§5. Control of LHD Type Fusion Reactor by Vertical Field Configurations and an Operation Scenario of FFHR

Watanabe, T., Sagara, A.

i) Control of magnetic field by vertical field coils

Volume enclosed with the last closed magnetic surface, V_{lcfs}, is one of the most important parameters for the performance of fusion reactors.

The helical pitch parameter ($= \gamma$) set up the basic structure of LHD type magnetic field configurations. To get the wide blanket space ($= \Delta$), the γ value has received a restriction ($\gamma \lesssim 1.2$).

In general, V_{lcfs} increases with the inner shift of the magnetic axis R_{ax}. When vertical magnetic field is restricted to minimize the leaked magnetic flux, the volume V_{lcfs} is small even for the case of inner shift R_{ax}.

Suitable magnetic field configurations for FFHR has been found by optimizing the vertical magnetic field, if the minimized leaked magnetic flux is not taken into consideration.

Figure 1 shows the comparison of magnetic configurations between minimized leaked flux case and the optimized case.

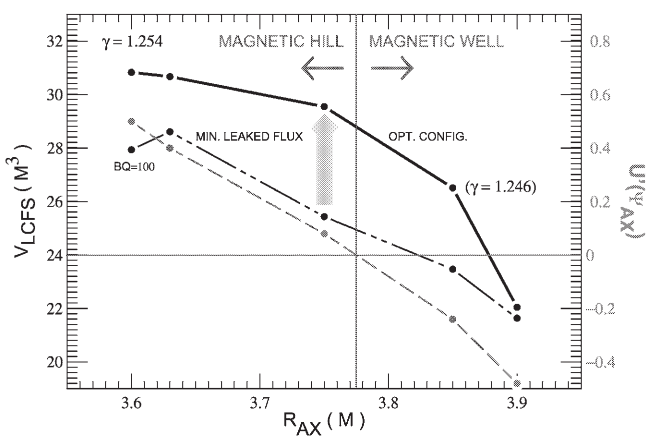

Fig. 1: Relation between the magnetic axis position R_{ax} and the Magnetic flux volume V_{lcfs} and the depth of magnetic well $U'(\Psi_{\mathrm{ax}})$ in the LHD. Vertical magnetic field is chosen as minimization of leaked magnetic flux or maximize the magnetic flux volume V_{lcfs}.

Numerical example for the FFHR configuration for the steady state burning phase is shown in Fig.2. Clean-folded diverter leg, thin chaotic field line layer, large flux volume ($V_{\mathrm{lcfs}} \simeq 1,956\mathrm{m}^3$) are confirmed. The rotational transform of the last closed magnetic surface is sufficiently high ($\iota_{\mathrm{lcfs}}/2\pi \simeq 2.103$).

ii) Operation scenario of FFHR

A small flux volume and high beta plasma confinement is preferable to ignite the fusion plasma by small heating devices. FFHR is possible to create a magnetic well as shown in Fig.1, by outward shifting of magnetic axes even in the vacuum configuration. The marginally stable pressure profile is shown in Fig.3 for the outward shift (start-up phase). inward shift(steady state burning phase) and super outward shift (ash removal phase) configurations. The super outward shift configuration is characterized by disappearance of the magnetic shear.

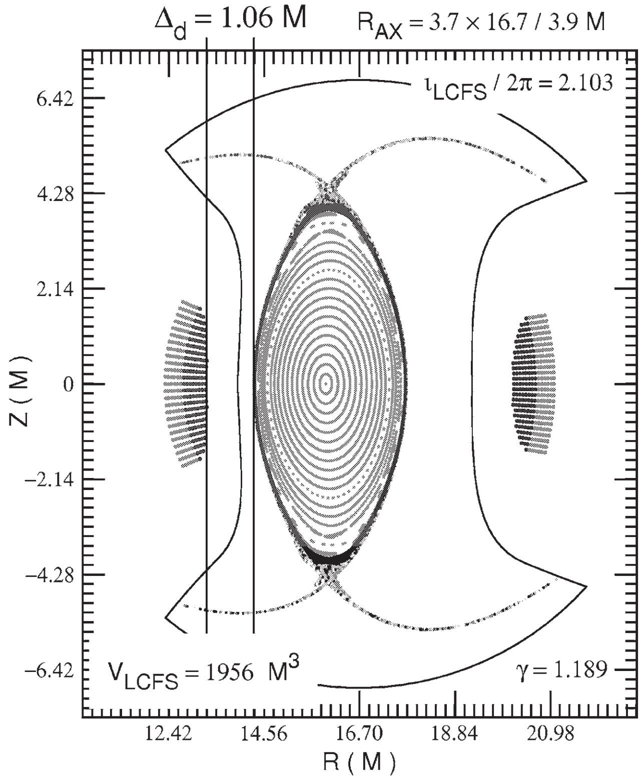

Fig. 2: One of optimized configuration for FFHR.

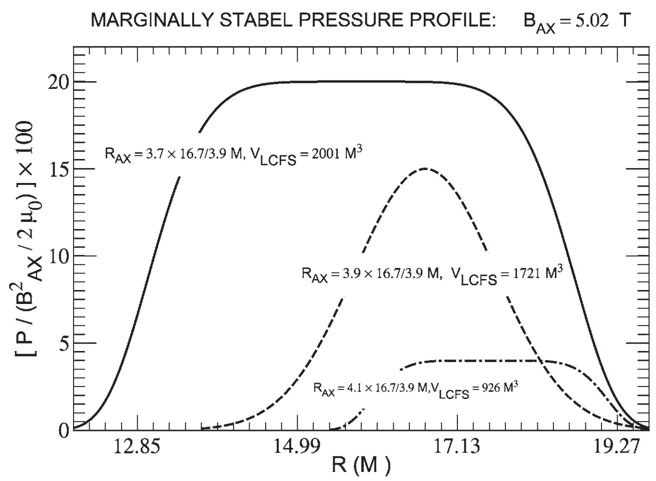

Fig. 3: Marginally stable pressure profile. Start up, steady state burning and ash removal phase profiles are shown by broken, solid and chain lines, respectively.