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# Features of the design and operating modes of the asynchronized turbogenerator T3FSU-320

**Yu.V. SHAROV[1], A.V. MIKHAILOV[2], A.B. SURKOV[2], D.V. Zhukov[3], M.B. Roytgarts[3], Yu.G. SHAKARYAN[4], P.V. SOKUR[4], P.Yu. TUZOV[4]**
**LLC «Inter RAO Engineering»[1], Branch of JSC "Inter RAO - Electric Power Plants" - Kashirskaya SDPP, PJSC «Power Machines»[3], JSC "R&D Center @ FGC UES"[4]**
**Russia**
Roytgarts_MB@power-m.ru

Asynchronized three-phase turbogenerator T3FSU-320-2U3 is designed to generate electricity in continuous operation mode S1 when connected to a steam turbine and installed indoors. The turbogenerator has been operated under load without any problems since 2009. The turbogenerator has a direct and quadrature axis excitation winding on the rotor, which in combination with an appropriate control system, ensures stable operation, both with the output and deep consumption of reactive power [1]. This changes the value and position of the resulting magnetic flux of excitation relative to the longitudinal and transverse axes of the rotor of the turbogenerator. The excitation system allows independently adjust the excitation currents of the two windings in steady state and in forced operation modes.

Microprocessor automatic voltage regulator carry excitation flux vector control in two independent channels: the voltage and electromagnetic torque. The technical parameters of the turbogenerator are shown in table 1.

The turbogenerator retains the nominal continuous power at voltage deviations from -5 to +5% of rated voltage. When the turbogenerator operates with a voltage from 90 to 95 and from 105 to 110%, power capacity should be reduced in accordance with the power diagram in Figure 1.

Table 1 Technical data of the turbogenerator at rated coolant temperature

| | | |
|---|---|---|
| Total power, kVA | 376470 | |
| Active power, kW | 320000 | |
| Voltage, V | 20000 | |
| Stator current, A | 10868 | |
| Excitation current, A: | | |
| - main winding | 3000 | |
| - control winding | 2250 | |
| Excitation voltage, V: | | |
| - main winding | 300 | |
| - control winding | 30 | |
| Power factor | 0.85 | |
| Efficiency factor, % | 98,6 | |
| Static overload, p.u. | 1,8 | |
| Short-circuit ratio, p.u. | 0,5 | |
| The number of phases of the rotor winding | 2 with a shift of 90° | |
| Number of rotor slip rings | 4 | |
| Rotation frequency, rpm | 3000 | |
| Turbogenerator excitation system | static thyristor reversible | |
| Field-forcing ratio, p.u. | by current | by voltage |
| - main winding | 2 | 2,5 |
| - control winding | 2,85 | 3,5 |

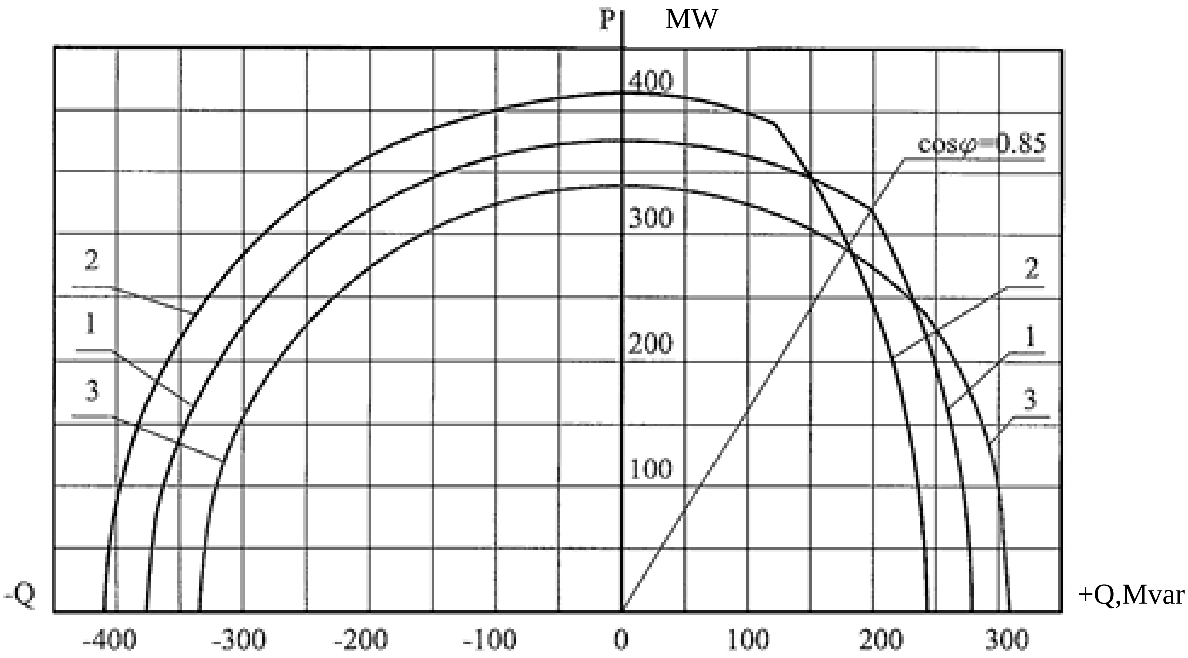


Fig. 1. Power diagrams at different voltages on the stator winding:
1 – U=(0.95-1.05) Un; 2 – U=(1.05-1.1) Un; 3 – U=(0.9-0.95) Un

The increase in the unit capacity of the turbogenerators with indirect air cooling is limited by the efficiency of the ventilation systems. Both the temperature difference from the copper of the stator core conductors to the iron of the stator core and the absolute temperature in the isolation zone are limited.

Cooling can be achieved by reducing heat generation or current in the slot. In some cases [2], winding circuits with a number of parallel branches which are greater than number of poles are used to reduce heat generation in the slot. At the same time, it is necessary to minimize equalizing currents and additional losses due to violations of the electric and magnetic symmetry of the windings along the poles.

On the other hand, at a given heat generation in the slot, the temperature difference across the insulation thickness is reduced, reducing the thickness of the groundwall insulation, that is, increasing the operating electric field strength in the insulation, and applying electrical insulation with increased thermal conductivity.

In all cases, the lower the absolute temperature of the stator iron core, then the lower the temperature of copper conductors and hence electrical isolation. Considering the well-known law, according to which the service life of insulation doubles when the temperature drops by every 10 degrees, to ensure long-term reliable operation of turbogenerators with indirect air cooling, efficient cooling of the stator core is of particular importance.

In the asynchronized turbogenerator T3FSU-320-2U3, methods are applied to reduce the heating of the stator winding without increasing the number of parallel branches. The electrical insulation of the stator winding is made according to the technology of pre-impregnated tapes with high thermal conductivity. The thickness of the ground insulation is chosen minimal and corresponds to electric field strength of 3.2 kV / mm. For effective indirect cooling of the stator winding, direct water cooling of the stator core is applied. For this purpose, flat silumin coolers are installed in the radial channels between the stator core packages, in which cooling purified water is flowing through stainless steel tubes.

For an asynchronized turbogenerator with indirect air cooling, the need for effective cooling and reliable fastening of the end zone of the stator is added to the task of providing effective indirect cooling of the stator slots zone in deep under-excitation modes.

The air cooling of the asynchronized turbogenerator T3FSU-320-2U3 is built according to an exhaust circuit. Two fans are used as pressure elements, cooling air is sent in one way to the channels of the end zones and pressure plates of the stator core, the other way to the rotor sub-channels [3]. The air is cooled with the help of air coolers through which water circulates. Eight air coolers are used: 4 vertical (rotory) and 4 horizontal (stator) in each set. The ventilation scheme is shown in fig. 2

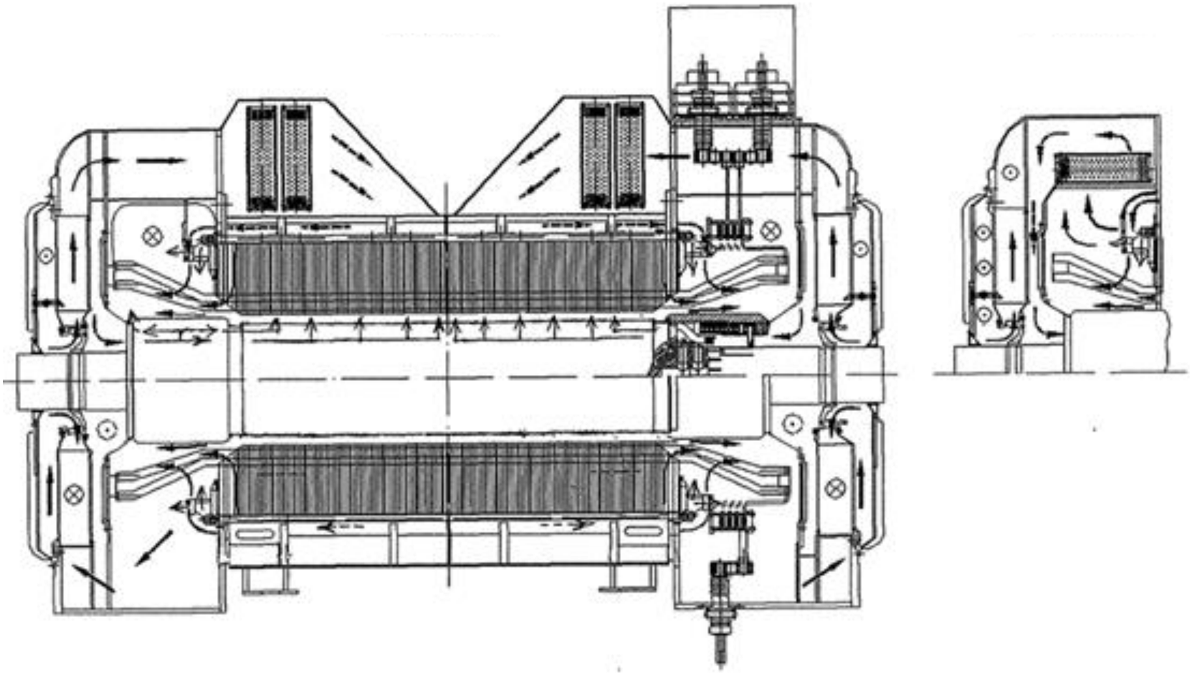

Fig.2. The ventilation scheme of the turbogenerator T3FSU-320-2U3

Turbine generator T3FSU-320-2U3 is operated at unit No. 3 of Kashirskaya GRES, which is connected to a 500 kV grid. Opportunities for a wide regulation of reactive power allow to maintain a given voltage level in the 500 kV grid. In the hours of minimum load with excess reactive power in the network, the turbogenerator operates with the consumption of reactive power, and in hours of maximum - with the output of reactive power.

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