19PA-038

Plasma Current Profile Measurement in TOKASTAR-2

TOKASTAR-2におけるプラズマ電流分布計測

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The plasma position and the radial profile of the plasma current density are evaluated in TOKASTAR-2 by magnetic field measurement using a multi-channel magnetic probe (MMP) having 10 sensors in the radial direction. The position of the current center and its movement were observed. A test probe that has a larger sensitivity was made and tested.

1. Introduction

TOKASTAR-2 is a plasma confinement device, which has two coil systems, tokamak and stellarator [1]. These two systems can be operated independently. The TOKASTAR-2 coil system consists of eight Toroidal Field (TF) coils (N_{TF}=50turns each), three-block Ohmic Heating (OH) coils (central solenoid with N_{OH1} = 84 turns, and upper and lower coils with N_{OH2} = 22 turns each), a pair of Pulsed Vertical Field (PVF) coils (N_{PVF} = 20turns each), a pair of Vertical Field(VF) coils(N_{VF} = 100 turns each), two outboard Helical Field (HF) coils (I_{HF} = 98turns each), and four Additional Helical Field(AHF) coils(N_{AHF} = 126 turns each). The coil configuration is shown in Figure 1. The tokamak plasma is generated by using the TF coils, the OH coils and the PVF coils. The duration and the peak value of the plasma current of tokamak discharge were improved by adjusting the pulse vertical magnetic field including the value of capacitance of the capacitor for the PVF coil circuit [2]. The plasma position is measured by a high speed camera in the tangential direction, but details are unclear because of the field of view is limited. In this study, by measuring the poloidal magnetic field inside the plasma column, it is intended to measure the radial distribution of the plasma current density and to evaluate the effect of the helical magnetic field superimposed to the tokamak and optimization of the tokamak.

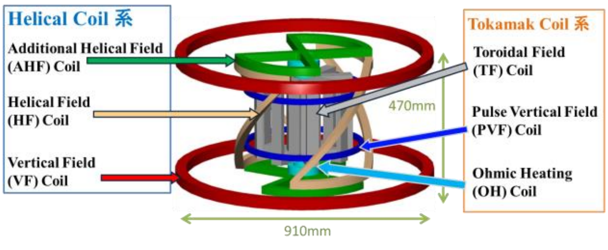

Fig.1. The coil configuration of TOKASTAR-2

2. Measuring method

The radial profile of the poloidal magnetic field was measure using a multi-channel magnetic probe (MMP) having 10 sensors in the radial direction. The location of the MMP is shown in Figure 2. When the MMP is inserted at the maximum, the innermost coil (coil 1) is located at 75mm from the center of device. The distance between adjacent coils is 10mm. Magnetic field distribution is obtained by numerically integrating the voltage of the measuring coils. In this study, the poloidal magnetic field generated by plasma current is shown, which is obtained by subtracting the field without plasma current and with the same OH and PVF coil current from the field with plasma current.

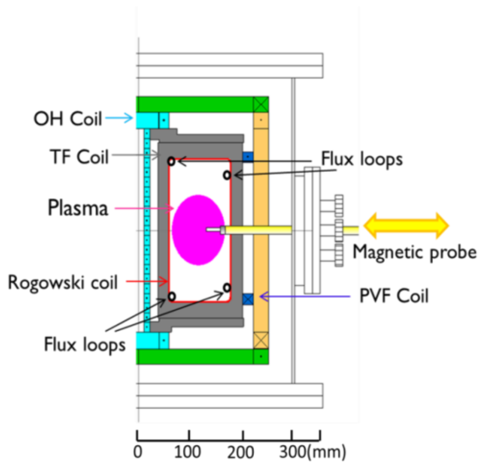

Fig.2. MMP insertion position

3. Experimental result

In order to measure the poloidal magnetic field distribution in the entire plasma, the MMP was inserted at the maximum. The coil 1 was located 75 mm from the center of device, and the coil 10 was located 165 mm. Figure 3 shows time evolution of the plasma current and the poloidal magnetic field generated by the plasma current measured by the

MMP. Figure 4 shows the magnetic field distribution in the radial direction at the peak of the plasma current (t = 2.65 ms). In Figure 4, the sign is inverted in the vicinity of R = 115 mm. Therefore, it is inferred that the plasma center is located at this position. In this experiment, the plasma current was lower than that in usual tokamak discharges without insertion of MMP; the plasma current was typically larger than 800A in the later case.

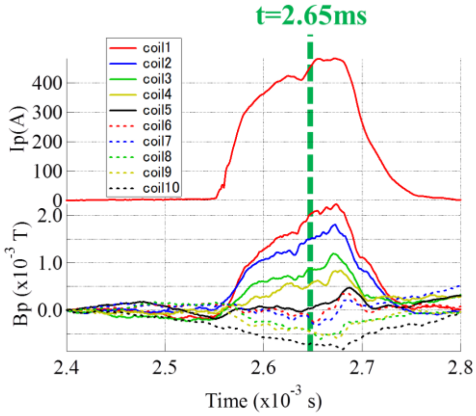

Fig.3. Plasma current and the poloidal magnetic field (MMP inserted at the maximum)

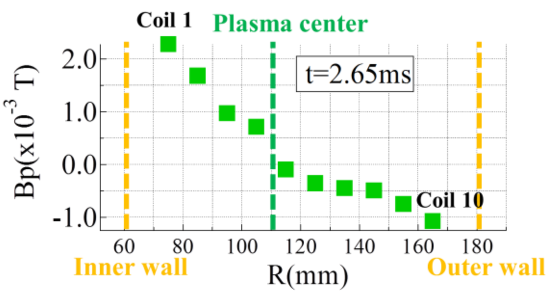

Fig.4. Magnetic field distribution (t=2.65ms)

Next, in order to obtain the data for plasmas with a higher plasma current, experiments were carried out with MMP pulled 50mm radially outward from the most inner position. Figure 5 shows time evolution of the plasma current and the poloidal magnetic field generated by the plasma current. Figure 6 shows the magnetic field distribution in the radial direction (t = 2.65, 2.7, 2.75 ms). As shown in Fig. 5, the peak value of the plasma current was increased to 1400 A from 500 A, the plasma current duration was also increased from 0.2 ms to 0.25 ms. In Fig. 6, the position of the center of the plasma estimated by extrapolating the measured field profile is moving.

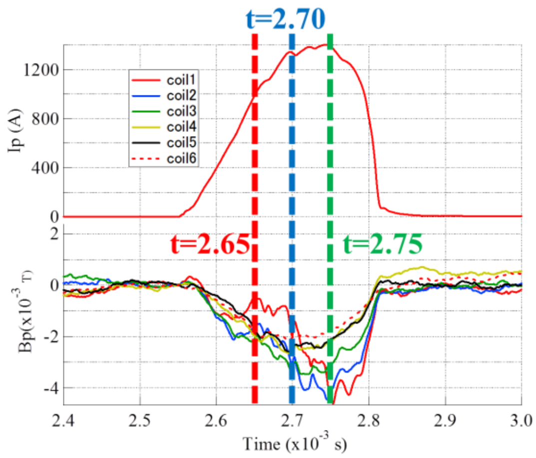

Fig.5. Plasma current and the poloidal magnetic field (MMP at 50mm outward)

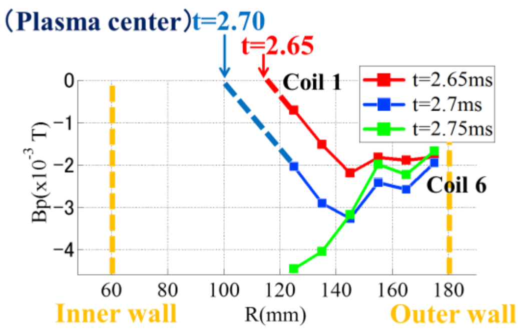

Fig.6. Magnetic field distributions (t =2.65, 2.7, 2.75ms)

In the poster presentation, results on the test probe that has a larger sensitivity will also be shown.

Acknowledgments

This work is performed with the support and under the auspices of the NIFS Collaboration Research program (NIFS14KOAP027).

References

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[2] R. Nishimura et al: J. Plasma Fusion Res. 9, 3402059 (2014).