

## §26. Improvement of 250 MVA Motor-Generator System

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The motor-generator (MG) was constructed in 1993<sup>1)</sup> to supply high power pulse mainly to plasma heating devices. The specified ratings are as follows;

Vertical-shaft, three-phase generator	
Pulse capacity at power factor = 0.7	: 250 kVA
Output voltage/current (AC)	: 18 kV / 8.2 kA
Maximum ejection energy per pulse	: 2,336 MJ
Maximum stored energy	: 1,400 MJ
Moment of inertia	: 3,466 t·m <sup>2</sup> (no external flywheel)
Pulse length	: 3-60 sec
Repetition rate at full ejection	: 300 sec
Output frequency	: 58-93.5 Hz
Revolving speed	: 435-701.2 Hz
Number of output circuit-breakers	: 6

In this year the MG was mostly utilized for conditioning and experiment of NBI (Neutral Beam Injectors) in the LHD. Besides, the operation to excite plasma-confining field coils in CHS (Compact Helical System) started in the autumn. The operation of the MG reached 48,644 shots in total; 45,593 shots for NBI (93.7%), 2,771 shots for CHS, and the others for the tests of ECH (Electron Cyclotron Heating) etc.

To improve the performance of the whole system, continuous efforts have been devoted. The main items are summarized in this report.

### i) Certification of control for multi-load operation

The multi-load operation of the control system in the MG has been performed. In the combined operation of NBI with CHS, the MG has worked without any trouble. In the combination of ECH and CHS, the operation has been also successful. As a result, energy feed for NBI, CHS and ECH has become possible simultaneously. The MG has certainly increased its flexibility for the multi-load operation of any combination of the loads.

### ii) Replacement of phase-advancing capacitor with the third harmonic filter

Phase-advancing capacitor of 3 MVA was ordinarily used in the 6.6 kV line to reduce reactive delaying power chiefly generated at the thyristor Scherbius device. However, this capacitor was found to possess a resonance around the third harmonic of 60 Hz. The resonance amplifies the third harmonic voltage in the commercial line, which might disturb the operation of other machines.

To suppress the third harmonic voltage, the phase-advancing capacitor has been replaced with the third harmonic filter of 3 MVA.

### iii) Protection for instantaneous voltage drop in the power line

The operation of the MG was compulsorily shut down and goes to zero revolving speed, when instantaneous voltage drops or interruptions in the commercial lines occurred. The over-current detector of the thyristor Scherbius device was so sensitive that little decrease of the current led to such a shutdown process. Then the detective level of the over-current has been moderately adjusted and the capacitance in the power circuit for the detectors has been increased to operate over 1 sec even if the power is cut off. When the current drop in the thyristor Scherbius device is detected the currents in the thyristors are decreased by the gate-shift before the over-current occurs. Then the operation of the MG does not stop and continues even at instantaneous interruption of the line voltage so long as its duration is below 1 sec.

### iv) Protection for unusual decrease in the revolving speed

The MG was so designed that the control system assumed as if a heavy trouble occurred when the revolving speed decreased below the stand-by speed of 435 rpm. Then it initiated to cease its operation and to decelerate toward zero revolving speed. In this case, two hours are required to recover its function. This causes loss of the in-servicing time for all the loads. Such occasion may occur if any loads consume more than their demanded energy. A protective method has been newly introduced. The MG computer measures the revolving speed every 50 msec, and whenever there are indications that the revolving speed goes under the stand-by speed after 0.1 sec, the principal output circuit breaker is instantly turned off. Thus the fatal shutdown process has been avoided and the operation can be continued without interruption.

### v) Modification of control system

The control system, including computers and hard logic, has been modified for the convenience of easy control, good man-machine interface and assurance of safety. Some alteration has been achieved in the operation control system.

a) Initiating procedure of the control program in all the computers has been changed from cricking icons to keying-in some commands. This process contributes to eliminate human miss-operation and crash by miss-touching the Mouse.

b) Counterplan for Y2K problems has been successfully settled down for all the computers.

### vi) Repair and maintenance of the whole system

To keep the whole system sound, some parts have been repaired and maintenance of them has been performed.

a) Two types of contactors for high current switchgears in the driving circuit of the motor have been renewed.

b) All the protective relays have been calibrated for exact protections of over-currents and over-voltage in the feeders.

## Reference

1) Kitagawa, S., Ann. Rep. of NII'S (April 1998-March 1999) 373