

OPTIMIZING THE RELIABILITY OF INDUCTION MOTORS IN OPERATION

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Abstract: *This article presents the results of the optimization of the reliability of the working asynchronous motors and the impact of the frequency conversion and induction motor speed control systems on the technical and economic indicators. Optimum modes of operation at different values of rotation speed of asynchronous motors were determined.*

Keywords: *asynchronous motor, frequency converter, energy saving technology, fan, pump, phase voltage, phase current, active and reactive power, output voltage and frequency of the frequency converter.*

ПОВЫШЕНИЕ НАДЕЖНОСТИ ЭКСПЛУАТАЦИОННЫХ ДВИГАТЕЛЕЙ

Аннотация: В данной статье представлены результаты оптимизации надежности работающих асинхронных двигателей и влияние систем преобразования частоты и регулирования скорости асинхронных двигателей на технико-экономические показатели. Определены оптимальные режимы работы при различных значениях частоты вращения асинхронных двигателей.

Ключевые слова: асинхронный двигатель, преобразователь частоты, технология энергосбережения, вентилятор, насос, фазное напряжение, фазный ток, активная и реактивная мощность, выходное напряжение и частота преобразователя частоты.

INTRODUCTION

The results of the research conducted in the field of application of energy-saving and cost-effective technologies in the production industry show that adjusting the rotation frequency of asynchronous motors is of practical importance and is considered one of the urgent issues [1,3]. It is known from the results of scientific research that changing the rotation speed of asynchronous motors in various areas of modern production industry has a positive effect on the smooth change of the starting current of electrical devices and the extension of their service life, on increasing the economic efficiency of the system, and on energy saving [5,7]. The results of recent research in this field, dedicated to the effective use of frequency converters in controlling the operating modes of short-circuited asynchronous electric motors as energy-saving technologies, have shown that frequency conversion, which provides a decrease in electricity consumption, the level of automation and ease of use of devices, and an increase in the quality of technological processes frequency converters made on the basis of semiconductor devices are used as devices [8,9]. On this basis, production enterprises of the oil and gas industry, where several thousand asynchronous electric motors with a capacity of 500 kW and a voltage of up to 1000 V are used, were selected as objects of scientific research. In these industries, frequency converters are used as auxiliary devices for fans and pumps used in technological production processes.

The purpose, tasks and methodology of the experiment. The main goal of the research work was to establish optimal operating modes and justify economic efficiency by changing the rotation speed of asynchronous motors used in the oil and gas industry using a frequency converter made on the basis of semiconductor electronic devices. The method of controlling the rotation speed of an asynchronous motor by adjusting the frequency was used in the research work.

Experimental results. It is known that asynchronous electric motors are considered reactive power consumers. When controlling asynchronous electric motors through frequency converters, it is required to supply the electric motor with reactive power.

Frequency converter devices generate reactive power for an induction motor based on active power received from the grid. The following results were obtained on the basis of the experimental studies carried out on the working devices of the "Shurtan" NGQChB objects according to the principle of operation of frequency converters. Table 1 shows the input parameters of the frequency converters used to control the asynchronous electric motors installed in the facilities of the "Shurtan" NGQChB facilities.

Table 1

Input parameters of frequency converters in control of asynchronous electric motors

No	Frequency converter installed device	Enter parameters					
		He _a (V)	He _b (V)	He _c (V)	I _a (A)	I _b (A)	I _c (A)
1	STvaK N-4 110 kW	237.7	237.7	238.4	31.6	53.1	53.8
2	Boiler room-1 D-1 75 kW	237.7	237.7	238.4	59.2	53.8	53.1
3	Boiler room-1 D-2 75 kW	237.7	237.7	238.4	35.8	35	42
4	Boiler room-1 V-1 45 kW	237.7	237.7	238.4	24.1	25.4	28.9
5	Boiler room-1 V-2 45 kW	237.7	237.7	238.4	16.5	17	21.1
6	Boiler room-1 D-4 75 kW	235.6	236.5	236.4	10.9	11.9	11.9
7	Boiler room-1 V-4 45 kW	235.6	236.5	236.4	14.7	15.4	15.8
8	Boiler room-1 TN-4 55 kW	235.6	236.5	236.4	43.6	54.2	54.5
9	Boiler room-1 TN-3 55 kW	235.6	236.5	236.4	53.6	53.6	55.1
10	Boiler room-2 TN-3 55 kW	238	238	236	53	54	61
11	Boiler room-2 D-3 75 kW	236	236.1	236.8	14.5	16	13.7
12	Boiler room-2 V-3 45 kW	236	236.1	236.8	16	14.7	14.6
13	Boiler room-2 D-1 75 kW	238.8	238.2	237	15.1	14.3	13.9
14	Boiler room-2 V-1 45 kW	238.8	238.2	237	16	16.2	15.3

In order to evaluate the technical and economic indicators of the systems by comparing the results of the experimental research, the output parameters of the frequency converters used to control the asynchronous electric motors installed in the facilities of the "Shurtan" NGQChB facilities are presented in Table 2.

Table 2

Output parameters of frequency converters in control of asynchronous electric motors

No	Frequency converter installed device	Exit parameters						
		P _{ch} (kW)	I _{ch} (A)	He _f (V)	f _{ch} (Hz)	I _{ac} (A)	S _{ch} (KVA)	Q _{ch} (kVar)
1	ST and K N-4, 110 kW	24.6	78.2	255	34,33	55.3	34.54	24,24
2	Kozonkhana-1 D-1, 75 kW	38.3	84.2	329	43.8	67.1	47.92	28.80
3	Kozonkhana-1 D-2, 75 kW	25.3	64.5	306	40.2	48.9	34,15	22.93
4	Kozonkhana-1 V-1, 45 kW	17.5	52.4	266	35,24	36.3	24.11	16.59

5	Kozonkhana-1 V-2, 45 kW	12	38	234	31.6	28.1	15.38	9,625
6	Kozonkhana-1 D-4, 75 kW	6.7	39	163	23,28	27.9	10.99	8.72
7	Kozonkhana-1 V-4, 45 kW	9.3	42.4	226	30.84	22.9	16.58	13.72
8	Kozonkhana-1 TN-4, 55 kW	32.7	73.4	371	47.25	68.9	47.11	33.91
9	Kozonkhana-1 TN-3, 55 kW	37	76	353	45.6	61.2	46.41	28.0199
10	Kozonkhana-2 TN-3, 55 kW	36.6	71	355	45.25	65.1	43.60	23.70
11	Kozonkhana-2 D-3, 75 kW	8.5	43.5	192	22.1	25.8	14.45	11.68
12	Kozonkhana-2 V-3, 45 kW	8.3	37.1	210	29	21.6	13.48	10.62

In the table of sizes literally determination as follows: U_f – exit line voltage (V), I_{ch} – output phase current (A), I_{ak} – torque generating output until (A), S_{ch} – exit full power (kVA), Q_{ch} – exit reactive power (kVar).

A consumable asset for generating reactive power in frequency converters power balance descriptive parameters It is presented in Table 3.

1- Table

Frequency in converters re active and asset powers balance parameters

No	A frequency converter is installed device	Parameters			
		Pk (kW)	Pch (kW)	Qch (kBap)	Cos (ph)
1	ST and KN-4, 110 kW	32.95911	24.6	24.24398	0.712242
2	Boiler room-1 D-1, 75 kW	39.51914	38.3	28.80678	0.79918
3	Boiler room-1 D-2, 75 kW	26.84196	25.3	22.93015	0.740957
4	Boiler room-1 V-1, 45 kW	18.65591	17.5	16.58938	0.725737
5	Boiler room-1 V-2, 45 kW	12.99319	12	9.625051	0.780074
6	Boiler room-1 D-4, 75 kW	8.19555	6.7	8.721091	0.609223
7	Boiler room-1 V-4 45 kW	10.84054	9.3	13.72316	0.561
8	Boiler room-1 TN-4 55 kW	35.97426	32.7	33.91301	0.694115
9	Boiler room-1 TN-3 55 kW	38.3302	37	28.0199	0.7972
10	Boiler room-2 TN-3 55 kW	39,862	36.6	23.70244	0.83936
11	Boiler room-2 D-3 75 kW	10.44376	8.5	11.68428	0.588278
12	Boiler room-2 V-3 45 kW	10.70395	8.3	10.6197	0.615799
13	Boiler room-2 D-1 75 kW	10.30644	8.5	9.861407	0.652886
14	Boiler room-2V-1 45 kW	11.30574	9.1	10.90747	0.640618

Here, $\cos(\varphi)$ is the active power coefficient, P_r is the active power (kW) used in the production of reactive power.

In-depth analysis of the experimental results showed that individual compensation of reactive power for each device used in the oil and gas production industry gives its technical and economic efficiency. In practice, frequency control is carried out by changing the voltage accordingly, while reducing the frequency, the amount of voltage is also reduced accordingly. As a result, the amount of electric current flowing through the network is reduced. As a result of this, if the magnitude of the changed frequency changes by how many percent, the consumed electric power will decrease accordingly. This process creates its own complexities in reactive power compensation. When compensating for reactive power, it is necessary to strictly consider the numerical values of the output voltage and output frequency of the frequency converter.

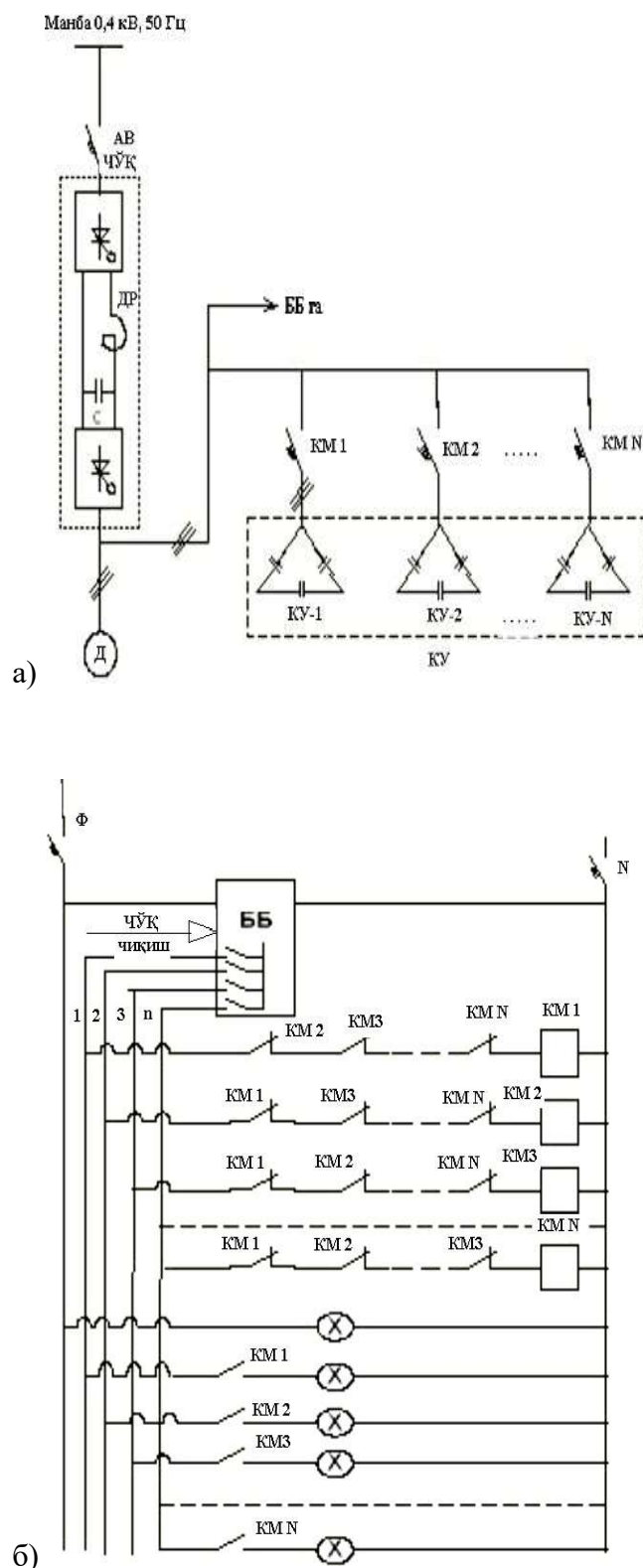


Figure 1. Scheme of individual compensation of reactive power in asynchronous motors controlled by frequency converters.

a) Individual reactive power compensation of an asynchronous ED controlled by a frequency converter. АВ-circuit breaker, С-capacitor, ЧО'Қ-frequency converter, ДР-choke, БТ-controlled rectifier, БИ-controlled inverter, Д-asynchronous electric motor, КМ-magnetic

starter. KU-different voltage reactive power compensation device. b) Control scheme: BB-control unit.

Research results have shown that connecting and disconnecting compensating groups corresponding to the output voltage and frequency of the frequency converter, automatic process control increases the efficiency of the system. Based on the results of experimental research, the scheme presented in Fig. 1 was proposed for individual compensation of reactive power in asynchronous electric motors controlled by semiconductor frequency converters.

Individual compensation of reactive power in an asynchronous electric motor controlled by a semiconductor frequency converter based on the scheme presented in Figure 1 above is economically efficient, and the control unit in the scheme adds and disconnects a group of compensation devices corresponding to the voltage value at the output of the frequency converter. The application of the frequency adjustment device to the technological processes of production ensures a reduction of the required electrical energy consumption from 5% to 40%, heat savings in hot water supply, reduction of noise during the use of devices, and provides an opportunity for the optimal selection of electrical devices.

Summary. Experimental research results show that individual compensation of the reactive power consumed by asynchronous electric motors controlled by frequency adjustment devices gives its technical and economic effect and implementation, rational reduction of the share of energy in the manufactured product and improvement of energy efficiency in the economic and social sectors of our government energy efficiency of the sector increase, introduction of energy-saving technologies and development of renewable energy sources is one of the practical issues solved.

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