§3. Bootstrap Current of LHD with Multi Layer Helical Coils

Ichiguchi, K., Nakajima, N., Okamoto, M., Motojima, O.

Each helical coil in the LHD is composed of three layers which are called the outer (O) , the mid (M) and the inner (I) layers. In the standard configuration corresponds to $\gamma_c = 1.25$, all three layers are used for generating the confinement magnetic field, where $\gamma_c = 1.25$. If only the O-layer is used, the radius of the helical coil becomes large and γ_c increases to 1.38, while γ_c decreases to 1.12 in the case of only the I-layer.

Here we estimated the bootstrap current based on the neoclassical transport theory. In this case, the bootstrap current is calculated consistenltly with the three-dimensional MHD equilibria by iterating the calculations of the MHD equilibrium and the estimation of the net toroidal current alternatively[1]. Here it is assumed that both the electrons and ions should be in the $1/\nu$ collisional regime and the density and the temperature of the ions and the electrons should be the same. The density is fixed as

$$n_i = n_e = 0.5 \times 10^{20}(1 - \Phi) \quad (m^{-3}), \quad (1)$$

where Φ denotes the normalized toroidal magnetic flux. The temperatures have the same profile of

$$T_i = T_e = T_0(1 - \Phi), \quad (2)$$

however, the factor of T_0 is adjusted to obtain the specified beta value. In this case, the bootstrap current I_{bs}can be estimated by[2]

$$I_{bs}(\Phi) = -2\pi \int d\Phi G_{bs}$$

$$\times \left(L_{31}\frac{dP}{d\Phi} + (L^e_{32} + L^i_{32} n \frac{dT}{d\Phi}\right) / \langle B^2 \rangle, \quad (3)$$

where $n = n_i = n_e$ and $T = T_i = T_e$. G_{bs} is so-called the geometrical factor which is calculated with the information of the equilibrium magnetic field calculated by the VMEC code. Since we assumed that all particles should be in the $1/\nu$ regime, L_{31} and L_{32} are proportional to the fraction of the trapped particles which can be also counted with the structure of equilibrium magnetic field.

Figure 1 shows the profiles of the bootstrap currents of the three types of $\gamma_c = 1.12$, 1.25 and 1.38 at $\beta_0 = 2\%$. It is seen that the current in the standard configuration with $\gamma_c = 1.25$ is larger than those in γ_c =1.12 and 1.38. Here it should be noted that the magnetic field in the standard configuration is about three times of those in other configurations because the current flowing inside the helical coil is proportional to the number of the layers. Therefore, the pressure in the equilibrium of the standard configuration is nine times of the others at the same beta value.

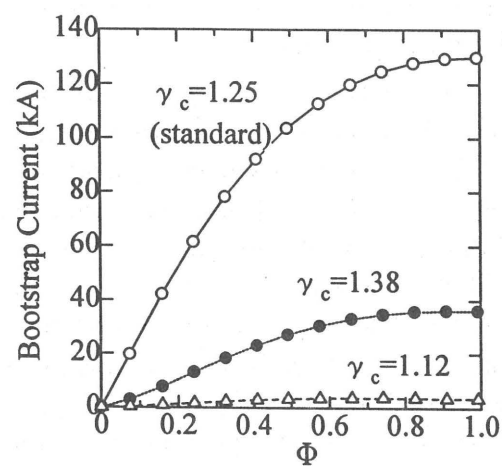

Fig.1 Bootstrap current for $\gamma_c = 1.38$, 1.25 and 1.12.

References
1) Watanabe,K., et al. : Nucl.Fusion 32 (1992) 1499.
2) Nakajima,N., et al. : J.Phys.Soc.Jpn. 61 (1992) 833.