

§6. Test and Improvement of Rotating Probe for Ultra Long Time Magnetic Field Measurement

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The technique widely used for the measurement of plasma current is to pick up the time derivative of the poloidal magnetic field produced by the plasma current and obtain the plasma current by integrating the output signal¹⁾. In recent large plasma devices, the duration time of plasma discharge becomes longer and longer, and the maximum duration time in a superconducting tokamak exceeds 2 hours. Then, it is urged to develop a technique for steady state magnetic field measurements which can be applied to long pulse tokamaks. In general, however, an integrating circuit has an accumulation problem of a zero-level drift, which prevents the use of magnetic probes for a long pulse discharge.

A hybrid magnetic probe system was proposed for the toroidal plasma current measurement²⁾, which is based on a proper combination of a conventional magnetic probe for the measurement of fast varying magnetic field and a transformer-coupled rotating magnetic probe for that of slowly varying field. The rotating magnetic probe for testing has been operated for 170 hours without any serious trouble, under the condition of the rotation speed being 7,800 rpm, and a uniform magnetic field intensity of 25 Gauss generated in a Helmholtz coil with a coil current of 1 A. There found no serious problems, such as abnormal change in rotation speed, heating, noise and others.

For the purpose of finding technical problems when applied to an actual tokamak in operation, the probe system has been applied to a preliminary experiment of magnetic field measurements on the TRIAM-1M superconducting tokamak³⁾ at the Advanced Fusion Research Center, Research Institute for Applied Mechanics, Kyushu University. The probe system was installed outside the outer vessel, the distance from the plasma axis being 1.6 m. The air to drive the turbine and bearing was supplied from a compressor in the utility room located approximately 70 meters apart. A rotation speed of 10,000 rpm is achieved even though the air is supplied remotely. The compensation circuit for the fluctuation of rotation speed has worked successfully. After the charging of the toroidal magnetic field coils, the direction of the rotating axis was adjusted so that the output signal is minimum before the plasma

discharge. The sensitivity is 220 mV/Gauss, and the minimum detection level is about 0.05 Gauss. Various technical problems to be solved were found⁴⁾.

In principle the rotating magnetic probe system detects the magnetic field component in the direction perpendicular to the rotation axis. In order to determine the direction of the magnetic field, tiny permanent magnets were embedded in the rear part of the rotor, and the flux change was picked up with an outside coil to define geometrical reference for the rotating coil output signal⁵⁾. The direction of the magnetic field is determined from the phase difference between this reference signal and the rotating coil signal, by the use of lock-in-amplifier, for example.

This collaborative work in NIFS was carried out jointly with a collaborative work in TRIAM "Magnetic Measurement by Rotating Probe in Steady State Tokamak Discharge."

Reference

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