ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 4, April 2023

Comparative Experimental Analysis of the Performance and Viability of Traditional and Biaxial Excitation Synchronous Generators in Asynchronous Mode Without Excitation

Nurali Pirmatov, Allabergen Bekishev

Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan

ABSTRACT: In this article, transient processes of operation in an asynchronous mode without excitation of traditional and synchronous generators with biaxial excitation are experimentally determined. Oscillograms of voltage and current changes during the unexcited asynchronous mode transient were obtained using a Tektronix MSO 64 series oscilloscope. In addition, the differences in the rotor design of these two types of synchronous generators are shown. Since the rotor of a synchronous generator with biaxial excitation has magnetic and electrical symmetries, it is shown that this generator can work stably without oscillations for a long time in an asynchronous mode and increase the efficiency and survivability in abnormal modes than in traditional synchronous generators.

KEY WORDS: synchronous generator, excitation, oscillations, excitation winding, non-salient pole rotor.

I. INTRODUCTION

Asynchronous mode occurs due to complete or partial loss of excitation of the generator. A complete loss of excitation occurs in the following cases: erroneous shutdown of the AFE (automatic field extinguisher), break or short circuit. in the power circuit of the excitation winding of the generator, damage to the exciter or circuit elements of the excitation circuits, when switching to a backup exciter, personnel errors, etc. Depending on the nature of the fault, the excitation winding of a generator that has switched to asynchronous mode may be open, shorted, shorted to a resistor, closed to valves or to the exciter winding.

The physical process of transition to the asynchronous mode occurs in the following sequence: when the current in the excitation winding of the generator disappears or significantly decreases, the excitation magnetic flux and the corresponding synchronous electromagnetic torque on the turbogenerator shaft decrease. At a certain value of the excitation current, the value of the synchronous electromagnetic torque becomes less than the torque of the turbine and the generator, continuing to remain in the network, falls out of synchronism. To maintain the magnetic field, the generator begins to consume the magnetizing current from the network. Due to the imbalance between the torque of the turbine and the electromagnetic (braking) torque of the generator, the rotational speed of the turbine unit begins to increase above the synchronous one.

II. LITERATURE SURVEY

An increase in the rotational speed of the turbine unit leads to the fact that the generator rotor rotates faster than the stator magnetic field and alternating currents appear in the rotor circuits, having a slip frequency sf. The interaction of the currents induced in the rotor circuits with the main stator flux creates an asynchronous electromagnetic torque on the generator shaft, which slows down the rotor torque. The established asynchronous mode occurs when the asynchronous electromagnetic torque and the turbine rotation torque are equal, the generator in this mode outputs active power to the network and consumes reactive power from the network.

Due to the uniaxiality of the excitation winding and the unequal magnetic conductivity in a traditional synchronous generator along the longitudinal and transverse axes of the machine, this asynchronous moment does not remain constant, but fluctuates around the average value.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 4, April 2023

A periodic change in the asynchronous torque leads to fluctuations in power and slip of the generator; thus, it can only be conditionally considered that the asynchronous run without excitation is a steady state. The active load at which the steady state occurs is determined by the turbine control characteristic and the value of the asynchronous torque of the generator, which is generally determined by the inductive resistances of the generator in steady and transient modes and the time constants of its circuits. The asynchronous torque of turbogenerators increases sharply with increasing slip, so the equilibrium between the asynchronous torque of the generator and the turbine torque occurs at relatively small slips (0.0025-0.01).

III.EXPERIMENTAL RESULTS

The asynchronous mode of operation of the generator is accompanied by the following changes in the readings of the instruments, which is shown in Fig. 1: the stator current increases and fluctuates with a slip frequency near some average value; the stator voltage decreases the more, the greater the load of the machine (by the value of the voltage drop Un in the block transformer); in the rotor winding, if it is short-circuited or to resistance), alternating current flows, the arrows of the current and voltage devices of the rotor oscillate with double the slip frequency in both directions from zero; The reactive power meter indicates the direction of power from the grid to the generator. In asynchronous mode, the voltage at the generator stator terminals is significantly reduced and, to a lesser extent, at the high-voltage busbars, on which this generator-transformer unit operates.

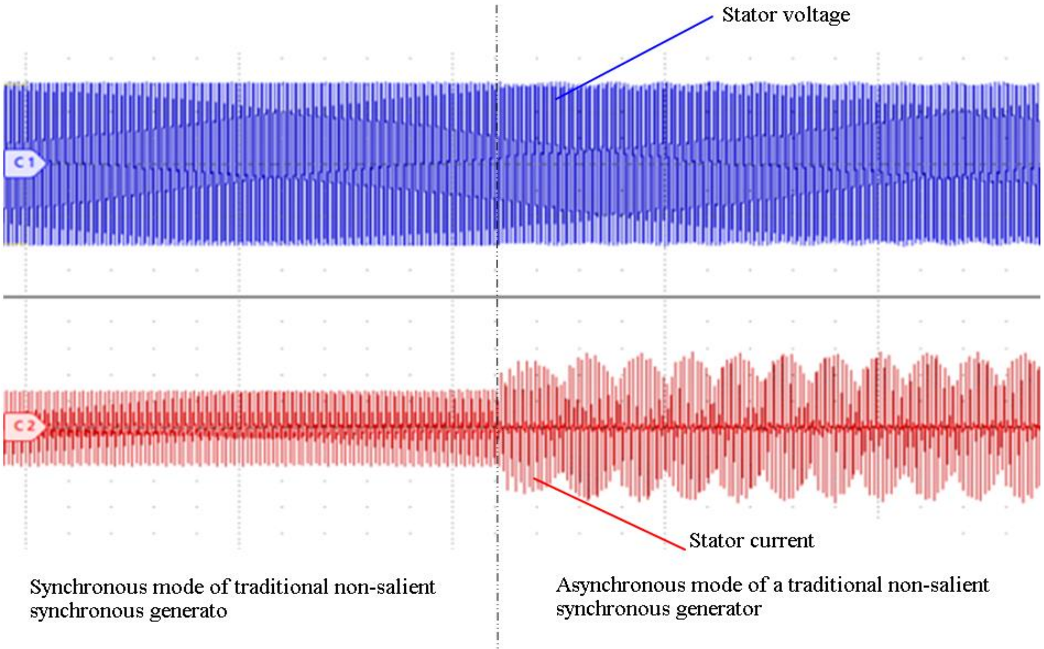

Fig.1. Oscillogram of the voltage and current of the stator of a traditional synchronous generator during the transition to asynchronous mode

The passage of induced currents through the barrel, teeth and wedges of the rotor causes losses proportional to slip and electromagnetic asynchronous torque. On the other hand, an increase in the resulting MMF of the stray flux in the area of the frontal parts causes an increase in the heating of the outer packs and the part of the stator back not protected by the pressure flange, which is characteristic of the deep underexcitation mode. Maintaining the operation of a turbogenerator that has lost excitation is possible only in those cases when the power system has the necessary reactive power reserve to maintain voltage at the nodal points of the power system. Fluctuations in currents, voltages and power on a turbogenerator operating in an asynchronous mode arise due to rotation of the rotor relative to the stator field.
On fig. 2 shows the design of the rotor of a conventional and biaxial synchronous generator. According to Fig. 2, the rotor of a biaxial synchronous generator has electrical and magnetic symmetry, therefore, when these biaxial synchronous generators switch to an asynchronous operation mode, as in Fig. 3, no fluctuations in its stator current and voltage are observed.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 4, April 2023

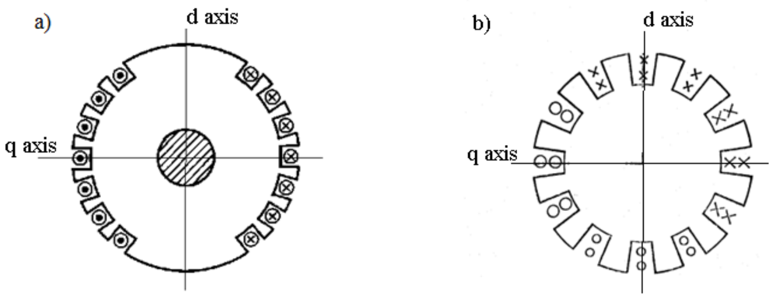

Fig.2. View of the rotor of a traditional and synchronous generator with biaxial excitation: a) traditional b) biaxial excitation

The permissible duration of asynchronous operation modes of turbogenerators depends on their design features. Generators with indirect cooling, regardless of the cooling medium, can operate in asynchronous mode for no more than 30 minutes with a load of up to 0.6 nominal. The allowable power in the asynchronous mode of turbogenerators with indirect cooling is limited by losses in the rotor, reaching the highest values in the wedges of the slots, teeth and in the contours along the ends of the rotor barrel (in the case of an open excitation winding).
The allowable duration of asynchronous operating modes of turbogenerators with biaxial excitation increases due to the absence of current and voltage fluctuations on the stator.

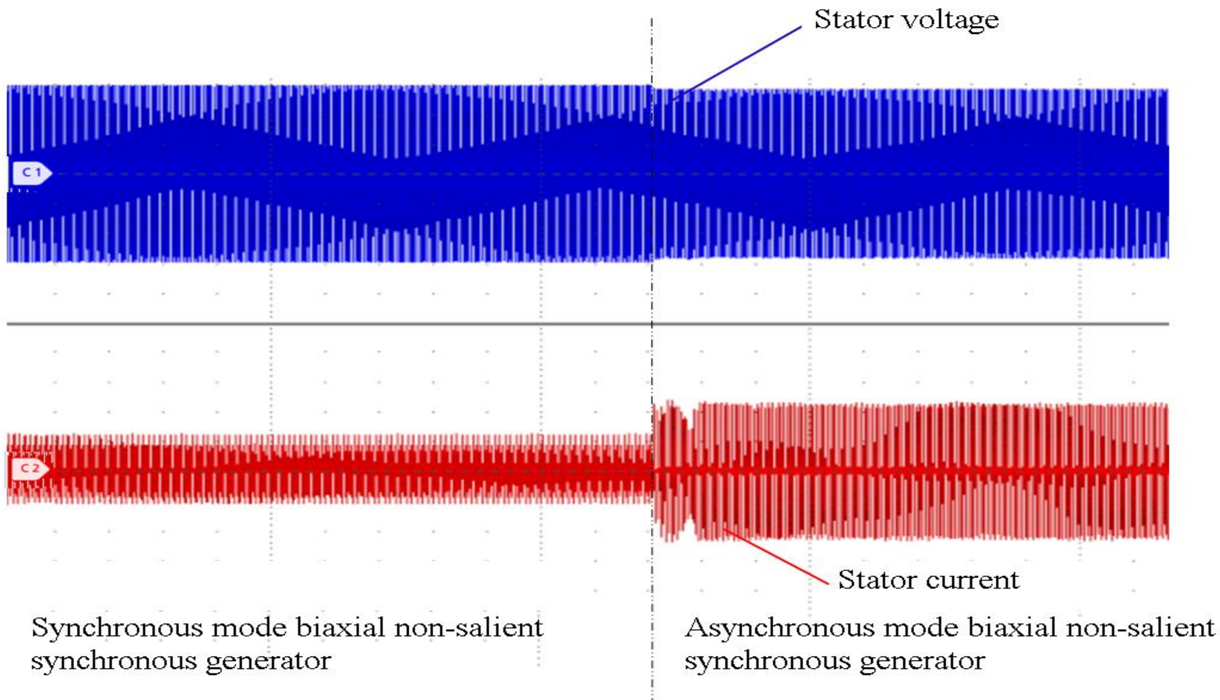

Fig.3. Oscillogram of the voltage and current of the stator of a biaxial synchronous generator during the transition to asynchronous mode

IV. CONCLUSION

Experimental analysis shows that a synchronous generator with biaxial excitation with magnetic and electrical symmetry is stable and without parameter fluctuations, operates in an asynchronous mode without excitation than with a traditional

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 4, April 2023

synchronous generator. This increases the efficiency and survivability of synchronous generators with biaxial excitation in asynchronous mode without excitation.

REFERENCES

[1] Labunets I.A., Sokur P.V., Pinchuk N.D., Kadi-Ogly I.A., Loginov A.G., Fadeev A.V., Zinakov V.E., Chernyshev E.V., Sheiko P.A. Asynchronized turbogenerators as a means of increasing stability and voltage regulation in electrical networks. // Power stations, No. 8, 2004.-p. 25-32.
[2] Pirmatov N.B., Akhmatov M.G. Anomalous modes of operation of a synchronous machine with biaxial excitation. Tashkent. Publishing house of Tashkent State Technical University, 2003. p. - 158.
[3] Pirmatov N.B., Bekishev A.E. Simulation of self-rocking synchronous generators. Problems of energy and resource saving. T. - 2020. St.-174-179.
[4] Pirmatov N.B., Bekishev A.E., Kurbanov N.A.,Simulation of self-rocking of a synchronous generatorand Simulink Matlab in the environment.International scientific and practical Internet conference. Trends and prospects for the development of science and education in the context of globalization: Sat. Scientific works. - Pereyaslav-Khmelnitsky, 2018. - Issue. 42.C585-589.
[5] Pirmatov N.B., Toirov O.Z. Bekishev A.E., Urakov S.E. Development of differential equations that calculate self-rocking oscillations of synchronous machines driven by conventional and longitudinal-transverse axes, and their solution using the Simulink Matlab program. Problems of Informatics and Energy /2019 No. 5. pp. 70-77.
[6] Bekishev A.E., Taniev M.Kh. Mathematical modeling of the process of self-rocking of a traditional synchronous generator and a synchronous generator with biaxial excitation and the solution of their differential equations using the mathcad package. Scientific and technical journal "Uzbekhydroenergy", 2022. No. 1(13).c-42-45.
[7] Bekishev A.E., Urakov S.E.Static stability in the electric power system. Technical sciences and innovations. No. 2, 2019. p. -175-183.
[8] N. Pirmatov, A. Bekishev, S. Shernazarov, N. Kurbanov, Regulation of mains voltage and reactive power using a synchronous compensator with biaxial excitation, E3S Web of Conferences, 2021, 264, 04028, https://doi.org/10.1051/e3sconf/202126404028
[8] Nurali Pirmatov, Olimjon Toirov, Allabergen Bekishev, Nazhmiddin Kurbanov, Oliyakhon Zainieva, Usman Norkulov. Calculation of U-shaped characteristics and reactive power of a synchronous compensator with longitudinal-transverse excitation.Conference Proceedings AIP 2552, 040020 (2023); https://doi.org/10.1063/5.0115727
[10] Toirov O., Bekishev A., Urakov S., Mirkhonov Yu. Development of differential equations and their solution using the simulink matlab program, which calculates the self-rocking oscillation of synchronous machines with traditional and longitudinal-transverse excitation. E3S Web of Conferences 216, 01116 (2020).
[11] N. Pirmatov, A. Bekishev, A. Egamov. Mathematical modeling of the self-swinging process of synchronous generators. AIP Conference Proceedings 2612, 050005 (2023). https://doi.org/10.1063/5.0135546