§3. Experiment of Helical Magnetic Field Configuration Optimization

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A hybrid configuration called TOKASTAR combined with a spherical tokamak and a compact stellarator has been proposed [1] to make an easy start-up of tokamak plasma current operation and to reduce the probability of plasma current disruptions by external helical field. In this configuration a natural built-in divertor is provided. According to the finite beta equilibrium analysis, the higher equilibrium beta value can be attained by adding plasma current and increasing average rotational transform. The particle orbit analysis denotes that the high energy particle confinement is improved by increasing inboard-side rotational transform created by the central conductor modification from tokamak-like straight central post to helical winding post. The experimental preparation (two machines, C-TOKASTAR and TOKASTAR-2) is performed for this concept demonstration.

As for C-TOKASTAR (TOKASTAR-1), the simplified coil configuration with two helical coils and a pair of poloidal field coils was adopted. The aspect ratio of the plasma is ~1.2, and its ellipticity is ~ 2. The rotational transform is large on the outboard side, but small on the inboard side. The stellarator-diode method was utilized related to particle orbit confinement research [2].

The tokamak-stellarator hybrid TOKASTAR-2 was constructed (Figs.1 & 2) within the framework of the LHD Project Research Collaboration program to demonstrate the confinement concept of this compact tokamak-stellarator hybrid configuration. The plasma major radius is 10 - 15 cm and the toroidal magnetic field is around 1 kG. Figure 3 shows helium plasma production by the 2.45 GHz electron cyclotron heating (ECH).

The tearing mode (TM) and neoclassical tearing mode (NTM) stabilization/destabilization analysis by applying external helical magnetic field in tokamak plasmas was performed [3] using the modified Rutherford equation, and the relevant experimental research will be carried out [4] by this TOKASTA-2 experimental machine.

1) Yamazaki, Y., Taira, U., Oishi, T., Arimoto, H., Shoji, T., *Analyses and Experiments of Compact Spherical Tokamak-Stellarator "TOKASTAR",* 14th International Congress on Plasma Physics (Fukuoka, Japan 2008/9/8-12)
2) Taira, Y., Yamazaki, K., Arimoto, H., Oishi, T., Shoji, T., *"Analysis of particle orbits in spherical tokamak-stellarator hybrid system (TOKASTAR) and experiments in Compact-TOKASTAR device"* The 18th International Toki Conference (ITC18) on Development of Physics and Technology of Stellarator/Heliotrons en route to DEMO (Toki, 9-12 December, 2008) P1-40
3) Taniguchi, S., Yamazaki, K., Arimoto, H., Oishi, T., Shoji, T., *"Analysis of Neoclassical Tearing Mode Instability in Fusion Plasmas"* Plasma Science Symposium PSS-2009 (Nagoya Univ., Nagoya, Feb. 2-4, 2009)
4) Okano, K., Tatematsu, M., Y., Yamazaki, K., Oishi, T., Arimoto, H., Shoji, T., *"Small Plasma Experiment of Tokamak-Helical Hybrid"* Plasma Science Symposium PSS-2009 (Nagoya Univ., Nagoya, Feb. 2-4, 2009)

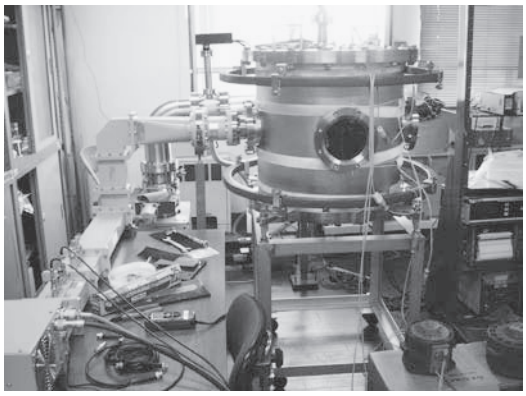

Fig.1. TOKASTAR-2 machine constructed in Nagoya University through the LHD Project Research Collaboration program

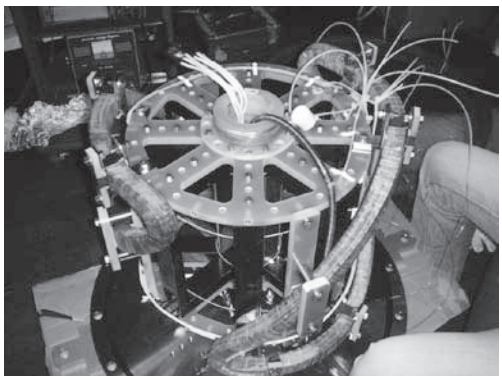

Fig. 2. Toroidal, poloidal and helical coil systems of TOKASTAR-2 installed inside the cylindrical vacuum chamber

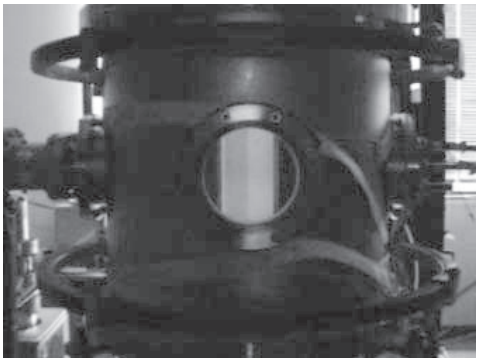

Fig. 3. 2.45GHz-ECH He plasma production in TOKASTAR-2.
Plasma light with inner vertical limiter stripe is shown between two TF coils