§8. FFHR Magnetic Field Configuration by Low Helical Pitch Parameter, Flat-type Helical Coils

Watanabe, T., Sagara, A.

The following conditions are necessary to achieve highly economical fusion reactor systems.

- Stable sustainment of high beta plasma.
- Built-in closed divertor systems.
- Good confinement of alpha particles.
- Installations of sufficient neutron shielding layer for the helical coils and the tritium breeding modules with breeding ratio greater than 1.

We have confirmed that low helical pitch parameter ($= \gamma$) flat-type helical coil systems can fulfill the above-mentioned requirement for the fusion reactors.

MHD stability of plasma is determined by the MHD potential energy($= W$), which is the sum of plasma thermal energy($= W_T$) and the magnetic filed energy($= W_B$),

$$W = \int \mathrm{d}V \left(\frac{3}{2} P + \frac{1}{2\mu_0} \boldsymbol{B}^2 \right) = W_T + W_B \,. \quad (1)$$

The integration domain is extended not only to the plasma volume but also to the outer region of external coils. Equilibrium with $\delta W < 0$ has no beta collapse.

We have studied the pitch parameter dependency of high beta equilibrium in the case of flat-top pressure profile. Numerical results are summarized in Fig.1. Low γ configuration has a strong MHD stability.

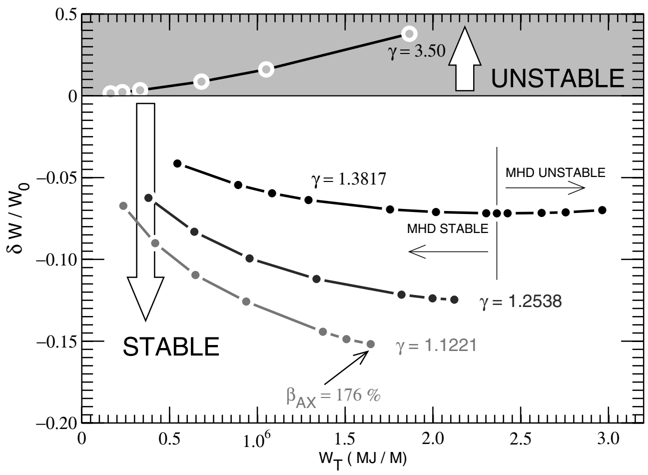

Fig. 1: Variation of MHD potential energy. Abscissa represent the plasma thermal energy stored in the magnetic surface.

The flat-type helical coil system has designed from the following viewpoints: ensuring of necessary field strength under the reasonable coil current density, decreasing of maximum magnetic field intensity and magnetic stress, and securing of liquid helium path.

Example of cross section of flat-type helical coil is shown in Fig.2(a). Figure 2(b) shows the magnetic field configuration created by the coil system.

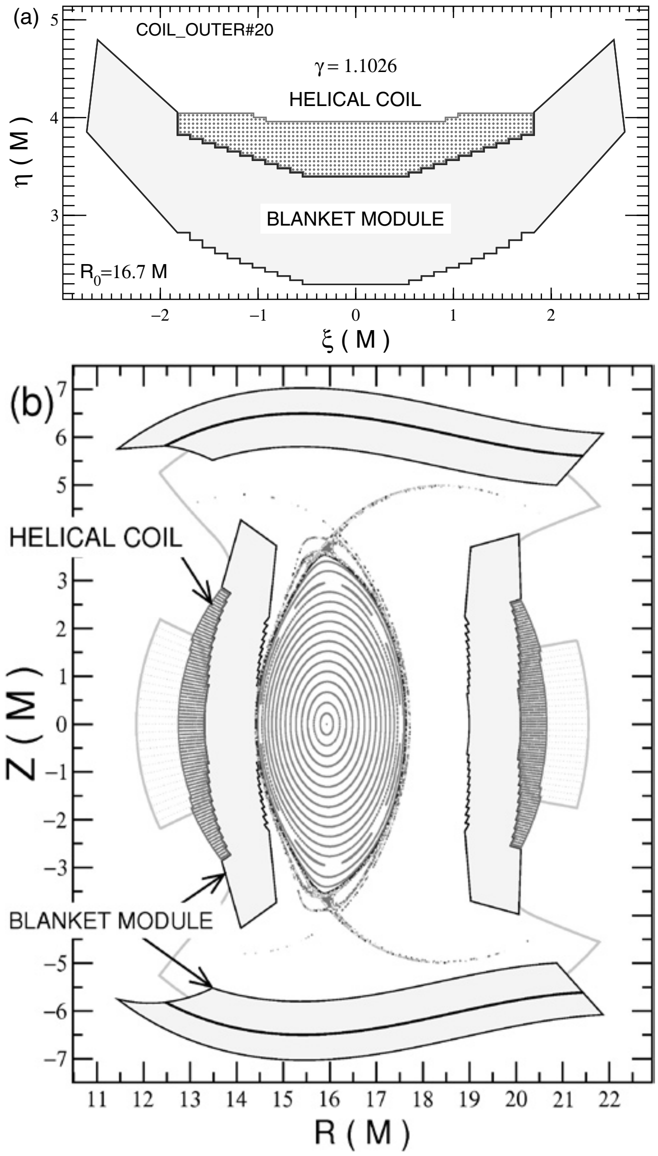

Fig. 2: (a) Cross section of Helical coil and blanket module. (b) Poloidal cross section of magnetic surface, divertor-leg and blanket module. Thin lines show the similarity extension profiles of the LHD vacuum vessel and helical coils.

R_0	B_{ax}	J_{c}	V_{lcfs}
16.7 m	5.0 T	25.36 A/mm^2	1649m^3

1) T. Watanabe and A. Sagara, "Bootstrap transition to high beta equilibrium in helical system", Plasma Fusion Res. (submitted, 2010).

2) T. Watanabe and H. Hojo, "Helical pitch parameter dependency of high beta equilibrium of helical plasmas", Plasma Fusion Res. (submitted, 2010).