§27. Ability of Long Pulse Operation of 250 MVA Motor-Generator

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The 250 MVA motor-generator was constructed to supply high power pulse, the duration of which was originally designed to be less than 30 sec [1]. Recently an operation has been demanded for over 120 sec to carry out quasi-stationary experiments in the LHD. Since the plasma vacuum vessel of the LHD has heat-removing capacity of 3 MW for continuous heat input, the plasma heating power is limited to the same value. For example, the power of about 10 MW (14 MVA) is required to obtain 3 MW output of NBI beam as its electric power efficiency and power factor are considerably low. In NIFS it is impossible to receive even such a low power from the existing commercial 6.6 kV line, because the power permitted for the heating devices is restricted only less than 7 MVA. This restriction, in the first place, comes from the fact that the heating devices use thyristor control in the 6.6 kV circuit and have only small capacity of higher harmonic filter without phase-advancing capacitor. This composition induces higher harmonic voltage and it might be noise sources for factories in 77 kV power line, because the 6.6 kV line is converted by the 77 kV/ 6.6 kV transformer. In the second place, the capacity of the transformer that supplies heating devices, is only 20 MVA with 15 % impedance in total. For these reasons, the voltage waveform in the 6.6 kV line is much distorted even if the power is used by far less than 7 MW.

An alternative and practical method was found, which was utilization of the existing MG as a long-pulse machine.

In the present state, the MG will be modified to separate into two steps. In the first step, the MG does not accelerate during generation of energy, as is the same at the present operation. In the second step, however, the MG is forced to accelerate even during generation of energy. The former is, of course, easier and cheaper at the modification of the system. On the other hand, in the latter, longer operation is possible for the same energy consumption of the heating devices. Comparison of the revolving speed of the MG is shown in Fig. 1, where the heating devices are assumed to use the power of 10.5 MW (15 MVA) continuously.

The former modification will be carried out in July of 2000. About 3 MW of the beam output will be drawn if NBI machine successfully operates. The duration of the output will be elongated up to 80 sec. The latter modification is more complicated and it will be performed after the forth cycle of the LHD experiment.

Some considerations have to be taken into account in modifying the MG system as a longer operating machine.

i) In the former case, NBI beam of 3 MW is to be available for 100 sec even if the power of 10.5 MW is consumed to produce it. The accelerating time of the MG is elongated by 30 sec if the pre-shot operation is introduced.

ii) The synchronization for the start of power generation with that of the heating devices is easy because the existing timing system is usable for both cases. However, the end time of the pulse is to be automatically determined by the control computer, which will be selected from **either** the preset time **or** the time that is caused by the operational limitation of the MG [2].

iii) Some signifying columns in all the computers are to be modified in accordance with longer operation so that they can preset various operating conditions especially concerning with times. The graphs indicating the output voltage and currents will be also increased in their time scales.

iv) The heat-removing capacities of some components of the MG, the exciting windings, the power supply for the exciter and the thrust bearings, were not designed for the long operation. The repetition rate of the operation might be somewhat limited. The temperature rise in the windings has to be carefully watched by increasing output power and duration time, because it is the critical path for long operation and its direct measurement is impossible.

v) It might be reconsidered whether the start pulse generated by the central timing system of the LHD can adapt to the preferable operation of the MG even for the longer pulse operation.

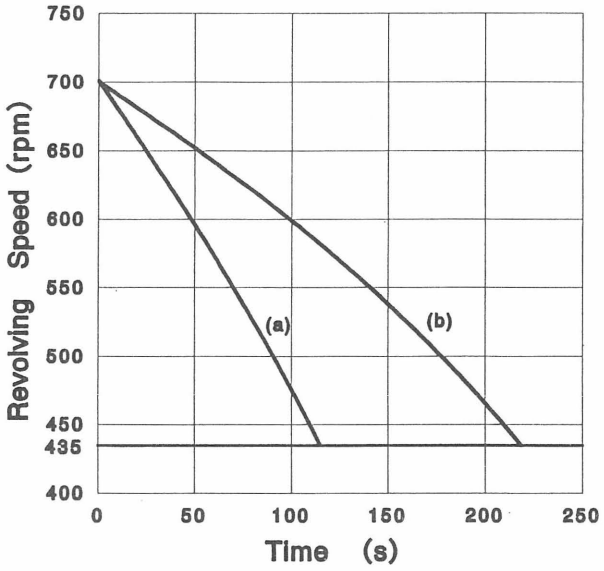

Fig. 1. Comparison of the changes of the revolving speed of the MG: (a) without, and (b) with acceleration of the rotor. The MG can be operated when it is above the stand-by speed of 435 rpm.

References

1) Kitagawa, S., *et al.* Fusion Engineering and Design **26**, (1995) 539
2) Kitagawa, S., *et al.* Annual Report of National Institute for Fusion Science, in the previous section of this report.