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Types of Electrical Machine Current Converters

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Abstract — *This article provides information on the types and operating modes of electrical machine current converters.*

Keywords — electrical energy, current, asynchronous machines, Converter, Motor-generator.

General comment

To convert electrical energy of one type into another, along with static devices (transformers, ion and electronic converters, various rectifiers), electrical machines are used.

The General form of an electro-mechanical current Converter is an aggregate consisting of two machines connected mechanically, but not electrically connected. This unit, called a motor-generator, allows you to convert the type of current, its voltage, frequency, and number of phases.

If we take, for example, an aggregate consisting of an AC machine (synchronous or asynchronous) and a DC machine, then when using the first machine as a motor, and the second as a generator, you can convert alternating current to direct current.

When using machines in reverse, you can convert direct current to alternating current.

With an Assembly of two AC machines, it is obviously possible to convert the frequency, voltage, and number of phases of AC.

A current Converter in the narrow sense of the word is a single-armature Converter that allows you to convert electric current using a single armature that has only one winding. In this case, in contrast to the engine-generator, there is a direct conversion of electrical energy without its intermediate conversion to mechanical.

6-1. Engine-generators

Motor-generators are usually used to convert AC to DC (Fig. 1). An asynchronous or synchronous machine is selected as the motor. At high capacities, you should prefer a synchronous machine, since it is more profitable than an asynchronous one.

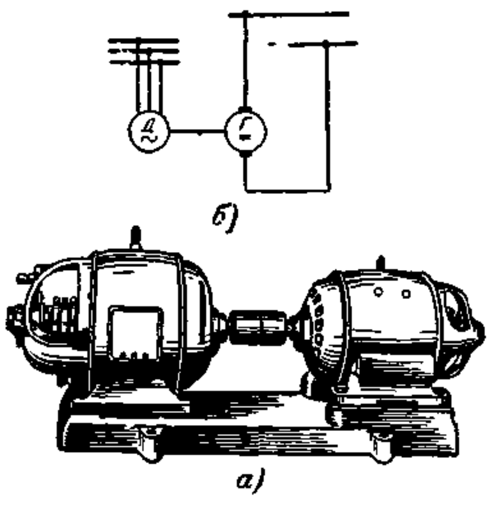

Fig. 1 Motor-generator.

As a generator, a DC machine is chosen, usually with parallel or mixed excitation.

The advantages of motor-generators in comparison with other electric-machine converters are: the ability to smoothly regulate the voltage within a wide range, greater reliability in operation, the ability to use serial normal machines (machines of General application).

Motor-generators are widely used in a wide variety of fields. Here we will Point out motor-generators that serve to power electrolytic baths, where smooth voltage regulation is required within a wide range. At metallurgical and other plants, engine-generators are used as aggregates in the "generator — engine" system.

We also note many testing laboratories that use motor-generators, which allow, for example, when converting DC to AC, to obtain smooth regulation of the voltage and frequency of alternating current.

The disadvantage of engine-generators is their relatively low efficiency, which is equal to the product of the efficiency of both machines.

It is also possible to convert DC voltage using an aggregate of two DC machines. But usually one DC machine is used for this purpose, placing two windings connected to its armature, each connected to its own collector, and the collectors are placed on different sides of the machine (figure 2). The ratio of the number of conductors of the armature windings is selected in accordance with the specified voltage ratio U_1/U_2.

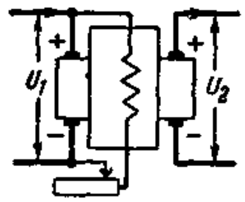

Figure 2. Diagram of a single-core DC Converter with two windings on the armature.

Such a machine is a single-core DC Converter with two windings on the armature It works on the primary side as a motor, on the secondary side as a generator the moment Difference M_1-M_2=M of the motor and generator windings is small and is determined only by magnetic and mechanical losses in the machine. In accordance with this the NPS of both windings are almost fully compensated for each other

A decrease in the voltage U_2 on the secondary side when the load increases is caused not only by a voltage drop in the generator winding circuit, but also in the motor winding circuit voltage Regulation U_2 at U_1 = const by changing the excitation current is practically impossible, since the speed of rotation will change, and the product nf = E_a□U_1 will remain practically unchanged

The considered converters have become widespread in radio installations. They convert voltage U_1 = 12÷24 V to voltage U_2 = 750÷1500 V.

6-2. Synchronous Converter

A single-core Converter has a single armature winding and differs from a DC machine in the device by having contact rings, usually located on the side opposite to the collector, and connected to certain points of the armature winding (Fig. 3).

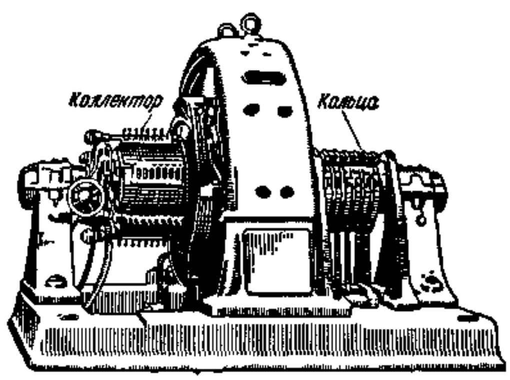

Fig. 3. Six-phase single-core Converter.

The principle of operation of a single-core Converter is based on the property of a closed collector winding to give simultaneously when rotating it in a stationary magnetic field on the collector constant voltage, and on the rings — alternating voltage

A loop winding is usually used as the armature winding.

The contact rings are connected in most cases via a transformer to the AC network. Depending on the number of phases of alternating current, single-phase, three-phase and six-phase converters are distinguished.

On Fig. 6-4 schematically shows a three-phase Converter, for greater simplicity, two-pole with an annular armature winding. The points of attachment of the contact rings on the armature winding must be shifted by 120 El. deg in relation to each other.

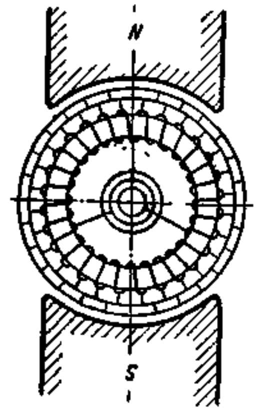

Fig. 4. Diagram of connections of the armature winding of a three-phase Converter with a collector and rings.

When converting AC to DC, the Converter receives alternating current from the rings and gives direct current from the collector side. On the ring side, it operates as a synchronous motor, and on the collector side-as a DC generator, usually with parallel excitation.

When converting DC to AC, the machine works as a DC motor on the collector side, and as a synchronous generator on the ring side.

The current in the armature winding of the Converter can be considered as the result of the superimposition of direct and alternating currents. The armature current, interacting with the machine's magnetic field, creates a torque that corresponds mainly to mechanical and magnetic losses in the machine. Determining the actual currents and the coils of the armature winding of the synchronous Converter and the resulting losses, we find that the total electrical losses in it when $m \geq 3$ ands □ = 1 have smaller values than in the case when the same coil passes only direct current or alternating current equal to the current from the collector or contact rings.

When operating a single-core voltage Converter from the side of the rings and the collector are connected by a certain ratio, since they can be considered equal to the corresponding e. d.s. armature windings (voltage drops in it are almost small), which are induced by the same magnetic flow. Thus, voltage regulation, for example, on the collector can practically be carried out only by changing the voltage on the rings.

The cross section of the armature from direct current is almost completely balanced by the cross section of the active component of alternating current. Therefore, the switching conditions of a single-core Converter with a quiet load approach the switching conditions of a DC machine with a compensation winding. However, they noticeably deteriorate with abrupt changes in load, since this breaks the specified balance of NSC in the switching zone. They are also degraded by asynchronous start-up, which is usually used for single-core converters, as well as for synchronous motors.

Single-core converters were used at traction tram substations, at substations of factories and factories where direct current was required (without regulating its voltage). At present, they are almost everywhere replaced by mercury and other rectifiers, which have proven to be more economical and convenient to operate.

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