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Analysis of Mechanical and Energy Parameters of Phase Rotor Asynchronous Motors in Mechanisms of Cotton Ginning Enterprises

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ABSTRACT: The article analyzes the correlations of the values of coordinating asynchronous motors with a short-circuited rotor in the mechanisms of cotton ginning enterprises with asynchronous motors with a phase rotor. In the analysis, when the rotor current of an asynchronous motor with a phase rotor changes, the stator current changes, the rotor rotation speed changes, and the useful work coefficient changes.

KEY WORDS: cotton cleaning mechanisms, phase rotor asynchronous motor, stator, rotor, torque, rotor resistance, current, load, relative unit. mechanical and energetic indicators.

I. INTRODUCTION

Competitiveness that increases the production potential and economy of our republic, launching the production of high-quality consumer light industrial products designed for the world market, made on the basis of scientific achievements, turning light industry into the most important and most relevant field based on the progress of science and technology are among the priority tasks. In recent years, significant work has been done to further deepen the social and economic reforms of our country. In particular, a number of production enterprises in the light industry were reconstructed, equipped with modern equipment, and joint enterprises were established [1].

At present, in order to increase the volume and quality of cotton products, providing enterprises with modern equipment, complex mechanization and automation of production, and improvement of technological processes are being carried out.

Since light industrial products are diverse and changing, technological processes are complex industries, specialists in this field are required to conduct constant research, apply advanced methods of production organization, correctly select modern equipment and perform work on their improvement [2].

After the independence of the Republic of Uzbekistan, in order to improve the cultural and social living conditions of the people, great attention was paid to the fact that the creation of progressive technology and highly efficient machines and equipment and their continuous improvement is related to the full automation of production processes [3].

Despite the fact that the demand for hemp, silk, wool and various fibers, which are used as raw materials in textile and light industry, is increasing year by year, among them, cotton fiber occupies the main place. Therefore, in Uzbekistan, the development of cotton growing in the national economy is given great importance [4].

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After the seed cotton grown in agriculture is collected from the fields and handed over to the state cotton ginning factories or their affiliated cotton processing centers, the initial processing processes begin. The primary processing technology of cotton includes the following main processes [2-4]:
- drying of cotton and cleaning it from weeds for the first time;
- to clean the cotton from the weeds and comb it;
- ginning of cotton - separating the fiber from the seed;
- Lintering of seed - separation of short fibers from seed;
- cleaning fiber, lint and fluff from small debris and pressing them into a ball shape;
- seed processing.

Cotton ginning plants and equipment, powerful hydropress, transport, mechanization equipment and power industry will be fully equipped to carry out the above-mentioned processes.

Currently, seeded cotton is grown in more than 80 countries of the world, of which the USA, Uzbekistan, the People's Republic of China, India, Brazil, Mexico, MAP are the main cotton-growing countries [2].

II. LITERATURE ANALYSIS ON THE TOPIC SURFACE

Technological devices for cotton processing plants, cotton ginning plants (machines and mechanisms used in cotton preparation, drying, cleaning, storage), saw and roller gin machines, linters, fiber cleaners, seed sorting and cleaning machines, conveyors, cotton manufactures gin breakers, cotton conveyors, tunneling machines, cotton gin ventilation and dust collection machines, as well as hemp processing machines and devices [1-2].

It is the main element of electrical equipment used in the process of separating the cotton fiber from the seed. The issues of designing the electrical operation of these technological devices and controlling the electromechanical system taking into account the technological processes are very important today [5].

The main consumer of electricity is the electric drive (more than 60%), and it is on it that the main attention of the world technical community working in the field of energy saving is paid. German experts believe that the economic potential of energy saving in the electric drive is practically exhausted, if we consider the individual components of the electric drive, they are already quite perfect. At the same time, there remains a huge potential based on improving the design of systems as a whole and optimizing their parameters [6-8].

More than 60% of the expected increase will be covered by energy savings, mainly during the transition to a controlled electric drive. Expert estimates show that a controlled electric drive is cost-effective in 25...50% of all technological installations, although it is currently used only in 10%. Let us consider in more detail the object of energy saving - an electric drive [8-14].

The process of separating the seed cotton fiber from the seed depends on the characteristics of the selective type of seed cotton, the industrial variety, its moisture level, the length of the fiber, the time of adding the mixture to the cotton, and the nature of the connection to the fibers. In order to fulfill all the requirements of technological processes, it is important to analyze the energy parameters of the device's electrical operation, taking into account the operating modes.

III. METHODOLOGY

Asynchronous motors installed in cotton ginning plants work with high efficiency only at certain times during continuous work processes. The reason is that we choose an asynchronous motor based on the load applied to the motor shaft, at the time of selection, it is selected according to the highest load in one cycle. In addition, the mechanical power delivered to the motor shaft is as follows

$$P = M_q \cdot \frac{n}{9.55} \tag{1}$$

Here: Mq-motor shaft resistance torque, n-motor shaft rotational speed.

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It can be seen from the formula (1) that the power is directly proportional to the two values, and if we take the resistance moment at its value, we do not have the opportunity to choose the speed of rotation of the shaft arbitrarily. Because asynchronous motors are single-pole 3000 rpm, two-pole 1500 rpm, three-pole 1000 rpm, four-pole 750 rpm, five-pole 600 rpm, six-pole 500 rpm, eight-pole 375 rpm A motor with the specified shaft speed may not always match the standard motors being manufactured. As a result, we are forced to choose a motor with a greater power than the calculated power, which lowers the efficiency of the motor. Sometimes a gearbox is used to adjust the shaft rotation speed to the power. This leads to the addition of another device to the technological process, which again reduces the overall useful efficiency. Because the efficiency of the gearbox is 94-96%, and the result means that the overall efficiency decreases to 6-7%. It can be seen that both solutions are not satisfactory solutions, therefore, an asynchronous motor control, i.e. motor shaft speed control, is an acceptable solution for them. There are two ways to control the speed of an induction motor shaft. The first way is performed by changing the speed of the rotating magnetic field generated in the stator.

This is done by changing the frequency of alternating current in the network and changing the amount of voltage in order for us to do this. To change the frequency of the network, the alternating current is first converted to direct current, in this process 8-10% of energy is lost. In the second process, constant current is converted into alternating current through an inverter, as a result of which energy is lost again. In addition, the combined price of the vipermeter and inverters is equal to the price of the motor and is higher, which is not always an alternative answer. An autotransformer can be used to control the mains voltage, but it requires the installation of an autotransformer control system and an autotransformer with a power greater than the motor power, which is an economically inefficient way.

The second way is to control the speed of the motor shaft by connecting additional resistance to the rotor shaft of the asynchronous motor through rings. Ring asynchronous motors are called phase rotor asynchronous motors. The phase rotor asynchronous motor belongs to the class of variable speed electric machines. It is pointless to install it on electrical systems where constant speed change is not required. But it is effective if it is used in electric drives whose speed changes several times in one work cycle. The main disadvantage of asynchronous motors with a phase rotor is that the external resistance of the rotor connected through the ring is not automatically controlled, or it is necessary to adjust it only according to the load value using a rheostat. There is an automatic system that does this but it is expensive. This affects the widespread use of phase rotor asynchronous motors. The analysis of the energy parameters of the motor shows us the advantages and disadvantages of the motor. For this reason, we will analyze the working processes of the phase rotor asynchronous motor.

IV. RESULT AND DISCUSSION

Analysis of the mechanical and energy indicators of phase rotor asynchronous motors in the mechanisms of cotton ginning enterprises, experimental studies were carried out on a small power phase rotor asynchronous motor in laboratory conditions. The results obtained in this article were obtained using the CBM-software in the "Induction machine 0.3 kW" laboratory. Let's consider the characteristics of the load of the asynchronous motor with a phase rotor, setting the rotor resistance at the nominal resistance. Table 1 shows the stator and rotor currents corresponding to the load on the motor shaft of the phase rotor asynchronous motor in relative units.

Table 1. Phase rotor asynchronous motor in the relative unit of the load on the motor shaft corresponding stator and rotor

M/M_n,	M_n, [N*m]	I_1, stator current [A]	I_2, rotor current [A]
0.1	0.19	0.88	0.17
0.2	0.38	0.87	0.32
0.3	0.58	0.87	0.51
0.4	0.76	0.86	0.65
0.5	0.91	0.87	0.81
0.6	1.15	0.88	1.06
0.7	1.34	0.9	1.3

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0.8	1.53	0.92	1.5
0.9	1.72	0.97	1.8
1.0	1.92	1.02	2.1
1.1	2.1	1.08	2.4
1.2	2.3	1.16	2.7
1.3	2.49	1.28	3.2
1.4	2.68	1.53	4.2

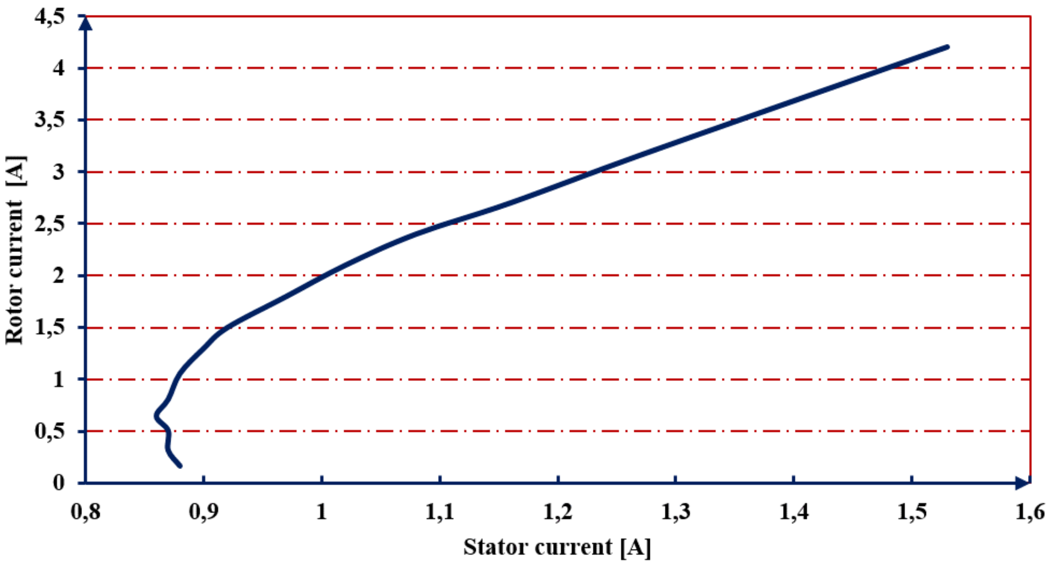

Figure 1. Connection between stator and rotor currents

The analysis from graph 1 and table 1 shows that when the stator current is increased from 0.1 range to 1.4 times relative to the nominal value, the change of these values is considered to be a large value in the rotor chain, when the stator current increases by 1.7 times and the rotor current increases by 24.7 times. If we compare the loss of active power in the rotor and stator alone, the increase in the stator chain by 2.89 times, and the loss in the rotor by 610 times, will lead to a decrease in the efficiency of the asynchronous motor. In addition, the increase in the amount of released heat leads to the destruction of the insulation in the stator and rotor circuits of the asynchronous motor and the rapid failure of the motor. One of the advantages of phase rotor asynchronous motors is that when the rotor current increases, we can reduce this amount by changing the rotor resistance.

Analysis 2. Analysis of the choice of external resistance corresponding to the rated torque of the phase rotor asynchronous motor

Table 2. The rotor rotation speed was measured in the rotor resistance of the phase rotor asynchronous motor in six units

Place	6	5	4	3	2	1
n, rpm.	1408	1365	1307	1188	1018	645

Table 2 and graph 2 show that the motor speed has decreased by more than two times, which means that the performance of the performed work has also decreased by more than two times. So, the conclusion is that as we increase the value of rotor resistance, we see that the speed of rotation of the rotor decreases. If the speed of rotation of the rotor starts to

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decrease, we change the resistance in the opposite order, i.e. reduce the ability to change it. For example, when the load of an asynchronous motor with a phase rotor, considered in the experiment, increased by 1.4 times from the range of 0.1, it can be seen that the rotor rotation speed decreased by 2.18 times, while the rotor resistance was at the 1 indicator. When we increase this value to the 6th indicator, we can see that the rotor speed returns to its nominal value.

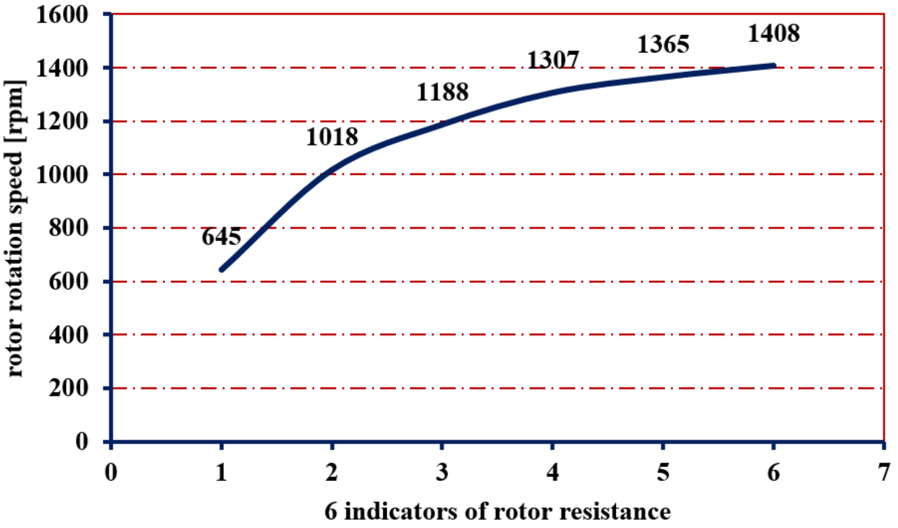

Figure 2. Phase rotor induction motor rotor speed corresponding to rotor resistance

The rotor speed and electrical parameters of the phase rotor asynchronous motor in six units of rotor resistance were obtained based on experimental studies, the results are presented in Table 3.

Table 3. Rotor rotation speed and electrical parameters in rotor resistance of phase rotor asynchronous motor in six units

M/M_n,	M_n, [N*m]	n, [rpm]	I_1, stator current [A]	$cos\varphi$	I_2, rotor current [A]	P_1, power [W]	P_2, mechanical power [W]	Efficiency,%	M_n, [N*m]	M_n, [N*m]	M_n, [N*m]	M_n, [N*m]	M_n, [N*m]
0,1	0,19	1480	0,88	0,23	0,17	81,96	29,43	35,909	0,18	0,19	0,21	0,253	0,399
0,2	0,38	1466	0,87	0,28	0,32	98,64	58,31	59,108	0,37	0,39	0,43	0,506	0,798
0,3	0,58	1449	0,87	0,33	0,51	116,26	87,96	75,66	0,55	0,59	0,65	0,759	1,197
0,4	0,76	1439	0,86	0,38	0,65	132,34	114,5	86,496	0,73	0,78	0,868	1,012	1,596
0,5	0,91	1428	0,87	0,42	0,81	147,97	136	91,119	0,92	0,98	1,08	1,265	1,995
0,6	1,15	1410	0,88	0,48	1,06	171,05	169,7	91,219	1,1	1,18	1,3	1,518	2,394
0,7	1,34	1400	0,9	0,53	1,3	193,16	196,4	91,22	1,28	1,37	1,5	1,771	2,793
0,8	1,53	1380	0,92	0,57	1,5	212,36	221	91,3	1,46	1,57	1,73	2,024	3,192
0,9	1,72	1361	0,97	0,61	1,8	239,61	245	91,4	1,65	1,77	1,95	2,277	3,591
1	1,92	1340	1,02	0,64	2,1	264,35	269,3	91,6	1,83	1,9	2,1	2,53	3,99

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1,1	2,1	1313	1,08	0,67	2,4	293,02	288,6	90,76	2,01	2,16	2,38	2,783	4,389
1,2	2,3	1276	1,16	0,69	2,7	324,12	307,2	89,36	2,2	2,36	2,6	3,036	4,788
1,3	2,49	1226	1,28	0,71	3,2	368,02	319,5	86,821	2,38	2,56	2,821	3,28	5,187
1,4	2,68	1141	1,53	0,72	4,2	446,1	320,1	71,746	2,56	2,75	3,038	3,54	5,586

Based on the given values, we adjusted the phase rotor asynchronous motor in the relative unit by changing the load in the range of 0.1 to 1.4 ratio and changing the rotor resistance from 1 to 6 indicators and obtained the torque change. Based on the obtained values, the following variable graph was created. It can be seen from the graph that there is a high and efficient solution for the small value of the rotor resistance. To explain this, the most optimal solution of the 6 changes is crossed by the curve, so the conclusion is that when the load reaches one relative unit, the optimal resistance value is in the optimal solution when the value of the resistance is at the 4th indicator.

The efficiency is high when our load is satisfied from 0.6 load to 1 load ratio. For this reason, it is desirable that the load is usually given in values. Another conclusion should not be forgotten, it is necessary and important to take into account the commutation processes in the process of changing the rotor resistance of the phase rotor asynchronous motor. Because according to the conclusion of Table 1, the rotor current increases by 24.7 times during this process, the value of commutation current $e^{24,7}$ can change times, that is, since the rotor circuit consists of inductive and active resistance, the electromechanical time constant is equal to $T = \frac{L}{r}$.

The value of the inductance of the rotor core L depends on the induction of the stator magnetic field, this value does not change in a large range, but we change the active resistance r of the rotor circuit in the range from 1 to 6, that is, as the load increases, the rotor resistance decreases. As a result, the electromechanical time constant increases, which leads to rapid failure of the rotor circuit switching devices. It is necessary not to forget this aspect, especially at high load it is impossible to reduce the active resistance sharply.

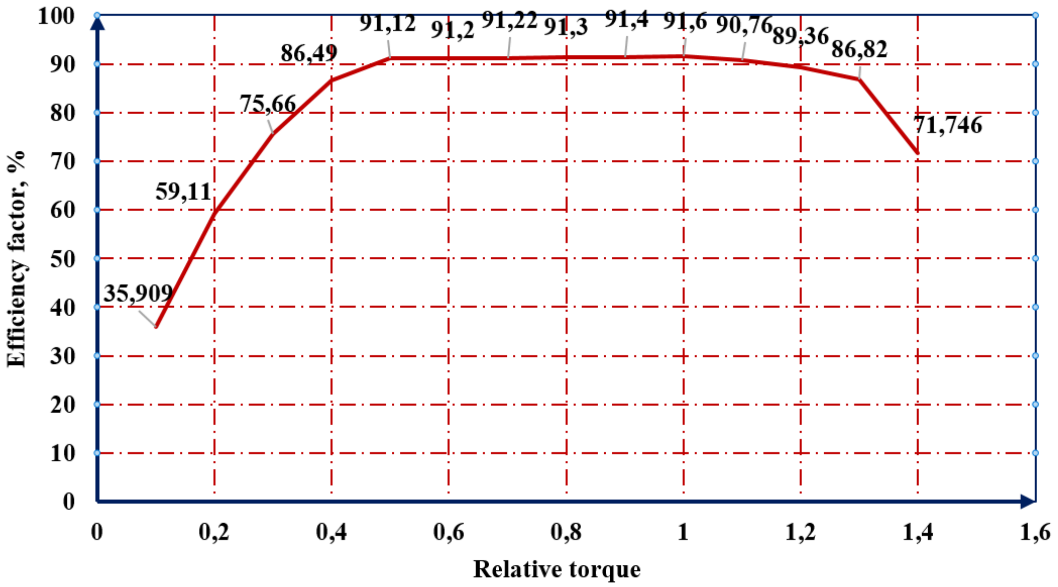

Figure 4. Useful performance coefficients corresponding to the relative torque values of the phase rotor asynchronous motor

The FIKi of the phase rotor asynchronous motor tends to its nominal value after the load torque increases from the relative value of 0.5, this value reaches the nominal efficiency value at the relative value of 1.1.

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Based on the results obtained in table 3 and graph 5, it can be said that the results obtained in the six parameters of the phase rotor asynchronous motor show that the 6 straight lines are the torques of the resistances in the six parameters in relative units, among which only one value is that is, it crossed only one of the curves characterizing the motor load. This is the 1st indicator resistance characterizing the line, it is the rotor resistance for a phase rotor asynchronous motor.

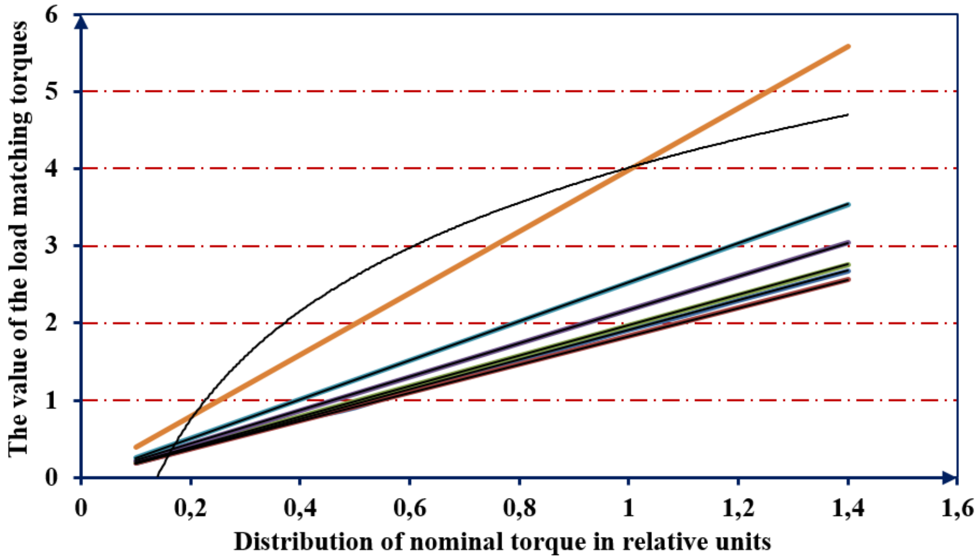

Figure 5. Characteristics of the nominal torque on the phase rotor asynchronous motor shaft with changes in rotor resistance [in relative units]

V. CONCLUSION

1. A The main feature of the article is to find the nominal value of the rotor resistance of the phase rotor asynchronous motor, and the main electrical indicators of the motor were taken into account when choosing this value. In the experiment, we changed the rotor resistance of a 300 W phase rotor asynchronous motor. The result is that the more we increase the rotor current, the more the waste increases, as a result, the FIK decreases. The increase in nominal rotor current continues until the stator current reaches the nominal value.
2. By changing the rotor resistance, the motor speed can only be increased to the nominal value.
3. By changing the rotor resistance, FIK can be kept at its nominal value from 0.5 load to 1.1 load.
4. By changing the resistance of the rotor to several values, the optimal value, the value corresponding to the value of the passport, was found.

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