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COMPARING THE EFFECTIVENESS OF USING SYNCHRONOUS MOTORS AND CAPACITOR BATTERIES

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ABSTRACT

This article analyzes the applications and efficiency of synchronous motors and capacitor batteries. Synchronous motors play a significant role in increasing efficiency in converting electrical energy into mechanical energy, as they are characterized by high power factor and stability. On the other hand, capacitor batteries are widely used in electrical networks to compensate for reactive power and stabilize voltage levels. The article compares the energy efficiency, economic aspects, and various practical applications of both technologies. The effectiveness of their use in electrical systems and their technical approaches will also be analyzed in depth.

Introduction. Reactive power management is an important part of increasing the efficiency of electrical networks in industrial and energy systems. Synchronous motors and capacitor batteries are often used to compensate for reactive power. These two technologies have their characteristics, advantages, and disadvantages. In this article, we will analyze the efficiency of synchronous motors and capacitor batteries, their areas of application, and their responsiveness.

Recommendations are given on the choice of locations for placing capacitor batteries in existing networks. The problems of using capacitor devices in enterprise facilities and their impact on nodes of static loads are carefully considered.

Since synchronous motors installed at the enterprise are used to generate reactive power, additional equipment costs should not be incurred. Regarding the installation of additional capacitor batteries, such an approach is not appropriate for some types of synchronous motors, as this leads to significant active power losses in the engines themselves.

Synchronous motors are used in electrical networks not only as a driving force but also as a means of compensating for reactive power. This allows for accurate control of reactive power in the network by controlling the magnetic field of the engine rotor.

Advantages: Dynamic control: Synchronous motors adapt to rapid load changes and effectively manage reactive power in the network in real-time.

Stability: shows high efficiency in protecting the network from stress and maintaining stability during load fluctuations.

Energy saving: Due to long-term energy saving and efficient control capabilities, synchronous engines are instrumental in high-power systems.

Disadvantages:

Price is high: Installation and maintenance costs of synchronous motors are much higher than that of capacitor batteries, which can make them economically more difficult for small businesses.

Complex structure: These engines have a complex structure, and the fact that they require operation and maintenance increases costs.

In conditions of the use of capacitor batteries together with synchronous motors, their adjustment laws should be adapted. Since capacitor banks have relatively low losses compared to synchronous motors, the reactive power adjustment sequence should be set so that when the total reactive power generation needs to be reduced, the synchronous motor reactive power is reduced first. The power regulator of capacitor batteries should work until such a decrease is allowed.

Such sequence operation is achieved by switching off sections and less installation of the rectifier, saving a large amount of time in the rectifier of capacitor batteries compared to the rectifier of synchronous motors.

It is possible to adjust the internal scale corresponding to the capacity of the capacitor battery sections, in addition, with its help, it is possible to set the insensitivity of the reactive current in a small region in the synchronous motor regulator. Therefore, it allows choosing a cheaper capacitor battery when solving the design task when there is a synchronous motor at the node.

Condenser batteries are one of the most common and inexpensive methods of reactive power compensation. They are mainly used for static compensation and help maintain a voltage balance in the power grid.

The power of the capacitor batteries is proportional to the square of the network voltage and the sum of the capacities of all phases, despite the connection of their circuits.

This dependence of battery power on network voltage is inappropriate, as reactive power increases with a decrease in voltage and decreases with its increase in the power supply system of the enterprise. This shortcoming is especially relevant in emergency situations, when the voltage decreases for a short period, and the decrease in reactive power that occurs during this period negatively affects the stability of the system. (Figure 1)

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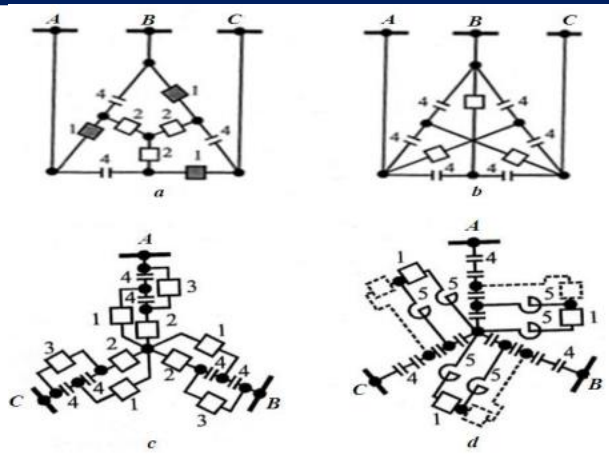

Figure 1. Schemes for accelerating the power of capacitor devices: a - star-to-delta reconnection; b - reconnection of the group of capacitors in phases; v, g - shunting of a group of series capacitors; 1,2,3 - power switches; 4 – main capacitor batteries; current limiting reactors.

In this scheme, the shunting of capacitors is carried out through current-limiting reactors with high-voltage circuit breakers. The use of the schemes under consideration is appropriate when short-term acceleration of battery power in catastrophic modes is required to maintain system stability. However acceleration schemes cause short-term overvoltages on capacitors, which are part of batteries and require special cosine capacitors for them, capable of holding high voltages on their terminals for a long time. The considered schemes are used in energy systems and large condenser equipment schemes in industrial enterprises. To implement these schemes, it is necessary to estimate the loading angle or stability of the system. It is advisable to use fast-acting thyristor switches to control the acceleration mode of capacitor batteries.

Advantages:

Simplicity and low price: Capacitor batteries are much cheaper and simpler to install and maintain than synchronous engines.

Technical maintenance is not required: The equipment is simple and requires almost no technical maintenance, making it suitable for small and medium-sized enterprises.

Small space occupancy: Condenser batteries take up less space, which allows them to be conveniently placed in any industrial facility.

Disadvantages:

Low adaptability: The ability to adapt to load changes is low, which reduces the efficiency of operating capacitor batteries in dynamic modes.

Harmonics: Capacitors can amplify harmonics in a network, which requires additional filters.

Comparison and Efficiency

Indicators	Synchronous Engines	Condenser Batteries
Price	*costly*	*cheap*
Technical Service	*complex*	*simple*
Adaptability	*high*	*low*
Energy saving	*Effective for high-power systems*	*Suitable for static systems*

Voltage control	*High dynamic control*	*Low*
Effect on harmonics	*Little*	*More filters required*

The problem of facilitating reactive power balance in the enterprise's power supply system, choosing the type and power of devices, and determining installation locations should be solved at the lowest cost. One of the main directions is to improve the quality of electric energy, reduce wastage, and increase the efficiency of electrical devices at the same time as reactive power compensation.

Conclusion

Synchronous motors are effective for high-voltage and variable electrical networks, and their dynamic control capabilities and the ability to maintain a stable voltage are important. However, due to their high cost, they are recommended only for large enterprises. Condenser batteries are an inexpensive and convenient solution for small and medium-sized enterprises, but they are less flexible and more suitable for static systems.

The choice depends on the needs of the enterprise and the specifics of the electrical system. For systems with dynamic load changes, synchronous motors predominate, but for systems operating under static loads, capacitor batteries are an effective solution.

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