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Use of a Dc Wind Generator to Power the Excitation System of Autonomous Synchronous Machines

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Abstract: This article is devoted to the use of wind generator as a source of direct current to power the excitation system of autonomous synchronous machines. Synchronous motor is a converter of alternating current electrical energy entering the stator winding and direct current electrical energy entering the rotor winding into mechanical energy. There are basically two types of supply of the synchronous motor excitation system with direct current static, where the current is drawn from the motor stator and independent, where the source of direct current is a battery or DC generator. For stationary machines in mining enterprises, mainly synchronous motors are used, where it is possible to use a DC wind generator as a source to power the field winding of synchronous motors.

Keywords: Winding, system, wind generator, source, battery, direct current, power, voltage, wind energy, rotation, harmonics, power quality, electromagnet, excitation, speed, frequency, synchronous motor, machine, source, electrical energy.

INTRODUCTION

A synchronous machine is one of the most common types of energy converters. In synchronous machines, the field winding is fed with direct current from various energy converters. The electric machine excitation system from an auxiliary DC generator, which converts mechanical energy into electrical energy. The power spent on excitation is from 0.2 to 5% of the useful power of the synchronous machine [1].

A wind turbine converts wind energy into electrical energy. Structurally, these units convert the kinetic energy of the wind, due to the installed rotor, into mechanical energy, which is then converted into electrical energy. Typical wind generator power ranges from 5 kW to 4500 kW, but it is also possible to generate a minimum wind energy of 4 m/s. In order to limit the rotor

speed at high wind speeds, wind turbine generators are fitted with special installations for normal operation of the generator. According to the location of the axis of rotation of the wind wheel, wind generators are divided into horizontal, vertical and inclined axes of rotation. With a horizontal axis of rotation, the axis coincides with the direction of air flow. Such installations include both ancient mills and most modern units [2].

METHODOLOGY

Excitation of synchronous motors of medium and large power is carried out by electromagnetic action, synchronous motors of small power from a permanent magnet. Electromagnetic excitation is carried out by two methods first, where a special DC generator is used, the second electromagnetic influence is carried out by self-excitation from the stator winding, in connection with its main purpose this device is called exciter. It is worth noting that the excitation system is also divided into two types according to the method of influence - direct and indirect. The direct method of excitation implies that the shaft of the synchronous machine is directly connected mechanically to the rotor of the exciter. The indirect method implies that to make the rotor rotate another motor is used, for example, an asynchronous electric machine, the so-called electro-machine [3].

As mentioned above, the principle of operation of a synchronous machine is that the field winding is supplied with direct current. The stationary machines of mining companies, such as compressors, pumps and wind turbines, are mainly driven in rotation by synchronous motors located in open spaces where the wind speed allows the generation of electricity, which can be used as a source to power the field winding.

Wind generators should be installed in places that are as open to the wind as possible. Uplands, coastal areas, steppes and open spaces away from buildings are most suitable. Do not locate a wind farm where there are even low trees nearby. Wind turbines do not emit waste into the environment, and are more accessible and affordable. In addition, the wind blows both day and night [4].

The quality of electrical energy depends on many parameters. The quality of direct current produced by a wind generator depends on the wind speed. The transistor regulator of Fig. 1 is a regulator of direct current and, consequently, of magnetic flux of the excitation system of a synchronous motor.

Harmonic distortion can affect the stability of the power supply and the quality of power in the network. This can lead to problems with equipment connected to the grid, including motor windings and transformers, which can lead to breakdown to the case or insulation failure.

Thus, harmonics are an important parameter affecting the quality of electrical power. They can affect the operation of various equipment, including wind generators and synchronous motors. Therefore, to ensure reliable operation of such equipment, it is necessary to take into account harmonic distortions and take measures to eliminate or minimize them[5].

RESEARCH RESULTS

In the proposed variant the power supply of the winding excitation of synchronous motor of stationary machines of mining production is carried out at the expense of electromagnetic influence, which is obtained from a mini DC wind generator installed on the roof of the building or hilly terrain in the vicinity of stationary machines [5].

Fig.1 shows the scheme of supplying the field winding of synchronous machines from a wind turbine, the operation of the scheme is carried out as follows: the stator winding 1 is supplied with alternating three-phase voltage, wind turbine 5 generates DC electrical energy which supplies the field winding 2 synchronous motor, microcontroller 6 controls the charge and discharge of the battery, transistor regulator 3 serves to regulate the field current [6].

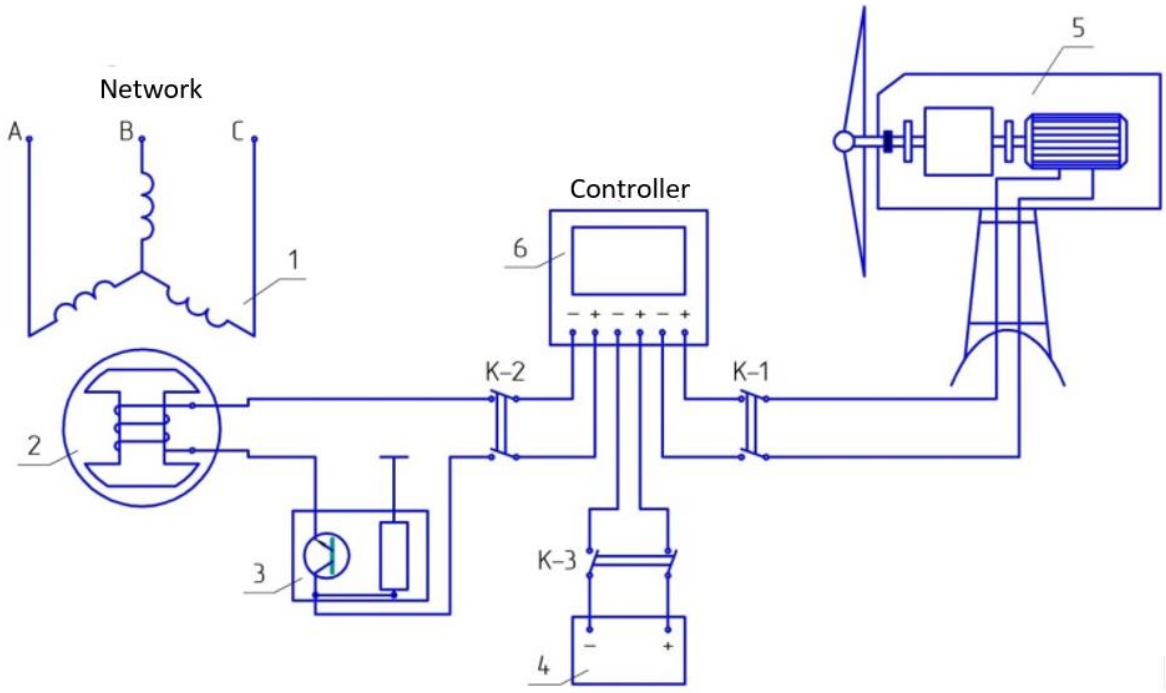

Fig.1. Electrical principle excitation system of synchronous machines with application of wind generator: 1- stator winding of synchronous motor; 2- rotor (excitation) winding of synchronous motor; 3- regulating rheostat; 4- accumulator; 5- DC wind generator; 6-microcontroller.

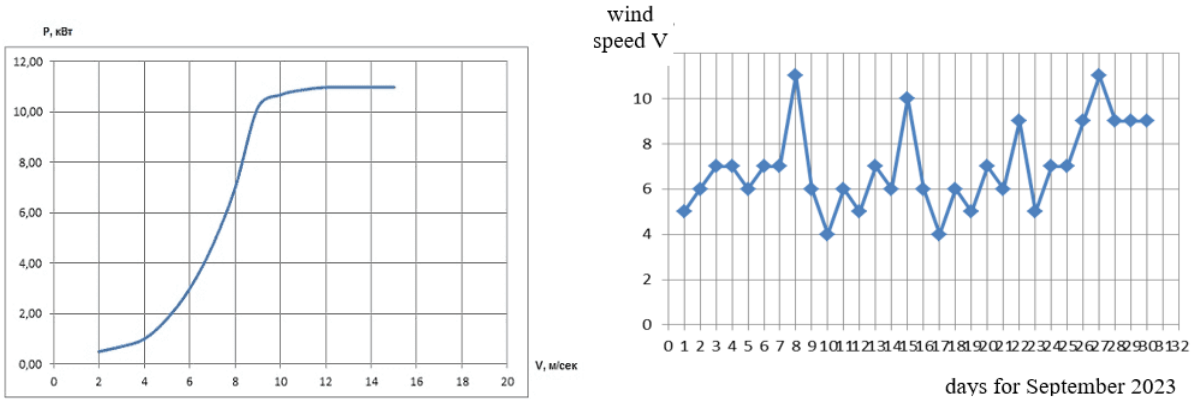

Fig. 2. Graph of wind generator power dependence on wind speed and graph of wind speed for one period of the investigated object

Fig.2 shows the graph of wind generator power dependence on wind speed and the graph of wind speed for one period. The object of study in this paper is a synchronous motor of a mine compressor station. The compressor station is located in a special building, where three compressors are used, of which two are working around the clock and one in reserve. The compressors are driven by synchronous motors. Power of compressor motors P_n = 200 kW, voltage U_n = 380 V, excitation voltage U_v = 33 V, excitation current I_v = 150 A. The required DC power to supply the excitation system of the compressor synchronous motor is P_v = 5 kW. Wind speed, where mine compressor units are operated, is on average 7-8 m/s [7].

At the present time in the object under study in the operation of synchronous motors of mine compressors, the excitation system is powered by solid-state thyristor converters, where the power required to power the excitation system is drawn from the stator winding [8].

Taking into account the fact that the wind speed is not constant for stable operation of the generator, a transistorized excitation voltage regulator is installed in the scheme of Fig. 1.

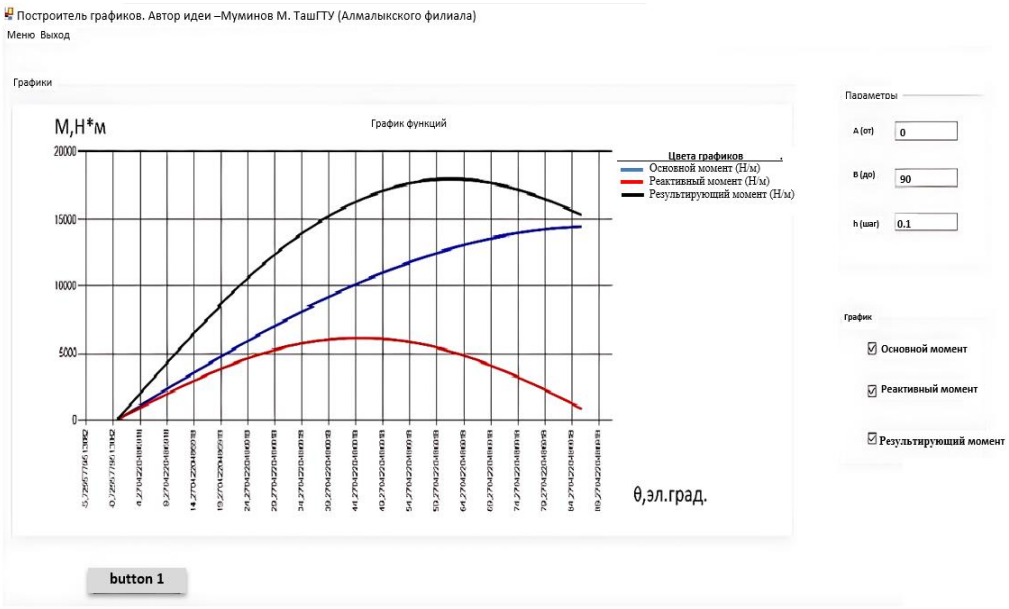

Figure 3. Angular characteristic of synchronous motor shaft compressor unit

Fig.3 shows the angular characteristic of the synchronous motor of the mine compressor plant with excitation from the DC wind generator, defining the curve of dependence of the motor torque on the "y" axis on the load angle on the "x" axis. The power of the synchronous machine P depends on the load angle θ. In order to study the important properties of synchronous motor with wind generator excitation, a mathematical model has been developed and the resulting angular response has been obtained. DC generators with permanent magnet excitation are used as a DC generator for wind installation [9].

DISCUSSION OF THE RESULTS

In the recommended variant the synchronous motor of the compressor is excited by electromagnetic influence. The excitation winding receives electromagnetic influence from a DC wind generator installed on the roof of the compressor station. The compressor station building is located near the shaft yard of the mine. The use of a permanent magnet DC wind generator as an exciter is recommended for stand-alone synchronous motors of small and medium power. Thus, the use of a DC wind generator as an exciter for synchronous drives is recommended for autonomous synchronous machines operated in conditions where the average wind speed will be able to ensure uninterrupted operation of the wind generator. When using a DC wind generator as a source for the excitation system of synchronous motors, it is possible to save electricity used to power the excitation winding, which is on average 3% of the useful power of the synchronous motor.

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