Mende - Dubrovin high-voltage direct-current generator

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Annotation.

From an energy point of view its transfer on the direct current is the most advantageous method of the transfer of the large volumes of electric power up to the great distances. However, up to now there does not exist such direct-current generators, which are capable of generating the necessary level of power with the lumped voltages. In this article this problem is solved. The law of capacitive parametric induction is assumed as the basis of the solution of problem.

The keywords: current, voltage, capacity, capacitive parametric induction, direct-current generator, transformer of constant voltage, water pump.

1. Introduction

Energy electrical systems include the generator of electrical energy (further generator) and electric power line (EPL). Since the electric transmission up to the great distances is accomplished with the aid of high-voltage EPL, and generators have low output voltage, the intermediate component between the generator and EPL is the high-voltage step-up transformer. All elements indicated have energy losses, and their calculation shows that into these losses they can reach 30% the percentages. Consequently, a question of reduction in these losses is very important.

In essence, EPL serve for the transfer of alternating current; however, the lines of direct current have smaller losses to capacitive and inductive components. Therefore EPL on the direct current build when necessary to betray the separately large volumes of electric power. IN the USSR were built several electric power lines of the direct current: High-voltage line of direct current Moscow- Kashira-

project “Elba” ; High-voltage line of direct current Volgograd- Donbass ; High-voltage line of direct current Ekibastuz- center and other.

The absence of the generators, which directly generate constant voltage of the assigned magnitude with the necessary level of power, is the essential problem of the creation of power systems on the direct current. Therefore it is necessary to at first manufacture electric power on alternating current with the low voltages, then, using high-voltage transformers, to increase voltage and with the aid of the high-voltage rectifiers to further manufacture direct current. All these intermediate components have energy losses, what is the basic problem of such systems.

From the aforesaid it follows that the creation of the high-voltage direct-current generators, which immediately can generate the voltage of the assigned magnitude with the necessary levels of power, is the key problem of contemporary electro-energetics. Up to now such generators are not created.

2. Operating principle of high-voltage direct-current generator

If there is a capacitor, whose capacity C , and this capacitor it is charged to a potential difference U , that the energy, accumulated in it, is determined by the relationship

$$W_C = \frac{1}{2} CU^2 \tag{2.1}$$

But charge Q , accumulated in the capacity, is equal

$$Q_{C,U} = CU \tag{2.2}$$

From relationship (2.1) it is evident that if the charge, accumulated in the capacity, remains constant, then voltage on it can be changed by changing the capacity. In this case is fulfilled the relationship

$$Q_{C,U} = CU = C_0 U_0 = const ,$$

where C , U - instantaneous values, and C_0, U_0 - initial values of these parameters.

The voltage on the capacity and the energy, accumulated in it, will be in this case determined by the relationships:

$$U = \frac{C_0 U_0}{C} = K U_0, \tag{2.3}$$

$$W_C = \frac{1}{2} \frac{\left(C_0 U_0\right)^2}{C}. \tag{2.4}$$

Coefficient

$$K = \frac{C_0}{C} \tag{2.5}$$

can be named the multiplication factor (transformation) of constant voltage.

The schematic of voltage transformer , realizing the principle examined, is represented in Fig. 1.

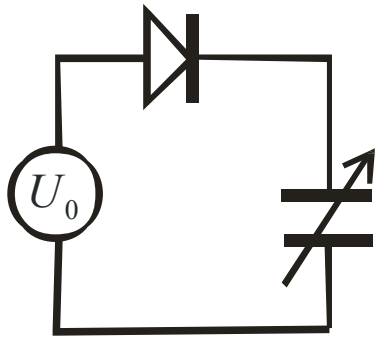


Fig. 1) Schematic of the transformer of constant voltage

In this diagram to the variable capacitor by means of the diode the dc power supply is connected U_0.

The incremental voltage, which can ensure this transformer, is determined from the relationship

$$\Delta U_C = \left(\frac{C_0}{C} - 1 \right) U_0. \tag{2.6}$$

As follows from the relationships (2.3) and (2.4) with the decrease of capacitance of capacitor on it increases not only voltage, but also the energy, accumulated in capacitor.

It should be noted that this transformer can work only in the regime of an increase in the voltage, since. with the attempt to obtain the decrease of voltage across

capacitor this cannot be made for that reason, that the diode ensures the straight connection of the voltage source to the capacitor and therefore voltage across capacitor decrease cannot.

An increase in the energy, accumulated in the capacitor, with a change in its capacity is determined from the relationship

$$\Delta W_C = \frac{1}{2}\left(C_0 U_0\right)^2 \left(\frac{1}{C} - \frac{1}{C_0}\right). \tag{2.7}$$

With a mechanical change in the capacitance of capacitor, the increase in the energy indicated ensures the spring mechanical energy source,

Properties of the transformer of constant voltage can be used for creating the high-voltage source of the direct current, whose diagram is given in Fig. 2

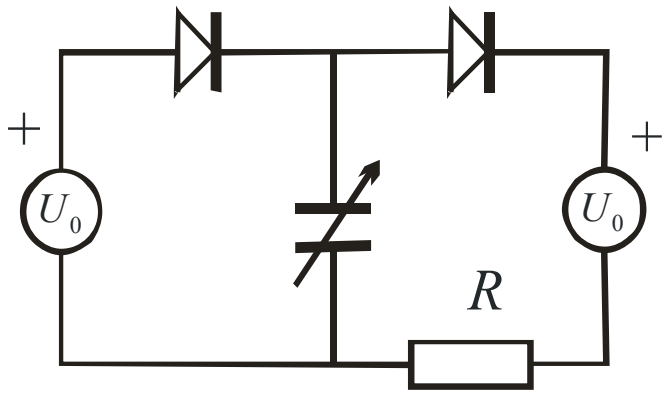


Fig. 2 Diagram of the high-voltage source of direct current.

In this diagram is present still one diode, additional compensating voltage source and load resistance R. Let us immediately point out that as the additional voltage source should be used a storage battery with the low internal resistance. Let us examine the cycles of the work of this source.

In the initial state the capacitance of capacitor is equal C_0, and voltage on it equally U_0. In this case the energy, obtained by capacitor from the right voltage source, comprises

$$W_0 = \frac{1}{2} C_0 U_0^2. \tag{2.8}$$

In this state the diagram is balanced, and current in all its outlines is absent. But as soon as capacitance of capacitor will begin to decrease, the secondary voltage, assigned by the relationship will appear on it, (2.5). The polarity of this voltage will be the reversed polarity of right source. This secondary voltage through the right diode enters the chain, which consists of the voltage source U_0, and also load resistance R and through the load resistance the current flows. This current there will be leak until voltage across capacitor is equaled with the voltage on by right source. The energy, isolated in this case during the load resistance, is determined by the relationship (2.7). For computed efficiencys of this process, it is necessary to compare the energy, spent by the right voltage source on the charging of capacitor and the energy, isolated during the load resistance. In this case efficiency it is defined as the relation of relationships (2.8) and (2.7).

$$EFF = \frac{\Delta W_C}{W_0} = \left(\frac{C_0}{C} - 1 \right) 100\% . \qquad (2.9)$$

In the following cycle proceeds an increase in the capacitance of capacitor from the values C to the value C_0. But voltage on it cannot be less than U_0, therefore the left voltage source begins to charge the being increased capacity. And up to the moment, when capacitance value reaches value C_0, voltage on it will be equal U_0. During this cycle the left voltage source will repeatedly consume the energy, determined by the relationship (2.8). In this case complete cycle to be completed and the system will return to the initial state.

It should be noted that the generator works successfully and without a right compensating voltage source. At the same time, the current of the right voltage source flows through the load resistance and in the reverse cycle, but this does not affect the efficiency of the generator, since the voltage of this source is much less than the voltage generated by the generator.

The operating principle of the generator examined is such to the operating principle of the valve water pump, whose schematic is represented in Fig. 3.

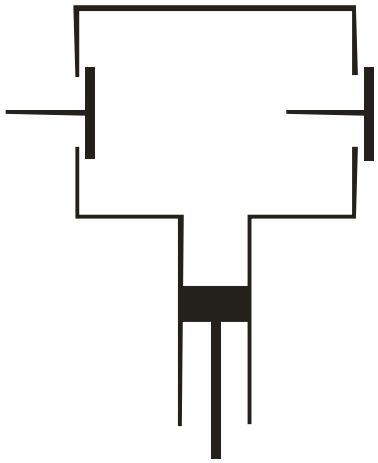
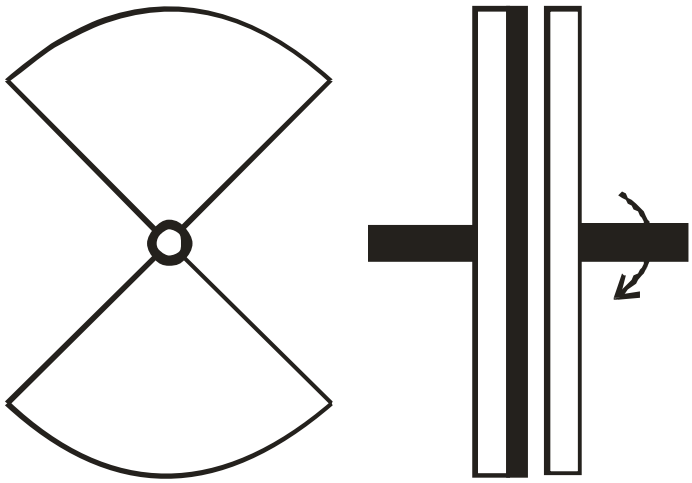


Fig. 3. Schematic of the valve water pump

With the displacement of piston downward left release valve is opened, and water is sucked in into the cavity of pump. With the displacement of piston upward the water through the right release valve is ejected outside.

The role of valves in the schematic of the described generator diodes play, while the role of cylinder with the being moved piston performs variable capacitor.

Hence it follows that by the basic problem of the creation of the proposed generator is the development of the mechanically controlled capacitor with the variable capacity, the great significances of initial and final capacity, also, with the high coefficient of overlap of these values. This question can be solved by the way of using the technology of the creation of the ceramic capacitors, when barium titanate, which has very large dielectric constant, is used as the dielectric between the capacitor plates. The construction of this capacitor is depicted in Fig. 4.



Ris.4. Construction of the capacitor

Capacitor consists of two metallic sectors of circle, mounted to the axis. Odina of vapor of sectors is fixed, and second revolving. In the sectors of fixed pair the layer of barium titanate is substituted (black strip on the right pair). Clearance between the layer of barium titanate and the contiguous pair of sectors must compose several microns. During this construction of capacitor the relation of maximum and minimum capacity can compose the value of the order 100. Generator can be multisection, as shown in Fig. 5.

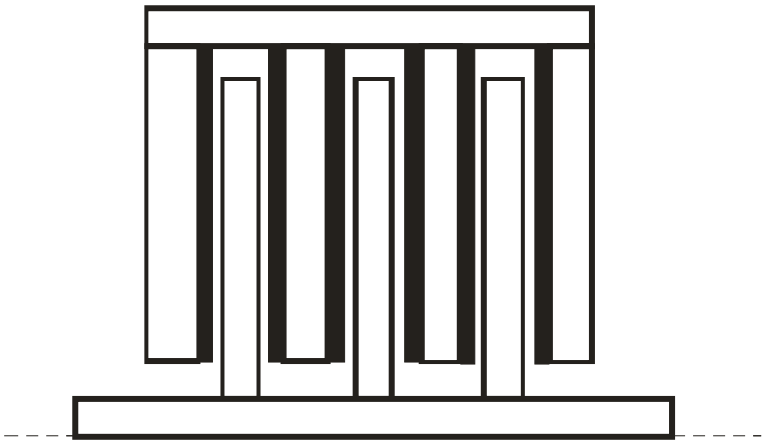


Fig. 5. Sectional generator

Let us calculate the practical construction of generator with the following parameters: the voltage of the voltage source $U_0 = 1000\ V$; the diameter of the revolving sectors $D = 1\ m$; clearance between the layer of barium titanate and the contiguous sector $d = 1 \mu m$; a quantity of the sections $N = 50$, the speed of rotation of the rotor $n = 1000\ \frac{1}{s}$ (this rotational speed it corresponds to speed 60000 r/min). If we consider that one section, which includes the sector of stator-rotor unit occupies 5 cm, then the length of this generator near 2.5 m.

We will calculate the capacity between the sectors of rotor and stator from the formula for the parallel-plate capacitor

$$C_S = \varepsilon \frac{S}{d}, \tag{2.10}$$

where S - the area of plates, ε - the dielectric constant of air, d - the distance between the plates of capacitor.

In the relationship (2.10) as the dielectric constant the dielectric constant of vacuum can be undertaken, since. this parameter for air and vacuum they are close in the value. As the distance between the plates should be taken the distance between the layer of barium titanate and the contiguous revolving sector. Such of assumption is justified, since the dielectric constant of barium several orders exceeds the dielectric constant of air.

Taking into account (2.10), we find maximum total capacitance between stator-rotor unit of the generator:

$$C_0 = \varepsilon \frac{\pi N D^2}{4d}. \tag{2.11}$$

In this relationship the doubled quantity of sections is undertaken, since in each section the layer of barium titanate is located on both sides the sector of rotor. Taking into account (2.4), (2.5), (2.8), (2,11) we find energy, which the generator in one revolution of the rotor manufactures

$$W = \frac{\pi\varepsilon KND^2U_0^2}{8d}. \qquad (2.12)$$

Multiplying relationship (2.12) to the doubled quantity of revolutions of rotor in second, we obtain the value of the power of the generator

$$P = \frac{\pi\varepsilon nKND^2U_0^2}{4d} = 2.8\times10^6\ W = 2.8\ MW. \qquad (2.13)$$

In the given formula the doubled quantity of revolutions is undertaken, since the overlap of the sectors of stator-rotor unit occurs twice in one revolution.

Efficiency generator, calculated according to the formula (2.9), comprises 10000%, i.e. the manufactured by generator power incommensurably greater than the power, consumed from the dc power supply.

The output voltage, which manufactures this generator, calculated according to the formula (2.3) equal 100 kV. Specifically, this voltage will be developed between the stator and rotary sectors, when the capacity between them is minimum. In order in this case to avoid the electrical breakdown between the rotor and the stator, it is desirable into the internal cavity of generator insertion air or by another gas under the high pressure.

The type of generator examined possesses still and that advantage that it can directly be mated with the axis of gas turbines, without requiring reducer, which simplifies system and increase efficiency.

The carried out calculations show the fundamental possibility of designing of highly effective direct-current generator. However, on the way of creating the generator of this construction are essential technological difficulties. They are connected with the fact that during the sequential assembling of the sections of generator difficult to ensure micron accuracy more rational is in this respect the cylindrical construction of the generator, whose mechanical schematic given in Fig. 6 .

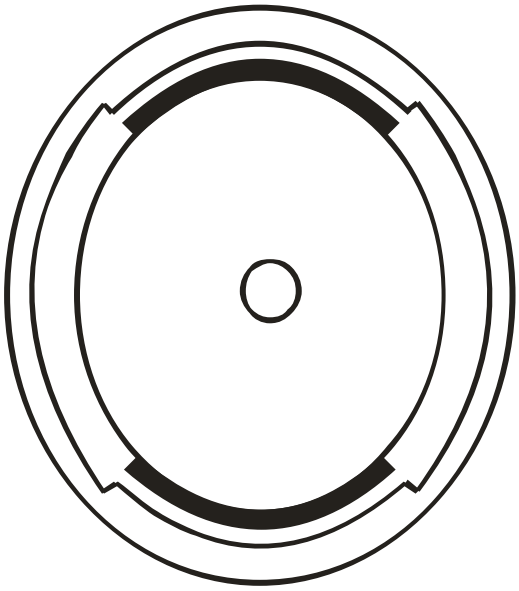


Fig. 6 . Mechanical the schematic of the cylindrical generator

The construction of generator consists of the cylindrical stator, in internal part of which are deepenings. The layers of barium titanate are substituted to the cylindrical part of the rotor. The thickness of these layers is such, that they form very small clearance between the rotor and the stator. With working of rotor, its diameter, including the layers of barium titanate, is carried out with the small allowance. After the subsequent rubbing the clearance between the layers of barium titanate and the stator can be practically zero. In this construction the overlap factor can reach the values of the order 10000. This coefficient is calculated as the relation of two distances. First of them it appears the maximum distance between the stator-rotor unit, when the body of stator, not covered with barium titanate, is located opposite the deepening in the stator. The second distance is minimum clearance between the layer of barium titanate and the body of stator. For obtaining the overlap factor, equal 10000, necessary that the depth of deepening in tele- stator would comprise not less than 10 mm.

Let us calculate the practical construction of generator with the following parameters: the voltage of the voltage source $U_0 = 100\ V$; the diameter of the rotor $D = 0.5\ m$; clearance between the layer of barium titanate and the stator

$d = 1\mu m$; the speed of rotation of the rotor $n = 500\ \frac{1}{s}$ (this rotational speed it corresponds to speed 30000 1/min); the length of the generator $L = 2m$.

The energy, manufactured by generator in one revolution, will comprise with the parameters indicated

$$W = \frac{\pi\varepsilon KDLU_0^2}{4d}.$$

But the power of generator will comprise

$$P = \frac{\pi\varepsilon nKDLU_0^2}{2d}. \qquad (2.14)$$

During the record of this formula are taken into account the fact that in one revolution of rotor it occurs two cycles of a change in the capacity between the rotor and the stator.

The substitution of the assigned parameters into the formula (2.14), gives power 1.48 MW.

Efficiency generator, calculated according to the formula (2.9), comprises 10000%. This means that practically entire mechanical energy, spent on the rotation of the rotor of generator, is converted into the mechanical energy.

The output voltage, which manufactures this generator, calculated according to the formula (2.3) equal 100 kV. This voltage will be developed between the stator-rotor unit, when the capacity between them is minimum. In order in this case to avoid electrical breakdown, the internal cavity of generator must be filled with air or another gas under the high pressure.

None of the existing generators can ensure this power with assigned overall sizes and this high efficiency.

Mechanical oscillator circuit, given in Fig. 6 has the deficiency, that the layers of barium titanate are located on the revolving rotor. Since the speed of its rotation is great, under the action of centrifugal force their scaling can occur from the surface of rotor. more rational from this point of view is the construction, in which the layers of barium titanate are located on the stator (Fig. 7)

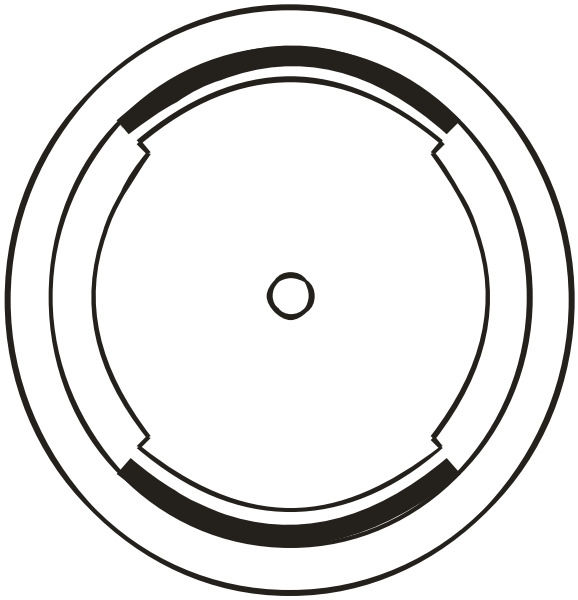


Fig. 7. The mechanical oscillator circuit, in which the supplementary sheets from barium titanate are located on the stator

In this construction the supplementary sheets can be preliminary molded on the mounts, are and then stuck on the stator.

3. Conclusion

From an energy point of view its transfer on the direct current is the most advantageous method of the transfer of the large volumes of electric power up to the great distances. However, up to now there does not exist such generators, which are capable of generating the necessary level of power with the lumped voltages, which impedes the development of the direction indicated. In the proposed article this problem is solved. The law of capacitive parametric induction is assumed as the basis of its solution. The solution of the problem indicated can lead to the revolutionary changes in electro-energetics, since the methods of designing of the high-voltage generators, which ensure the high level of power on the direct current, can be reviewed. The previously solution of this problem required in the required

order the use of a low-voltage generator and high-voltage transformer. The proposed solution possesses large simplicity and high efficiency. The moreover, examined generator allows direct jointing with the gas turbine, passing reducer. All this gives the possibility to use in practice entire spent mechanical work for the electric energy generation.

References

1. F. F. Mende, A. S. Dubrovin. Special properties of reactive elements and fluxes of charged particles. Engineering Physics, No. 11, 2016, p. 13-21.
2. F. F. Mende, New Properties of Reactive Elements and the Problem of Propagation of Electrical Signals in Long Lines, American Journal of Electrical and Electronic Engineering, Vol. 2, No. 5, (2014), p. 141-145.
3. F. F. Mende. Induction and Parametric Properties of Radio-Technical Elements and Lines and Property of Charges and Their Flows, AASCIT Journal of Physics Vol.1, No. 3, Publication Date: May 21, 2015, p.124-134.
4. F. F. Mende, A. S. Dubrovin. Alternative ideology of electrodynamics. M .: Pero, 2016. - 198 p.