

DG 4-Pole Turbogenerators

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

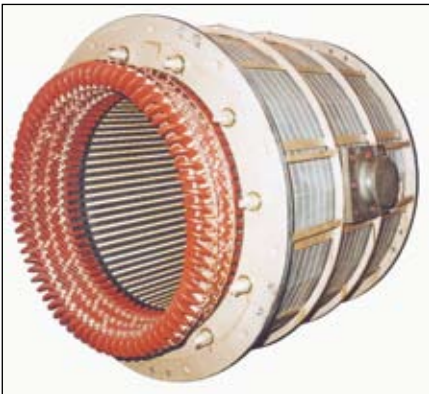




21MW gas turbine driven generator with a multi-stage air inlet filter system.



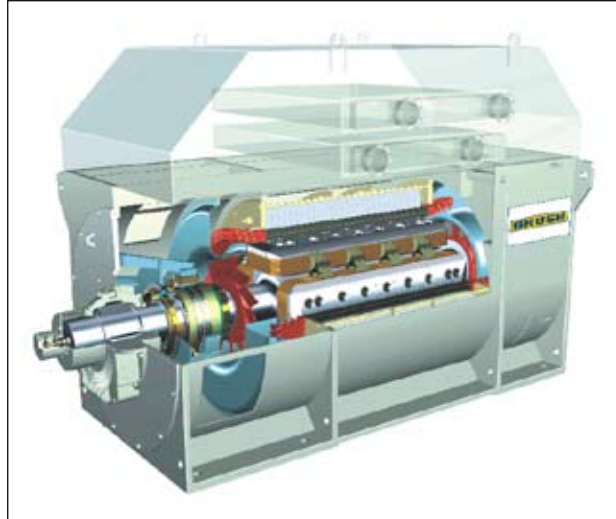
Packaged generator with closed circuit cooling through a top-mounted air-to-air heat exchanger.



Completed stator core.



Celebrity Cruises' GTS "Infinity" cruise liner, where a steam turbine driven DG 4-pole generator operates in combined cycle with two gas turbine driven BRUSH 2-pole generators.



Introduction

BRUSH DG salient pole rotor, air cooled generators are extensively used in public utility, cogeneration, CHP, industrial and offshore applications. These generators are designed to be driven by both steam turbines and gas turbines, with extensive operational experience of both applications. BRUSH has more experience of the use of gas turbines than any other generator manufacturer in the world and has also supplied machines to a large number of the major steam turbine companies. The continued success in both gas turbine and steam turbine power generation 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 during operation and under accidental short circuit conditions. Mounting pads are incorporated at appropriate points on the underside, with holes in each pad for foundation and jacking bolts.

The core is built up from segmented laminations of low-loss, high permeability, high silicon content electrical steel.

Radial ventilation ducts are formed at intervals along the core by steel spacers.

The core is hydraulically pressed at predetermined stages during the building operation to ensure uniform compaction, the pressure being carefully monitored. The finished core is clamped between heavy endplates.

The stator winding is of the two layer diamond type, consisting of identical diamond wound coils with six winding ends brought out, three to the line terminals and three to the neutral terminals.

The insulation system is based on a glass fabric baked mica paper tape which, when processed, results in a high performance class F insulation system.

The coils are inserted into the stator slots and interconnected. To ensure a good fit of the winding in the slots, glass fabric wedges, and packers that expand on contact with the impregnation resin, are inserted into the slots above the winding.

The endwinding is securely braced to an insulated support ring. 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.

Finally, after an extensive vacuum pressure impregnation (VPI) process, the completed stator is heated in an oven to fully cure the insulation.

Rotor

The rotor of a BRUSH DG turbogenerator is manufactured from a one-piece forging of high quality alloy steel, which is de-gassed, vacuum poured and stress relieved to obtain a uniform material which has excellent tensile properties.

The four individual coils of the rotor winding are built up from copper strips, brazed to each other by means of inductive heating and silver brazing. The copper strips are insulated from each other with a layer of aramide (Nomex), covered with an epoxy resin adhesive layer. The resin is polymerised at high pressure and temperature, consolidating the coil into a compact, solid unit. Flexible connections connect the coils in series with the d.c. output of the brushless exciter.

The coils are held in place by forged steel poles shoes that are bolted to the top of each pole body. During manufacture, the pole shoes are subjected to the same close control and extensive quality testing as the rotor forging. Radial circumferential grooves are machined into the pole shoe to reduce eddy current losses on the outer surface.

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 cylindrical bearings with forced lubrication.

Thrust bearings can be provided where necessary to suit particular turbine or site conditions.

Cooling

BRUSH DG turbogenerators are cooled by air, either in open circuit or closed air circuit configuration.

The generator internal system is similar in all cases.

Cooling air 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.

Open ventilated generators are cooled by ambient air drawn into the machine through filters and exhausted through an outlet duct connected to the stator air outlet flange.

Site considerations such as severe desert conditions, extremely salty atmospheres or

unsuitably contaminated environments may necessitate the use of a closed air circuit machine, where the hot exhaust air is cooled by a secondary coolant before being returned to the inlet. The secondary coolant is usually air or water.

Excitation System

BRUSH DG turbogenerators are fitted with brushless excitation systems.

The brushless exciter consists of a three phase, rotating armature, alternating current generator, with a shaft mounted rotating rectifier. The field winding is stationary. The brushless concept enables the exciter output to be connected to the generator field without the use of commutators, brushgear or sliprings.

Double end drive generators use a brushless exciter that is capable of transmitting the full power from one of the turbines.

Research & development

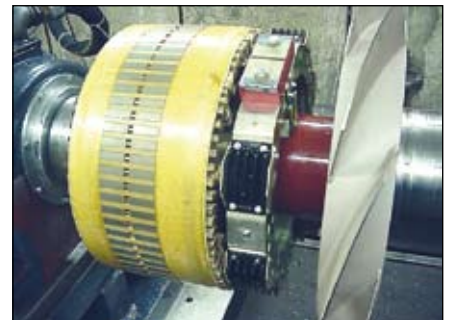
The Company's Research & Development Department constantly searches for further improvements in processes, materials and design methods. Finite element analysis has become one of the major tools in our design and optimisation processes. As a result of accumulated knowledge built up over years of experience, finite element models have been validated and continually improved. Our areas of modelling expertise include static and dynamic stress analysis, thermal models and frequency response analysis. The software used can exchange data with a number of other finite element software formats, enabling us to exchange or combine our model with those of customers or suppliers. A typical application for this could be, for example, the interaction between the generator and the foundation.



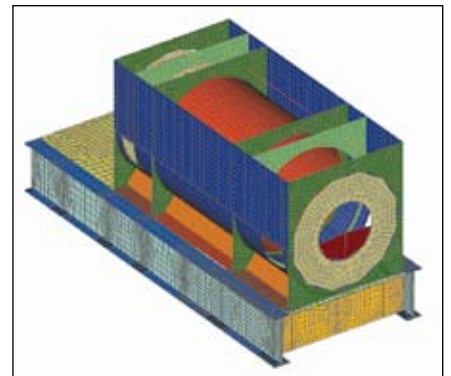
26MW generator with closed circuit cooling air-to-air) at a cogeneration plant in Spain.



Completed rotor of a 30MW DG generator.



Shaft mounted exciter armature and rotating rectifier.



Typical finite element model of a generator stator mounted on a baseplate.



Features

The BRUSH DG range of turbogenerators has the following features:

- Simple foundation design for economic and speedy civil work.
- Minimum number of individual power station components, offering substantial savings on expensive site time.
- All units are fully factory tested, reducing commissioning to proving interconnections and combined turbine/generator testing.
- Heavy duty design, with modular construction giving a fine balance between flexibility and standardisation of components for fast economic construction.
- Fully developed system readily adapted to any turbine design.
- High efficiencies, resulting in low life cycle costs.
- Low noise and vibration levels.
- Fully compliant with the provisions of the relevant international standard specifications, including IEC and NEMA.

Specification

Voltage range:
Up to 15kV.
Speed:
1500 rev/min for 50Hz operation.
1800 rev/min for 60Hz operation.
Excitation:
Brushless.
Drive:
Single or double end.
Output range:
10 to 65MVA - also capable of synchronous compensator operation.
Cooling:
Open circuit, filter ventilated.
Closed air circuit, water cooled.
Closed air circuit, air cooled.

Experience

BRUSH 4-pole generators have been supplied for the following turbines/companies:

Industrial Gas Turbines	Units delivered up to December 2008	Aero Derivative Gas Turbines	Units delivered up to December 2008	Steam Turbines	Units delivered up to December 2008
General Electric Frame 3	1	Dresser Rand expander	2	Austrian Energy & Environment	2
General Electric Frame 5	110	Dresser Rand Vectra 40G	4	Allen Power	3
General Electric Frame 6	54	General Electric LM1600	9	Fincantieri	8
General Electric GE10	12	General Electric LM 2500	31	General Electric	5
Hitachi H25	43	General Electric LM 2500+	35	IMO Delaval	1
Hyundai THM1304D	2	General Electric LM 6000	12	Mitsubishi Heavy Industries	4
Kawasaki L20A	4	Rolls-Royce Avon	3	Ormat	28
Mitsubishi SB60	3	Rolls-Royce RB211	15	Shin Nippon Machinery Co	3
Siemens GT35	2			Siemens	20
Solar Mars	15			Turbomach	4
Solar Titan	20				

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