P.438155 Counter-rotating generator with electrical transmission of mechanical power

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The counter-rotating generator with electrical transmission of mechanical power, which is the subject of the invention, is a multi-structure electric machine with one shaft and with: (a) one or two generator structures and one motor structure, or (b) one generator structure, one motor structure and one frequency transforming structure. The generator structures are described as a two-rotor generator which is the main generator and a single-rotor generator which is the auxiliary generator. They are alternating current generators. The rotors of a two-rotor generator are driven in opposite directions, while the electrical transmission of mechanical power includes a motor drive for a contra-rotating rotor. The motor drive is powered by a single-rotor generator, a two-rotor generator or a frequency transformer.

The essence of the invention is to obtain higher values of the generated voltage and frequency at the output of the counter-rotating generator than in the case of conventional alternating current generators without the need to increase the rotational speed of the shaft. The counter-rotating generator is driven on one side, e.g. by a wind turbine, while the mechanical power is transmitted: (1) to the co-rotating rotor of the two-rotor generator directly through the shaft and (2) to the contra-rotating rotor via electrical transmission of mechanical power.

The co-rotating rotor of the two-rotor generator, mounted on the shaft 13, is composed of a laminated core 15 with a three-phase winding 14. The contra-rotating rotor 10 is composed of a solid core 17 with permanent magnets 16. The electrical transmission of mechanical power of the basic variant of the generator (Fig. 1) consists of a single-rotor alternating current generator, e.g. a synchronous generator, and an alternating current motor, e.g. a squirrel-cage induction motor. The single-rotor generator is composed of a solid rotor core 19 mounted on a shaft 13, permanent magnets 18, a laminated stator core 2 mounted in the body 4 of counter-rotating generator, and a three-phase winding 3. The AC motor consists of a laminated stator core 8 embedded in the body 4, a three-phase stator winding 9, a laminated rotor core 7 mounted on the outer surface of the contra-rotating rotor 10, and squirrel-cage rotor winding 6 . The co-rotating rotor of a two-rotor generator and the rotor of a single-rotor generator are mounted in the bearings 12 embedded in the body 4 , while the contra-rotating rotor 10 of the twin-rotor generator is mounted in bearings 11 embedded in the body 4.

The laminated core of the co-rotating rotor 15 of the two-rotor generator is separated by an air gap from the solid core of the contra-rotating rotor 17 with permanent magnets 16. In the three-phase winding 14, which rotates in a rotating magnetic field excited by permanent magnets 16, voltages with the frequency $f_1 = p_1*(n_1 + n_2)/60$ are induced, where n_1 – rotational speed of the generator shaft 13 and the co-rotating rotor, n_2 – rotational speed of the contra-rotating rotor 10, p_1 – number of pairs of poles of the two-rotor generator. The value of the voltage induced in the winding 14 is proportional to the frequency f_1.

Under the influence of the rotating magnetic field excited by permanent magnets 18, voltages of the frequency $f_2 = p_2*n_1/60$ are induced in the three-phase winding 3 of the single-rotor generator, where p_2 is the number of pairs of poles of the single-rotor generator. The three-phase winding 3 is electrically connected by three connecting wires 5 to the three-phase winding 9 of the internal motor. The voltage from the three-phase winding 3 is supplied through these wires to the three-phase winding 9, which produces a magnetic field rotating at the speed n_{2s}, where $n_{2s} = 60*f_2/p_s$, p_s – number of motor pole pairs. The laminated core 8 with the three-phase winding is separated by an air gap from the laminated core 7 with the squirrel-cage winding. The rotating field induces voltages in the bars of the cage 6, which force the current to flow in the closed cage winding. As a result of the interaction of the magnetic fields, an electromagnetic torque is produced which drives the contra-rotating rotor 10 with a rotational speed n_2, where n_2 - the rotational speed of the internal motor drive depends on the electromagnetic torque according to the mechanical characteristic curve of the motor.

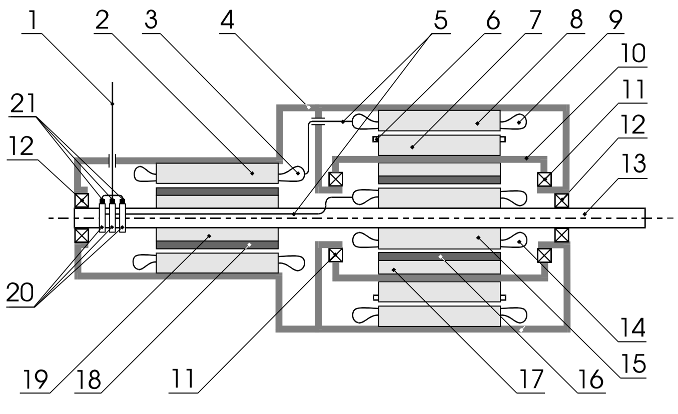

Fig. 1. Counter-rotating electric generator with electric transmission of mechanical power - basic variant, where: 1 - power cables, 2 - laminated single-rotor generator core, 3 - three-phase winding of a single-rotor generator located in slots, 4 - generator body, 5 - connecting cables, 6 - squirrel-cage winding of an induction motor, 7 - laminated core of an induction motor with a squirrel-cage winding, 8 - laminated core of an induction motor with a three-phase winding, 9 - three-phase winding of an induction motor, 10 - contra-rotating rotor, 11 - contra-rotating rotor bearings, 12- generator shaft bearings 13 - generator shaft, 14 - three-phase winding of a two-rotor generator, 15 - laminated core of a two-rotor generator with three-phase winding, 16 - permanent magnet of a two-rotor generator, 17 - solid core of a two-rotor generator, 18 - permanent magnet of a single-rotor generator, 19 - solid core of a single-rotor generator 20 - slip rings, 21 - brushes

The electrical transmission of the mechanical power of the reduced variant of the generator (Fig. 2) is based on an alternating current motor, e.g. a squirrel-cage induction motor, powered by a two-rotor generator. In the three-phase winding 14, which rotates in a rotating magnetic field excited by permanent magnets 16, voltages are induced with the frequency $f_1 = p_1*(n_1 + n_2)/60$, where n_1 - rotational speed of the generator shaft 13 and the co-rotating rotor, n_2 - rotational speed of the contra-rotating rotor 10, p_1 – number of pairs of poles of the two-rotor generator. The value of the voltage induced in the winding 14 is proportional to the frequency f_1.

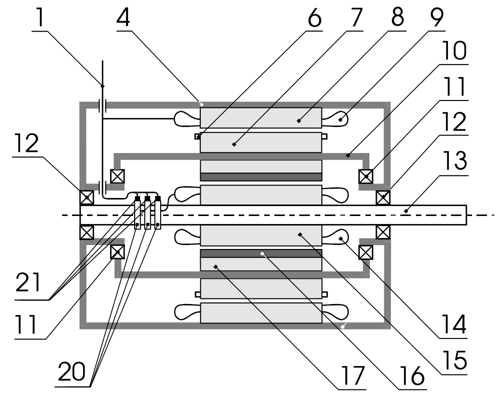

Fig. 2. Counter-rotating electric generator with electric transmission of mechanical power - reduced variant, markings as in Fig. 1

The three-phase winding 14 is electrically connected via slip rings 20 and brushes 21 to the three-phase winding 9 of the internal motor. The voltage from the three-phase winding 14 is supplied to the three-phase winding 9, which excites a magnetic field rotating at the speed n_{2s}, where $n_{2s} = 60*f_1/p_s$, p_s – the number of motor pole pairs. The laminated core 8 with the three-phase winding is separated by an air gap from the laminated core 7 with the squirrel-cage winding. The rotating field induces voltages in the bars of the cage 6, which force the current to flow in the closed cage winding. As a result of the interaction of the magnetic fields, an electromagnetic torque is produced which drives the contra-rotating rotor 10 with a rotational speed n_2, where n_2 - the rotational speed of the internal motor drive depends on the electromagnetic torque according to the mechanical characteristic curve of the motor.

The electrical transmission of the mechanical power of the brushless variant of the generator (Fig. 3) is based on an AC motor, e.g. a squirrel-cage induction motor, and a frequency transformer. The frequency transformer is composed of a laminated rotor core 19 mounted on a shaft 13, a three-phase rotor winding 18, a laminated stator core 2 embedded in the generator body 4 and a three-phase stator winding 3.

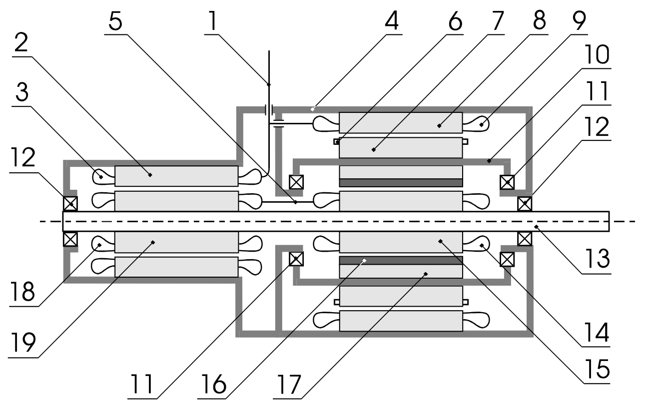

Fig. 3. Counter-rotating electric generator with electric transmission of mechanical power - brushless variant, where: 2 - laminated stator core of the frequency transformer, 3 - three-phase stator winding of the frequency transformer placed in slots, 18 - three-phase winding of the rotor of the frequency transformer placed in slots, 19 – laminated rotor core of the frequency transformer, other markings as in Fig. 1

In the three-phase winding 14, which rotates in a rotating magnetic field excited by permanent magnets 16, voltages are induced with the frequency $f1 = p1*(n1 + n2)/60$, where n1 - rotational speed of the generator shaft 13 and the co-rotating rotor, n2 - rotational speed of the contra-rotating rotor 10, p1 – number of pairs of poles of the two-rotor generator. The value of the voltage induced in the winding 14 is proportional to the frequency f1.

The three-phase winding 14 is electrically connected via three connecting wires 5 to the three-phase winding 18 of the rotor of the frequency transformer. The voltage from the three-phase winding 14 is applied through these wires to the three-phase winding 18, which produces a rotating magnetic field. The laminated core 19 is separated by an air gap from the laminated stator core 2 of the frequency transformer. The rotating field induces voltages in the winding 3 with the frequency $f2 = pf*n1/60 + f1$, where pf – the number of pole pairs of the frequency transformer. Winding 3 is electrically connected to the supply wires 1 and to the three-phase winding 9. The voltage from the three-phase winding 3 is supplied through these wires to the three-phase winding 9, which produces a magnetic field rotating at the speed n2s, where $n2s = 60*f2/ps$, ps – number of motor pole pairs. The value of the voltage induced in winding 3 is proportional to the frequency f2. The laminated core 8 with the three-phase winding is separated by an air gap from the laminated core 7 with the squirrel-cage winding. The rotating field induces voltages in the bars of the cage 6, which force the current to flow in the closed squirrel-cage winding. As a result of the influence of the magnetic fields, an electromagnetic torque is produced which drives the contra-rotating rotor 10 with a rotational speed n2, where n2 - the rotational speed of the motor depending on the electromagnetic torque according to the mechanical characteristic curve of the motor.