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METHOD OF DETERMINING ADDITIONAL THERMAL LOSSES IN THE WINDINGS OF ELECTRIC MOTORS

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Increasing the energy efficiency of asynchronous electric drives plays an important role in development of electrical engineering and power engineering [1, 2]. Increasing the efficiency of asynchronous electric drives is associated with an increase in the number of poles, a decrease in current resistances, and an increase in power coefficients. Also, to achieve the maximum efficiency of asynchronous motors, they should be used at full load (variable load). Frequency converters, most commonly used to control the speed and torque of asynchronous motors, operate using pulse-width modulation of sinusoidal or spatial vectors. Therefore, it is also important to improve the efficiency of frequency converters in asynchronous electric drives [3, 4]. Types of power losses in power switches and possible ways to reduce these losses are listed in Table 1.

Table 1 – Methods of reducing power losses in inverter power switches

Type of loss	Inventory loss	Reasons for loss	Possible methods of reducing losses	Disadvantages
Static	– losses in a providential state; – leakage currents	– dependence on the amount of current and voltage on the device	– changing the internal design of the power switch to reduce the voltage drop	– high cost of switches based on silicon carbide
Dynamic	– transistor switching losses; – diode recovery losses; – loss in drivers	– magnitude of current and voltage during commutation; – duration of commutation; – number of switches	– methods of soft commutation; – improvement of the design of drivers; – reduction of commutation frequency	– complication of the circuit design of the device; – decrease in the quality of the output current of the inverter

The reduction of power losses and the corresponding increase in efficiency in the "frequency converter – asynchronous motor" system can be achieved, in addition to the constructive method, by algorithmic methods, that is, by the characteristics of the algorithm or the operating mode of the control system [5]. One way to improve the energy efficiency of frequency converter induction drives is to optimize the frequency of the power switch. The higher the frequency of the resistor, the greater the power loss in the power switch, but the higher the sinusoidal current of the induction motor, the lower the power loss in the induction motor due to higher harmonics. The dependence of power losses in asynchronous motors and frequency converters is shown in Figure 1.

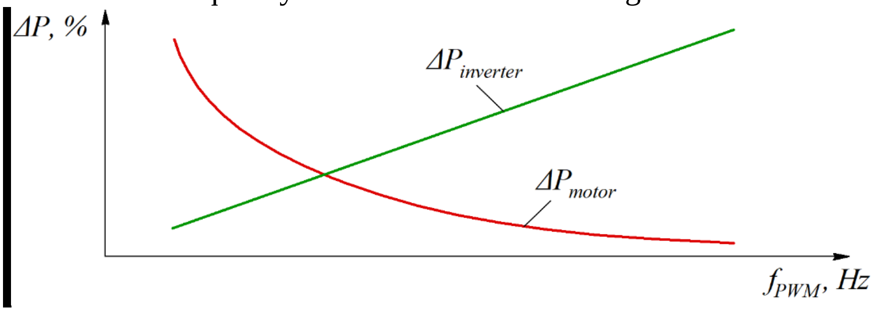

Figure 1 – Dependence of power losses in the motor and inverter on the modulation frequency

A method is proposed for determining additional heat losses in the windings of AC motors, based on the value of coefficient harmonic characteristic of the motor current. This method can be used when the effect of skin effects on the current consumption of a motor with a limited spectrum of higher current harmonics is negligible. In the winding, due to the large rated current, additional losses are calculated based on the increase in average value of current in relation to the value of the first rating, resulting in a secondary dependence of losses on the average value of the secondary current. The effective value of an AC, if it is equal to one cycle of an AC, is equal to the time value of such a DC that performs the same work (thermal or electromagnetic effect) as the corresponding AC.

Modeling of the constant voltage inverter – asynchronous motor system was carried out with a constant motor load (constant resistance and constant speed). In the experiments, only the frequency of pulse width modulation and, accordingly, the frequency of current transmission by the power switch changed. Based on the simulation results, the values of the parameters of the initial output voltage and output current practically do not change with respect to changes in the modulation frequency, while the content of higher parameters decreases with an increase in the frequency of pulse-width modulation, which leads to a decrease in the average value of phase currents and a decrease in power losses in effective resistance to the flow of motor current.

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