Feasibility of electron cyclotron wave in DEMO reactor at JAEA

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Japan Atomic Energy Agency (JAEA) has been designing a compact Fusion DEMO plant [1]. A small size center solenoid (CS) has a large impact on reducing the reactor size and weight. On the other hands, the function of the CS coil is limited in the DEMO at JAEA. The heating and current drive (CD) are now considered to be made by using neutral beam injection (NBI) and electron cyclotron (EC) wave [2]. However, a large scale use of EC wave have merits of high tritium breeding ratio (TBR) and high locality of CD compared with the use of NBI. The high TBR is due to the following reasons: EC wave can be transported by a wave-guide, easy equipment of a shield, widely permitable location of port and small area of port ($30cm^2$/MW). Thus the use of only EC wave can make the DEMO attractive.

Role of EC wave in the DEMO is current ramp-up and suppression of neoclassical tearing mode (NTM). An outline of operation scenario is as follows: 1) formation of initial closed magnetic surface by the CS coil, 2) current ramp-up to steady nuclear fusion reaction using only EC wave, 3) steady state of nuclear fusion reaction. Issues are feasibility of plasma current ramp-up by only EC wave, and estimation of necessary EC power for the ramp-up and the suppression of NTM.

Although the plasma current can be ramped up to 3.8MA using the total volt-seconds of small CS coil in the DEMO [1], the plasma current is assumed to be ramped up to 1MA by the CS coil and then be raised by EC wave. The current drive by EC wave is evaluated in the phase 2) of the operation scenario. The ammount of EC current drive is calculated by the ACCOME (Advanced for Current drive Consistenrt with MHD Equilibrium) code. When the electron temperature (T_e) is higher, the efficiency of CD is higher. In order to ramp up effectively, the electron temperature should be more than about 5keV according to ACCOME's results in the cases of low plasma current (I_p) (I_p ~ 1 MA). Moreover, the condition of $\beta_p \varepsilon \leqq 1$ restricts the operation path in the n_e-T_e region from viewpoint of equilibrium, where β_p, ε, n_e, poloidal beta, inverse aspect ratio, and electron density, respectively. The guideline of ramp-up scenario is as follows: In final stage of the phase 1), the current is ramped up to 1 MA by the CS coil, and T_e > 5keV, and n_e~5x 10^{18} m^{-3}. In the phase 2), the plasma current is ramped up to the flat top by using EC wave. The detail operation scenario in the phase 2) using EC wave and necessary power will be presented in the conference.

The necessary power for the suppression of NTM can be evaluated by using modified Rutherford equation [3]. Moreover, the merit of EC wave is discussed compared with NBI from the viewpoint of reactor *i. e.* area and location of port, and TBR etc.

References

[1] K. Tobita, et al: Fusion Engnering and Design (2006) to be published.
[2] K. Sakamoto, et al: Fusion Engnering and Design (2006) to be published.
[3] N. Hayashi, et al:Nucl. Fusion 44 (2004) 477