

4-Pole Turbine Generator

TMEiC

TOSHIBA MITSUBISHI-ELECTRIC INDUSTRIAL SYSTEMS CORPORATION



4-Pole Air-Cooled Turbine Generator

What is TMEIC?

TMEIC (Toshiba Mitsubishi-Electric Industrial systems Corporation) has a proud and rich history of providing the latest generator technology for a broad range of industrial market. Many application and design experience make the solutions that have high reliability and lowest expense of customer. We utilize the latest mechanical and electro-magnetic design tools to assure our product meets customer requirements while optimizing performance, efficiency of operation. Not only for providing the equipment, TMEIC also supports the customer's engineering works and site commissioning to complete the generator system.

Feature of 4-Pole Turbine Generator



Toshiba and Mitsubishi Electric lead the large generator business field and TMEIC is assigned to the market of large capacity 4-pole generator for global requirement.

Flexibility

TMEIC provides the various kind of generator for customer's requirement. Each generator is customized and designed during the engineering stage.

- *Compliance to global standards (IEC, IEEE)
- *Project requirement (Cooling system, excitation type)
- *Performance (Efficiency, Power factor, Short-circuit ratio, Impedance, etc.)

Reliability

TMEIC offers the best and highest reliable performance.

- *High insulation technique with global VPI (Vacuum Pressure Impregnation) is TMEIC standard insulation procedure by large VPI facility, which provides many benefits to the customer and achieves a longer life.
- *Robust rotor construction.
- The rotor is of salient solid pole construction. The rotor shaft is integrated with the pole bodies, which makes the shaft more rigid, increasing reliability up to over speed.

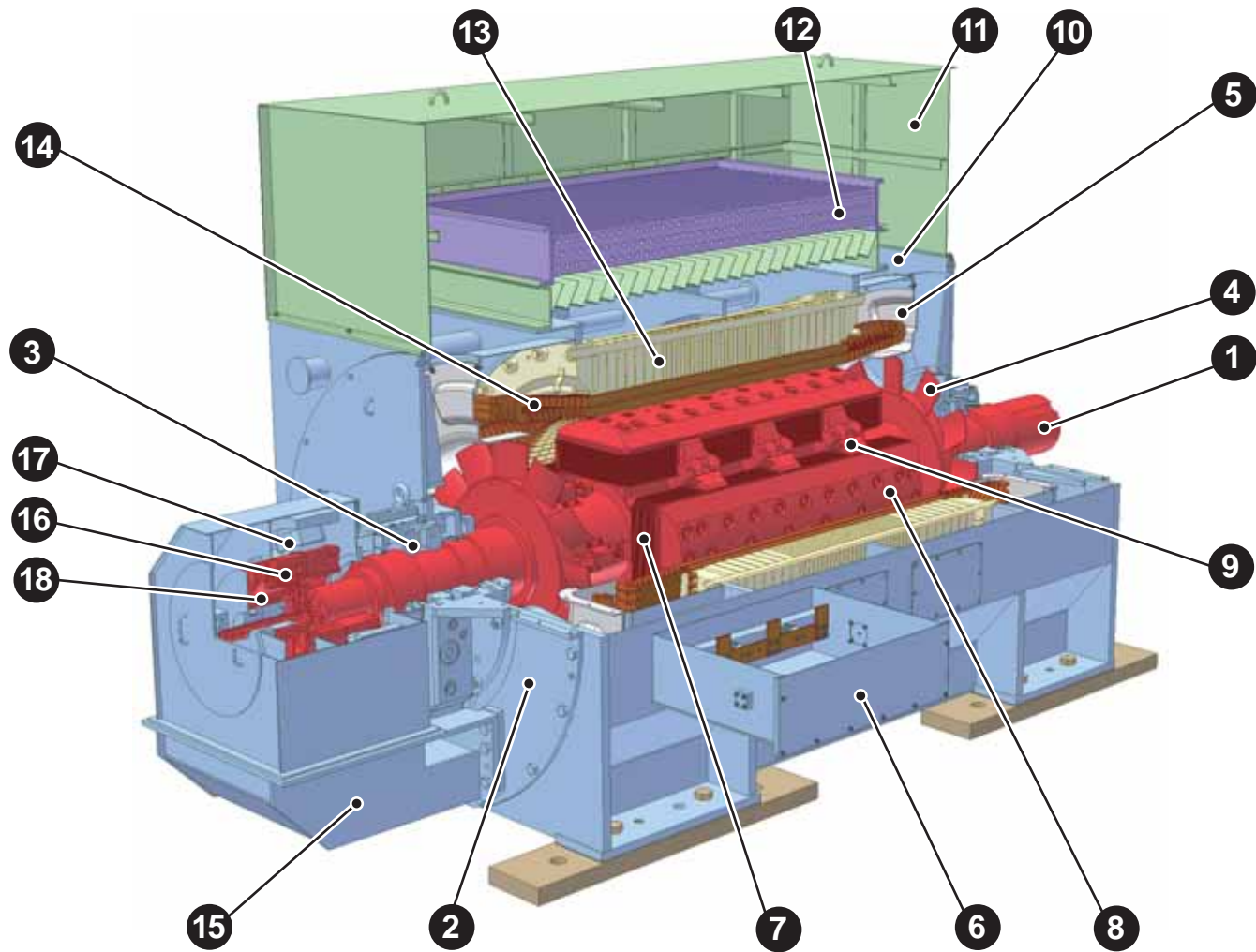
Maintenance

Easy and less maintenance is important for operation.

- *Brushless type AC-exciter system, our standard excitation system, realizes the easy maintenance and long continuous operation.
- *Bracket type generator is available to be transported and installed without dismantling. The world wide standard sleeve bearing is used and no oil leakage occurs at bearing by floating labyrinth seal system.

INTERNAL CONSTRUCTION

A typical construction of generator is shown below. The cooler is mounted on the top, AC-exciter with PMG (Permanent Magnetic Generator) is at the anti-coupling side and the frame has bearing bracket. The generator is assembled completely and tested at our factory and shipped without dismantling. This feature enables a compact size and small foot print. The minimum erection work is required.



Part NO.	NAME OF PARTS	Part NO.	NAME OF PARTS
1	ROTOR SHAFT	10	FRAME
2	BRACKET	11	AIR COOLER COVER
3	BEARING WITH INSULATION	12	AIR COOLER
4	FAN	13	STATOR CORE
5	FAN GUIDE	14	STATOR COIL
6	MAIN TERMINAL BOX	15	EXCITER SUPPORT
7	ROTOR COIL	16	ROTARY RECTIFIER
8	POLE HEAD	17	AC. EXCITER
9	ROTOR COIL BRACKET	18	PMG

Totally Enclosed Air-to-Water cooled type generator protects environmental affect, such as, dust, debris, water splash, etc. The standard protection of degree is IP44 for indoor, IP54 for outdoor, and IP55 is proposed for severe condition. The line and neutral main terminal box is located at the side of generator for easy installation. The cooler is located at the top and cooling water inlet/outlet interface location is upper, not to interrupt the turbine and generator mechanical system. The lubrication oil is supplied by common oil unit of turbine and the connection point is conjunction with coupling and anti-coupling side bearing. Over-hang type AC-exciter with PMG is integrated with main shaft and the common cooling air is used.

STATOR 1

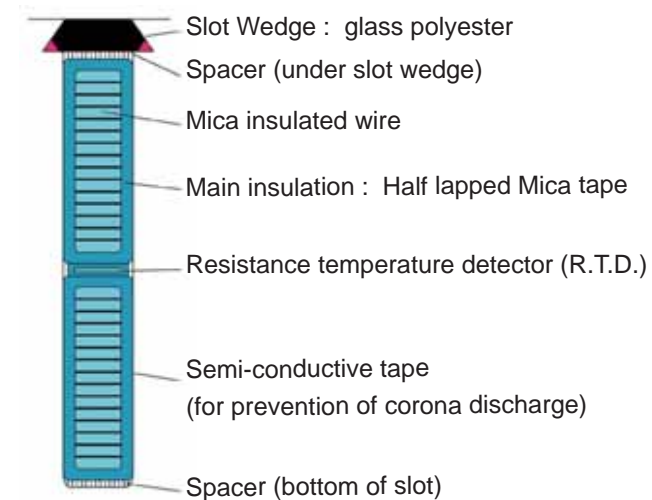
Stator Cores

Stator cores are high quality silicon steel plates and are laminated vertically by computerized robot automatically. After lamination, they are fixed with high tension by press machine for stator.



Stator Coil

Each winding coil is wrapped with insulation tape by wrapping machine and they are set in the stator. Coil end is stiffened so firmly by experienced workers that no vibration harmful occurs.

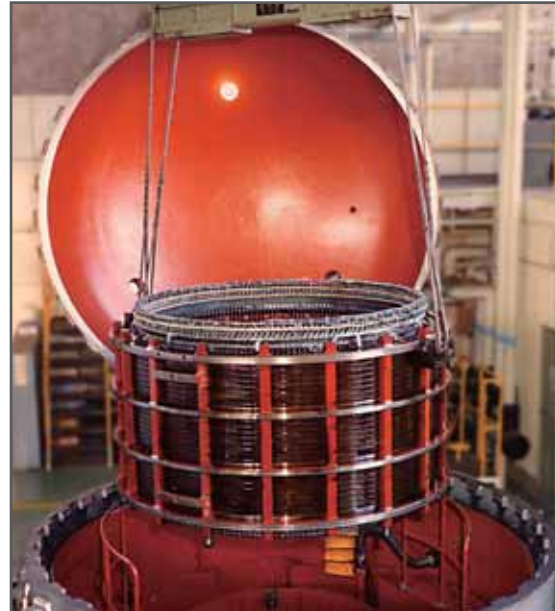


Constitution of Stator coil insulation

STATOR 2

VPI treatment

Stator with coil is impregnated completely with insulation material as global VPI (vacuum pressured impregnation). Whole stator with coil is impregnated completely by VPI facility, has a high reliability. Not only the mica but all of the iron core parts, including the bound parts of the coils, are impregnated with resin.



Frame

After VPI process, Stator is fixed in frame. Rectangular frame is robust and supports the stator core firmly and the bearing bracket is combined with frame. This standardized design achieved vibration free operation. The temperature and vibration instrumentation for remote sensing and the junction boxes (auxiliary boxes) is provided at the side of generator frame and the arrangement of boxes are flexible for external cable connection.



ROTOR

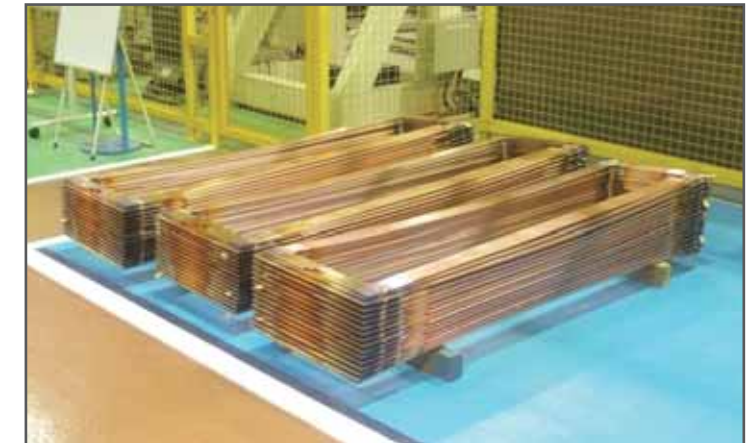
Machining Rotor Shaft

The rotor is constructed of the pole body, pole heads and field coils. The pole body is machined from a single steel forging and is of salient pole construction. To cope with vibration and overspeed, the rotor shaft, which is forged integrally with the pole body, is designed to withstand the primary critical speed being increased by 20% or more over the rated speed. This means that starting and stopping can be performed without passing the primary critical speed, resulting in greater resistance to vibration.



Rotor Coil

The rotor coil is fabricated from rectangular copper strips, with fin effects for optimum cooling. Insulation is provided between layers, and field coils are formed under pressure and heat.



Completed Rotor

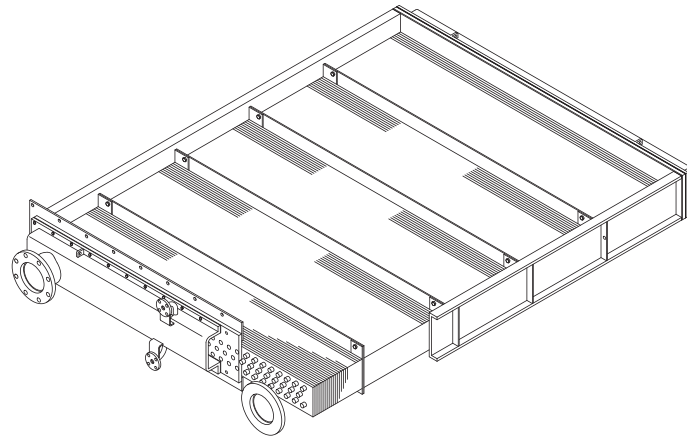
After the pole body has been fitted with field coils, the pole head are tightly bolted. All bolts, subjected to nondestructive inspection, are tightened under strict fastening control to ensure high reliability.



COOLER AND LUBRICATION

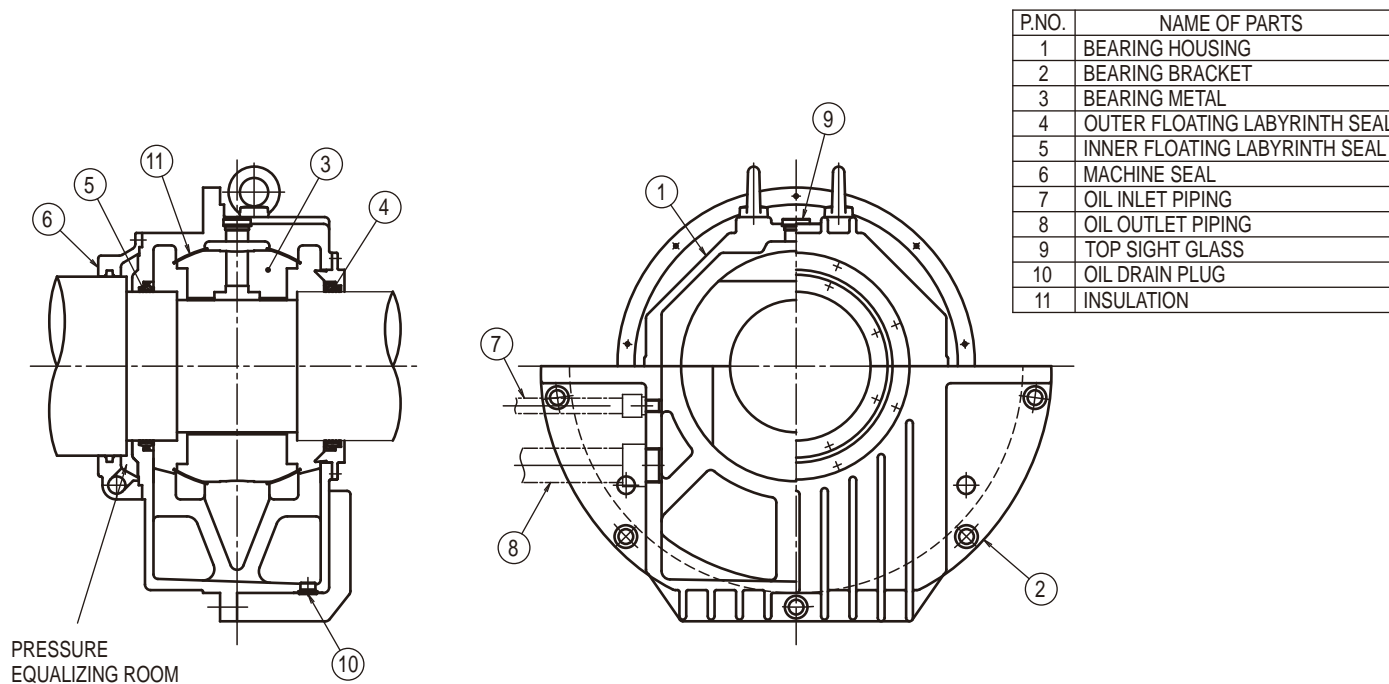
Cooler unit & Ventilation system

Cooler is mounted on the top of generator to transport and install with generator without additional site works.
 Even though water leakage occurs in the cooler, the water goes down on the protection sheet between cooler and generator frame and it is detected water leakage detector.
 The standard cooler tube material is deoxidized copper.
 Various options are proposed for project requirement and water quality, etc.
 Cooling air is isolated from the external and circulates in the generator body. The heated air goes through the cooler and becomes cold.



Bearing and Lubrication system

Sleeve bearing with forced oil lubrication makes the simple and excellent maintenance. Air seal structure prevents oil leakage, since it keeps the internal air positive pressure that no oil enters into the generator. The bearing is electrically isolated between rotor shaft and frame not to circulate the shaft current at anti-coupling side.
 Forced lubrication oil is supplied from turbine oil unit for sleeve bearing.
 The enough size inlet and outlet pipes make the smooth oil flow and prevent the vapor phenomena.
 Floating labyrinth seal of bearing also prevents oil leakage.

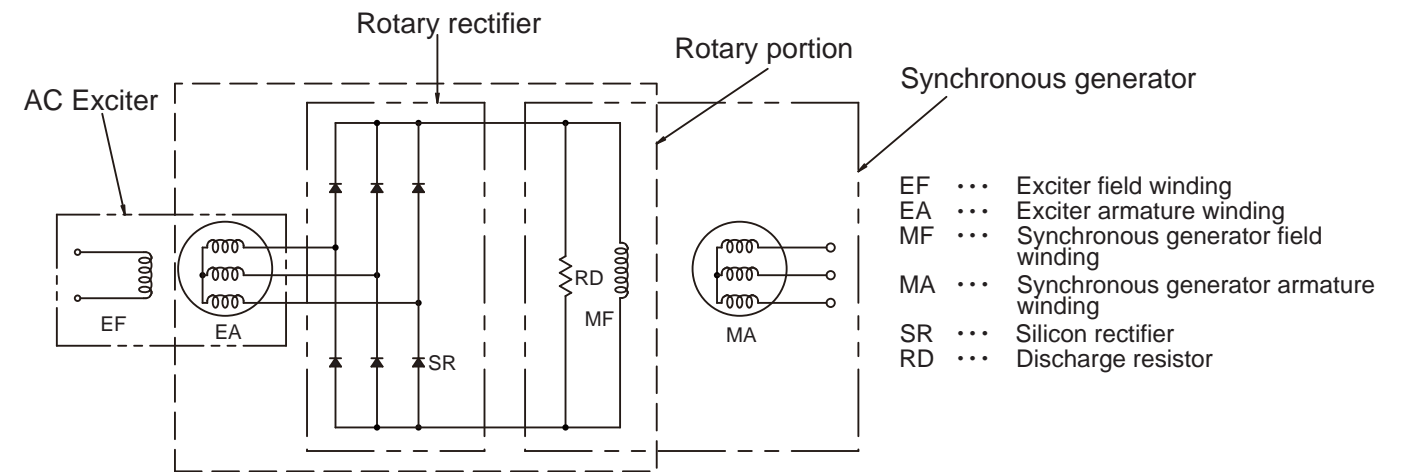


EXCITATION SYSTEM

Excitation system: Brushless type excitation with PMG (Permanent Magnetic Generator) is our standard and recommended for easy and less maintenance with continuous operation. The system consists of an AC-exciter, a rotary rectifier and a PMG. AC-exciter is a 3-phase AC generator of the revolving armature type and the rotating rectifier has a rectifier circuit mounted on shaft firmly at anti-coupling side. No initial excitation is required. Because excitation power is supplied from PMG during generator rotates. Short circuit current also keeps its value by field current supplied from PMG when short circuit occurs. Rectifier diode has enough margined to satisfy the severe operation.

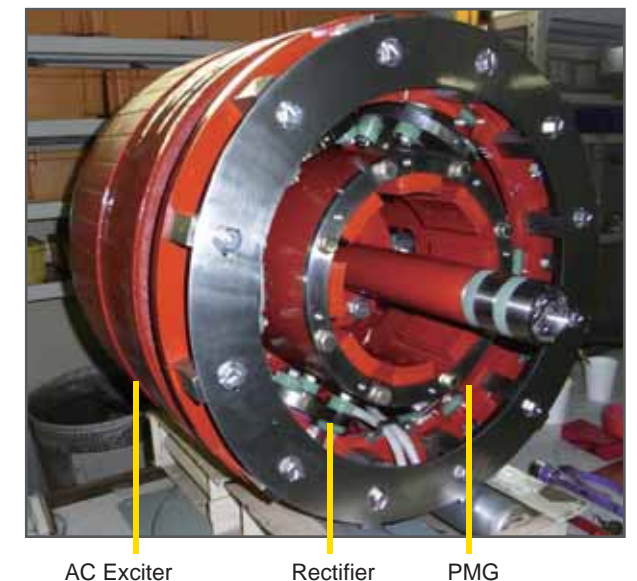
Rectifier

Rotating rectifier is mounted on the shaft, and consists of high reliability diodes for 6 arms (1S-1P-6A). Discharge resistor protect the diodes from abnormal induced voltage.



Exciter and PMG

Brushless exciter with PMG is over-hung on the generator shaft. So, additional bearing is not necessary. Collector ring is not equipped and there is no carbon brush and no carbon dust, no daily inspection is required.



OTHERS

TEAAC Enclosure

When cooling water is not available, we can apply totally enclosed air to air (TEAAC) type enclosure.



Accessories

Various type instrumentation is equipped on the generator for remote sensing and local indication, such as, RTD(Resistance Temperature Detector) for stator winding and inner air temperature detection, leakage water detector, etc.

The orifice at oil inlet flange is also provided after calibration during actual oil flow test at our factory. The detail application is fixed during the engineering stage to comply with customer's requirement.

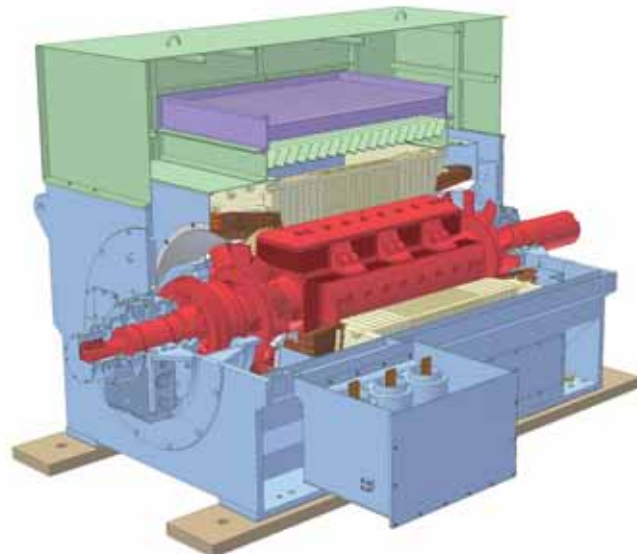
Standard Instrumentation		
Designation	Quantity	Type
Winding temperature	6	RTD
Inner air temperature(cold/hot)	3	RTD
Bearing temperature	2	RTD
Water leakage detector	1	---
Orifice	2	---
Space heater	1set	---
Sole plate	1set	---
Anchor bolts	1set	---

The separate space heaters for generator body are provided as standard for anti-condensation. The suitable rating is designed for site ambient condition and the heater operation is coincided with stopping status.

Sole plate, fixing bolt, shim, etc. are standard scope. They can be delivered separately prior to the generator shipping schedule.

Internal construction of medium size

The construction of medium size generator is shown below. General construction is same as large size generator, except for exciter is located inside of generator.



TEST & INSPECTION

TESTS OF GENERATOR

The tests of generator are performed in accordance with IEC60034 standard unless otherwise specified. The generator will be driven by a suitable driving motor during running test.

Test item	First Unit (No.1)		Duplicate Unit (No.2-)	
	Factory Test	Witness Test	Factory Test	Witness Test
A. Electrical measurement and test for generator(with AC exciter)				
1) Measurement of coil resistance				
2) Measurement of insulation resistance				
3) Dielectric test				
4) Open-circuit characteristic test and voltage balance and phase sequence check			x	x
5) Three phase short circuit characteristic test and current balance check			x	x
6) Measurement of segregated losses			x	x
7) Efficiency calculation			x	x
8) Equivalent heat run test			x	x
B. Mechanical inspection and test for generator(with AC Exciter)				
1) Outline and layout check				
2) Measurement of vibration				
3) Overspeed test				

: marked item will be done.
 : marked item will not be done. Test report will be submitted.
 x : marked item will not be done.

Rotor Shaft Balance Test

To minimize the vibration at operate condition, the rotor balancing is adjusted by adding the weight on each correction plane.

For up to 30,000kVA, two plane dynamic balancing test is carried out after completion of the rotor assembly. Over 30,000kVA, running balance test is carried out after final assembly.



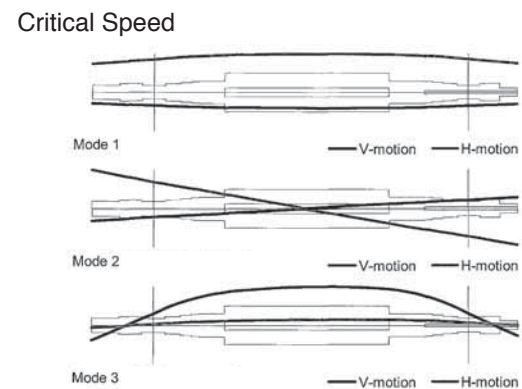
RESEARCH AND DEVELOPMENT

Research Introduction

We continue developing in pursuit of a better 4-pole generator. It needs design and manufacture technique to judge the application for creation plan. The design technique involves the following wide range of special knowledge which are electromagnetic, mechanical, material and insulation. This chapter introduces an example of the research.

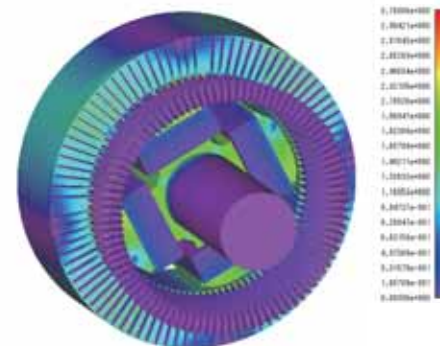
Reserch1 (Rotor characteristic)

4-pole generator rotor is long and thin, additionally, rotated high speed, so we should get the characteristic. Critical speed, Q-factor, vibration mode and stability of bearing are analyzed for each generator, measuring balance weight effect and vector at routine test process.



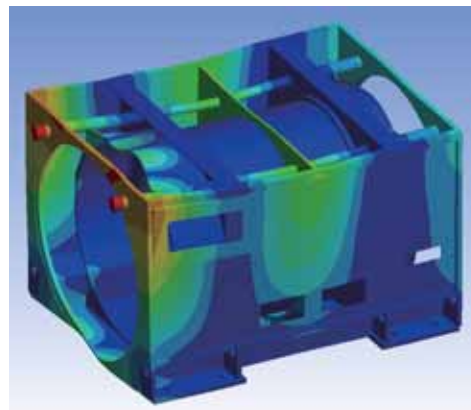
Reserch2 (Magnetic flux)

Magnetic flux analysis is effective for design of high efficiency machine. It leads to high promotion of efficiency to reduce leakage magnetic flux. In addition, we can avoid a local heating by excessive magnetic flux density.



Reserch3 (Frame eigen frequency)

Frame is joined to stator core, so it is subjected to excitation force by stator core. If frame eigen value harmonize excitation frequency, frame vibration grows, and it occur various problems. We get a frame eigen frequency with analysis and confirm vibration with measurement for real machine.



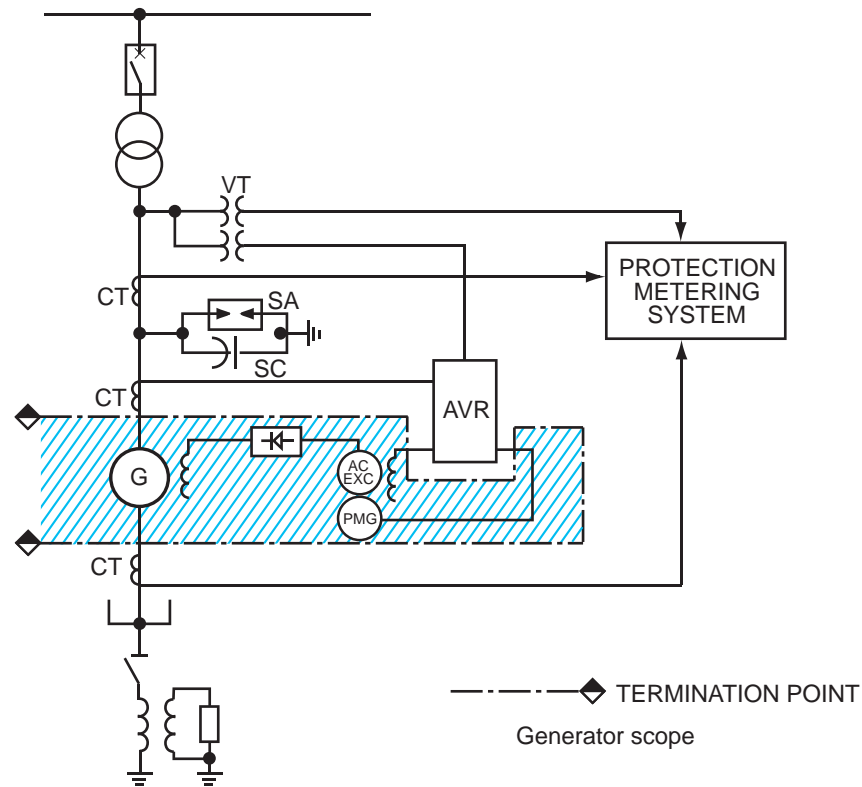
SPECIFICATION

Item	Standard Specifications	Options
Ratings		
Rated output	10000 ~ 50000kVA (approximately)	
Rated voltages	6.6kV, 11kV or 13.8kV	According to customer's specifications
Frequency	50Hz or 60Hz	
Poles	4	
Rated speed	1500min ⁻¹ or 1800min ⁻¹	
Rated power factor	80% ~ 90% lagging	According to customer's specifications
Enclosed type		
Protection	Totally enclosed, water to air cooled type (TEWAC)	According to customer's specifications
Cooling method	IP44	According to customer's specifications
Applicable standard	IC8A1W7	According to customer's specifications
Site conditions		
Location	IEC60034	According to customer's specifications
Location	Indoor	Outdoor
Ambient temperature	MAX.+40°C MIN.-5°C	According to customer's specifications
Altitude	Less than 1000m	According to customer's specifications
Humidity	Less than 95%	According to customer's specifications
Voltage variation	Less than±5%	According to customer's specifications
Frequency variation	Less than±2%	According to customer's specifications
Rotor configuration	Salient pole solid rotor	
Insulation rating	F-Class insulation	
Temperature rise	F-Class temperature rise	B-Class temperature rise
Excitation system	Brushless excitation (with PMG)	According to customer's specifications
Direction of rotation	According to customer's specifications	
Shaft construction		
Shaft extension	Single shaft	According to customer's specifications
Shaft end geometry	Solid	According to customer's specifications
Air-Cooler		
Location	Top mount	According to customer's specifications
Water inlet temp.	32°C	According to customer's specifications
Supply pressure	0.5MPa (Allowable design value)	According to customer's specifications
Kind of water	Fresh Water	According to customer's specifications
Type of cooling tube	Single tube	According to customer's specifications
Tube material	Deoxidized copper	According to customer's specifications
Direction of piping flange	Left side (viewed from exciter side)	Right side (viewed from exciter side)
Bearings		
Type of bearings	Sleeve bearings (forced lubrication)	
Oil temperature	45°C	According to customer's specifications
Oil pressure	approx. 0.1MPa	
Lubricating oil	ISO VG32	According to customer's specifications
Direction of piping flange	Left side (viewed from exciter side)	Right side (viewed from exciter side)
Main terminal		
Number of terminal	6 terminals (Star connection)	According to customer's specifications
Terminal box position	Right side (viewed from exciter side)	According to customer's specifications
Painting		
Painting color	Munsell 2.5PB6/2	According to customer's specifications
Thickness	50µm or Above	According to customer's specifications
Accessories		
	1 set - Sole plate	
	1 set - fixing bolts	
	6 pcs - Stator winding temperature detector RTD	
	2 pcs - Bearing temperature detector RTD	2 pcs - Dial type bearing temperature indicators
	2 pcs - Inlet air temperature detector RTD	
	1 pc - Outlet air temperature detector RTD	
	1 set - Space heater	
	1 set Auxiliary terminal box for instrumentation	
	1 pc - Air-cooler water leakage detector	
	1 set - Orifice for lubrication oil inlet	
	1 set - Earth terminal	
	1 set - Special tool	
		1 set - Vibration probe fixing work at factory (Probes to be supplied by turbine manufacturer)
		1 set - Oil flow sight
		1 set - Copper belt/carbon brush for shaft earthing

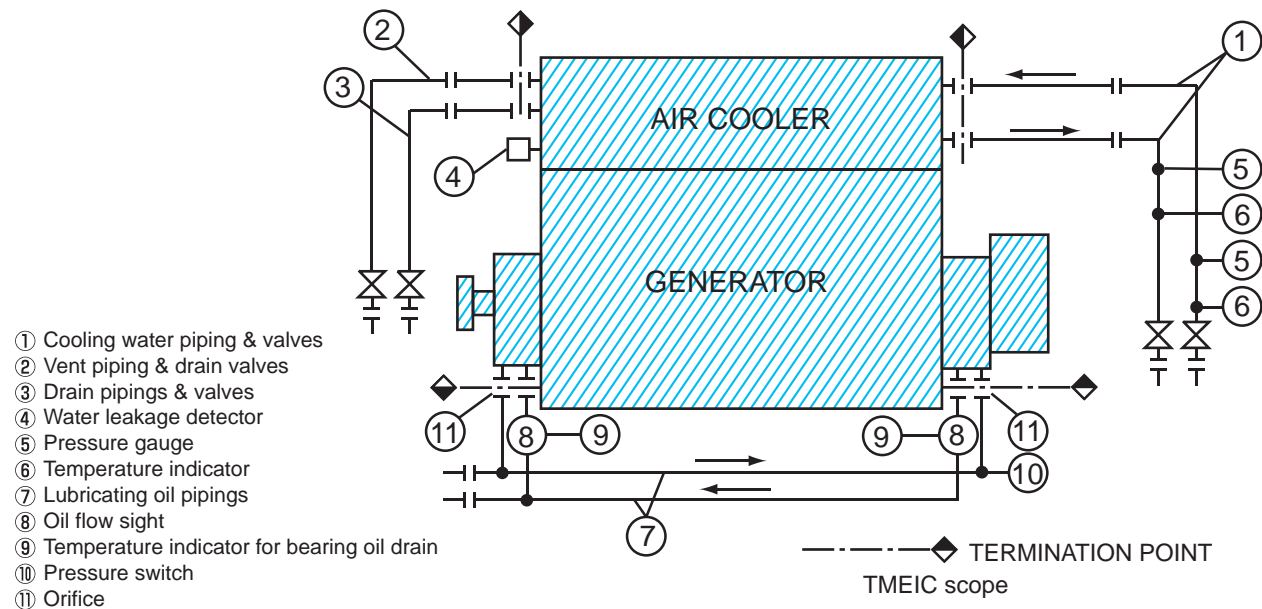
TERMINATION POINT

The single line diagram and piping & instrument diagram show the typical termination point of our generator system with excitation and purchaser's scoped.

Electrical system



Lubrication and Cooling water system



Overseas Network



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