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Investigation of asynchronous electric motor winding in heating mode and drying mode to prevent moisture

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Abstract. Asynchronous motors are used in many agricultural industries. Agricultural production is a production with high humidity. As noted above, one of the main reasons for the failure of electric motors in agricultural installations during prolonged downtime is the insulation breakdown due to its dampness. Moistening the winding insulation will degrade the dielectric performance of the insulation. If the electric motor is often switched on and the total operating time per day is at least 4 - 6 hours in rooms with high humidity but without ammonia vapors, then dangerous waterlogging of the windings does not occur. Preheating the windings for an electric motor with a power of 3 kW, to maintain the state of the insulation resistance at a level safe for switching on, can be provided with a power of 12 W.

1 Introduction

Influence of the thermal regime of the electric motor and environmental conditions on the degree of dampness of the windings and a decrease in insulation resistance.

As noted above, one of the main reasons for the failure of electric motors in agricultural installations during prolonged downtime is insulation breakdown due to its dampness. Therefore, developing methods for preventing insulation dampness is an urgent issue. At present, agriculture does not apply any methods to prevent moisture isolation.

There are several methods and devices for maintaining and maintaining a high level of insulation resistance of electrical machines in a humid environment. These methods require an individual winding power source for each electric motor to heat them during pauses. In agricultural production, engines used in animal husbandry and subsidiary enterprises need heating. This is especially necessary for those electric motors, the operating time of which ranges from a few minutes to 3 - 4 hours a day. These are, first of all, electric motors of manure machines, which work from 10 minutes to 4 hours and, in other cases, stand idle for up to 10 days.

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2 Methods

The insulation resistance of the electric motor windings changes depending on the environmental conditions - temperature and humidity, the work schedule, and the duration of interruptions in work, on the insulation class.

In our experiments, the insulation resistance of an electric motor of type 4A90L64UZ with a power of P = 1.5 kW at 100% humidity decreased from 1000 to 0.7 mOhm within 16 hours, and for an electric motor of type 4A71A2UZ P = 0.75 kW from 150 mOhm to 0,6 mOhm for 16 hours.

If the motor is idle in an atmosphere with high relative humidity, the motor insulation absorbs moisture from the air. The process of sorption - humidification will take place. The outer layers of insulation are moistened first, then the inner ones. The humidification process continues until an equilibrium state of moisture between the insulation, and the environment is reached.

Wetting the winding insulation will degrade the dielectric performance of the insulation. If the electric motor is often switched on and the total operating time per day is at least 4 - 6 hours in rooms with high humidity but without ammonia vapors, then dangerous waterlogging of the windings does not occur.

In cases where the duration of the operation is less than indicated above, and the duration of pauses in the presence of ammonia vapors is more than 8 hours. It is necessary to heat the motor windings in the intervals between switching on the operation.

The method of selecting the capacitance of capacitors for the winding heating circuit When the power contacts of the magnetic starter are washed, the capacitors are connected by a triangle and serve as reactive power compensators. When the power contacts of the starter are opened, the capacitors remain connected in series with the motor windings. In this case, there is no need for a circuit of additional switching devices.

If the torque on the motor shaft has a fan-like character, i.e., when the moment is static Mst, the possibility of spontaneous rotation of the engine in the heating mode is very slight (fig. 1). To eliminate this phenomenon, it is necessary to change the phasing of the windings, which is ensured by the wedging of capacitors according to the scheme shown in Fig. 2. The value of the capacitance should be chosen so that when the windings are heated, the excess of its temperature over the ambient temperature is within the range of 7 - 15 °,

and when compensating for SOC, its improvement is carried out by 0.2 - 0.3. In short, the same capacitors should be used in both cases.

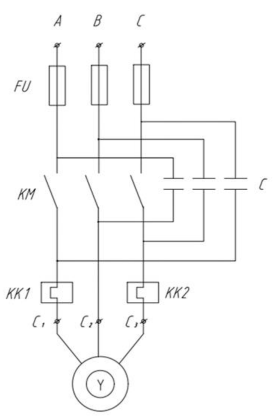

Fig. 1. Scheme of switching capacitors for heating the windings during pauses and compensation of reactive power during operation of the electric motor.

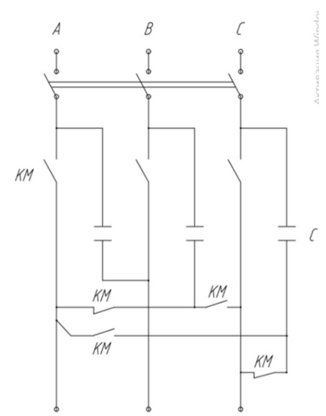

Fig. 2. Scheme for switching on capacitors at low Mst for heating the windings during pauses and compensation of reactive power during operation of the electric motor.

And the value of reactive power in (kVar) or (Var) is determined by the expression

$$Q = U^2 \cdot \omega 3C \qquad (1)$$

$$3C = \frac{Q}{U^2 \cdot \omega} = \frac{Ptg\varphi}{U^2 \cdot \omega \cdot \eta \cdot 10^6} \text{ mkF}, \qquad (2)$$

$$Q = \frac{Ptg\varphi}{\eta} \text{ VAr}. \qquad (3)$$

And in fig. 3 shows curves that make it possible to determine the values of C for heating and Q for reactive power compensation depending on the pole of the electric motor.

For each power of the electric motor, options from 5 to 12 W per kW of electric motor power were adopted; experiments have confirmed that the necessary excess of the temperature of the windings over the environment (to have sufficient insulation resistance) is achieved at the cost of exactly 8-12 W per kW of electric motor power.

In agriculture, electric motors of the 4A type are currently used, and in addition, as noted above, 75 - 80% of the total are electric motors with a capacity of 0.4 to 10 kW. In our experiments, we focused on these electric motors.

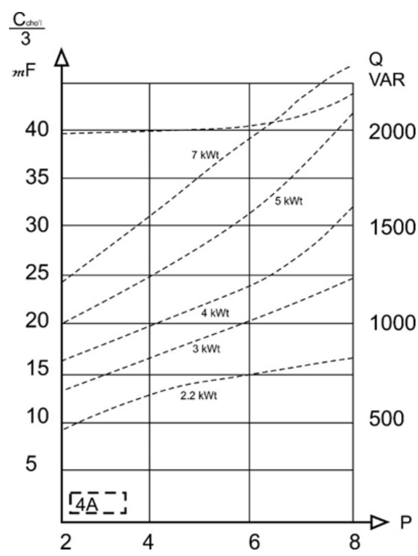

Fig. 3. Curves of changes in reactive power depending on the number of pairs of poles of the electric motor

3 Results and Discussion

Results of experiments on heating the windings of an electric motor to prevent dampness. Experimental studies to prevent dampness of the insulation of the windings of electric motors were carried out on the farm "Vazir Chorvador" in the Khorezm region. The results of the experiments showed that the safe heating of the electric motor windings for 20 hours at 100% air humidity ensures that the insulation resistance is maintained at a level that is quite sufficient for safe switching on of the electric motor in the future. The results are reflected by the dependencies shown in Figure 3.4. Namely, here are the changes in the insulation resistance of electric motors of type 4A90L6SU1 and 4A80V6SU1 with a power of 1.5 and 1.1 kW for 17 hours at 90% humidity when heating the windings Ppod = 10 W.

As can be seen from the figure, the insulation resistance was maintained at a fairly high level. This ensures the safe further inclusion of electric motors in operation. To determine the excess temperature of the windings at the beginning of turning on the heating and upon reaching the steady state, the experiments were carried out with electric motors from 0.55 to 1.1 kW.

In our experiments, a thermocouple of the chromel-copel group was installed in the windings of each electric motor to record the temperature of the windings. And the temperature course was recorded by an electronic potentiometer. The winding temperature was measured at the beginning of the experiment every 30 min. At the same time, the insulation resistance was also certified with a megohmmeter.

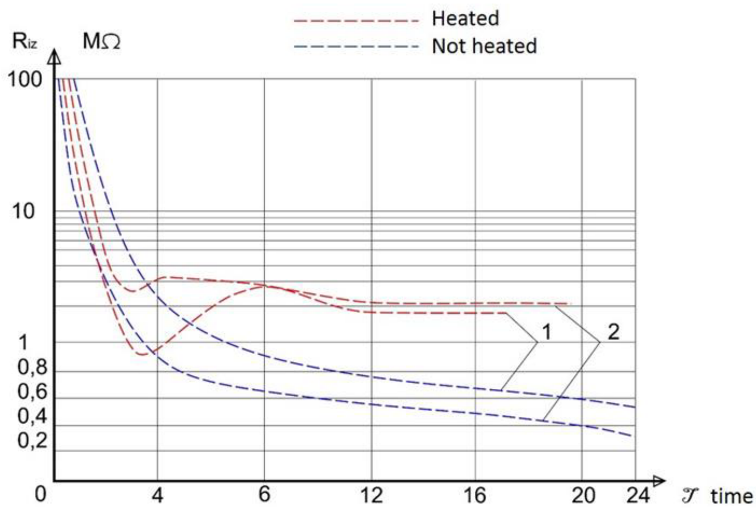

Fig. 4. Change of insulation resistance of motor windings depending on time: 1 - electric motor of type 4A90L6SU1, Rn = 1.5 kW. 2 - electric motor of type 4A80V6SU1, Pн = 1.1 kW.

Analysis of the change in indicators shows that the temperature rise of the electric motor windings increases for about 7 hours. Then the temperature reaches a steady-state value. The insulation resistance drops sharply during the first 90 minutes after turning off the engine from the network and hardly changes; temperature fluctuations were observed when the humidifier was turned on when the moisture content in the chamber increased sharply.

Also, an experiment was carried out to determine the state of insulation resistance for a long time. The motors were kept warm for 80 hours. Then the heating was removed. For about 20 hours, the insulation resistance was kept at the achieved level due to the accumulated heat and then went down. Some fluctuation at the beginning of the experiment (up to 30 hours, from 110 hours and beyond) is explained by fluctuations in the ambient temperature, the values of which were not stabilized during the experiment, i.e., the conditions of the experiments were close to real conditions.

Analyzing the experimental dependencies, the following can be noted. When heated (Ppod = 10 W), the insulation resistance of the motors was kept at the level of 10 mΩ. Starting from 100 hours, after stopping the heating, the insulation resistance value began to fall, and after 90 hours, it decreased by about 10-15 times, reaching a value somewhere in the range from 0.5 to 1 mOhm. The resistance value continued to fall; then, it was to be expected that after a few days, the insulation resistance of these motors could reach a value dangerous for the next turn-on.

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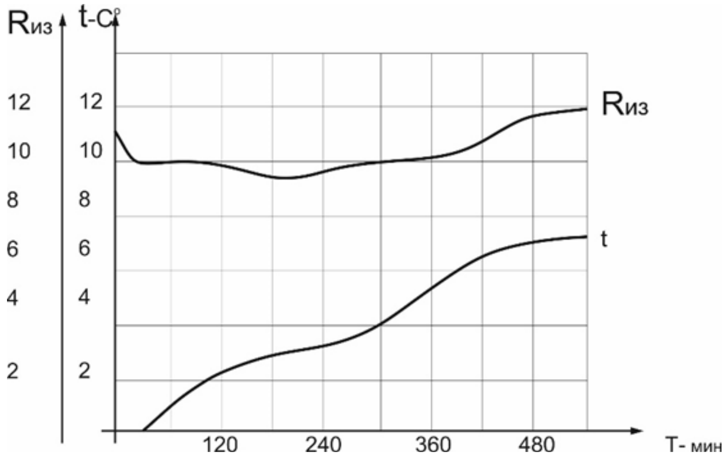

Fig. 5. The course of the change in the temperature rise of the windings over the environment (At) and the change in the insulation resistance (Rj) depending on the time: a) electric motor of the 4A71V6UZ type, P = 0.55 kW; b) 4A80A4UZ, P = 1.1 kW.

Experimental studies were carried out on heating windings in natural conditions. The experiment was carried out in November. An electric motor of type 4A112MV8UZ, P = 3 kW, was installed in the open air. At the same time, the ambient temperature was measured with a mercury thermometer and humidity - with a psychrometer. The heating was switched on continuously for 10 days. During this period, the ambient air temperature ranged from 0 to +4 0C, and the relative humidity from 85 to 96%. It was pouring rain for several days.

The insulation resistance state was measured once a day with a megohmmeter. The results of the experiments showed that during the period when the heating was switched on, the insulation resistance first decreased from 1500 to 200 mΩ, then did not fall, and with a decrease in the ambient humidity, the insulation resistance increased.

Then the heating of the windings was turned off. Within 10 days, the insulation resistance dropped from 1000 to 15 mΩ.

The curves of changes in the insulation resistance of the electric motor and changes in air humidity are shown. An analysis of the R ^ curve shows that preheating the windings for a 3 kW electric motor to maintain the insulation resistance state at a safe level for operation can be provided with a power of 12 W.

4 Conclusions

Summarizing the above, we can conclude that the results of a three-year study on heating the windings of electric motors confirm that the proposed method of preventing the drop in the value of its insulation resistance to a dangerous limit is suitable for those electric motors that have an initial normal insulation resistance.

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