20pD2-8

Construction and First Experiment of A Small Non-circular Tokamak
非円形断面小型トカマクの製作と初期実験

Shoichi Hatakeyama, Yuichi Asahi, Tatsuya Baba, Zhipeng Yao, Takayuki Kobayashi, Masaki Watanabe, Masamichi Murayama, Hiroaki Tsutsui and Shunji Tsuji-Iio
畠山 昭一, 朝比 祐一, 馬場 達也, 姚 志鵬, 小林 孝行, 渡辺 正樹,
村山 真道, 筒井 広明, 飯尾 俊二

1) *Tokyo Institute of Technology 2-12-1-N1-11, Ookayama, Meguro-ku, Tokyo 152-8850, Japan*
東京工業大学 〒152-8850 東京都目黒区大岡山2-12-1-N1-11

A highly elongated cross-section tokamak was constructed to investigate vertical instabilities under non-axsymmetric helical fields. One of the most important feature is two ways of vertical position control coils. Conventional axisymmetric active control coils are located inside of the vacuum vessel. In addition, non-axisymmetric passive control coils are arranged on the outboard side of vacuum vessel. In this paper, we discover the following topics: design and construction progress of the new device and discharge tests of toroidal field coils with flywheel power supply.

1. Introduction

The Troyon scaling law for plasma stability implies that high β plasma can be achieved with highly elongated plasmas [1]. However, the plasma position is unstable vertically when the cross-section of the plasma is highly elongated in tokamaks. Therefore, sophisticated feedback control with axisymmetric poloidal field coils are required to suppress vertical instabilities in high β operations.

On the other hand, non-axisymmetric magnetic fields can passively stabilize the vertical instabilities of tokamak plasmas. A theoretical stability criterion for a large aspect current carrying stellarator was derived [2, 3]. The objective of our study is to stabilize vertical instabilities by the use of saddle coils which generate helically perturbed fields. Several experimental studies have been made on the effects. However, they have been conducted in tokamaks with circular cross-sections [4, 5].

For the next step of this study, we have been constructing a highly elongated small tokamak as shown in Fig. 1 to demonstrate the stabilizing effect. Among the progress of the construction, we will report the following topics: design and progress of construction of the new device and discharge tests of toroidal field coils with flywheel power supply.

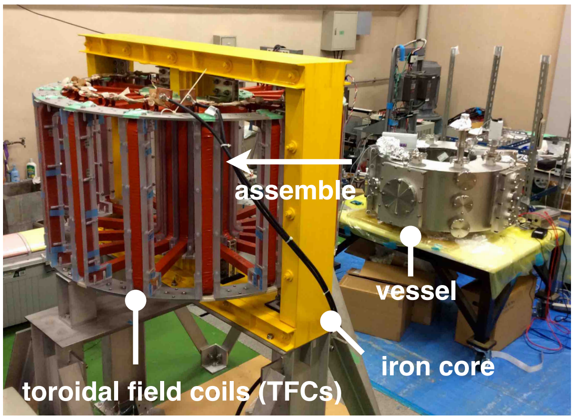

Fig. 1 Picture of the small tokamak device under construction.

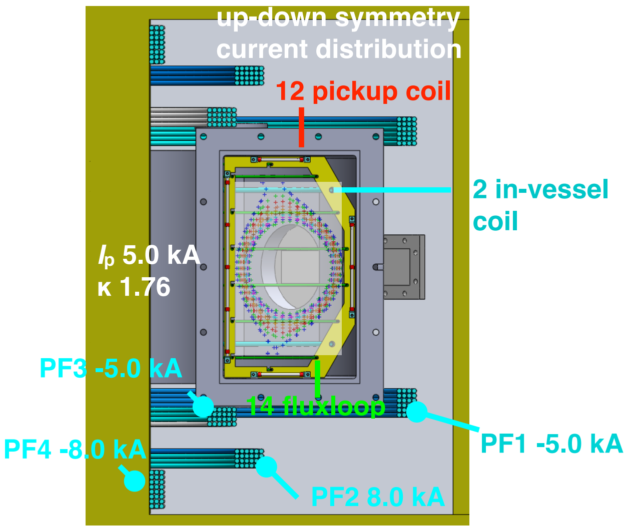

Fig. 2 Poloidal cross-section of the device and an example of MHD equilibrium configuration.

2. Design Feature and Progress of construction

The design value of device parameter is as follows: major radius R = 0.33 m, minor radius a = 0.09 m, plasma current I_p is up to 5.0 kA, toroidal field B_t is 0.3 T and discharge duration is 20 ms. At the plasma start-up, electron cyclotron wave system

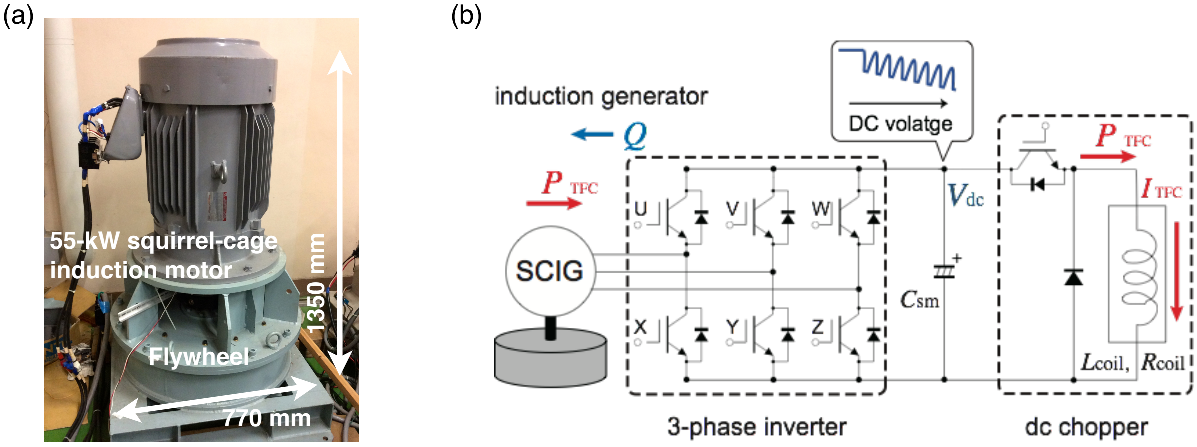

Fig. 3 (a) Picture of the flywheel generator and (b) circuit configuration of the flywheel generator system

(2.45 GHz, 4 kW) is employed for pre-ionization and Ohmic heating (OH) coil with iron core is used to ramp up and sustain I_p inductively.

One of the unique feature of this tokamak is a highly elongated configuration (elongation $\varkappa = 1.8$). The poloidal cross-section of the device is shown in Fig.2. To suppress vertical instabilities, two sets of coils were installed; axisymmetric fast plasma position control coils in the vacuum vessel and non-axisymmetric saddle coils on the outboard side of vacuum vessel as mentioned before.

For quick vertical position control in the conventional tokamak operation, this tokamak uses in-vessel magnetic diagnostics; poloidal array of 12 magnetic pick-up coils on a poloidal limiter and 14 flux loops.

3. Flywheel Power supply for TFCs

In the commissioning phase, long pulse ECR discharge (B_t ~875 Gauss, > 1 s) is planed. We equipped a new flywheel generator system as the power supply for TFCs as shown in Fig. 3. The 55-kW squirrel-cage induction generator (SCIG) is connected to a rotational mass storing mechanical energy which can be converted into electrical energy. The SCIG is employed to compensate Joule loss in the TFCs. The power supply consists of two parts connected with DC line: 3-phase inverter with SCIG and dc-chopper with TFCs. The DC chopper regulates the voltage of the TFCs to control coil current. The 3-phase inverter controls power generation of the SCIG based on a “vector control method” [6]. DC-link voltage V_{dc} of the smoothing capacitor is maintained under the appropriate power control.

Discharge test of the TFC power supply has been conducted as shown in Fig. 4. It was demonstrated that the proposed power supply can

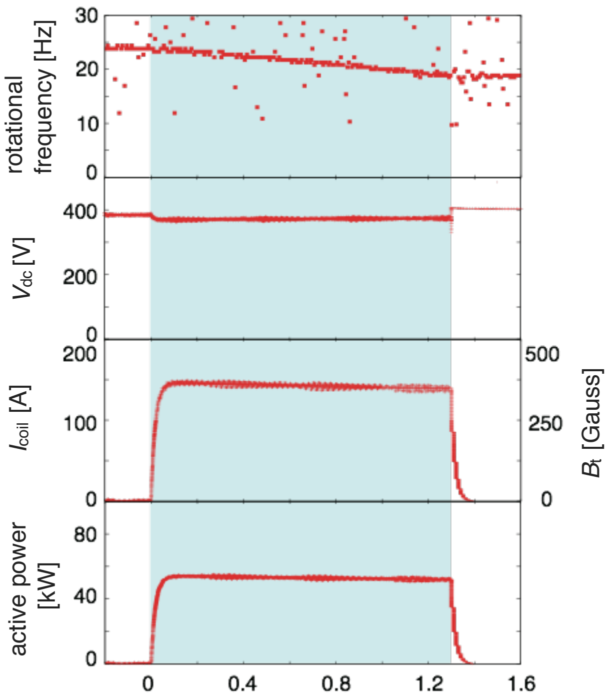

Fig. 4 Discharge waveforms of the TFCs energized with flywheel generator

energize TFCs maintaining terminal voltage V_{dc} for 1 s which is long enough for our small tokamak experiments. It is possible to achieve B_t = 875 Gauss by adjusting control parameters.

References

[1] F. Troyon and R. Gruber, Phys. Lett. A110, 29(1985).
[2] G. Y. Fu, Phys. Fluids 7, 1079 (2000).
[3] R. Reiman, Phys. Rev. Lett. 99, 135007(2007).
[4] H. Ikezi and K. F. Schwarzenegger, Phys. Fluids 22, 2009 (1979).
[5] M. C. ArchMiler, et al., Phys. Plasmas 21, 056113(2000).
[6] D. W. Novotny and T. A. Lipo (1996), *Vector Control and dynamics of AC drives,* OUP.