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RESEARCH ON THE METHOD FOR CALCULATING THE AMOUNT OF REACTIVE POWER AND SELECTING A COMPENSATION DEVICE

Abstract: In the world, in order to provide consumers with high-quality and uninterrupted electricity, it is important to design and develop systems for generating a rotating magnetic field in asynchronous motors, power supply of industrial enterprises and consumer devices, using accurate and effective methods in their development, and correctly selecting the capacity of the compensation device. One of the main issues in industrial enterprises is the issue of reactive power compensation, which is explained with practical solutions. Two cases are considered in this regard. In the first case, the reactive power required by the consumer is directly transmitted from the power system. In the second case, the reactive power required by the consumer is generated by the consumer himself. As a result of comparing the two cases, the relevance of the issue of reactive power compensation and its impact on technical and economic indicators are determined, and the operation of electrical equipment in production enterprises in the specified and highly efficient operating modes is achieved.

Keywords:reactive power, compensation, tgφ–reactive power coefficient, asynchronous motors, active and reactive power coefficient, capacitor bank.

One of the main issues considered in the design of power supply of industrial enterprises is the issue of reactive power compensation. As we know, the system generator, along with active power, also produces a certain amount of reactive power, depending on the generator's τγφ–reactive power coefficient. Analysis of the technological process of industrial enterprises shows that the main power consumers in enterprises are asynchronous motors.

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The power triangle is an important element of electrical power systems, facilitating power analysis. Understanding the relationship between active, reactive, and apparent power is essential for effective control of electrical systems. By increasing the power factor, system losses can be reduced and efficiency can be increased. Figure 1 shows a power triangle graph.

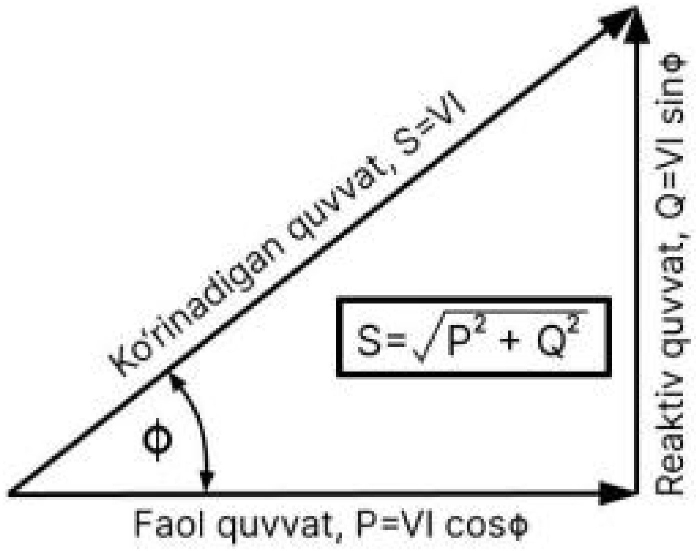

Figure 1 shows a power triangle graph in electrical networks.

It is precisely asynchronous motors that are considered the main consumers of reactive power, that is, consumers of 60-65% of the total reactive power generated. Therefore, the consumption of reactive power in industrial enterprises is increasing relative to active power. If we analyze the manifestations of waste in power networks:

$\Delta P = R$; $\Delta Q = X$; $\Delta U =$ $\frac{P^2+Q^2}{U^2}\frac{P^2+Q^2}{U^2}\frac{PR+QX}{U}$

From the above expressions for active and reactive powers, power dissipation and losses, it is clear that reactive power dissipation is directly proportional to the square of the power flowing through the network. That is, the more reactive power is transmitted to the consumer through the power grid, the greater the amount of dissipation in the grid. This leads to a deterioration in technical and economic indicators. Therefore, it is considered expedient to generate reactive power close to consumers. This uses special devices that generate reactive power.

We will explain the above considerations using the following example. Two cases are considered. In the first case, the reactive power needed by the consumer is directly transmitted from the power system. In the second case, the reactive power needed by the consumer is generated by the consumer himself. As a result of comparing the two cases, the relevance of the issue of reactive power compensation and its impact on technical and economic indicators are determined.

Case 1. The amount of reactive power required by the consumer is transmitted from the power system. The consumer's active power requirement is assumed to be 500 kW and the reactive power requirement is 450 kVA.

S=P+jQ=500+j450.

Taking into account the losses of this power in the line and transformers, the station generator transmits 600 kW of active power and 550 kVA of reactive power.

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Therefore, to transmit power in the amount of S=P+jQ=600+j550 through lines and transformers, it is necessary to select transformers, overhead and cable lines, and switching devices that transmit this power.

Case 2. The amount of reactive power required by the consumer is generated by the consumer himself. Here, as in case 1, the consumer's active power requirement is taken as 500 kW, and the reactive power requirement is 450 kVA. Only 450 kVA of reactive power is not transmitted from the power system. This power is generated by the consumer himself with the help of special compensation devices. Taking into account power losses in the lines and transformers, it can be seen that 600 kW of active power and 100 kVA of reactive power are transmitted from the station generator.

So, to transmit power in the amount of S=P+jQ=600+j100 through lines and transformers, we need to select transformers, air and cable lines, and switching devices that transmit this power.

If we analyze the two cases, it turns out that in the first case, the transmission of power S=P+jQ=600+j550 requires more economic costs than in the second case, which is S=P+jQ=600+j100. This is due to the selection of large-capacity power transformers and the increase in the cross-sectional areas of overhead and cable lines. If these indicators worsen the economic performance of the system, then the significant difference between the amount of waste, as a result of calculating the power values in the first and second cases in the above waste expressions, indicates a deterioration in the technical performance of the system.

From the above cases, it is clear that reactive power compensation is an important issue for industrial enterprises.

This practical exercise examines the issue of reactive power compensation for industrial enterprise workshops, and the amount of reactive power generated by the consumer and transmitted from the power system is calculated and determined using expressions.

As an example, consider the issue of reactive power compensation for the sodium sulfate workshop of a chemical plant for which power supply is being designed, and select the power of the compensating devices.

$Qkq = Ph\sum \cdot (tgph1 - tgph2) = 734.6 \cdot (0.62\text{-}0.33) = 205.3$ kVar

where: tgφ1 is the reactive power coefficient of the consumer up to compensation, which is determined as follows:

$\tan\varphi 1 = = = 0.62 \frac{Q_h}{P_{h\sum}} \frac{446}{734{,}6}$

tgφ2 is the normative reactive power coefficient, which is equal to 0.328. In general, the reactive power coefficient of the consumer should be equal to tgφ2=0.328. This is expressed by the fact that the active power coefficient is equal to cosφ=0.95. The presence of power coefficients at these values characterizes the normal operating state of the power system (the fact that power losses in the networks are within permissible values). The main goal of reactive power compensation is to ensure the normative indicators of active and reactive power coefficients.

For consumers with a voltage rating of less than 50 kVAr, the issue of compensation is not considered. The reason is that, as noted above, compensation is carried out using special compensating devices. For consumers with a voltage rating of less than 50 kVAr, the installation of these devices is not economically justified.

Depending on the value of Qkq, the capacitor bank capacity is selected according to the condition Qkq ≤Qkb. Here Qkb is the capacity of the compensation device that produces the compensated power. Today, capacitor banks are used as compensation devices in industrial enterprises. Using the data, we select the capacity of the capacitor banks that satisfy the above condition. Qkq=205.3 kVAr. A capacitor bank device with a value close to and above this value

Qkb=250kVar is selected. But this value is much larger than Qkkq. This, in turn, leads to additional power waste. In such cases, it is recommended to select compensating devices with a difference of ±10 kVAr as an exception. Based on this, a capacitor bank with a value of Qkb=200 kVAr of the brand UKT – 200 - 0.38U3 is selected. Here: U–device (device); K – compensating (compensating); T – control current (by load current regulation); i.e. a compensation device adjusted by current; 200 – the nominal power of the device, kVAr; 0.38 – nominal voltage, kV; UZ – operation of the device in closed buildings.

6/10 kV discharge capacitor banks

Table 1

Type	Nominal power KBar	Nominal strength kW	Number of branches	Dimensions, mm			Weight kg
				main		Height	
				long-league	width		
UKL56-6.3-450-UZ	450	6.3	1	2210	820	1600	570
UKL 56-6,3-900-UZ	900	6.3	2	3010	820	1600	825
UKL 56-6.3-1350-UZ	1350	6.3	3	3810	820	1600	1080
UKL 56-6.3-1800-UZ	1800	6.3	4	4610	820	1600	1335
UKL 56-6.3-2250-UZ	2250	6.3	5	5410	820	1600	1590
UKL 56-6.3-2700-UZ	2700	6.3	6	6210	820	1600	1845
UKL 56-6,3-3150-UZ	3150	6.3	7	7010	820	1600	2100
UKL 56-10.5-450-UZ	450	10.5	1	2210	820	1600	570
UKL 56-10.5-900-UZ	900	10.5	2	3010	820	1600	825
UKL 56-10.5-1350-UZ	1350	10.5	3	3810	820	1600	1080
UKL 56-10.5-1800-UZ	1800	10.5	4	4610	820	1600	1335
UKL 56-10.5-2250-UZ	2250	10.5	5	5410	820	1600	1590
UKL 56-10.5-2700-UZ	2700	10.5	6	6210	820	1600	1845
UKL 56-10.5-3150-UZ	3150	10.5	7	7010	820	1600	2100

0.4 kV controlled capacitor banks

Table 2

Type	Nominal power, kVA	Dimensions, mm			Weight kg
		length	width	height	
UK-0.38-75-UZ	75	700	560	1260	150
UK-0.38-150-UZ	150	700	560	1600	245
UKN-0.38-75-UZ	75	700	560	1660	175
UKT-0.38-108-UZ	108	700	560	1660	300
UKT-0.38-200-UZ	200	700	560	1660	350

- The calculated reactive power after installing the compensating device is determined by:

$$Qkk = Qh - Qkb = 446 - 200 = 246 \text{ kVA}$$

- The full computational power after compensation is determined:

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$$S_{hkk} = = = 775 \text{ kVA} \sqrt{P_{\sum h}^2 + Q_{kk}^2} \sqrt{446^2 + 246^2}$$

For the remaining workshops of the plant, the power of the compensating devices, compensating for reactive power, is selected using the same expressions and filled in Table 3.

Table 3

No.	Name of the shop	tgφ	Wow, kVAr	Qkb, kVAr	Hello, kVAr	Shkk, kVA
1	Sodium sulfate workshop	0.61	205.3	200	246	775
2	Grinding shop	1.30	520.9	525	172	563
3	Factory management	0.98	54.3	0	150	117
4	Test and inspection department	0.75	236.7	250	172	590
5	Pump room	0.86	324.9	325	200	641
6	Compressor room	1.00	444.8	450	213	699
7	Fluoride salt workshop	0.73	232.5	225	195	604
8	Superphosphate workshop	1.01	402.7	400	197	624
9	Warehouse	0.51	16.1	0	45	98
10	Solution warehouse	0.49	23.3	0	70	158
11	Grinder body	0.75	255.4	250	206	645
12	Kitchen	0.96	40.1	0	61	88
13	Gas generator workshop	1.31	246.6	250	79	264
14	1-acid section	0.87	452.6	450	250	883
15	2nd acid section	1.73	1796.4	1800	417	1348
	ABOUT THE FACTORY:					8097

From the results of the above research, it can be concluded that in industrial production enterprises, it is possible to provide high-quality and uninterrupted electricity supply to three- and single-phase electrical devices supplied from electrical energy sources such as solar panels or diesel generators, and centralized power grids, by selecting capacitor battery devices, which provide symmetrical and sinusoidal electricity to three- and single-phase electrical devices, allowing the devices to operate at their passport values and in highly efficient operating modes.

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