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Operation of Asynchronous Frequency Controlled Electrical Drives in Energy Efficient Modes

Olimjon TOIROV*, Shokhijakhon ATOEV, Sardor UROKOV

*Doctor of Technical Sciences, Professor, Head of the Department of Electrical machines, Tashkent State Technical University, Tashkent, Uzbekistan and Chief Researcher of Institute of Energy Problems of the Academy of Sciences of the Republic of Uzbekistan
PhD Student of the Department of Electrical machines, Tashkent State Technical University, Tashkent, Uzbekistan
PhD Student of the Department of Electrical machines, Tashkent State Technical University, Tashkent, Uzbekistan

ABSTRACT: In this article, considering the fact that the most reliable way to achieve electrical energy efficiency depends on the development of ways to prevent energy inefficient consumption, the study of the energy consumption of the asynchronous frequency electric drive, which is the basis of modern production for industrial and consumer electric power, and the technical aspects of energy inefficient consumption you can familiarize yourself with the analysis of the control system, the asynchronous electric drive control system developed and simulated in operation. In this, the stability of the considered electric drive is greatly affected by the value of the angle, you can get acquainted with the conveniences of the speed adjustment mechanisms in the fast control system.

KEY WORDS: power supply, electric drive, asynchronous frequency controlled electric drives, energy consumption, energy efficiency, frequency control, technological loading, control software.

I. INTRODUCTION

Relevance of the topic. In developing countries, including in Uzbekistan, petrochemistry, metallurgy, construction, mining, and production are increasing day by day, and energy consumption is increasing. We know that our main energy sources are gas, water, oil, coal, and solar energy (heliotechnics, heliophysics). If we look at today's statistics, the consumption of electricity alone is equal to 120-150 kW/h per 1 square meter per year on the world scale, and in our country this figure is 400 kW/h. 40% of the electricity consumption is for residential sources and 60% for the industrial zone [1,2].

Similarly, the consumption of gas and oil products in the last 5 years, no matter how much the production volume increases, the consumption indicator is growing more rapidly. Such statistics are a problem of resource scarcity, the whole world energy crisis. It cannot be said to be good compared to the past period. As the demand for energy increases, creating new sources of its production, creating mechanisms for coordinating the efficiency of energy consumption is a more urgent and important issue in the energy economy. In turn, this process causes economic pressure on the energy production industry. At the same time, environmental standards impose another important requirement on them. Today, one of the most common types of industrial mechanisms are turbomechanisms (compressors, blowers, exhaust devices, etc.). The electric drive (ED) of these mechanisms based on an asynchronous squirrel-cage motor (IM) is largely unregulated, which is still the cause of energy inefficiency and its energy consumption in industry, share is 20-25% [2-4].

Due to the high power rating of the system, most asynchronous power turbomachines (TM) have difficult direct starting conditions, which require scheduled stops of the process equipment, during which time they are forced to stop the work process. It is not possible to reduce the consumption of electricity with the reduction of unregulated ET TM process loads. These characteristics of TM operation are the cause of excessive energy consumption.

The transition to soft start and speed control systems leads to longer service life of TMs and their drive motors, as well as energy savings of up to 30-40% in most cases. In order to save energy, modern two-link frequency converters have been developed in fully controlled switches. However, during their use, their maintenance costs will increase even more [5-9].

II. LITERATURE ANALYSIS ON THE TOPIC SURFACE

Due to the constant increase in the price of electricity, the increase in the cost of power lines during the expansion of the new manufacturing industry, the mining industry, and the emergence of the tendency to switch to autonomous power supply sources for the technological devices of the gas industry, it will be economically economical. Also, the use of asynchronous frequency-controlled electric drives provides many conveniences from a technical point of view.

The working principles of the electric drive were developed in the early 30s of the last century. A lot of work has been devoted to the development and research of AChEH with a classical system of joint or separate management. Among them are G. G. Jemerov and G.V. Grabovetsky. However, the widespread adoption of LPFCs has been hindered by the limited range of frequency regulation of the output voltage from 0 to 25 Hz at a grid frequency of 50 Hz. The LPFC regulation range expansion algorithm is possible by introducing a control system with a new structure based on modern high-performance microcontrollers, based on the principle of software formation of the defined frequency steps of the LPFC. In this case, it is recommended to abandon complex functional units such as a separate control device, a block for generating control voltage, and switch to direct digital control of thyristors.

- In this regard, the comprehensive solution of the problems of the frequency-controlled electric drive according to the AFCD Scheme is relevant.
- AFCD, which allows both energy-saving modes of ET TM and multi-step frequency triggering due to stepwise regulation of IM speed.
- Development and introduction of a new structure of the management system. Of these mechanisms.
- Development of algorithm for software formation of fixed frequency steps of output voltage of LPFC.
- Development of an EC model reflecting electromagnetic and electromechanical processes occurring in the AChEH system in both dynamic and static operating modes.
- Study of AFCD in terms of flow pressure and supply chain impact.
- Development of hardware and software for technical diagnostics of faults in the AFCD system.

III. METHODOLOGY

For the theoretical studies we have used: the theory of electric machines, alternating current electricity, the theory of object-oriented and structured programming, as well as technical diagnostics.

Scientific innovation: A model of the LPCH-IM system for computers designed to study both dynamic and static operating modes of the electric drive, as well as to search for and debug new LPCh control algorithms that expand the functionality of the electric drive**,** has been developed.

IV. RESULT AND DISCUSSION

The significance of the frequency-controlled electric drive is not only economical for converting electrical energy into mechanical energy, but also an effective means of technological process control, including in closed-loop automatic control systems as part of various automated process control systems.

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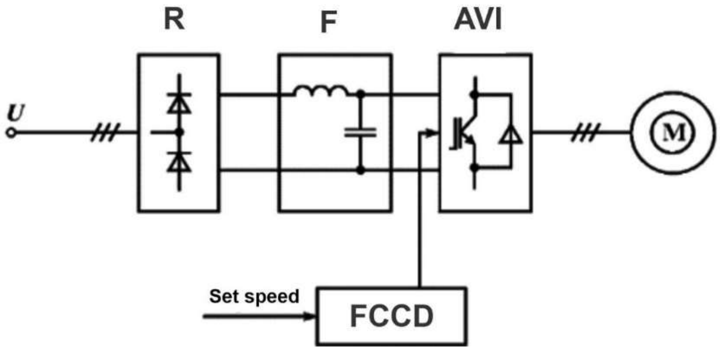

Fig. 1. The structure of an asynchronous frequency electric drive

R – Rectifier; F – Filter; AVI - Autonomous IGBT voltage inverter; FCCD - Frequency converter control device; M – an engine.

The effectiveness of using frequency-controlled electric drives depends on the following: High energy efficiency •Flexible adjustment system of electric drive parameters and operating modes through software. Developed interface and adaptation to various management and automation systems, including high-level ones; Simplicity and ease of management and maintenance High static and dynamic properties that ensure high performance of controlled machines Optimum in terms of energy performance and adjustment and mechanical properties Modern frequency-controlled electric drive structure with an asynchronous squirrel-cage motor Intermediate direct current includes an FC with a generator. An autonomous voltage inverter built on an inductive capacitive DC filter and IGBT power transistors. The inverter generates the fundamental harmonic of the output voltage of the inverter using the PWM method [5-6].

The power part of the adjustable electric drive based on this structure has the following advantages:

- wide range of speed control (D = 30-60);
- high efficiency (except for the engine, it reaches 0.98);
- high power factor (up to 0.98);
- high reliability and small size of the converter.

It is easier to ensure the electromagnetic compatibility of the electric drive with the power source and other consumers of electric energy. When adjusting the speed of the electric drive, the frequency and voltage at the output of the inverter will change in accordance with the required ratio. By changing the frequency, the rotation speed of the motor rotor can be smoothly adjusted over a wide range. In this case, at a certain load value, the slip of the asynchronous motor changes imperceptibly during regulation, and therefore the losses in the rotor circuit proportional to the slip also change significantly, which ensures energy savings. Currently, the production of frequency-controlled electric drives is carried out by dozens of different companies in many countries is being implemented (Fig. 2).

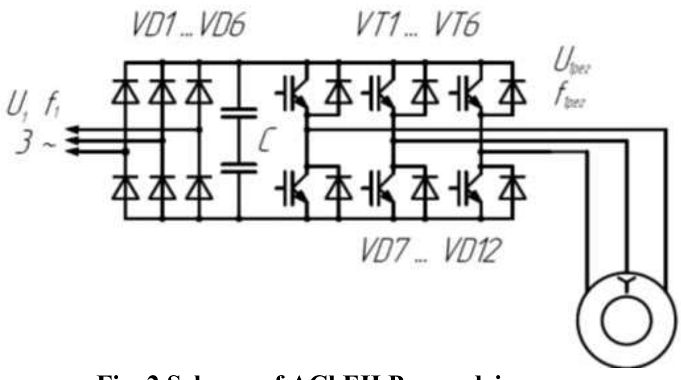

Fig. 2 Scheme of AChEH Power drives

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Despite the fact that inverters of different companies differ in the types of power semiconductor devices used, their design, and types of protection, it is necessary to emphasize the general principles of construction of modern frequency-controlled electric drives. We will pay attention to some of them [7-9].

1. Power section - frequency converter consists of an IGBT or IGCT inverter with a rectifier, a DC filter and a brake module in the DC link. At the input of the inverter, the input filter block can be turned on to reduce the level of radio noise (spread through the conducting wires), limit the overvoltage at the drive motor terminals and protect its winding insulation from deterioration and rapid failure, and the output filter block is turned on at the motor terminals.

2. The control system is based on a microprocessor, which generates the inverter control signals according to the algorithm, which allows the maximum use of the source voltage with minimal distortion of the output voltage waveform. The principle of operation of the frequency converter is often called an inverter: the control system voltage of the production line is rectified by a block of rectifier diodes and filtered from a large capacitor through a battery to reduce the resulting voltage fluctuations. This voltage bridge, six IGT or MOSFET transistors, with antifouling diodes, protects the transistors from working in the motor windings. In addition, the diagram sometimes contains a transistor with a power circuit "Gedns" - a high-power resistance of the dispersion. This circuit is used to recharge and de-energize the motor voltage and safety capacitors in braking mode.

The principle of frequency control of the speed of an induction motor is to change the frequency of the supply voltage F1 according to the formula:

$$\varpi_0 = \frac{2\pi * f_1}{p}$$

A constant number of poles p pairs of poles change the angular velocity of the stator magnetic field. This method provides uniform speed regulation over a wide range and has high stiffness with mechanical properties.

The speed control does not involve the increase of the induction motor, so there is less power loss during adjustment. To obtain high energy performance of induction motor-to-power ratios, efficiency, overload capacity, and voltage must be varied simultaneously. The alternating voltage law depends on the nature of the MC load. MC \ u003d CEST must be adjusted at a constant point proportional to the stator frequency:

$$\frac{U_1}{f_1} = const$$

The following situation is typical for the load fan:

$$\frac{U_1}{f_1^2} = const$$

Speed during loading is inversely proportional to:

$$\frac{U_1}{\sqrt{f_1}} = const$$

Thus, to continuously control the speed of the asynchronous motor shaft, the frequency converter must provide the same frequency and voltage to the computer winding of the asynchronous frequency electric drive.

Advantages of using an adjustable electric drive in technological processes

The ease of setting up the system, the use of an electric drive provides energy savings and allows you to get new quality systems and equipment. Energy saving is ensured by adjusting any technological parameters. If it is a conveyor or a conveyor, you can adjust its speed. If it is a pump or ventilation, the pressure can be maintained or the operation can be adjusted.

The special cost-effectiveness of using asynchronous electric drives with gas provides frequency control in facilities that provide fluid transportation. Until now, the most common way to regulate the operation of such objects is the use of valves or control valves, but today there is a frequency control of an induction motor such as a pump block or a GR. When using variable speed drives, flat speed control often avoids gearboxes, options, structures, and other adjustable equipment. When connected through a frequency converter, the motor starts continuously without currents and shocks, which reduces the load on the motor and mechanisms, thus ensuring a long service life of the equipment.

V. CONCLUSION

A practical study of AChEH asynchronous frequency-controlled electric drives for power supply systems developed with built-in SD allows us to draw the following conclusions:
Circuit solutions developed for the control and diagnostic system of asynchronous frequency-controlled electric drives can be used for any power supply.

A new method of formalization of complex algorithms involving periodically repeating operations using cyclic sequences is proposed. The ease of use of T-cyclic sequences is represented by the simplicity of software synthesis, the simplicity of its debugging, and the reduction of performance requirements for MC. The implementation of MK software of the control system of Asynchronous frequency-controlled electric drives according to the proposed new method of using algorithms using cyclic sequences showed the performance of the algorithms implemented in this way.

In embedded system diagnostics, Asynchronous frequency-controlled electric drives allow to reduce the time spent on searching for possible faults, thereby increasing the level of maintenance of the Power Supply.

The distribution of the complex functions of the control system between 4 microcontrollers and the functions of the built-in diagnostic system between 3 microcontrollers made it possible to build the information part of the control system on the basis of common and relatively inexpensive microcontrollers.

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