motors, mainly asynchronous motors, which expend reactive power to create rotating magnetic fields. Transformers consume 20% of reactive power, the remaining 10% are consumed by various electrical machines and devices with inductance, and electrical networks [2].

With a decrease in the power factor of consumers, electricity losses increase not only in the supply networks, but also in transformers and generators installed at power stations. So, with a significant decrease in the power factor, transformers and generators become really loaded with reactive currents that it becomes impossible to obtain the installed active power from them.

Low power factor leads to the necessity to enhance the power and size of power supplies, which is not economically feasible.

An increase in power factor can be achieved [2]:

1) measures aimed at improving the use of electrical equipment;

2) measures to compensate for the reactive inductive component of the total power.

Measures aimed at improving the use of electrical equipment (such as: using of asynchronous squirrel-cage mechanisms instead of asynchronous ones with slip rings; eliminating prolonged operation of electrical equipment at idling; using of equipment with nominal characteristics close to the rated ones; switching the stator windings of lightly loaded asynchronous motors from triangle to star; preferred application of synchronous motors), will improve efficiency in relatively small limits. In this case, the power source and power lines are not completely unloaded from reactive currents [3].

Measures to compensate for the reactive component of power are much more effective.

Such measures include the use of static (cosine) capacitors. Static capacitors have become most widespread in industrial enterprises as a means of reactive power compensation. The main advantages of static capacitors for reactive power compensation are insignificant active power losses, lying in the range of 0.3-0.45 kW per 100 kVAr; absence of rotating parts and relatively low weight of the installation with capacitors, and therefore no need for a foundation; simpler and cheaper operation than other compensating devices; the ability to increase or decrease the installed capacity depending on the need; possibility of installing static capacitors at any point in the network.

In addition, the failure of an individual capacitor, if properly protected, does not usually affect the operation of the entire capacitor installation.

However, static capacitors have some disadvantages. Thus, at significant powers and high rated voltages, the cost of static capacitors may be slightly higher than for other compensating devices [3].

Static capacitor banks are installed directly at the electricity consumer or, if the calculated capacitance of the capacitor bank is significant, they are switched on through a step-up transformer [4].

To determine the rational parameters of static capacitors and the circuit for connecting capacitor banks, an analysis of the dependences of the cost of reactive power compensation devices on their parameters was previously carried out. As initial data, information was taken on the parameters of static capacitors combined into capacitor banks, using the example of the Russian-made NUCON PSPE3 model with reactive power from 2.5 to 50 kVAr at a rated voltage of 0.4 kV and the UKKZ LLP CEP model with reactive power from 50 up to 500 kVAr at rated voltages 6.3; 6.6 and 10.5 kV [5-8]. Graphs of the cost of reactive power compensation devices depending on their parameters, including when switched on via a step-up transformer, are given in [9]. Based on the results of the analysis, the following conclusions were drawn:

a) the cost per unit of capacitor bank capacity increases with increasing voltage;

b) if the required reactive power exceeds 300 kVAr, it is necessary to provide for the inclusion of static capacitors using a step-up transformer. The indicated value of reactive power corresponds to the capacity of one phase of the battery of the order of 2000 μF at a voltage of 0.4 kV.

Taking into account the findings obtained, an algorithm of actions for selecting consumer reactive power compensation devices is proposed (Figure 1).

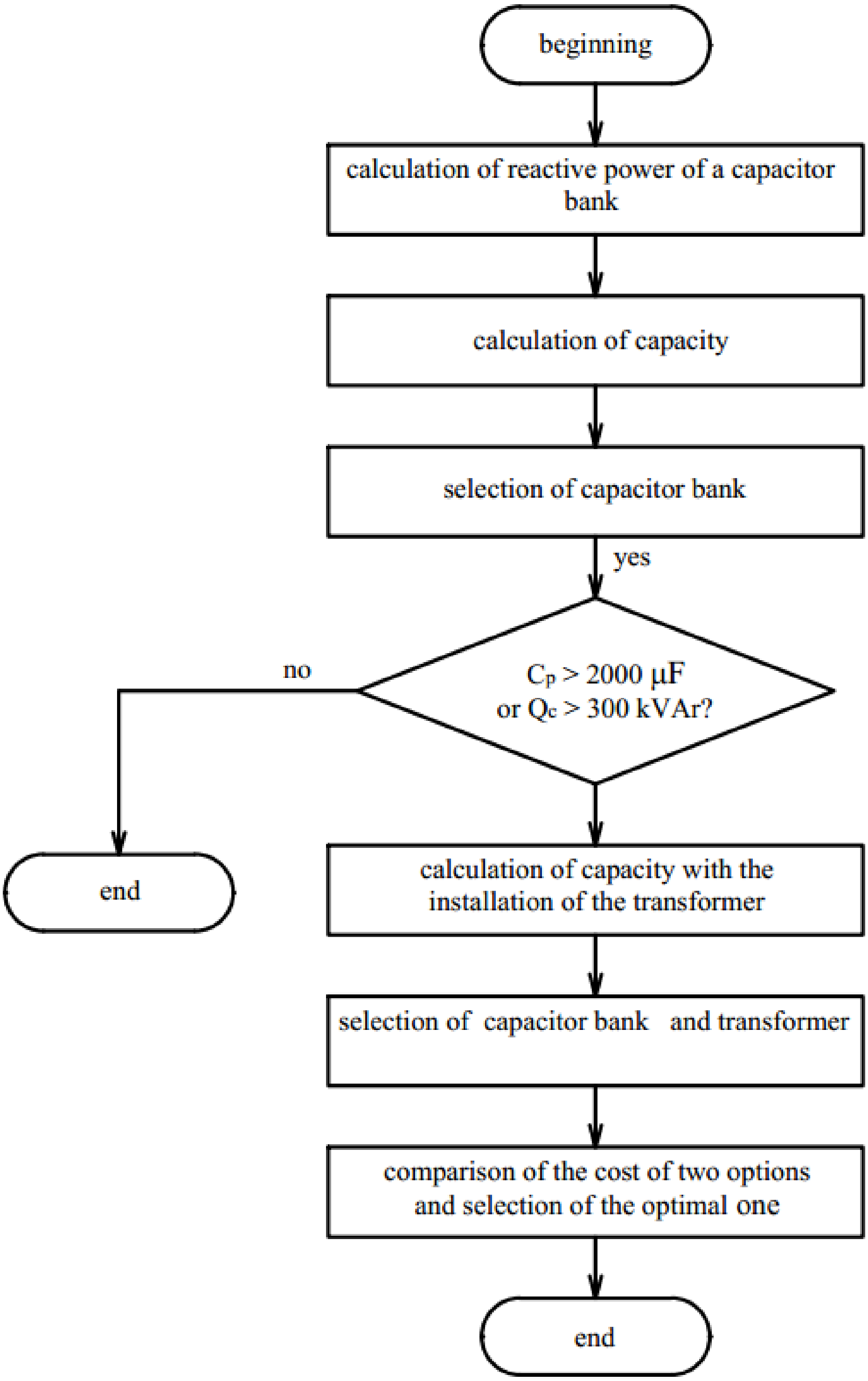

Fig. 1. The algorithm of actions for choosing consumer reactive power compensation devices

An algorithm of actions:

a) calculation of capacitance C_p and reactive power of the capacitor bank Q_c;

b) selection of a capacitor bank based on calculated data;

c) if the selected reactive power of the capacitor bank is Q_c equal to or more than 300 kVAr, calculation of capacitance C_p taking into account the transformation ratio of the transformer squared;

d) comparison of the obtained options and selection of equipment that is rational in terms of cost.

This algorithm will reduce calculation time and select the most optimal parameters for capacitor banks in terms of cost.

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