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2-Pole Air-Cooled Turbine Generator

2-Pole Turbine Generator

TMEIC Corporation

Who is TMEIC?

TMEIC have a proud and rich history of providing the latest generator technology for a broad range of industrial markets.

Vast application and design experience create solutions that have high reliability and lowest operational expense for customers. 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 providing genaration equipment, TMEIC also supports the customer's engineering works and site commissioning to complete the generator system.

Feature of **2-Poie Turbine Generator**

Toshiba and Mitsubishi Electric lead the large generator business field and TMEIC have been assigned market responsibility for the supply of turbine generators up to 100MVA capacity.

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 class leading reliability and performance. *High quality insulation technique with VPI (Vacuum Pressure Impregnation) is TMEIC standard insulation procedure utilizing our class leading large VPI facility, which provides many benefits to the customer and achieves a longer life.

*Low vibration through optimal structual design. Spring support system of stator reduces the influence of electrical magnetic force and the optimized design of rotor stiffness with cross slot also reduces the specific frequency vibration. The rotor itself is manufactured and tested by high speed balancing machine.



Maintenance

Easy and less maintenance is important for operational availability.

*Brushless type AC-exciter system, our standard excitation system, realizes the easy maintenance and long continuous operation. Thyristor type with brush are also available based on customer's specific requirement. *Bracket type generator are transported to site without the need for dismantling and installed at site without the need for re-assembly. First class sleeve bearings with air-seal systems are used eliminating risks of oil leakage.

INTERNAL CONSTRUCTION

A typical construction of generator is shown below. The cooler is mounted on the top, AC-exciter with PMG 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 makes a compact size generator and the small installation space is required. The minimum erection work is obtained.



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

Totally Enclosed Air-to-Water cooled type generator protects from environmental affects, such as, dust, debris, water splash, etc. The standard protection of degree is IP54, and IP55 is proposed for severe conditions. The line and neutral main terminal box is located at the bottom of generator for mezzanine installation type turbine generator system. The cooler is located at the top and cooling water inlet / outlet interface location is within the upper section so as, not to interrupt the turbine and generator mechanical system. The lubrication oil is supplied by common oil unit of turbine. Over-hang type AC-exciter with PMG is integrated with main shaft and the common cooling air is used.

STATOR **D**

Stator Cores

Stator cores are high quality fan shaped silicon steel plates and are laminated vertically by computerized robot automatically.

After lamination, they are fixed with high tension by press machine.



Stator Coils

Each winding coil is wrapped with insulation tape by wrapping machine and they are set in the stator. Coil end is stiffened by experienced workers and proven techniques to eliminate vibrations which can lead to premature failure. The conductors are transposed at the ends in order to minimize eddy-current losses. In the case of one-turn coils, Roebel transposition and External transposition are employed to minimize copper.









Roebel transportation



Stator Coil Assembling

STATOR **B**

VPI treatment

Stator with coil is impregnated completely with insulation material through VPI (vacuum pressured impregnation). Whole stator with coil is impregnated completely by VPI facility, resulting in high reliability.

Not only the mica taped coils but the complete iron core parts, including the bound parts of the coils, are impregnated with resin.



Frame

After VPI process, Stator is fixed in frame with spring support system, which reduces the deformation vibration from stator to frame.

Rectangular frame is robust and supports the stator core firmly and the bearing bracket is combined with the 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.



Main terminal

Line and neutral main terminals are located at the bottom of generator frame. Star connection winding and 6 terminals are brought out. The terminals are enclosed in the main terminal box for NSPB (Non Segregated Bus Duct) or cable. Various options to mount CTs for control panel is offered.



ROTOR

Machining Rotor Shaft

Special alloy steel material is purchased after ultrasonic flaw inspection and machined at our factory. Cross slots at Y-axis is also machined as standard. The rotor balance test is carried out after machined.

Rotor shaft

Special alloy steel material is selected for 2 pole rotor shaft to withstand large centrifugal force under 3000min-1 or 3600min-1 operation. The material inspection by ultrasonic flaw detection and rotor balance test are carried out after machining, since the quality of rotor material and manufacturing is the key factor of 2 pole turbine generator longevity.

Completed rotor shaft

Rotor coil end extends to anti-coupling side, is fixed by shrinkage-fitted retaining ring. The ring is made of non-magnetic 18Mn / 18Cr steel for large capacity machine. High speed balancing test of rotor is carried out before final assembling.

Cross slots engraved at Y-axis equalize the stiffness at X-axis and Y-axis, and high balance performance is obtained.







ROTOR

Rotor coils

Rotor conductors are of flat, annealed copper plate material and wrapped by insulation tape (mica) between layers and inside the slot.

And the coils are held by nonmagnetic wedges driven into the slot.



Method of cooling

For cooling of rotor coil, air flow ducts are cut under rotor slots and holes are cut to rotor coils. Cooling air pass through these ducts and holes, then rotor and rotor coils are cooled.





Coupling end

Turbine coupling end is of forged integral type. During the manufacturing stage, the template turbine manufacturer supplies are used to comply with the actual dimension of coupling.



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 if water leakage occurs in the cooler, the water collects on the protection sheet between cooler and generator frame and it is detected by the water leakage detector. The standard cooler tube material is 90-10 cupronickel, and 2x67% capacity coolers are provided for IEC standard. Various options are also available for project requirement and water quality, etc.

Cooling air is isolated from the surrounding environment and circulates within the generator body. The warm air passes through the cooler and becomes cold before being recirculated.

Bearing

Sleeve bearings with force fed oil lubrication makes for simple and reduced maintenance. Air seal structure prevents oil leakage, since it keeps the internal air at positive pressure against ambient preventing oil from entering into the generator.

The bearing is electrically isolated between rotor shaft to eliminate the circulation of shaft currents.

Lubrication system

Forced lubrication oil is supplied from turbine oil unit for sleeve bearing. Appropriately sized inlet and outlet pipes make the smooth oil flow and prevent the vapor phenomena. Air seal labyrinth of bearing also prevents oil leakage. The arrangement of flange location, piping material and instrumentation of lubrication system are agreed during the engineering stage.











EXCITATION SYSTEM

Excitation system: Brushless type excitation with PMG (Permanent Magnetic Generator) is our standard and recommended for easy and maintenance free 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 firmly mounted on the shaft at anti-coupling side. No initial excitation power is required, as the excitation power is supplied from PMG as the 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 and no discharge resistor is required.

Rectifier

Rotating rectifier is mounted on the shaft, and consists of three parallel diodes with two serials for 6 arms (2S-3P-6A). The redundant diode system achieves the high reliability and the generator can run continuously.



Exciter and PMG

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

Failure detector

Both diode failure and field earth fault are able to be detected.

Exciter option

Over-hung exciter is adopted as standard eliminating the need for any additional bearings however when special performance is required, separate large capacity AC exciter can be provided. Static type of collector ring is also available for project requirement as option.



PMG AC Exciter

OTHERS

Enclosure

The natural ventilation type outdoor enclosure can be provided for sound proof and/or severe environmental circumstance, equipped with inner luminescence and entrance door. The enclosure is divided into adequate size plates for shipping and can be easily assembled at site by purchaser. The dimension is engineered to integrate with turbine cover and installation limitation.

Instrumentation

Various types of instrumentation is equipped on the generator remote sensing and local indication, such as, RTD(Resistance Temperature Detector) for stator winding and inner air temperature detection, vibration probe for shaft and bearing housing running condition monitoring, leakage water detector, of The orifice at oil inlet flange is also provided after calibration during actual oil flow test at our factory. The detail application i fixed during the engineering stage to comply with customer's requirement.

Space heater

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

Sole plate and fixing bolt

Sole plate, fixing bolt, shim, etc. are standard scope. They can be delivered separately prior to the generator shipping schedule for installation within the foundations at an appropriate time scale.



for				
101	Standard Instrumer	strumentation		
	Designation	Quantity	Туре	
	Winding temperature	6	RTD	
	Inner air temperature(cold/hot)	3 or 4	RTD	
etc.	Bearing temperature	2	RTD	
	On-shaft vibration	2		
is	Water leakage detector	1		
	Orifice	2		





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		Standard	First Unit		Duplicate Unit	
			Factory	Witness	Factory	Witness
A. Electrical measurement and test for generator						
1)	Measurement of coil resistance	IEC-60034	0	\triangle	0	\triangle
	Measurement of insulation resistance	IEC-60034	0	0	0	\triangle
2)	Dielectric test	JEC-2130	0	\triangle	0	\triangle
3)	Open-circuit characteristic test	IEC-60034	٠	•	×	×
	Voltage balance check	IEC-60034	٠	•	×	×
	Phase sequence check	IEC-60034	•		×	×
4)	Three phase short circuit characteristic	IEC-60034	•		×	×
	Current balance check	IEC-60034	•		×	×
5)	Measurement of segregated losses	IEC-60034	•		×	×
6)	Efficiency calculation	IEC-60034	•		×	×
7)	Equivalent heat run test	IEC-60034	•		×	×
8)	THF measurement	IEC-60034	٠	•	×	×
B. Mechanical inspection and test for generator						
1)	Outline and layout check	TMEIC standard	0	0	0	\triangle
2)	Measurement of vibration	IEC-60034	0	0	0	\triangle
3)	Overspeed test	IEC-60034	0	\bigtriangleup	0	\bigtriangleup

O : Marked item will be done. Test report will be submitted.

- Marked item will be done if the generator is new design. But if the generator is repeat design, marked item will not be done. Type test result will be submitted.
- \triangle : Marked item will not be done. Test report will be submitted.
- : Marked item will not be done.

Rotor Shaft Balance Test

A high speed dynamic balance test is carried out after completion of rotor assembly at our factory. Along with measuring minimizing the vibration, rotor balance is adjusted by adding the small weight under different speed up to rated speed and at 120% of rated speed.



RESEARCH AND DEVELOPMENT

Introduction of TMEIC's Research and Development

We are producted and designed based on the Research and Development to continue supplying all customer with a better 2-Pole-Generator.

Wide and special knowledge such as the technology of electromagnetic, mechanical, material and insulation are necessary to achive this our an aim.

This chapter introduces an example of our Reserch and Development.

Research1 (Rotor characteristic)

2Pole-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, measuringbalance weight effect and vector at routine test process.

Research2 (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.



Developing New Construction

Now we develop new construction for 2Pole-Generator. The drastic change is improved spring support system for electro-magnetic vibration.

As a result, we will be able to shut down a vibration transmission from stator core to frame and frame construction became simple.



Research3 (Frame natural frequency

Frame is joined to stator core, so it is subjected to excitation force by stator core. If frame natural value harmonize excitation frequency, frame vibration grows, and it occur various problems.

- We get a frame
- natural frequency
- with analysis and
- confirm vibration with measurement for real
- machine.







Spring support

SPECIFICATION

Item	Standard Specifications	Options
Ratings		
Rated output	5000~100000kVA (about)	
Rated voltages	11kV, 13.8kV	According to customer's specifications
Frequency	50Hz or 60Hz	
Poles	2	
Rated speed	3000min ⁻¹ or 3600min ⁻¹	
Rated power factor	85% lagging	According to customer's specifications
Enclosed type	Totally enclosed, water to air cooled type (TEWAC)	
Protection	IP54	According to customer's specifications
Cooling method	IC8A1W7	According to customer's specifications
Applicable standard	IEC60034	According to customer's specifications
Site conditions		
Location	Indoor	Outdoor
Ambient temperature	MAX.+40°C MIN5°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	Cylindrical 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	90-10 Cu-Ni	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	Bottom	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	Data Distance bearing to many sectors indicators
	2 pcs - Bearing temperature detector RTD	≥ pcs - Dial type bearing temperature indicators
	2 pcs - Inlet air temperature detector HID	
	I pc - Outlet air temperature detector HID	
	I set - Space neater	
	1 set Auxiliary terminal box for instrumentation	
	i pc - Air-cooler water leakage detector	
	1 set - Orifice for lubrication oil inlet	
	1 set - Earth terminal	
	1 set - Special tool	Drohoo to he cupplied he turking many facture
	i set - vibration probe fixing work at factory	robes to be supplied by turbine manufacturer
		I set - Oll flow sight
		i set - Copper beit/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 system

