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CHANGING THE SPEED OF AN INDUCTION MOTOR BY RECALCULATING THE STATOR SLOTS

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Abstract
Many mechanisms that perform common technological and production processes do not require smooth speed control. For them, procedures designed to adjust the speed in two or three steps will be sufficient. Such motors are made with several coils of different pairs of poles located on one stator slot, which allows you to change the number of pole pairs for a certain connection of coil sections. This article provides information about the structure and types of multi-speed asynchronous motors.

Keywords: Asynchronous motor, number of poles, multi-speed, frequency, torque, magnetic field.

Introduction

A change in the rotational speed of the electric motor is associated with the replacement of the winding according to new data, which leads to a change in the number of conductors in the stator slot, and, consequently, the magnetic flux and power. To obtain the appropriate value of magnetic flux for a new number of poles, it is necessary to select a method and recalculate the winding data.

The multi-speed motor, with multiple windings per stator, lags behind other motor types due to its size, weight, efficiency and low power factor. Scheme of alternating the number of pairs of poles in a ratio of 2:1 (Fig. 1).

For simplicity, here is a single-phase stator circuit. As can be seen from the circuit diagram, the number of even poles is obtained by connecting sections in series and parallel. In cars with a multi-speed engine, the speed range is controlled by different clutches. These connections can be made in constant torque and constant power modes[1,3,4,5].

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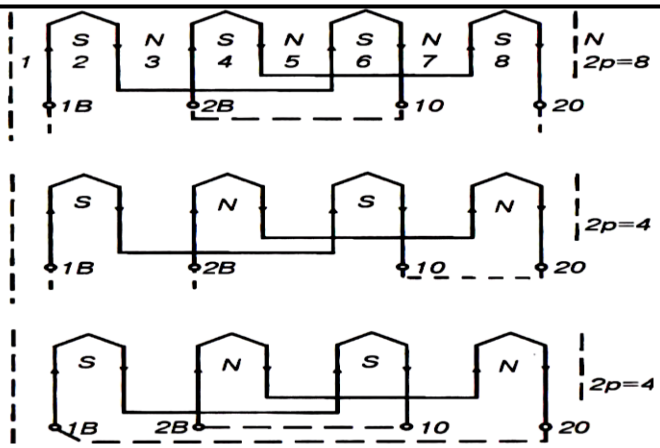

Figure 1. Connection diagrams for stator phase sections of a multiphase asynchronous motor.

The figure shows that with a change in the number of pairs of poles, the width of the pole division changes proportionally, and therefore the number of teeth per pole. At the same time, the new number of conductors in the stator slot corresponds proportionally to the magnitude of the magnetic flux. This relationship ensures normal saturation of the teeth with magnetic flux. From this we can conclude that when the number of pole pairs changes, despite the change in the magnitude of the magnetic flux, and therefore the power of the electric motor, the magnitude of the magnetic induction in the teeth remains essentially unchanged.

Taking into account the above , recalculation of the winding to lower speeds for all electric motors must be done according to formula 1:

$$\mathrm{N_p} = \frac{2\mathrm{p} * 10^5}{\mathrm{Z}^2 * b * l * B_z * K_u}; \qquad (1)$$

A new, larger number of poles is substituted into the formula and, accordingly, from the table. 1, the indicator of magnetic induction in the teeth is taken.

When recalculated to change speeds , as indicated above, the normal magnetic induction will be largely retained in the teeth, while in the back it will necessarily decrease in proportion to the decrease in the magnetic flux, so there is no need to check the maximum permissible value of magnetic induction in it. The power of the electric motor will decrease in proportion to the decrease in the speed or in proportion to the decrease in the cross-section of the wire. Replacing the electric motor winding with a lower rotation speed can be done by one or several speed steps [2,6,7,].

The situation is more complicated when changing the electric motor to a higher rotation speed. It is impossible to recalculate the electric motor winding to a higher rotation speed using this formula due to the insufficient height (section) of the stator back, if the factory manufactured it for one speed level.

The back has a certain (constant) size, therefore, with an increase in the number of pole pairs, it is unloaded from the reduced magnetic flux, while the magnetic induction decreases, and with a decrease in the number of pole pairs, it is loaded with an increased magnetic flux, which means the magnetic induction increases and can reach significantly above the permissible limit .

To recalculate the winding of electric motors to a higher rotation speed, it is necessary to apply the converted formula 3, taking into account the height of the backrest:

$$\mathrm{N_p} = \frac{\pi * 10^4}{Z * b * h * B_s * K_u}; \qquad (2)$$

As the rotation speed of the electric motor increases, the pole division also increases. Despite the increase in magnetic flux, the magnetic induction in the teeth remains basically unchanged, so it is unnecessary to check its maximum permissible value.

In addition to formulas 1, 2, for converting all electric motors to lower speeds and to high speeds of electric motors manufactured by the factory with the same core at two speed levels, usually 1500 and 1000, 1000 and 750 rpm, etc., and if their the winding is made at the lowest speed level, you can use the calculation of the proportional relationship between the number of conductors in the stator slot and the number of pole pairs according to formula 3:

$$\mathrm{N_n} = \frac{N_s * p_i}{p_s} \qquad (3)$$

Where $\mathrm{N_n}$. N_s- old and new number of conductors;

p_s, p_i- old and new number of pole pairs.

Since with a change in the rotation speed of the electric motor, the number of slots per pole and phase, the winding pitch and (slightly) magnetic induction change, it is necessary to reduce when moving to lower speeds, and when moving to higher speeds to increase the result obtained from formula 3 by the change factor windings K_i = 1.1.

For electric motors manufactured for two speed levels, the height of the backrest allows an increased magnetic flux to pass through for the highest speed level with high electric motor power. In this case, the power of the electric motor increases in proportion to the decrease in the number of pole pairs (with a decrease in the number of conductors in the stator slot) [8,9,10].

Electric motors manufactured by the factory for one speed level, in which the height of the backrest is designed strictly for a specific magnetic flux (despite the accepted maximum value of magnetic induction in the backrest), when converted to high speeds, the number of conductors in the stator slot decreases slightly, and often remains the same, what it was like at lower speeds. Such electric motors have very low magnetic induction in the stator teeth (due to weak magnetic flux saturation) and low no-load current, and therefore insufficient starting and torque. The power may increase slightly or remain the same, or even decrease compared to the initial performance of the electric motor until the rotation speed increases.

Magnetic induction; in the teeth (optimal size) and in the back (maximum) depending on the number of poles and stator boring or power, taking into account the design and series of electric motors.

Table 1.

Pure poles 2p	Magnetic induction in teeth - B_z in T_l				Magnetic induction in the back - $V_s T_l$
	D to 12 cm P to 5 kW	D 12-20 cm P 5-25 kW	D 20-30 cm P 25-75 kW	D>30 cm P > 75 kW	
2p=2 2p=4 2p=6 2p=8	1.55 1.60 1.65 1.75	1.40-1.65 1.45-1.60 1.50-1.70 1.55-1.75	1.30-1.65 1.35-1.60 1.40-1.70 1.45-1.75	1.20-1.65 1.35-1.60 1.42-1.60 1.45-1.75	1.65(1.70) 1.60(1.65) 1.60 1.55

In parentheses are data for > 30 cm or power P > 75 kW.

If the electric motor is manufactured for one speed level, then the rotation speed can be increased, provided that the back has a section reserve, and only by one speed level from 1000 to 1500, from 750 to 1000 rpm. etc., and at 3000 rpm. is not allowed at all, since in this case there will be the worst case scenario, in which the pole division and magnetic flux increase at least twice, but the size of the backrest remains unchanged.

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