Status of the MG installation and the result of the dummy load commissioning

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1. Introduction

The Korea Superconducting Tokamak Advanced Research (KSTAR) Motor Generator (MG) system has been installation. It is a device which supplies large amount power to the Poloidal Field Magnet Power Supply (PF MPS) for maximum 300 seconds. In the 300 seconds operation scenario in every one hour, the peak reactive power is reached 160 MVA. But the available grid power is only 100MVA at the National Fusion Research Institute (NFRI) site. Also flicker phenomenon may be occurred because PF MPS uses large power for a short time. MG was considered, designed and installed as a method of resolving such problems. Therefore if the MG is operated with a Reactive Power Compensation (RPC) system which is currently used, it will be possible to supply power more stably. Figure 1 shows the entire power system for the KSTAR including the MG power system and RPC system [1].

The components of the MG system are the generator, Variable Voltage Variable Frequency (VVVF) and Excitation system. After installing the MG, individual and linkage commissioning were conducted to determine the stability and performance of the MG system before the superconducting coil commissioning. The main purpose of the superconducting coil commissioning is to check a stable supply of required power by the operation of MPS in the superconducting state. Therefore this test will be performed in the last section of 2014 KSTAR campaign.

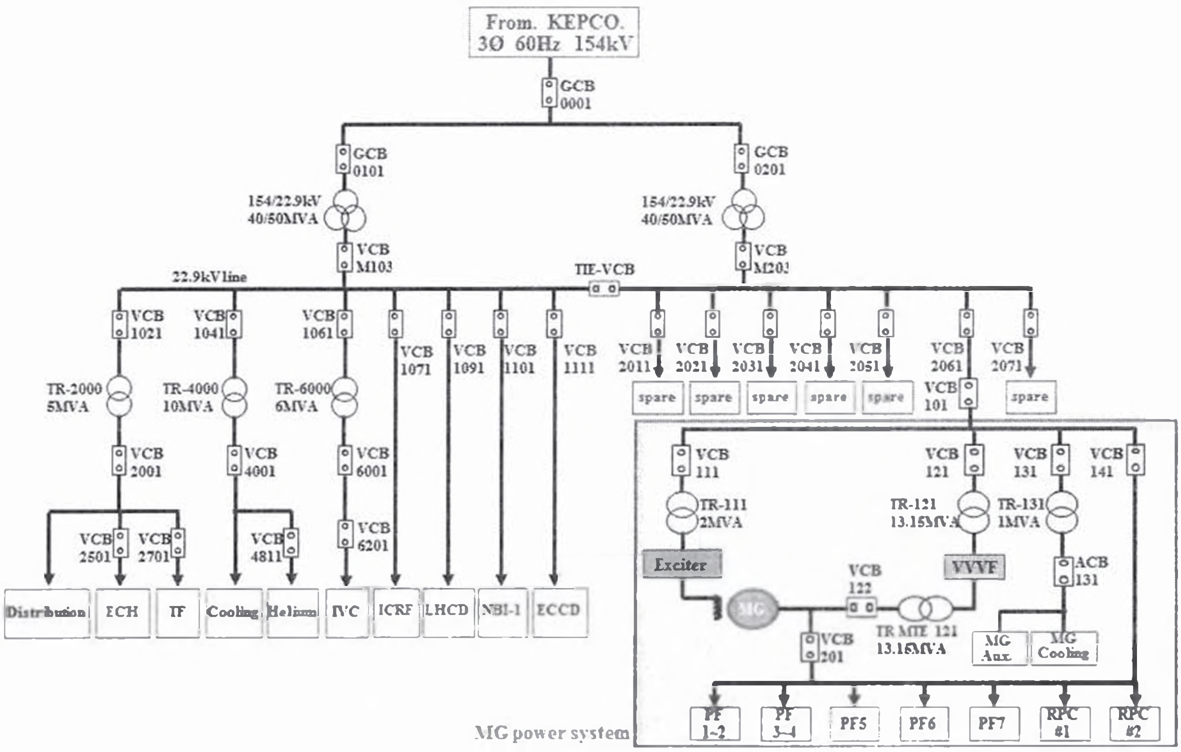

Figure 1. The KSTAR power system

2. Installation of the MG system

The functions of the individual components are VVVF to the MG speed and frequency, excitation system to regulate the voltage, RPC & HF system to remove the harmonics, and cooling facilities to supply cooling water to each device. The nominal operating power of the MG system is about 17.7 MVA from the 154 kV systems. The MG system could deliver power and energy of 200 MVA, 1.6 GJ required by the PF MPS to operate at full rating. [1] The specifications of KSTAR MG system is shown as Table 1.

Table 1. The specifications of MG system

Generator		VVVF	
Type	Vertical type	Capacity	12 MVA
Pole	14 pole, Salient pole	Rated Output Voltage	3.3 kVac
Capacity	200 MVA	Rated Output Current	2,100 A
Rated speed	480 ~ 548.5 RPM	Control Method	Inverter, PWM
Winding	3 Phase, Y Connected	Output Frequency	0~64 Hz
Rated Voltage	22.9 kVac	**Excitation system**	
Rated Current	5,042 A	Rated Output Capacity	954 kW
Weight	563 ton	Rated Output Voltage	580 Vdc
Stored energy	2,193 MJ(at 548.5 RPM)	Rated Output Current	1,645 A
Inertia. WR^2	$1.33X10^6$ kgm^2	Control Method	Converter, 6 pulse

The generator is consists of three parts (stator, rotor, and bearing). The generator is a capacity of 200 MVA, a vertical type, has 14 poles and the total weight is 563 ton. The VVVF is an inverter which has a capacity of 12 MVA, and control the frequency within 0~64 Hz range. The excitation system is a 6 pulse converter of 2 MVA capacities. The generator assembly states of each part are shown in figure 2. Especially, the KSTAR MG system does not have pony motors used to accelerate the generator. The motoring and generating is carried out by controlling the VVVF and excitation system. The VVVF supplies active power to the MG during the motoring and rotational speed is controlled. The rated voltage (22.9 kV) is maintained by synchronous operation of the VVVF and stator output.

MG control system consists of the main control system, power analysis system and cooling water control system. The collected information from the VVVF controller, exciter controller, temperature sensors and vibration sensors are transferred to the main control system through the interface controller. The control system of the MG set communicates in Modbus Transmission Control Protocol/Internet Protocol (TCP/IP) method with controller of each device. The configuration of KSTAR MG control system is shown in Figure 3 [2].

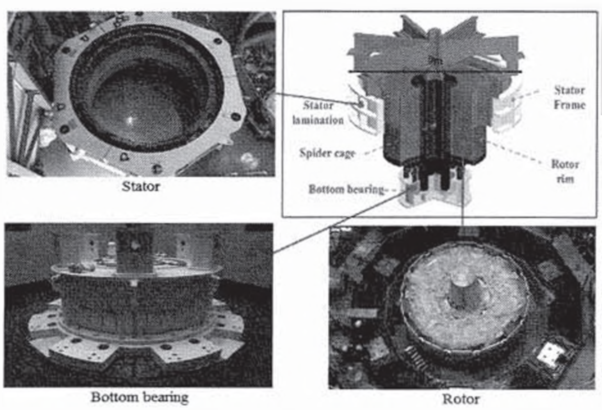

Figure 2. Each parts of the generator

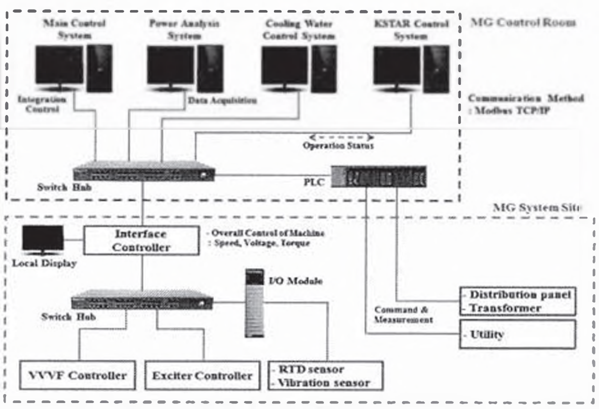

Figure 3. KSTAR MG Control system

To achieve effective MG operation, it is therefore necessary to install a cooling water system to remove the heat load of 3.926 MW generated from the rotor, stator, bearing and VVVF of the MG. During MG operation, even if blackouts or incorrect operations occur, the MG cannot be stopped because it continues to rotate by inertia. To stop the rotating MG, heat energy must be completely discharged [2]. Therefore the cooling system has been installed to allow removing the created heat from the MG system under all circumstances.

3. Result of the commissioning

The commissioning of the MG system is divided into two steps (individual and linkage commissioning). The individual commissioning was conducted in order to verify the performance of each device before the linkage commissioning. The measurement and inspection of each device (generator, VVVF, exciter, as well as power and cooling equipment) for individual test were conducted. Also these tests were passed for the each criterion. The commissioning items are shown in Table 2.

Table 2. The KSTAR MG commissioning items

Division		Test items	
Individual commissioning	Mechanical assembly test	-Stator winding electrical test	-Rotor electrical test
	Static test	-Radial air gap measurement -Mechanical brake system check -Bearing insulation inspection -Grounding test -Top bearing inspection	-H.P jacking oil system driving -Stator winding cold resistance -Speed encoder inspection -Stator winding Capacitance -Bottom thrust bearing inspection
	Rotational test	-Rotor alignment & shaft run-out -Initial rotation and direction check -Vibration measurement -Dynamic braking test -Over speed test -Open & short circuit characteristic -Shaft voltage measurement	-Rotational air gap measurement -Balancing inspection -Mechanical braking test -Maximum rated speed operation -Voltage balancing test -Noise measurement -Deceleration test
Linkage commissioning	No-load test	-Interlock test(Alarm, Trip check) -MG + RPC operation test	-Logic performance check -MG+RPC+PF MPS operation test
	Dummy load test	-Capacity operation (34, 38MVA) -Frequency operation (60, 61Hz)	-With / without RPC test

The linkage commissioning is divided into no-load and dummy load test. Through the no-load test, the MG system's performance and the correlation among the MG, RPC system and PF MPS were verified. The interlock levels of MG system are composed of 4 steps. The actual test of each level has been conducted and confirmed that were normal. The RPC system injection test and PF MPS transformer power input test both have been completed successfully. Based on the results of these tests we have known that the RPC system is possible to inject at any speed or voltage, and it is more stable to turn on the PF MPS after injection of the RPC system at idle mode.

For the dummy load test, several scenarios were prepared by changing the operation capacity, di/dt, duration time, with-without RPC, MG speed, etc. The typical scenario and result of the dummy load test are shown in Figure 4. (Capacity: 33.9MVA, di/dt: 4kA, Duration: 100sec, MG speed/voltage: 514.3 rpm/22.9kV) The PF MPS is operated using the KSTAR main control system during the dummy load test.

According to the results of dummy load test, the MG speed fluctuation range is increased proportionally against the operation capacity and di/dt of the PF MPS. However there was no change by whether injecting the RPC system or not. In both situations the speed and frequency of the MG have almost the same changing rate. But in case of the Voltage, it was more stable to inject the RPC system than without the RPC system. 36.09 Mvar reactive power is measured and after insert 33 Mvar of the RPC system about 5 Mvar leading reactive power is created.

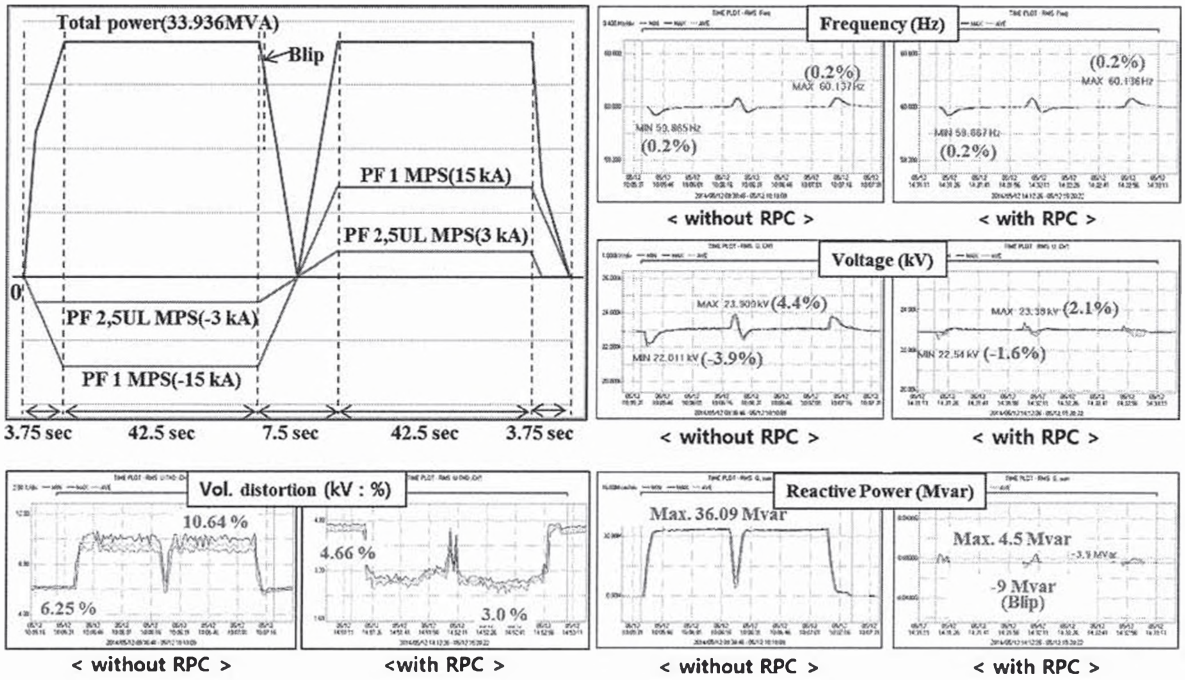

Figure 4. The typical scenario and results of the dummy load test

4. Plan for the superconducting commissioning of the MG system

The external heat exchanger has been installing to manage more stable for the bottom bearing oil temperature. Once this installation is completed, the bottom bearing heat run test is expected. The superconducting commissioning of the MG system will be started in November. The test capacity is up to 130 MVA and will be performed gradually increasing the operation capacity. In addition, the Identification tests of the reasonable capacity of the RPC system will be conducted.

Acknowledgement

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References

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