WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979, Volume 3, Issue 6, June, 2022

REDUCTION OF POWER CONSUMPTION IN ASYNCHRONOUS ELECTRIC DRIVES

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Annotation

The article highlights the issues of reducing power consumption in asynchronous electric drives , increasing efficiency by using energy- efficient and energy -saving electric motors , the possibility of reducing the energy consumption of an underloaded asynchronous motor in the zone of minimum speeds through the use of a thyristor voltage converter - TVC on the control characteristics, ways to optimize energy consumption in an EA with a valve voltage regulation . The article also discusses ways to reduce power losses by ensuring the operation of the engine with optimal slip, increasing efficiency while optimizing control in the valve voltage regulation system.

Keywords and expressions : Power consumption; energy- efficient and energy -saving asynchronous electric drive; efficiency; thyristor voltage converter; electromagnetic power losses; optimal glide; automatic control system; control system ; frequency method of speed control; power loss; efficiency; small starting current; soft start, limitation of shock moments, accelerations and jerks; quality criteria; reliability of electric drives; optimal control to minimize losses.

Introduction

The most important organizational and technical measures for energy saving in asynchronous electric drives is the correct choice of the installed power of an asynchronous motor. This task is especially relevant when using unregulated motors, which still prevail among industrial electric drives.

When using an asynchronous motor with a lower rated power than required by the operating conditions of the mechanism, the motor overheats and prematurely fails. And the overestimation of the engine power in comparison with the required one increases the capital costs for the electric drive, reduces the efficiency and power factor of the engine.[1]

An increase in the efficiency of unregulated IM by several percent is possible by using energy- efficient engines, in which, due to the increase in active materials (copper and steel), an increase in efficiency by 2-5% was provided. An increase in efficiency is also

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possible by increasing the load factor of engines, it is believed that the average load of engines should exceed 60-70%.

The electric drives of most production facilities have an overestimated power, exceeding the necessary one by 2-3 times, and some electric drives of mechanisms, due to technological features, work part of the time with underload (presses, forging mechanisms, metalworking machines, etc.). These features make it possible to reduce the power consumption of an underloaded asynchronous motor in the zone of minimum speeds through the use of a thyristor voltage converter - TVC on the control characteristics (Fig. 1).

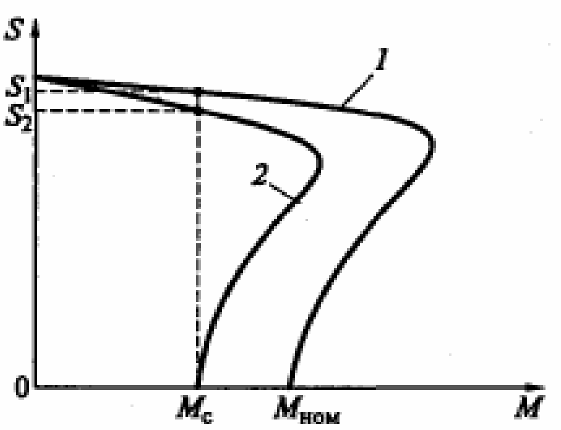

Fig.1. Natural (1) and regulating (2) characteristics of blood pressure

Electromagnetic losses in the motor are determined by the expression

$$\Delta P_{эм} = \Delta P_{1м} + \Delta P_{2м} + \Delta P_{1c}.\text{(one)}$$

When an asynchronous motor is operating in the TVC-IM system, the power loss components are determined by the formulas

$\Delta P_{1м} = [A + (1 - A)\dot{M}_c^2]\Delta P_{1м.н}$;

$\Delta P_{2м} = \dot{M}_c^2 \Delta P_{2м.н}$;(2)

$\Delta P_{1c} = [B + (1 - B)\dot{M}_c^2]\Delta P_{1c.н}$;

It follows from expression (2) that when the AM is operating on a natural characteristic, when the slip changes from 0 to S $_n$, the losses $\Delta P_{эм}$depend only on the static moment.

For a thyristor voltage converter, the optimum slip value can be determined

$$s_{опт} = s_н \sqrt{\frac{Ak_п^2 \Delta P_{1м.н} + B\Delta P_{1c.н}}{(1-A)k_п^2 \Delta P_{1м.н} + k_п^2 \Delta P_{2м.н} + (1-B)\Delta P_{1c.н}}} (3)$$

A change $k_п^2$in the range 1 ÷ 1.2 does not significantly affect the value $s_{опт}$. As follows from formula (3), the value $s_{опт}$does not depend on M $_{c*}$, which allows you to set the blood pressure and maintain the appropriate speed with a changing load torque. [one]

Energy consumption optimization is most simply implemented in the presence of a speed sensor in the automatic speed control system of TVC-IM. Figure 2 shows a diagram of the automatic control system (ACS) for the speed of the TVC - IM. In this system, the given speed will be

$$\omega_з = \omega_0(1 - s_{опт}).$$

In this case, the drive will run in the process of speed control at $s_{опт}$, whose value will not change.

For different types of asynchronous motors $s_{опт} = (0{,}5 \div 0{,}9)s_н$, and is determined by the coefficient A , that is, the value of the no-load current. For engines of crane and metallurgical series, characterized by an increased air gap and no-load current I_0, the optimal slip $s_{опт}$approaches the nominal $s_н$. If $s_{опт}/s_н > Mc*$, then the engine can operate with optimal slip. At the same time, the speed is somewhat reduced compared to operation on a natural characteristic, losses in copper and steel of the stator decrease and losses in copper and steel of the rotor increase, and electromagnetic losses at $s_{опт}$less than ats_1.

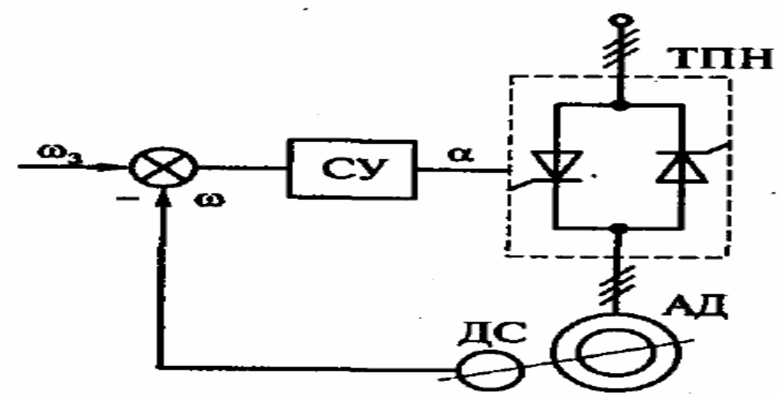

Fig.2. Scheme of the ATS of the speed of the TVC - AD system:
DS - speed sensor; CS - control system; α is the valve opening angle; $\omega_з$, ω – set and true IM speeds.

The greatest reduction in losses during operation in the zone of maximum speed can be achieved in crane-metallurgical engines, which have a large value of the moment M_{c*}, at which a reduction in energy consumption can be achieved. When operating in a steady state with $M_{c*} = 0.05$, the value $\Delta P_{эм}$for crane-metallurgical engines can be reduced by 5-8 times, and for engines of a single series by 3-6 times.

Electromagnetic motor efficiency

$$\eta_{эм} = \frac{P_{мех}}{P_{мех} + \Delta P_{эм}};$$

The value of efficiency can increase, respectively, by 2 - 3 or 1.5 - 2 times.

Loss reduction can also be ensured when running a non-controlled drive in continuous mode when controlling mechanisms of continuous operation, such as a fan, when the engine is selected with a significant margin of power. In this case, work at reduced voltage can be implemented during and the entire time of operation (up to 9000 hours per year).[2]

Energy savings when using the TVC-IM system is not so significant to ensure a quick payback of the TVC included in the IM stator circuits. The use of TVC in most cases is caused by the technological requirements of production mechanisms that require soft start and limitation of shock moments, accelerations and jerks that occur when the IM is directly connected to the rated mains voltage. Therefore, TVC, used according to the terms of the technology, allows you to simultaneously solve the problem of reducing energy consumption with virtually no additional costs.[3]

With the frequency method of speed control, the losses in the motors depend both on the frequency and on the load torque. At low loads, the total losses in the motor decrease with decreasing frequency. When overloaded, the nature of the total losses in the engine change. In these cases, as the frequency decreases, the total losses in the motor begin to increase due to an increase in copper losses in the stator and rotor windings, while steel losses and mechanical losses decrease. So, with $\omega_1 = 0{,}25\omega_н$and an overload of the engine by 10%, the total losses in it increase by 2 times. The efficiency also depends not only on the frequency, but also on the load moment. In the frequency range of 0.25 ÷ 1, the maximum efficiency value corresponds to 0.5M of torque. In the FC-IM system, the main part of the losses are losses in the motor, however, due to losses in the frequency converter, the losses in the system increase, and the efficiency decreases.[1]

One of the most important quality criteria for energy reasons and the reliability of electric drives are power losses. Loss optimality requirements can be considered in relation to the motor, frequency converter and, in general, to the electric drive. The identification of the optimal control mode by minimizing engine losses is important in the following cases:

- While ensuring a minimum of losses to limit the heating of the engine and expand the area of admissible load torques;
- To analyze the effectiveness of the laws of frequency control according to the criterion of losses in the engine.

The goal in these cases is to ensure reliable operation of the motor, since even a slight repeated excess of the stator winding temperature above the permissible one leads to accelerated aging of the insulation and a reduction in the life of the IM.

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ISSN: 2776-0979, Volume 3, Issue 6, June, 2022

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