TRANSPORT SYSTEMS

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MAGNETOELECTRIC GENERATOR

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Abstract. *The principles of construction and comparative evaluation of voltage regulating systems of magnetoelectric generator.*

Keywords: permanent magnet; bias winding; magnetic flux; voltage regulating.

Introduction

Creation of airplanes with an all-electric equipment (AAEE) requires the new powerful systems of power supply on a few MV·A.

Development of the independent systems of power supply and electromechanics for AAEE requires achievement of next characteristics:

− minimum mass and overall dimensions;
− a maximum efficiency;
− minimum values of production and exploitation;
− limitation of electromagnetic time constant;
− possibility of operation, both in the mode of generator and motor;
− harmonicity of voltage shape or minimum pulsation of the rectified voltage;
− high mechanical durability, first of all circulating elements of construction;
− compatibility of electromachines with the electronic apparatus of control and system of power supply;
− requirement of inflexibility of external characteristic;
− workability of construction of both electromachine and all structural site which it is included in.

The output parameters of machines with permanent magnets correspond to the above-mentioned requirements to the electric machines.

The regulated synchronous generator with permanent magnets with excitation of armature back, offered by A. I. Bertinov and worked out to the industrial prototypes jointly with V. Andrejev and S. Mizjurin, has for this purpose an additional toroidal winding of magnetic bias 1 (Fig. 1), located in overhead part of stator slot 2 and back which embraces it, 3. For the placing of magnetic bias winding in overhead part of stator sheet of generator there is the special comb 5.

Essence of voltage regulating by means of excitation of core parts by a direct current consists in change of separate areas magnetic core resistance in the back of armature 3 (Fig. 1).

The value of necessary MMF of bias winding is usually small, as there are not air gaps on the path of bias flux. The expense of power on regulating is also insignificant. Regulating system consumes minimal power in the operating mode of generator and maximal in the open circuit mode. According to A. I. Bertinov's data a regulated magneto-electric generator of power 1000 BA at $f = 400$ Hz spends on regulating in the operating mode a 3 % of nominal power and up to 10 % at idling. Due to the presence of bias winding and rack on stator a mass of regulated generator increases in comparison with uncontrolled approximately on 25–30 %, and relative power, necessary for the feed of bias winding, diminishes with the increase of generator power. Bias winding as a result of air gaps absence on the path of the created flux has large inductance.

A calculation of regulating performance of generator and choice of parameters of bias winding is a difficult task, interfaced with account of nonlinear characteristics of bias areas of generator core, that are under the simultaneous action of permanent magnet MMF of generator rotor and MMF of immobile bias winding.

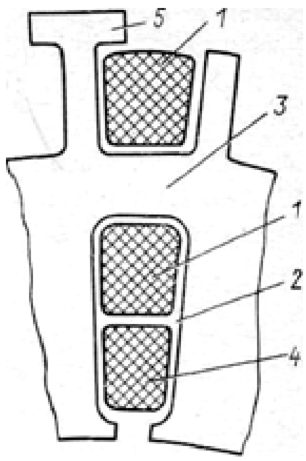

Fig. 1. Stator slot with armature winding and bias winding, where: *1* is bias winding; *2* is stator slot; *3* is stator back; *4* is armature winding; *5* is rack

The accounting of nonlinear characteristics of bias areas allows to define inductance and time constant of bias winding, and also dynamic behavior of all regulating system in whole. Thus exactness of voltage stabilizing is not limited to the parameters of generator, but depends only on the used regulator.

At all advantages of this method it has a substantial defect, which consists in that a maximal depth of flux change of Φ_δ is in the air gap of generator $k_{\Phi\delta} = \Phi_{\delta max}/\Phi_{\delta min} \le 2$. Therefore this method finds application for synchronous generators with permanent magnets which operate with constant rotation frequency n = constant at the variable load. To the lacks of this regulating method also follows to refer the necessity of complication of generator construction due to the presence of bias winding, and also increasing of its mass and sizes.

There is also voltage control mode at the expense of mechanical moving of parts of magnetic core of generator relative to each other (Fig. 2)

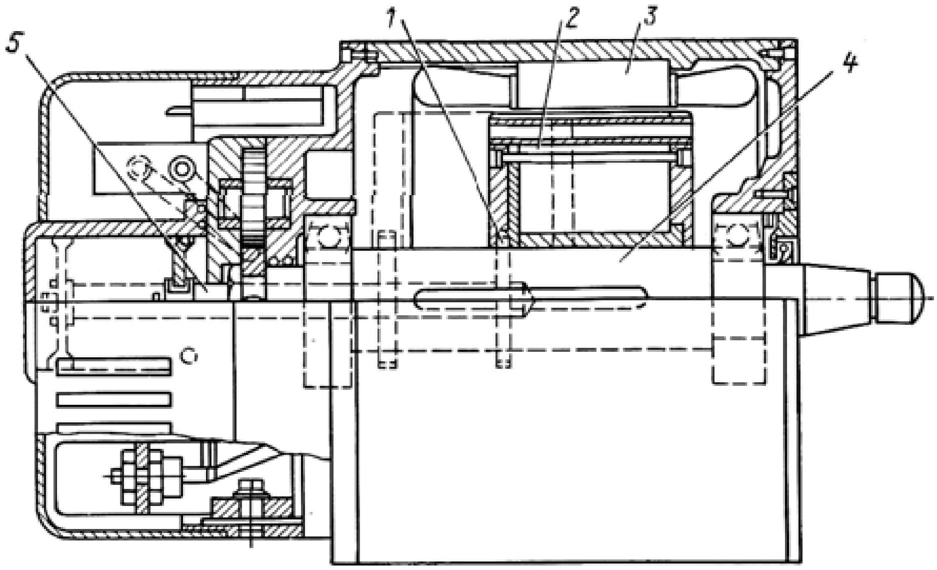

Fig. 2. AC generator with permanent magnets with voltage regulating at the expense of axial rotor moving relative to stator: *1* is washer; *2* is rotor; *3* is stator; *4* is shaft; *5* is piston

Essence of voltage regulating consists in pulling-out of rotor from the air gap or pull-in, if frequency of rotation accordingly increases or diminishes.

In a Fig. 2 a three-phase alternator is represented with a rotor *2* with permanent magnets, pressed-on on a shaft *4* on the sliding landing. From the left butt end of generator the hydraulic system which contains a hydraulic driver and block of its control is set. The piston *5* of hydraulic drive is mechanically connected with the washer *1*, to which a rotor is hardly fastened *2*. At moving of piston *5* a rotor *2* moves along a shaft *4*. Controller of hydraulic drive contains an electromagnetic valve, amplifier and element which reacts on deviation of generator voltage from nominal value. If generator voltage becomes higher nominal value then sensor through an amplifier plugs in a winding of electromagnetic valve to generator voltage and valve opened. Thus moving of piston *5* will happen and rotor *2* will begin to pull out from a stator *3*, a generator voltage will go down here. At generator voltage below nominal takes place a pull-in of rotor *2* in the air gap of stator *3* and increase of voltage. At presence of highly sensitive element (Zener) in CU at application of this method the high static accuracy controling of voltage (to ± 1 %) can be got. However presence of movable parts in a regulator does this system in the dynamic mode by very inertia, that is its considerable disadvantage. The controling system is structurally difficult and unreliable.

So, to the known magnetoelectric generators such disadvantages are inherent, as absence of direct method of voltage regulating as a result of difficulty of change of permanent magnet flux, dispersion of magnet`s characteristics, which is determined by character of technological processes of their making, relatively high cost of generators.

The purpose of article is a receipt of magnetoelectric generator, in which the non-linearity of function of $B = f(H)$ at the change of load and speed of drive motor is eliminated, simultaneous bias by the constant (from the excitation winding) and variable (from a rotatory rotor with permanent magnets) fields is diminished, eliminated regulator influence on exactness of voltage stabilizing, diminished inductance of excitation winding, depth of flux change in an air gap is increased, and voltage regulating is carried out by the common action of centrifugal regulator of magnetic flux value and direct-current of excitation.

Solution of problem

The general substantial sign of invention object is application of mobile rotor, in which regulating of magnetic flux value is carried out by moving of rotor relative to stator along shaft, what stabilizing of initial voltage of generator is due to.

In a Fig. 3 the general view of magnetoelectric generator is represented.

Location of elements *2* and *3* corresponds high speed of drive motor rotation. A magnetic flux is here created by a during its pulling out outside stator. At diminishing of shaft *1* rotation speed a centrifugal regulator *3* and spring *2* moves a permanent magnet *6* to the left, that results in the increase of magnetic flux of excitation and, thus, to stabilizing of EMF in accordance with a formula:

$$E = 4{,}44\, f\, w\, k_w\, k_c\, \Phi.$$

As known, voltage at the synchronous generator output equals to

$$U = E - jx_d I_d - jx_q I_q - R_a I,$$

therefore at the increase of generator load it is necessary to increase EMF E for stabilizing of voltage U.

At the increase of generator load a current grows automatically in the inductor winding *9*, that results in voltage stabilizing. It is possible to substitute valve *8* by a voltage regulator and, thus, realize the desirable law of regulating.

Thus the value of permanent magnet flux is regulated by the change of area of the mutual overlap of stator and rotor, and influence of generator load change is compensated by the change of excitation current.

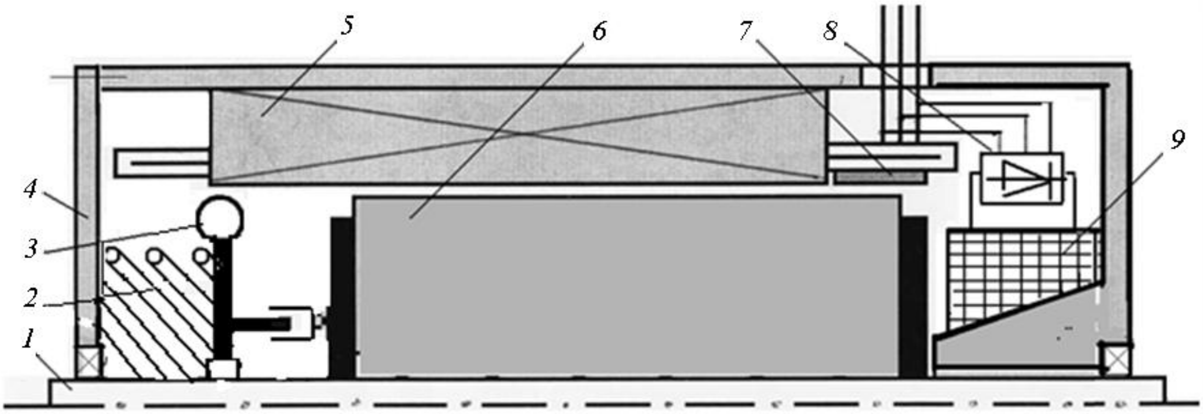

Fig. 3. General view of magnetoelectric generator:
1 is active shaft; *2* is spring; *3* is centrifugal regulator; *4* is diamagnetic bearing unit; *5* is armature; *6* is permanent magnet; *7* is ferromagnetic shunt; *8* is valve; *9* is winding of inductor

Conclusions

The turned out results: direct method of voltage regulating, linearity of function of $B = f(H)$ at the change of load and speed of drive motor, eliminated regulator influence on exactness of voltage stabilizing, diminished inductance of excitation winding, depth of flux change in an air gap is increased, and voltage regulating is carried out by the common action of centrifugal regulator of magnetic flux value and direct-current of excitation.

References

Balagurov, V.A.; Galteev, F. “Electric generators with permanent magnets.” *Energoatomizdat*. 1988. 280 p. (in Russian).

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В. С. Мартинюк, В. О. Гришин. Магнітоелектричний генератор

Викладено принцип будови магнітоелектричного генератора, в якому регулювання магнітного потоку відбувається за лінійним законом, а навантаження генератора компенсується автоматично.

Ключові слова: постійний магніт; обмотка підмагнічування; магнітний потік; регулювання напруги.

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Напрямок наукової діяльності: авіаційні системи електропостачання.
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Освіта: Національний Авіаційний Університет, Київ, Україна (2005).
Напрямок наукової діяльності: авіаційні системи електропостачання.
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В. С. Мартынюк, В. О. Гришин. Магнитоэлектрический генератор

Изложен принцип построения магнитоэлектрического генератора, в котором регулирование магнитного потока происходит по линейному закону, а нагрузка генератора компенсируется автоматически.

Ключевые слова: постояный магнит; обмотка подмагничивания; магнитный поток; регулирование напряжения.

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