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Characteristics of synchronous generators of autonomous power plants excited from alternative energy sources

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ABSTRACT:This article discusses the use of alternative energy sources for the excitation of synchronous generators of autonomous power plants. Autonomous power plants include mini hydro plants, wind generators, diesel power plants, car generators, aircraft generators, etc. The synchronous generators of these units are excited from batteries, from semiconductor rectifiers, or from other DC generators.

KEYWORDS:Synchronization, excitation, source, generator, alternatives, power, voltage, electrical engineering, solar energy, wind energy, characteristic, regulation, electricity, solar battery, thermogenerator, wind generator, installation, current, voltage, power, engine, contact, installation.

I. INTRODUCTION

Current global trends in the development of electrical engineering are: increasing the reliability of energy supply to consumers, reducing the cost of generating electricity and, therefore, reducing its cost, using environmentally friendly primary sources. Energy shortages today are one of the main constraints to the development of the economy .A synchronous machine is called such an alternating current machine, the speed of which in steady state is equal to synchronous and does not depend on the load. The scope of synchronous machines is very wide synchronous generators - as sources of electrical energy of alternating current in thermal, nuclear and hydroelectric power plants, as well as low-power autonomous sources of electricity. Synchronous motors - in installations that do not require speed control, with a power of 100 kW and above, pumps, fans, compressors, etc., in automation circuits and household appliances synchronous motors with permanent magnets, induction, hysteresis, step.

The stator of a synchronous machine is also designed as asynchronous: a three-phase winding is located in the grooves of the stator core.
The rotor winding is powered by an external DC source through slip rings and brushes and is called an excitation winding. Currently, there is the following type of excitation of the rotor winding of synchronous electrical machines where a direct current generator is used as an exciter with thyristor, transistor, diode, semiconductor rectifiers.In our system, the rotor of a synchronous machine is powered by solar panels, a thermoelectric generator, and a wind by a direct current generator.

II. SIGNIFICANCE OF SYSTEM

The rotor winding is powered by an external DC source through slip rings and brushes and is called an excitation winding. It creates in the synchronous machine the main magnetic flux Φ_0.There are two rotor designs: explicit pole and implicit pole. When the rotor rotates with a frequency n1, the flux Φ_0 induces variables in the stator windings EMF with a frequency $f_1 = p\ n_1 / 60$.When a load is connected to the stator winding, a current arises in it, which creates a rotating magnetic field with a frequency $n_1 = 60f_1 / p$. Thus, the rotor rotates with the same frequency as the magnetic field of the stator. Therefore, the machine is called synchronous. In synchronous machines, the stator winding, in which EMF occurs and the load current passes, is called the armature winding. The part of the machine on which the field coil is located is called an inductor.In synchronous machines, the inductor is the rotor.The interaction of the rotating magnetic field of the stator with the main magnetic flux Φ_0 creates an electromagnetic moment *M*, which, when the synchronous machine is operated by the generator, is a braking moment, and when the engine is rotational.

Figure-1 shows the simplest circuit of a synchronous machine, the letters A, B, C indicate the stator winding of the machine N, S of the pole of the rotor winding. The main value of the system is the use of alternative sources of

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electricity to excite the rotors of synchronous machines of small and medium power autonomous power plants. As alternative energy installations, use a solar battery, a thermoelectric generator and a direct current wind generator.

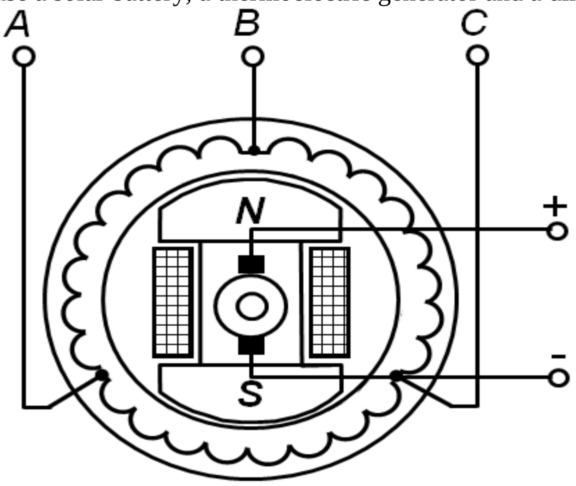

Figure 1.Scheme of a synchronous machine.

III. LITERATURE SURVEY

Excitation of synchronous machines can be due to electromagnetic effects or a permanent magnet. In the case of electromagnetic excitation, a special DC generator is used, which feeds the winding, in connection with its main function, this device is called the pathogen. It should be noted that the excitation system is also divided into two types according to the method of exposure - direct and indirect. The direct excitation method implies that the shaft of a synchronous machine is directly mechanically connected to the exciter rotor. The indirect method assumes that in order to make the rotor rotate, another engine is used, for example an asynchronous electric machine.

IV. METHODOLOGY

The scientific novelty lies in the fact that the theoretical concepts of the methodology for the analysis of low and medium power electric generators of their parametric synthesis are developed and deepened in the work; new methods of excitation of autonomous synchronous machines using alternative energy sources are proposed.Unlike large energy, which requires significant investments to increase its capacities, small energy is able to supply direct consumers with electricity in a short time, solving the problem with relatively low capital costs. An important place in the development strategy of small electric power industry is occupied by autonomous synchronous generators. Autonomous synchronous generators are systems for generating electric energy, which are usually not connected to centralized power supply systems. To stationary autonomous synchronous generators can be attributed autonomous power plants of small and medium power, including those using renewable wind energy, micro hydroelectric power stations, generators with micro turbines and internal combustion engines.

A separate class of autonomous synchronous generator is electric vehicle generators. The energy saturation of modern vehicles is growing exponentially. Especially this trend can be traced in a special technique. Armored vehicles need powerful, compact and highly reliable sources of electricity. Similar requirements are also imposed on generator sets of special equipment of the Ministry of Emergencies and other emergency services. Generators and starter-generator aircraft should be allocated in a separate group of autonomous synchronous generators.

Electric start systems for ground-based gas turbine engines require economical, energy-efficient electromechanical converters, which are close to autonomous generator sets in their structure, principle of operation, and a number of unresolved scientific and technical problems. The main element of any autonomous synchronous generators is an electromechanical converter operating in the generator mode. Autonomous synchronous generators must satisfy a wide range of requirements, including high reliability, energy efficiency, low overall dimensions and operating costs. One of the most promising directions for solving this important scientific and technical problem is the improvement of contactless electromechanical converters based on synchronous machines of small and medium power.To improve the excitation system of synchronous machines using alternative sources of electricity.

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Figure-2 the proposed method of excitation of synchronous machines by a thermoelectric generator, the method of synchronous machines can be introduced to production facilities where heat carriers are used, electric furnaces, the external heat generated reaches several hundred degrees, settles.
Figure-3 the proposed method for the excitation of synchronous machines by a direct current wind generator can be implemented for synchronous machines operated in an open space where the wind speed allows the operation of a wind generator.

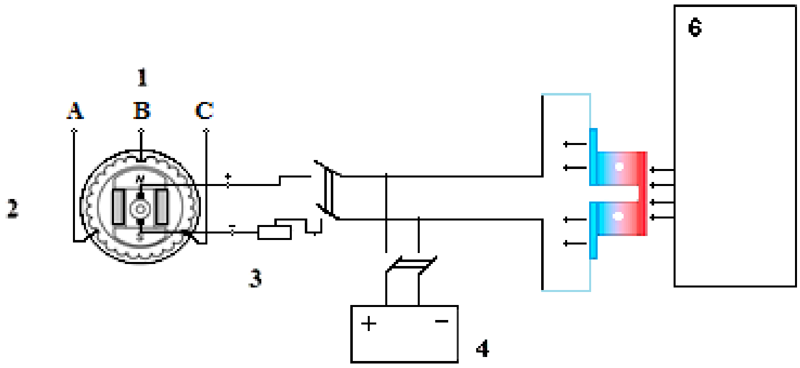

Fig. 2. Excitation of synchronous machines by a thermoelectric generator

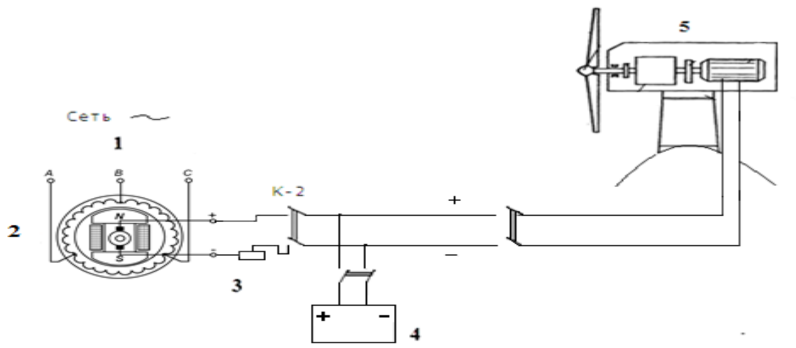

Fig. 3. Excitation of synchronous machines from a solar battery.

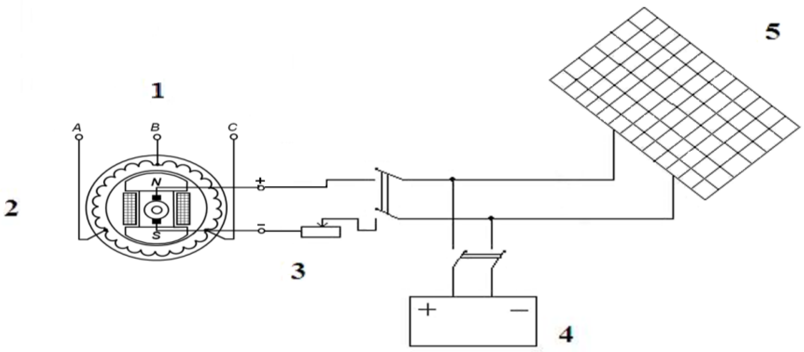

Fig. 4.Excitations of synchronous machines by a solar battery.

Figure-4, the proposed method of exciting synchronous machines with a solar battery can be implemented in any conditions where the radiant energy of the sun in the daytime is achievable.

IV. EXPEREMENTAL RESULTS.

According to the results of the study, an experiment was performed under laboratory conditions of excitation of the G-273A automatic synchronous generator with a power of 1 kW, a linear voltage of 28 volts, a nominal current of 30 amperes and an excitation voltage of 12 volts. To excitement used solar battery. The operation of the synchronous generator G-273A when idling by excitation from a solar battery.

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When idling, the stator current $I = 0$ and the magnetic flux Φ_0 is created only by the excitation winding and is directed along the axis of the poles of the rotor. When the rotor rotates, the flux Φ_0 induces an EMF in the stator winding

$$E_0=4.44\, f_1 w_1 k_{об\,1} \Phi_0.$$

Idling characteristic $E_0 = f\,(I_B)$ at $I = 0$ and $n_1 = const$.

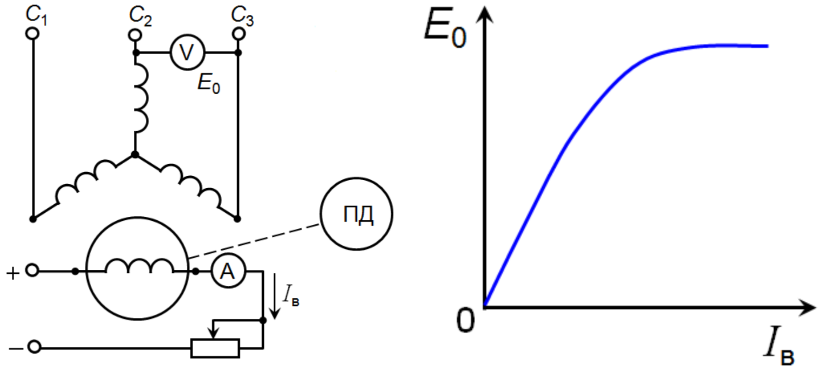

Fig. 5. Idling characteristic of the synchronous generator G-273A

External characteristic at $U_1 = f\,(I_1)$ at $I_B = const$, $\cos\varphi_1 = const$ and $n_1 = const$

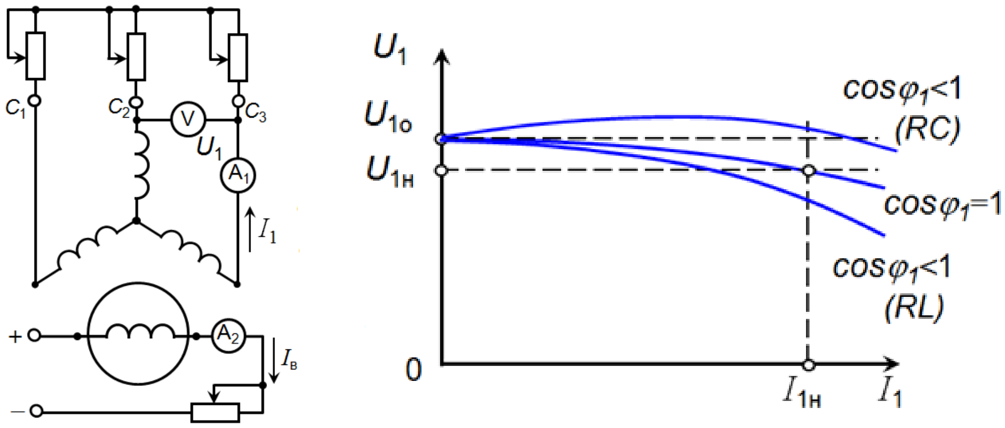

Fig. 6.External characteristic of the synchronous generator G-273A.

The relative change in voltage of the generator at rated current is called the nominal change in voltage.

$$\Delta U_H = \frac{U_{1o} - U_{1H}}{U_{1H}} \cdot 100\%$$

Adjustment characteristic of a synchronous generator.

The control characteristic shows how the generator excitation current should change (be adjusted) when the load changes, so that the voltage at the generator terminals remains unchanged at the nominal value.

Adjusting characteristic:

$$I_B=f(I_1).\ \text{with} U_1= U_{1н} = const,\ \cos\varphi_1= const \text{and} n_1=const.$$

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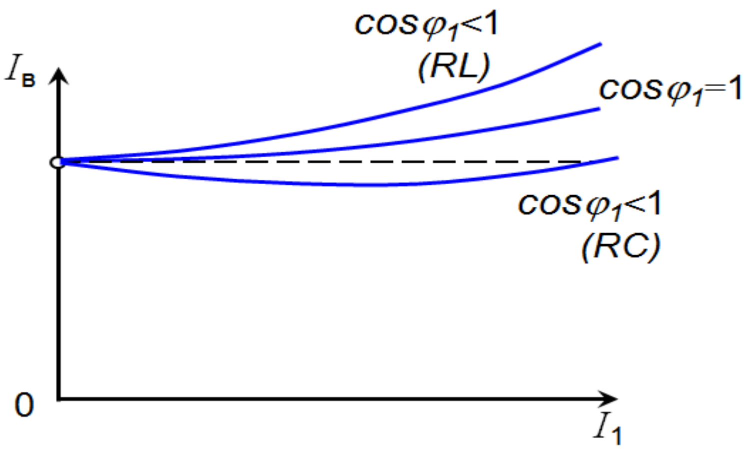

Fig. 7.Adjustment characteristic of the G-273A synchronous generator.

According to the experimental data of the laboratory installation, collected at the Department of Electrical Engineering and Electromechanics of the Almalyk branch of Tashkent State Technical University to study the synchronous generator of the G-273A truck when excited by a solar battery, the following characteristics were obtained:
Figure 5.Idling characteristic of the synchronous generator G-273A.
Figure 6.External characteristic of the synchronous generator G-273A.
Figure 7.Adjusting characteristic of the synchronous generator G-273A.

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