§49. Formation of Initial Magnetic Surface by ECH under Various Aspect Ratios

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The electron cyclotron heating and current drive (ECH/ECCD) has been useful for formation of initial closed flux surface with no use of central solenoid in a number of low aspect devices including CDX-U, LATE, TST-2 and CPD. It is remarkable that the formation has been achieved under steady external vertical field Bv. Then a question arises, that is, whether or not initial closed flux surface is formed under steady field of Bv in the case of conventional aspect ratios. The equilibrium characteristics on the radial force balance along the major radius depends on aspect ratios and predicts that some control of Bv field is required for the formation of initial closed flux surface as aspect ratio increases to the conventional values.

Experiments in the range of aspect ratios of R/a=2.0-3.0 have been prepared in the LATE device. Various aspect ratios will be realized by using a movable limiter as shown in Figures 1 and 2. Microwaves at 2.45 GHz, ~30kW and 2 s will be used for ECH/ECCD. First we will attempt at R/a~2, then, R/a~2.5, and finally R/a~3. And also, first we will attempt preprogram operation of Bv field and then develop feedback control.

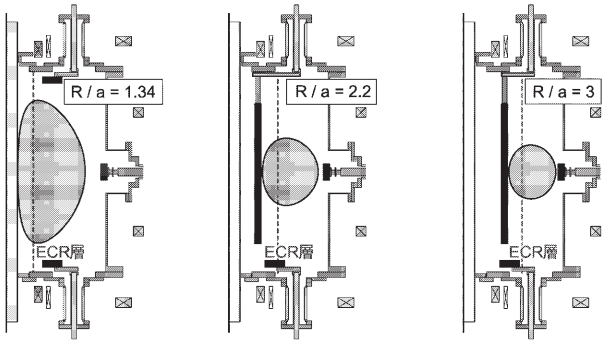

Fig.1 Various aspect ratios with adjusted ECR layers

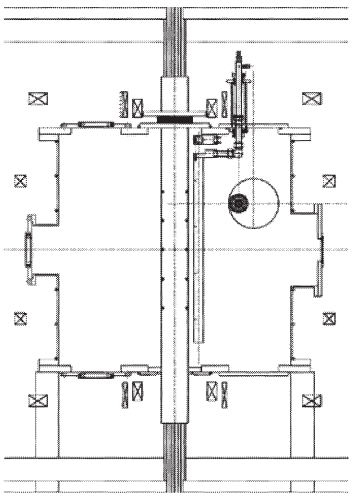

Fig.2 Movable limiter fabricated in the LATE vacuum vessel

The radial force balance of a plasma torus may be given by the following generalized Shafranov formula

$$R_0 I_P B_V = \frac{\mu_0}{4\pi} G(R_0/a, \kappa, \ell_i, etc) I_P{}^2 + 2S\langle p \rangle \quad (1)$$

The first term of the right hand side represents the current loop expanding force proportional to Ip^2 and the second term does the pressure ballooning force. In the original Shafranov formula, $G=\ln(8R_0/a)+li/2-3/2$. In the present case the formula may still hold with an appropriate G value that reflects low aspect ratio and noncircular cross section since the first term must be proportional to Ip^2. A comparison between the formula (1) and an current ramp-up discharge[1] is shown in Figure 3.

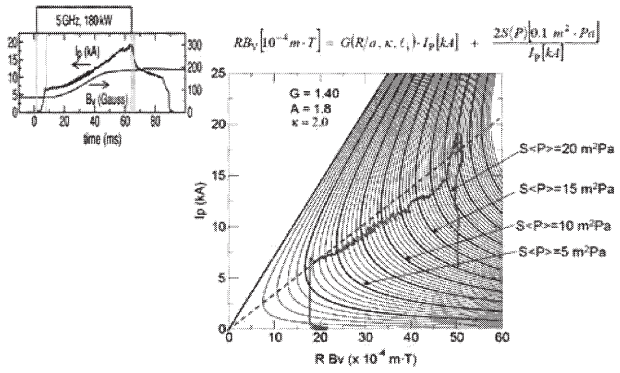

Fig. 3 Time evolution of equilibrium of plasma loop

1) Tanaka H, Maekawa T, Uchida M et al., Proc. 22th IAEA Fusion Energy Conf. 2008, EX/P6-8, Geneva