



BRUSH TURBOGENERATORS



COMBINED (HYDROGEN & WATER) COOLED 2-POLE TURBOGENERATORS

Equipment supplied to over 130 countries
Over 120 years of electrical experience

Right: One of two 1000MW combined cooled generators at Temelin Power Station in the Czech Republic.



The machine hall of Dukovany Power Station in the Czech Republic, comprising eight 220MW combined cooled generators.



The 500MW steam turbine generator at Melnik Power Station in the Czech Republic.



The unrolled stator core of a 1000MW generator.



Stator core and winding of a 1000MW generator.



Introduction

BRUSH combined cooled generators are extensively used in steam turbine based power generation applications. The characteristics of these machines are the result of an in-depth knowledge, gained from BRUSH's extensive experience, and the latest design techniques, backed by modern manufacturing methods. The continued success of this range of generators can be attributed to BRUSH's ability to meet the demanding interface requirements of the turbine manufacturers, coupled with competitive prices and keen deliveries.

Stator

The stator frame is a rigid structure, fabricated from mild steel plate and designed to withstand the mechanical stresses imposed both during operation and under accidental short circuit conditions. The stator is also capable of withstanding an explosion of the hydrogen coolant. Mounting pads are incorporated at appropriate points on the underside of the frame, with holes in each pad for foundation bolts and dowels.

The core is built up from segmental laminations of low-loss, high permeability, high silicon content electrical steel, with radial ventilation ducts formed at intervals along the core by 'H' section steel spacers. The core is hydraulically pressed at predetermined stages during the building operation to ensure uniform compaction, the pressure being carefully monitored, and the finished core is clamped between heavy endplates.

In order to reduce the possibility of transmission of core vibration to the machine foundation, the internal frame, into which the core is built, is suspended in the outer frame on leaf springs.

The stator winding is of the two layer diamond type, using half coils consisting of fully transposed Roebel bars to reduce eddy current losses. The surface of the cured insulation is provided with a semi-conductive protective layer to prevent the occurrence of surface electric discharges.

The insulation system is based on a resin rich mica glass tape which, when processed, results in a high performance insulation capable of continuous operation at temperatures up to class F limits. The half coils are placed in the stator slots in two layers and wedged securely in position by polyester or epoxy glass wedges prior to connection of the endwinding.

The endwinding is securely braced to insulated support boards bolted to the core endplate or to a combination of support boards and rings. Spacer blocks are fitted between adjacent coil sides to produce a strong archbound, yet resilient, composite structure, capable of withstanding the forces that could arise in the event of an accidental short circuit.



Rotor of a 220MW generator.

Rotor

The rotor of a combined cooled BRUSH turbogenerator is manufactured from a one-piece forging of nickel chromium molybdenum alloy steel, which is de-gassed and vacuum-poured to obtain a uniform material which has excellent tensile properties. Axial slots, to carry the windings and for ventilation, are milled on the periphery of the body of the rotor.

The rotor winding is made of high conductivity copper/silver alloy hollow conductors. The pre-formed coils are inserted into the slots, each turn being insulated from the next. The class 'F' insulation system is moisture resistant, shockproof and capable of withstanding the high mechanical forces to which it will be subjected. The conductors are held in place by retaining wedges, which are connected together at each end by the endcaps to form a fully interconnected damper winding.

The rotor endwinding is braced with packing blocks between the conductors and is wrapped with insulation, after which the rotor endcaps are fitted. The endcaps, which retain the rotor endwinding, are manufactured from austenitic non-magnetic 18-18 manganese chromium steel.

All completed rotors are tested in the Company's rotor overspeed test facility, which is equipped with comprehensive monitoring equipment.

Bearings

The main bearings are normally fixed profile, white metal lined, hydrodynamic elliptical bearings. Other profiles, including tilting pad bearings, may be used for specific applications. Thrust bearings can be provided where necessary to suit particular turbine or site conditions.

Cooling

BRUSH combined cooled turbogenerators are cooled by hydrogen and water in closed circuit configuration. The stator winding is cooled directly with water; the rest of the machine is cooled directly with pressurised hydrogen.

The stator winding water circuit is supplied with chemically pure water. Hydraulically, pairs of bars are arranged in series and connected to supply and discharge piping by PTFE (Teflon) hoses. A centrifugal pump, with an identical standby pump, is used to circulate chemically pure cooling water in the stator winding circuit. With the exception of the copper winding itself, the entire cooling circuit is made of stainless steel.

Hydrogen is forced around the generator by means of two axial flow fans mounted on the rotor shaft. Cooling circuits are designed to cool the windings as uniformly as possible. The hot exhaust hydrogen is cooled by hydrogen / water heat exchangers before being returned to the inlet. The removal of losses is a relatively simple, very efficient process that ensures maximum utilisation of active material.

Auxiliaries

The gas supply system, which can be "tailored" to suit the individual requirements of a power station layout, contains the equipment for scavenging air from the turbogenerator with carbon dioxide and for the initial fill, and subsequent continuous maintenance, of the hydrogen coolant. A "freezing out" process achieves hydrogen drying.

The sealing oil system contains the equipment for maintaining the oil pressure in radial type shaft seals.

Purification of the stator winding cooling water is effected by an ion filter.

Excitation system

BRUSH combined cooled turbogenerators are fitted either with a static excitation system or a shaft-mounted a.c. exciter with a static thyristor excitation system.

In the static excitation system, power is taken from the generator output through suitable transformers and fed back to the main field via a controlled rectifier, brushgear and sliprings.

A shaft-mounted a.c. exciter with a static thyristor excitation set is a three-phase constant voltage synchronous generator with a rotating field, with the stator voltage selected to suit the required ceiling voltage and with the frequency identical to that of the power system. The power is fed to the main field via a controlled rectifier, rushgear and sliprings.

The excitation system is digitally (electronically) controlled to ensure reliable operation and fast-acting voltage regulation.



The stator endwinding of a 500MW generator, showing the PTFE hoses that supply the cooling water.



The machine hall of Tusimice Power Station in the Czech Republic, showing the four 200MW units.



The 2000MW Temelin Power Station in the Czech Republic.

Features

BRUSH combined cooled turbogenerators have the following features:

- Reduced weight of active components.
- All units are fully factory-tested, reducing commissioning to proving interconnections and combined turbine/generator testing.
- Fully developed system readily adapted to any turbine design.
- Fully compliant with the provisions of the relevant international standard specifications, including IEC and IEEE.
- Low ventilation losses, resulting in improved efficiency.
- Extended insulation life.

Specifications

Voltage range:	15 to 24kV
Speed:	3000 rev/min for 50Hz operation 3600 rev/min for 60Hz operation
Excitation:	Static or shaft-mounted a.c. exciter
Drive:	Single end
Output range:	250 to 1,100MVA - also capable of synchronous compensator operation.
Cooling:	Closed hydrogen and water circuits, water cooled

Experience

BRUSH combined cooled turbogenerators are operational in the following countries:

Brazil	Germany
China	Jugoslavia
Cuba	Romania
Czech Republic	Slovak Republic
Egypt	United Arab Emirates



Certificate No 21024



Certificate No 21025



Certificate No 936683



Certificate No 00282



Certificate No 00066

BRUSH ELECTRICAL MACHINES Ltd
Falcon Works, Nottingham Road,
Loughborough, Leics. LE11 1EX, England
Tel: +44 (0)1509 611511
Fax: +44 (0)1509 610440
E-mail: salesuk@brush.eu
Web: www.brush.eu

BRUSH HMA b.v.
PO Box 3007, 2980 DA Ridderkerk
The Netherlands
Tel: +31 180 445500
Fax: +31 180 445566
Email: salesnl@brush.eu
Web: www.brush.eu

BRUSH SEM s.r.o.
Edvarda Benese 39, 301 00 Plzeň
Czech Republic
Tel: +420 37 8210111
Fax: +420 37 8210214
Email: salescz@brush.eu
Web: www.brush.eu

BRUSH TURBOGENERATORS Inc.
15110 Northwest Freeway, Suite 150,
Houston, Texas 77040, USA
Tel: +1 (281) 580 1314
Fax: +1 (281) 580 5801
Email: salesus@brush.eu
Web: www.brush.eu