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Reactive power Compensation in Power supply Networks

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ABSTRACT: The article examines the issue of increasing the efficiency of reactive power in power supply and installing reactive power consumers in an induced manner, as well as preventing power losses.

KEY WORDS: Compensation, power supply, reconstruction, power supply, voltage asymmetry, distribution, reactive power, waste, electricity.

I. RELATED WORK

Currently, much work is being done in our country to develop power supply systems, including the recentralization of low-voltage electricity supply airlines and the implementation of new projects, therefore, today we can observe the leakage of power lines and the need for repair, and the increase in consumers means an increase in the demand for electricity. in particular, the need to increase the power consumption of electricity in the country, such as an increase in the power consumption of reciprocating batteries and other devices, which leads to a sharp decrease in the power consumption of recip devices with this characteristic are typically asynchronous motors that use reactive power to the maximum in the process of starting such motors, which in turn causes electricity losses in the networks and obligates the consumer to pay for excess reactive power. In the proverb under consideration, the aforementioned problems are most likely to be solved by inductive compensation for reactive power consumers, compensation of reactive capacity will save 840,000 kWh of electricity per year.

II. INTRODUCTION

Today, we know that most electrical receivers, as well as electrical energy converter devices, in order to function according to their physical properties, in addition to the active energy Wp entering from the network to the electrical receiver, require the energy necessary to create a variable electromagnetic field, which is called reactive WQ. Therefore, the total transmitted power S in AC electrical networks is equal to the geometric sum of the active power R and the reactive power Q [1.1]:

$$S = \sqrt{P^2 + Q^2} \qquad (1.1)$$

The total current I is proportional to the active IA and the reactive Ir components:

$$I = \sqrt{I_A^2 + I_P^2} \qquad (1.2)$$

Its value in the power line, at the network voltage U, is:

$$I = \frac{S}{\sqrt{3}} \cdot \frac{1}{U} \qquad (1.3)$$

Dial elements of the three-phase line with opposition R active power losses ΔP will be equal:

$$\Delta P = 3I^2R = \frac{S^2}{U^2}R = \frac{P^2+Q^2}{U^2}R = \frac{P^2}{U^2}R + \frac{Q^2}{U^2}R = \Delta P_A + \Delta P_P\,, \qquad (1.4)$$

where ΔP_A and ΔP_B are the components of active and RM transmission losses, Despite the fact that active power and, consequently, no fuel is directly consumed for the production of PM, its transmission through the network causes active energy costs WTP, which are covered by the active energy of the generators (due to additional fuel consumption). The magnitude of these losses can be represented as follows:

$$W_{tr} = \frac{Q^2}{U^2} \cdot R \cdot \tau \quad (1.5)$$

where τ is the time characteristic of the RM transmission schedule. When evaluating the WTP value, it is possible to rely on the known concept of RM equivalent - kek, which is equal to 0.08 kW/quare and means that an average of 8 kW of active RM is consumed per 100 quares of RM transmission, but, unlike active RM can be generated by compensating devices (synchronous compensators and electric motors, capacitors, RM static sources), while fuel is practically not consumed. The peculiarity of RM is also that the costs of its transmission do not depend on the direction, that is, the consumption and generation of equivalent RM volumes into the network are equally poor. In this sense, the concept of "supplier" or "consumer" for RM loses its meaning, and the term " RM compensation" (not production) is absolutely correct. For a long time, the main regulatory indicator characterizing RM consumption was the weighted average power factor cos φ, which in general is defined as:

$$\cos\varphi = \frac{P}{S} \quad (1.6)$$

However, the P/S ratio does not provide an idea of the dynamics of the change in the real value of PM. Thus, with a change in cos φ from 0.95 to 0.94, the consumption of PM (·S ·sin · φ) increases by 10%, and with a change in cos φ from 0.99 to 0.98, the increase in PM is 42%. Therefore, it is convenient to use the actual ratio of the active and reactive components of the total power - tg φ [4] as the RM coefficient:

$$\mathrm{tg}\,\varphi = \frac{Q}{P} \quad (1.7)$$

The weighted average load factor used in customer calculations was determined based on the indicators of active and reactive commercial meters over a given period of time. If for the t2 - t1 calculation period, the indicators of the active energy meter were WA=WAt2 -WAt1, and the reactive - WP=WPt2 -WPt1

$$\mathrm{tg}\,\varphi = \frac{W_P}{W_A}. \quad (1.8)$$

Therefore, the overall task of optimal electricity consumption [6], both at the design stage and at the operation stage of power supply systems, includes the task of ensuring the load on the MPC - in the periodic voltage network of infinite power, the load must consume the current from the network, which coincides with the voltage in form and phase (1.1). It is assumed that if the current consumed lags behind the voltage phase (the inductive nature of the load, Fig. 1.1), then RM has a positive value (consumption of RM, undercompensation mode), if the current surpasses the voltage phase (capacity nature of the load), RM has a negative value (generation of RM into the network, overcompensation mode).

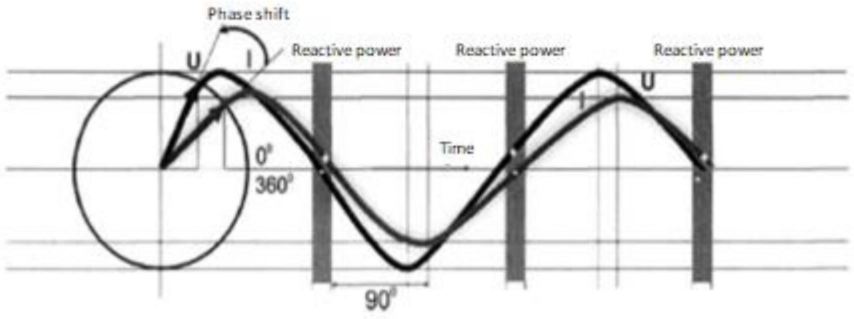

Figure 1.1. Changes in line voltage and current with inductive load

In general, CMR is used for several purposes: firstly, it is necessary to comply with the condition of the load node balance RM (see section 1.3); secondly, RM compensation devices are used to reduce losses in the power grid (see section 1.3); thirdly, RM can be used to regulate voltage and improve power quality norms (see section 2.2).

One of the main components of energy-saving power supply technologies and ways to reduce losses by consumers of electricity is SMR, which includes the issues of choosing SM, their rational placement in the network and regulation of the operating mode. At enterprises, the main consumers of RM are asynchronous electric motors (60...65%), power transformers (20...25%), other electrical receivers (up to 10%), and in recent times, the increase in RM consumption has often exceeded the increase active power consumption. According to the reference data, the presence of CMC in the production electrical networks reduces the total active energy consumption by 3-4 W. The installation in the UK enterprise network, in general, is designed to ensure the optimal balance of PM, and consequently, the stability reserve in the load nodes, voltage regulation, and voltage asymmetry or non-synusoidality For this purpose, synchronous compensators and electric motors, inductive couplers and couplers can be used.

$$Q_E = P_{SD,nom} \cdot \beta_{SD} \cdot \tan\varphi_{nom} \,, \qquad (1.9)$$

$P_{SD.nom}$. nominal active power SD; β_{SD}- the load coefficient by active power; tan ·φ_nom · - nominal coefficient of PM. Then the compensation capacity of the SD of a specific QSD electric drive will be equal to:

$$Q_{SDR} = \alpha_m \cdot S_{SD.nom} = \alpha_m \sqrt{P_{SD.nom}^2 + Q_{SD.nom}^2} \,, \qquad (1.10.)$$

α_M - The permissible overloading coefficient of the SD, which depends on the degree of its load according to

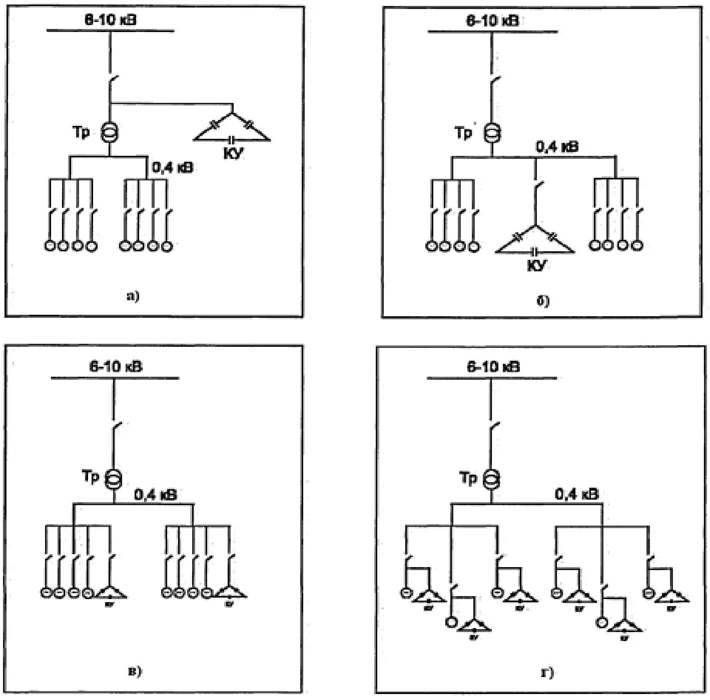

Figure 1.2. Methods of reactive power compensation in consumers' electrical networks: a) centralized compensation on the side of VN; b) centralized compensation on the side of NN; c) group compensation on the side of NN; d) individual compensation on the side of NN For SMEs, the most widespread use in industrial, urban, and rural electrical networks is 0.4... 10 kV, complete Different constructive KOs

Research shows that taking into account the dependence of the cost of annual electricity losses caused by the generation of PM, which is a quadratic function of Qsd P5] and the effect on the compensation power of the SD (1.10), makes the use of low-voltage SDs for CMR any capacities, as well as high-voltage capacitors with a capacity of up to 1600 kW, are inefficient. With the help of KU, the following types of compensation are possible:

1. Individual (unregulated) - CBs are placed directly at the and are switched on simultaneously with them. Preferred in case of compensation of single,constantly connected power over 20 kW for a long time (1.8g-figure). Disadvantages of this type KPM - the dependence of the efficiency of KB on the coefficient of simultaneous switching on electrical receivers and the need to coordinate the 1SB capacity with the receiver's inductance to prevent the occurrence of resonant phenomena or the application of special connection schemes (shifting from "star" to "triangle," parallel connection to the engine windings of three single-phase capacitors).

2. Group (also unregulated). It is used in the case of multiple inductive loads connected to one RU with a common KB (1.8b-figure). Increasing the total coefficient of simultaneous load switching on reduces the power and increases the efficiency of switching on KB; Disadvantages - separate switching of KB and incomplete unloading of distribution units

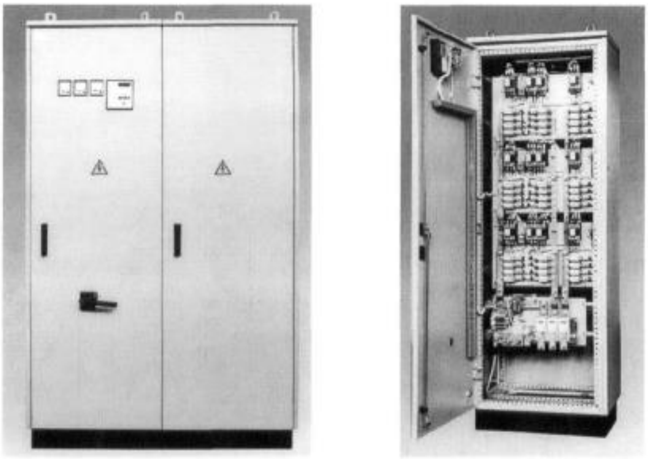

Figure 1.10. Power module 100 quares: front view (a), rear view (b) and voltage supply to the installation when the input cell door is open or the main knives of the disconnector are unfastened.

Therefore, the doors of the input cell are blocked using an electromagnetic lock with a disconnector drive and mechanically with the doors of the KB cells. The input cell contains a three-pole disconnector with a grounding, these knives, blocking elements for signaling and measuring equipment, some types of devices are equipped with a device to protect against current overloads. The three-phase circuit breakers, consisting of three single-phase capacitors with built-in discharge resistances, connected according to the "star" scheme and connected to the installation's assembly tires through three savers, are installed in the circuit breakers cell. Holes are provided in the cell doors to inspect the safety valves during operation. The gearbox of the 6 (10) kV unit is calculated for a three-phase short-circuit power of 200...300 MBA at.

III. CONCLUSION

In conclusion, it can be said that at the current stage of electricity development in our country, it is necessary to switch to energy-saving technologies that reduce the need for new generation capacities and various methods of reducing electricity losses. At the current stage of the country's electric power development, the transition to energy-saving technologies that reduce the need for new generation capacities and various methods of reducing electricity losses, as well as the correct selection of compensating devices both at the design stage and during the operation of power supply systems, allows for: unloading distribution lines and transformers; reducing electricity losses and voltage drop from the RM flow, which is especially important for remote rural networks; reducing the impact of pulsed network interference and high harmonics, resulting in improved electricity quality.

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