ANALYSIS OF EXISTING METHODS FOR SOFT STARTING ELECTRIC DRIVES OF PUMPING UNITS

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Abstract. This article presents a new method for smoothly starting high-voltage and powerful asynchronous electric drives of pump installations in mining enterprises and thermal power plants. For smooth starting of low- and medium-power asynchronous motors, the "Tyristor Voltage Converter-Asynchronous Motor" system is used. For smooth starting of high-voltage and powerful asynchronous motors, a method for starting using combined low-power thyristors was proposed, taking into account the fact that the prices for high-power thyristors are expensive and unreliable.

Keywords: asynchronous motor, frequency converter, starting current, power, voltages, thyristor, smooth starting mode, electric drive, service life, overhaul, microprocessor control.

Annotatsiya. Ushbu maqolada tog ' -kon korxonalari va issiqlik elektr stantsiyalarida nasos qurilmalarining yuqori voltli va kuchli asenkron elektr drayverlarini muammosiz ishga tushirishning yangi usuli keltirilgan. Past va o'rta quvvatli asenkron motorlarni silliq ishga tushirish uchun" tiristor kuchlanish konvertori-asenkron Motor " tizimi qo'llaniladi. Yuqori kuchlanishli va kuchli asenkron motorlarni silliq ishga tushirish uchun yuqori quvvatli tiristorlarning narxi qimmat va ishonchsiz ekanligini hisobga olgan holda, kam quvvatli tiristorlardan foydalanishni boshlash usuli taklif qilindi.

Kalit so'zlar: asenkron dvigatel, chastota konvertori, boshlang'ich oqim, quvvat, kuchlanish, tiristor, silliq boshlash rejimi, elektr haydovchi, xizmat muddati, kapital ta'mirlash, mikroprotsessorni boshqarish.

Аннотация. В данной статье представлен новый способ плавного запуска высоковольтных и мощных асинхронных электроприводов насосных установок на горнодобывающих предприятиях и тепловых электростанциях. Для плавного запуска асинхронных двигателей малой и средней мощности используется система "Тиристорный преобразователь напряжения - асинхронный двигатель". Для плавного пуска высоковольтных и мощных асинхронных двигателей был предложен способ пуска с использованием комбинированных маломощных тиристоров с учетом того, что цены на мощные тиристоры дороги и ненадежны.

Ключевые слова: асинхронный двигатель, преобразователь частоты, пусковой ток, мощность, напряжения, тиристор, режим плавного пуска,

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электропривод, срок службы, капитальный ремонт, микропроцессорное управление.

Introduction

One of the important directions in the development of efficient electricity generation by thermal power plants in the world is to meet the specific needs of the enterprise, paying special attention to the smooth starting of powerful and high-voltage asynchronous electric drives of self-service units in mining enterprises and thermal power plants, reducing the starting current, increasing the service life of electric motors without repair, and conducting scientific research. Research in this area, including reducing the starting current during microprocessor control of powerful high-voltage asynchronous motors in mining enterprises and thermal power plants, and increasing their service life without repair, is a priority. At the same time, one of the urgent tasks is to identify additional opportunities for energy saving based on a comprehensive analysis of electricity consumption in mining enterprises and thermal power plants[4-7]. Soft starting methods for electric drives in pumping units are used to reduce mechanical stress, limit inrush current, and provide smooth acceleration of the pump. This prevents hydraulic shocks, increases equipment lifetime, and improves energy efficiency. Below is an analysis of the most common techniques.

A frequency-regulated electric drive is used in the automated control systems (ACS) of pump installations to bring the pump operating mode into compliance with the operating mode of the serviced liquid supply system, for example, the water supply or sewerage network of a city or industrial enterprise [1-3].

Direct-On-Line (DOL) Start – Baseline for Comparison. Although not a soft-start method, DOL starting is important as a reference point.

Characteristics. Full voltage is applied directly. High starting current (typically 6–8 × rated current). High mechanical and hydraulic shock.

Drawbacks: Strong pressure surges in the pipeline, rapid wear of mechanical parts, not suitable for modern pumping systems.

Autotransformer Starting. This method reduces voltage using an autotransformer.

Advantages: Reduced inrush current, lower mechanical shock compared to DOL.,Simple and reliable.

Limitations

Voltage steps are not continuous; switching may cause torque dips.

Bulky equipment.

Less effective for pumps requiring smooth hydraulic transition.

Star–Delta (Y-Δ) Starting

A common method for induction motors designed for delta connection.

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Advantages

Decreases starting current to about one-third of DOL.

Economical and simple design.

Limitations

Only one reduced-voltage step.

Sudden transition from star to delta creates torque shocks.

Not suitable for pumps requiring gradual speed increase.

The required rotational speed is set depending on many factors. These include: the flow rate of the liquid in the system, its level in the tanks, the values of static and dynamic counterpressure, the number of parallel operating pumps and pump units supplying the liquid to the system, etc. The water drainage of mining enterprises is an important element of the entire complex of mining equipment, and its reliable operation largely determines the continuity and failure-free operation of mining operations for the extraction of minerals. Additionally, automating pumped water drainage systems, applying new technology for smooth start-up, and increasing their energy efficiency [1-3].

With a smooth start, the following tasks are:

- reduction of the starting current;

-increase in torque

As a result of the research, the developed control system for the mine water drainage unit in the industrial use zone of pumps is most effectively regulated by changing the rotational speed of their impellers. Changing the rotational frequency of the pumps' impellers is carried out using the REP, which allows determining the pump control regulations for feed, forming appropriate signals, and consequently, increasing the reliability of the water drainage unit, reducing electricity costs, and also reducing the number of emergency situations during the operation of water drainage units [4-7,10].

Materials and methods

At the water supply pumping station, the D3200-75 type pump delivers water to a height of Np = 36 m, developing it at maximum flow rate Q_b = 1.0 m^3/s, pressure N_b = 60 m, minimum flow rate Qm = 0.5 m^3/s. The pump's operating mode is regulated by throttling with a gate valve on the pressure line. The installation's operating time in the estimated time period (year) is 8760 hours.

We calculate the relative minimum feed rate.

$$\lambda = \frac{Q_м}{Q_б} = \frac{0,5}{1,0} = 0,5 \quad (1)$$

and relative static pressure

$$H_п^* = \frac{H_п}{H_б} = \frac{36}{60} = 0,6 \quad (2)$$

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The relative losses of electrical energy corresponding to these values of λ and H_n* are determined using the calculated curves (Fig. 1.a).

$$w^* = 0{,}182 \qquad (3)$$

We calculate the maximum power consumed by the pump unit using formula (4)

$$N_б = \frac{9{,}81 \times 1 \times 60}{0{,}85} \approx 692{,}5 \text{ кВт} \qquad (4)$$

The electrical energy consumption for exceeding the head in this unit is determined by (5):

$$W_{\sum} = 692{,}5 \cdot 8760 \cdot 0{,}182 = 1104067 \text{ кВт} \qquad (5)$$

Operation of the pump unit exceeding the static component of the head. In a number of pump installations, a change in the dynamic component of the head is observed, but not the static one. It occurs due to fluctuations in the level in the receiving or pressure reservoir of the installation, as well as during fluctuations in the water level in the reservoir from which the pump takes water [1-3].

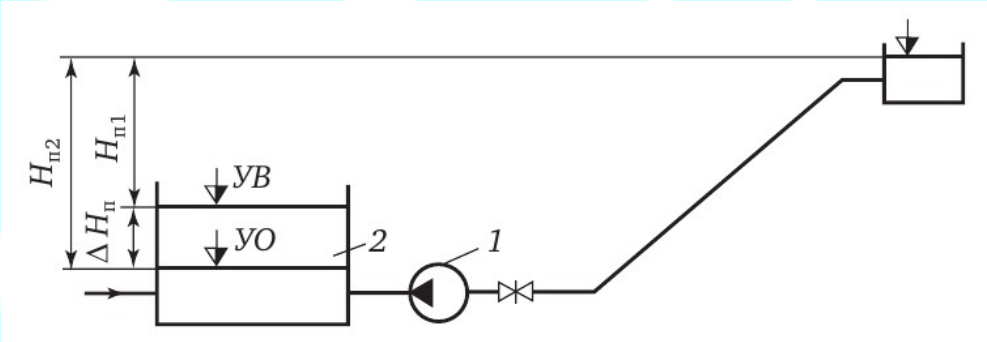


Fig.1. Diagram of a pump unit with variable static pressure: *УВ - pump activation level; УО - pump disconnection level;*

Regulating the operating modes of pump installations can be carried out by changing the number of operating units, changing the hydraulic scheme of the pump installation, throttling the pressure lines, changing the rotational speed of the working wheels of all or individual pumps, and discharging part of the water from the pressure lines into the suction lines. Often, the regulation of pump installations' operating modes is carried out by combining the regulation methods mentioned above [9-10].

Frequency-regulated electric drive (Fig. 2, a). The main element of the frequency converter is the frequency converter, through which practically unchanged network voltage parameters U1 and frequency f1 are converted into changing parameters U2 and f2, required for the pump unit's control system. The rotational speed of the electric motor connected to the converter output changes proportionally to the frequency f2 [1-3].

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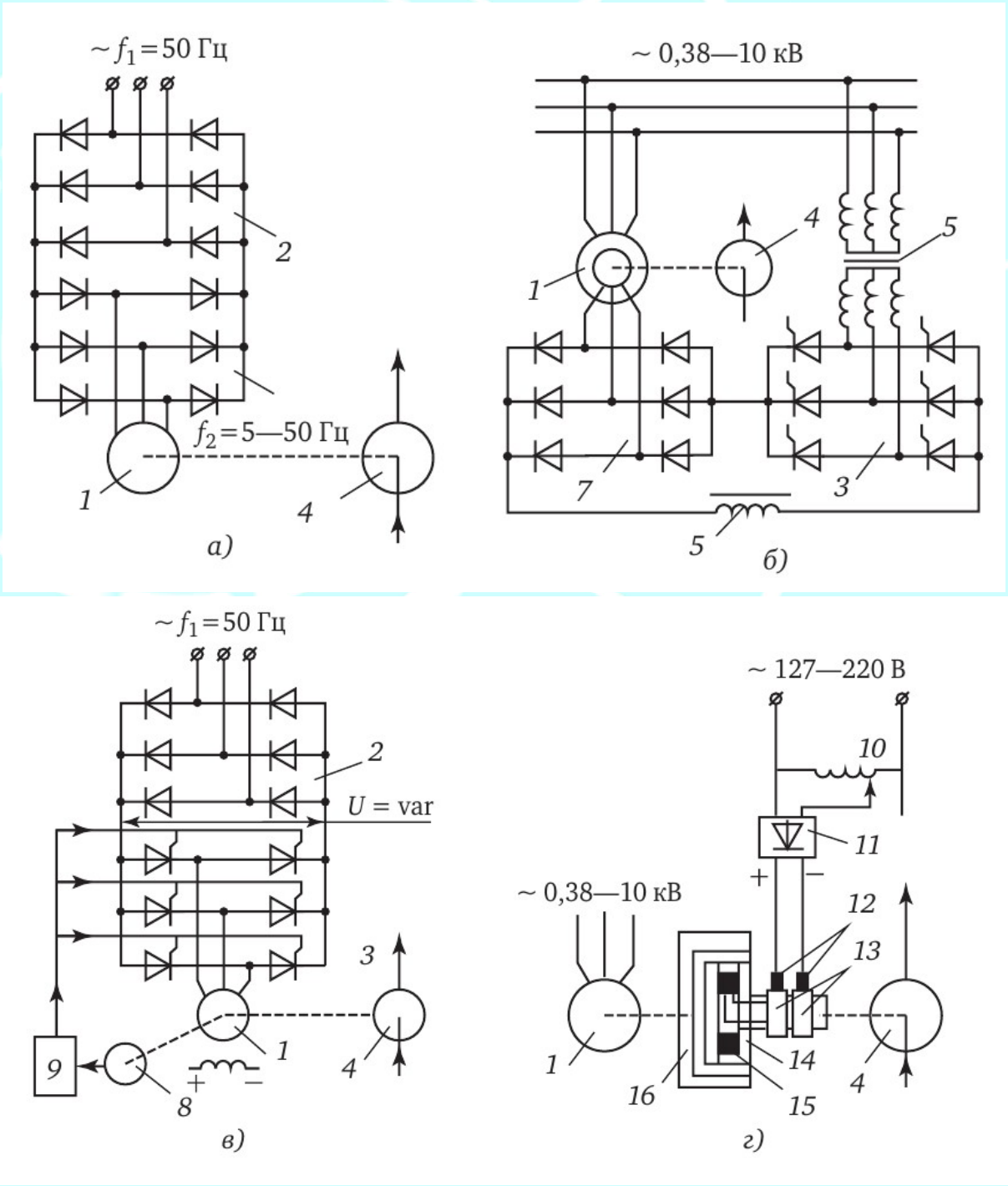


Fig.2. The main types of RES used in pumping units are: *a - frequency; b - asynchronous-valve cascade; c - based on a valve electric motor; d - with an electromagnetic sliding clutch (1 - asynchronous electric motor; 2 - frequency converter controlled rectifier; 3 - inverter; 4 - centrifugal nozzle; 5 - matching transformer; 6 - smoothing throttle; 7 - uncontrolled rectifier; 8 - rotor position sensor in space; 9 - Inverter pulse-phase control system (PPSC); 10 - controlled rheostat; 11 - single-phase rectifier; 12 - brushes; 13 - contact rings; 14 - inductor; 15 - EMC excitation winding; 16 - EMC anchor).*

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For smooth starting of high-voltage high-power "TPN-AD" systems, instead of a single TPN thyristor, it is proposed to use thyristor groups connected in parallel-sequential order, as shown in Figure 3.4.

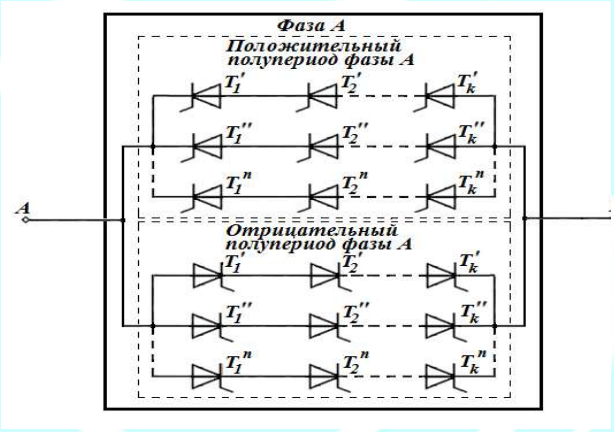


Fig.3.Tyristor groups phases A TPN

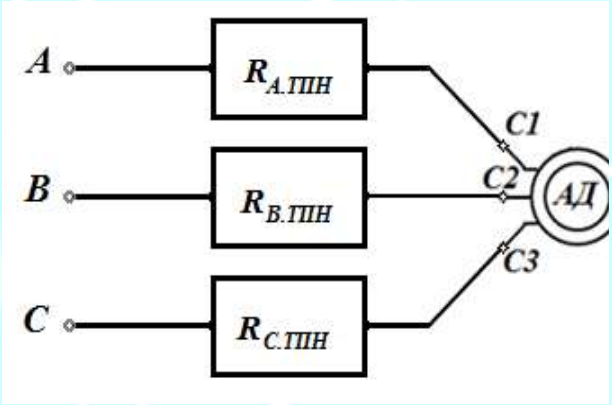


Figure 4. Principal diagram "TPN-AD" model

Analysis of the results of scientific research on the starting modes of asynchronous motors - drives of self-service units in mining enterprises and thermal power plants used in various installations, published in scientific and technical literature, showed that they have a number of significant shortcomings and require further improvement. The conditions for the uninterrupted operation of the commutation of the thyristor groups in the composition of the thyristor voltage converter have been developed. As a result, the simultaneous opening of all thyristors and the duration of thyristor control pulses are no less than the duration of opening each thyristor separately [4-7].

Conclusion

The theoretical conclusions of the study confirm that the advantage of using a group of parallel and sequentially connected thyristors to create a "TPN-AD" system with microprocessor control has been proven. As a result, the starting current of powerful asynchronous motors using the "TPN-AD" microprocessor system is reduced by 2.5 times, and the service life without repair is increased from 6-7 months to 25 months. The use of "TPN-AD" with microprocessor control of the electric drive provides:

• saving 5÷15%, and in some cases up to 30% of electricity

• reduction of wear of hydromechanical and electrical equipment due to a reduction in the number of starts and stops of pumping units;

• reduction of the likelihood of accidents caused by hydraulic impacts due to smooth changes in the operating modes of pumping units. Modern pumping units increasingly rely on thyristor soft starters and variable frequency drives (VFDs) because they provide the best balance of electrical, mechanical, and hydraulic performance.Soft starters are ideal when smooth starting is required without speed

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control.VFDs are preferred when energy saving, flow regulation, and full process control are needed.

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