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Fri-Af-Po.09-03: Magnetic field coil power supply using a flywheel generator with a planetary gear and a very small capacity inverter

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Flywheel generators are used as power sources for various plasma experiments because of their long-life span and high-power repetition. However, huge capacity inverters for energy conversion have been necessary to charge and discharge rotating energy. Furthermore, in conventional flywheel generators, the power output also decreases as the rotation speed decreases. In response to this, the authors propose a flywheel generator equipped with a type of continuously variable transmission gear called a planetary gear and an extremely small capacity motor that controls that gear. This flywheel generator can always charge and discharge rotational energy at rated output without using the huge inverter mentioned above. Here, it is assumed that the magnetic field coil is composed of a diode rectifier and a coil current-controlled chopper.

First, the mechanical shaft connection of this flywheel generator and the planetary gear is as follows. Conventionally, the flywheel shaft and the generator shaft are connected by a coupling and have the same rotation speed. However, the proposed flywheel generator is unique in the connection of both shafts. The flywheel shaft is connected to the sun gear, the generator shaft to the carrier gear, and the control motor shaft to the ring gear. By adjusting the ring gear rotation speed with the control motor, the stored energy of the flywheel generator can be discharged to the magnetic field coil.

Next, the method for adjusting the rotation speed of the control motor is explained as follows. First, the flywheel rotation speed and generator rotation speed are measured. In response to the drop in the flywheel rotation speed due to discharge, the control motor rotation speed is adjusted to keep the generator rotation speed constant. In other words, even if the flywheel rotation speed drops, the generator rotation speed is kept constant. This is because the planetary gear mechanism is a continuously variable transmission. Therefore, the generator can always achieve the rated output. This control method has been experimentally verified with a 1-kW class flywheel generator.

Finally, the specifications of a newly manufactured 10-kW class flywheel generator are as follows. The flywheel diameter and thickness are 500 mm and 135 mm respectively. The rated flywheel speed is 3000 rpm, the maximum and minimum speeds are 125% and 75% respectively, and the available energy is 150 kJ at 10 kW for 15 seconds. The generator is a 6-pole capacitor self-excited induction generator, the speed increase ratio of the planetary gear mechanism when the rotation of the control motor is locked is 3, and the inverter capacity for the control motor is 1 kW, 1/10 of the generator. In other words, the inverter capacity that adjusts the rotation speed of the control motor is also 1 kW.

In the future, we plan to experimentally verify this 10-kW class flywheel generator as a power source for magnetic field coils that can significantly reduce the inverter capacity.

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