§26. 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 position is to pick up the time derivative of the poloidal magnetic field produced by the plasma current, obtain the poloidal fieldt by integrating the output signal, and calculate the plasma position according to a formula for a plasma equilibrium[1]. 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[2]. 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 poloidal field measurement[3], 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 tokamak[2]. 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 440 mV/Gauss, and the minimum detection level is about 0.05 Gauss. Various technical problems to be solved were found[4].

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 signal[5]. 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.

On the equatorial plane, the probe position was scanned from R=2.45m to 3.55m. The poloidal field by the plasma current at R_P=0.84m is approximated as $B_P=\mu_0(\pi R_P^2 I_P)/(4\pi R^3)$. The measured magnetic field coincides with the calculated one in the magnitude and R-dependence. Accordingly, the plasma position may be measured by setting a pair of them on the top and bottom of a tokamak, for example.

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