Study Committee A1

ROTATING ELECTRICAL MACHINES PS3

Paper 10354_2022

Features of Akkuyu NPP turbogenerators and factory test results

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Motivation

Turbine islands based on GE's ARABELLE™ steam turbine and GIGATOP 4-pole turbogenerators of 1200 MWe class are used in scope of Rosatom State Corporation's program of nuclear builds outside the Russian Federation (the VVER-1200 and VVER TOI projects) for plants such as:

- Paks (VVER-1200)
- El Dabaa (VVER-1200)
- Akkuyu (VVER TOI)

Method/Approach

For Akkuyu NPP special attention was given to the following design considerations:

- The grid operator's requirements
- The specific aspects of design review and acceptance in line with the requirements of the Russian codes and standards
- The seismic properties of the construction site
- The requirements of the plant General Design
- Climatic design
- Service life.

The main design parameters of the GIGATOP 4-pole type W100 turbogenerators are as follows:

- Rated active power: 1251.9 MW
- Rated voltage: 24 kV (+5/-10 %)
- Rated frequency: 50 Hz (+/-2 %)
- Rated power factor: 0.9
- Speed: 1500 rpm
- Cooling water temperature: 27 ˚C
- Temperature class 130 (B), thermal class 155 (F) regarding insulation

Experimental setup & test results

Balancing pit tests

Stator winding assembly area

Acceptance tests of complete generator on the test bench

Discussion

The design of generator is in line with calculations and standard criteria

Parameter description	Discrepancies between measure and calculation values, %	IEC tolerance, %
Efficiency, %	+0.7%Total Losses	+10%Total Losses
SCR	0%	±15%
Xd, p.u.	+0.5%	±15%
X'd, p.u.	-2%	±15%
X''d, p.u.	-0.35%	±15%
X_2, p.u.	-0.7%	± 30%
X_0, p.u.	-16.7%	± 30%
J, kg·m^2	+1.5%	10%

Conclusion

Design features and tests results of the TA 1200-78 generator have demonstrated compliance with:

- Turkish grid requirement
- Specific conditions of Power Plant General Designer
- Mechanical requirement linked to seismic spectra of Akkuyu site

Electrical characteristics and efficiency have been confirmed through an extensive running test campaign which demonstrated accuracy of used calculation tools.

Objects of investigation

- Turbogenerator design

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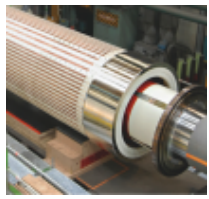
Frame

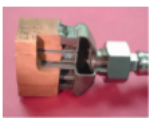
- Static loads,
- H_2 explosion inside the machine,
- Loads from generator operation and short circuits,
- Seismic loads,
- Loads from handling and transportation.

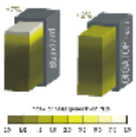
Rotor Dampers

- Solid slot damper system in active part
- End-part of damper system: end conductors and plates
- Absolutely Closed high conductive damper system with lower quantity of contact zones
- Lower resistance to eddy currents (100 Hz)
- $I_2 \leq 0.08$ p.u.; $I_2^2 t \leq 6$ p.u. s.



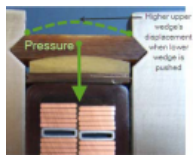
Stainless steel tubes technology





- No clogging within the cooling tubes, whatever the water quality
- Separation of electrical and cooling circuits → improved reliability
- Reduced on-load losses → improved turbogenerator's efficiency
- A balanced distribution of the circulating currents → reduction stray losses → homogeneous distribution of circulating currents, temperatures, mechanical stresses inside the bar → extended life

Stator winding wedging system and Stator end winding structure

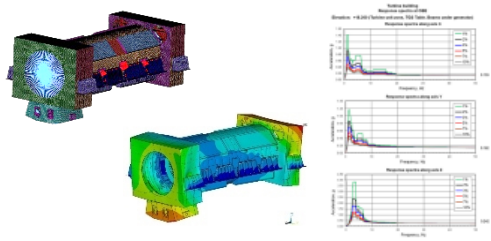


- A steady state and careful fixation of the bars in rated and fault conditions
- Prevention of core damage during wedge installation
- Compensation of slot filling settling and mutual thermal expansion of bars and core in operation
- Inspection of wedging with rotor in-situ by a robot and simple re-tightening
- High robustness of phase rings and droppers

Stator Bars Insulation System

- A key GIGATOP 4-pole feature is GE's MICADUR® insulation system, the result of over 50 years of continuous development
- Meets all the requirements of thermal class 155 (F), while GIGATOP 4-pole operates in thermal class 130 (B)
- Excellent durability and reliability under all operating conditions
- The MICADUR® insulation system meets all the requirements of Akkuyu Project both for operation and for acceptance tests.

Investigation of seismic factors influence



- The stresses in the main static parts of the generator
- The deflections between the rotor and the static parts
- show that the design criteria (stresses under the Yield Strength of the material, no interference between the rotor and the static parts) are fulfilled.

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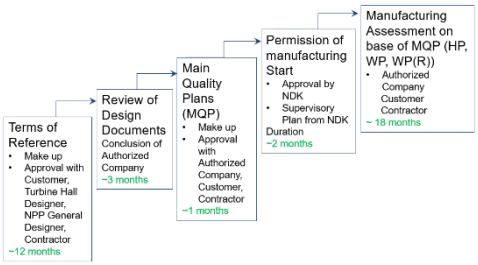
Features of application of Russian Nuclear Rules and Codes

- Akkuyu turbogenerator are assigned safety class 3 in accordance with NP-001 (equipment important for NPP safety)



Manufacturing Assessment on base of MQP

- Manufacturing Readiness Assessment
- WP(R) manufacturing assessment of sub-supplied parts and materials
- WP(R), WP, HP manufacturing assessment of factory (manufacturing report review)
- NCRs review
- WP of intermediate test of not assembled generator
- HP of generator running test
- Acceptance inspection
  - Check of completeness
  - Check of supplied documentation (manuals, certificates, ToR, passport, etc.)
  - Check of packing
  - Check of shipping documents