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Excitations of synchronous machines of small and medium fractions by a thermal generator

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ABSTRACT: This article discusses a new method of excitation of synchronous machines. Nowadays power installations, which are heat carriers are operated in industrial enterprises. The goal of a heat generator is to convert thermal energy into electrical energy and use it as a source for exciting synchronous machines.

KEY WORDS: Thermo-generator, direct current, exciter, machine, synchronous, electromagnet, thermal energy, coolant, rheost, electric, current, voltage, power, battery.

I. INTRODUCTION

All electrical engineers are aware that the 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 has taken the name of "the exciter". It is worth noting 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 connected directly by mechanical method 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.

II. SIGNIFICANCE OF SYSTEM

There are many power installations in which, according to the technological regime, the thermal energy released in the housing is not used in industrial enterprises. A heat generator is a converter of thermal energy into electrical energy. At present, some industrial enterprises use a thermal generator as a source for low-power LED lighting systems. The task is the direct conversion of thermal energy into electrical energy and the use of this electricity as a source for the excitation systems of synchronous machines of small and medium power.

As you know, on the windings of synchronous machines you need to constantly supply current. This invention uses a constant current source for excitation winding, while the inclusion of both contacts, the thermal generator charges the battery. In cases of a decrease in the power of the thermal generator, the excitation system is powered by a battery.

2.1. Types of thermoelectric generators in use:

• Fuel: heat from burning fuel (natural gas, oil, coal) and heat from burning pyrotechnic compositions (checkers).
• Radioisotope: heat from the decay of isotopes (decay is not controlled and the work is determined by the half-life).
• Nuclear: the heat of an atomic reactor (uranium-233, uranium-235, plutonium-238, thorium), as a rule, here a thermoelectric generator is the second and third stage of conversion.
• Solar: heat from solar collectors (mirrors, lenses, heat pipes).
• Utilization: Heat from any sources emitting waste heat (exhaust and furnace gases, etc.).

In power engineering equipment, the chemical, metallurgical, mining, concentration, industry, thermal and nuclear power facilities temperature reaches from 100 ° C up to several 1000 ° C.

Operating temperatures: The widest possible temperature range is desirable for using high potential heat and, consequently, increasing the converted heat power.

2.2. Ways to develop and increase efficiency

• Effective thermoelectric material: conversion efficiency, thermo-EMF, ductility, thin-film design.
• Efficient and compatible with the heat exchanger liquid metal coolant.
• Expanding the use of high-quality ceramics in the design of TEG.

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• Unification of units adapted for different applications.
• Ultimate increase in energy density of TEGs to the level of automobile and aircraft engines and higher.
The proposed options the thermo generator serves as a constant current source for the excitation system of synchronous machines.

III. METHODOLOGY

For thermoelectric generators, semiconductor thermoelectric materials are used that provide the highest coefficient of conversion of heat into electricity. The list of substances having thermoelectric properties is quite large (thousands of alloys and compounds), but only a few of them can be used to convert thermal energy. Modern science is constantly looking for new and new semiconductor compositions and progress in this area is provided not so much by theory as by practice, due to the complexity of the physical processes occurring in thermoelectric materials. It can definitely be said that today there is no thermoelectric material that fully satisfies the industry with its properties, and the main tool in creating such a material is experiment. The most important properties of a semiconductor material for thermoelectric generators are:
• Efficiency: The highest possible efficiency is desirable;
• Manufacturability: Possibility of any kind of processing;
• Cost: It is desirable that there are fewer or fewer rare elements in the composition, a sufficient raw material base (to expand the areas of assimilation and accessibility);
• Thermo-EMF coefficient: The highest possible thermo-EMF coefficient is desirable (to simplify the design);
Toxicity: The absence or low content of toxic elements (for example: lead, bismuth, tellurium, selenium) or their inert state (in the composition of the alloys) is desirable.

IV. EXPEREMENTAL RESULTS

Description of the proposed circuit on the excitation windings of a synchronous machine from the thermo generator is supplied with direct current that feeds the excitation winding, the thermo generator is the pathogen. At the same time, the thermo generator charges the battery which serves as a backup source of the field winding. The excitation current of synchronous machines is regulated by a resistor.
The figure shows the installation scheme of the excitation of synchronous machines using a thermal generator.

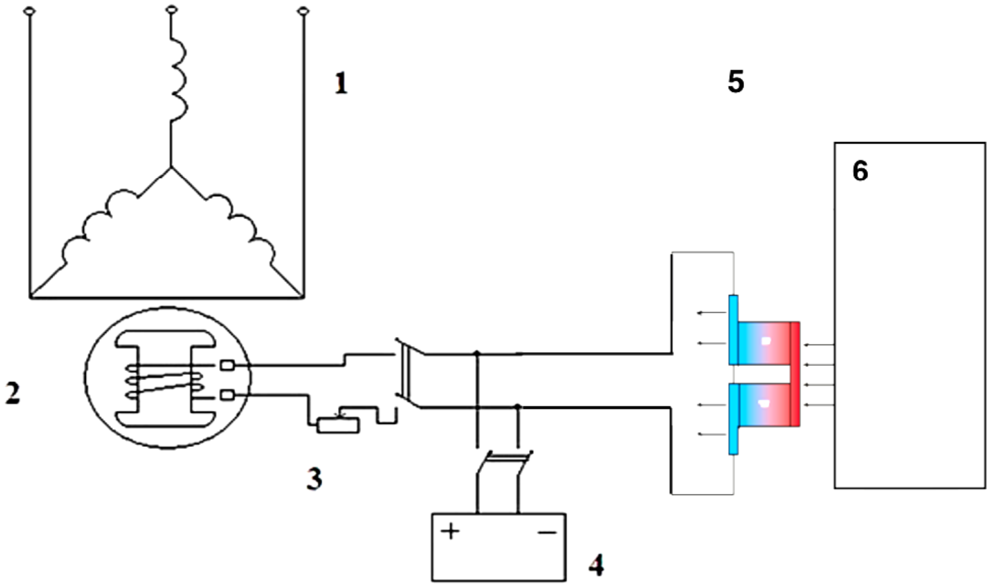

Fig.1. 1 - the stator of synchronous machines, 2 - the rotor and field winding, 3 - adjusting rheostat, 4 - battery, 5- thermo generator, 6 - heat source

U - shaped characteristics. During operation of the synchronous motor, EMF is induced in its stator winding, the sum of which $\sum E$ is approximately equal to the mains voltage U_c. supplied to the stator winding. This sum of EMF is

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equivalent to the resulting magnetic field caused by the action of two magnetically moving forces: excitation $F_B=I_B$ and stator $F_1=I_1$.
With a constant mains voltage $U_c \approx -\sum E$ =const , the resulting magnetic field is constant. Therefore, when changing the MDS of the excitation F_B (changing the excitation current I_B), the MDS of the stator F_1 changes with the purpose of their combined action remains unchanged, that is, the resulting magnetic field of the synchronous motor remains unchanged. This change in the MDF F_1 can only occur due to a change in the magnitude and phase of the stator current I_1 , i.e., due to a change in the reactive component of the stator current I_6.
For example, with an increase in the excitation current I_B , starting from its lowest value $I_B \approx 0$, the MMF of rotor increases, while the MMF of stator decreases. This decrease in the MMF occurs when the inductive component (with respect to the mains voltage U_c) of the stator current I_6 decreases, which has a magnetizing effect on the magnetic system.
In this case, the total stator current $I_1= I_q+ I_6$ decreases, and the motor power factor cosφ1 increases. At a certain value of the excitation current I_3, the inductive component of the stator current drops to zero. In this case, the stator current will reach its minimum (at a given load) value, since it will become purely active $\left(I_1 = I_q\right)$, and the power factor $\cos\varphi_1$=1.
An increase in the excitation current in excess of the value of I_B , i.e., an over excitation of the motor, will cause an increase in the current I_1 , but now this current will be leading (capacitive) with respect to the voltage U_c. Thus, in case of under-excitation ($I_B< I_B$), the synchronous motor operates with a lagging current, and in case of overexcitation ($I_B> I_B$) - with a leading one. The dependence of the stator current on the excitation current for a synchronous motor is represented by U - shaped characteristics (Fig. 2).
That is, a synchronous motor is a generator of reactive current: inductive with respect to the mains voltage when under-excitation and capacitive when over-excited. The indicated ability of synchronous motors is their valuable quality, which is used to increase the power factor of electrical installations.
Similar to a synchronous generator switched on in parallel with the network, a synchronous motor has a stability limit at a minimum excitation current (dashed line on the left side (Fig. 2).
The operational characteristics. The operational characteristics of a synchronous motor is the dependence of the rotor speed n_2, the power consumption P_1 of the useful moment M_1,, the power factor $\cos\varphi_1$ and the current in the stator winding I_1 on the useful motor power P_2. The rotational speed of rotor n_2 is always equal to the synchronous frequency $n_1 = \frac{f_1 \cdot 60}{p}$, therefore the graph $n_2=f(P_2)$ has the form of a straight line parallel to the abscissa axis a useful moment on the shaft of the synchronous motor $M_2 = \frac{P_2}{\varphi_1}$. Since the operating characteristics are taken under the condition $f_1=const.$, the graph $M_2=f(P_2)$ has the form of a straight line coming from the origin. Engine input power $P_1= P_2+\sum P$. With increasing load on the motor shaft, the losses $\sum P$ also increase; therefore, the power consumption P_1 grows faster than the useful power P_2 and the graph $P_1=f(P_2)$ has a somewhat curved shape.
The form of the graph $\cos\varphi_1 = f(P_2)$ depends on the type of setting of the excitation current: if in the regime x.x. the excitation current is set like $\cos\varphi_1 =1$, then with increasing load the power factor decreases, if $\cos\varphi_1 =1$ is set at rated load, then when the engine is underloaded, it will take the reactive leading current from the network, and lag behind when overloading. Usually, the drive current is set as $\cos\varphi_1 =1$ at medium load. In this case, the power factor in the entire load range remains quite high. If, however, the current in the excitation winding of the synchronous motor is set as $\cos\varphi_1 = 1$ is slightly higher than the nominal load, then at rated load $\cos\varphi_1 \approx 0,8$ and the motor will consume outrunning the current in relation to the mains voltage, which will increase the power factor this network. In this relation, synchronous motors compares favorably with asynchronous motors operating with a lagging phase current (especially when the engine is underloaded) and reducing the energy showing of the mains.

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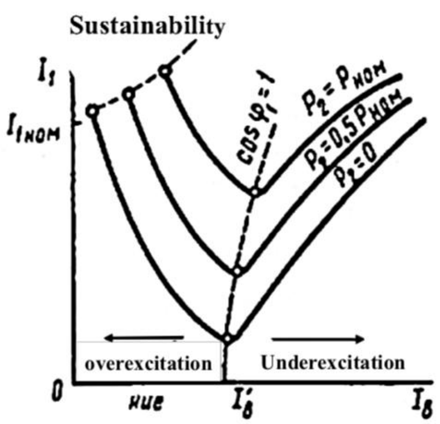

Fig. 2. U - shaped characteristics

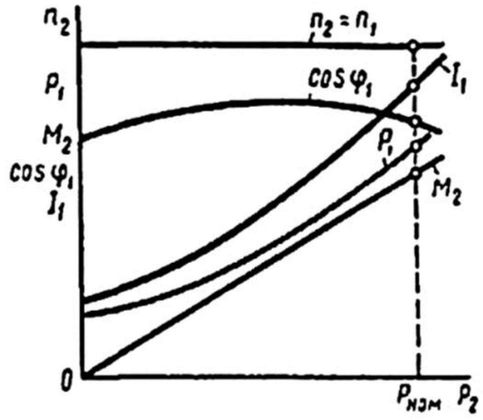

Fig. 3. The operational characteristics of synchronous motor synchronous motor

Current in the motor stator winding. From this expression it is seen that the current I1 with increasing load on the motor shaft grows faster than the power consumption P1, due to the decrease.

Since the rotor of the synchronous motor rotates in the same direction as the stator field, the direction of rotation of the rotor is determined by the sequence of phases of the linear wires connected to the stator winding and the order of the phases of the stator winding. To change the direction of rotation of a three-phase synchronous motor, it is necessary to switch two linear drives connected from the network to the terminals of the stator winding.

In conclusion, it should be noted that synchronous motors compared with induction motors have the advantage that they can work with $cos\varphi_1=1$ without creating inductive currents in the supply network, causing additional energy losses. Moreover, when working with overexcitation, synchronous motors create a capacitive current in the network, which contributes to an increase in the power factor of the energy system as a whole. Another advantage of synchronous motors is that, the main component of the electromagnetic moment is proportional to the voltage U_1, and for asynchronous motors the electromagnetic moment U_1^2 is proportional. For this reason, when lowering the voltage in the network, synchronous motors retain a greater overload capacity than asynchronous motors.

The disadvantages of synchronous motors include their more complex design and increased cost compared to squirrel-cage induction motors. In addition, a synchronous motor requires a device for supplying direct current to the field winding.

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