

APPLICATION OF ECW TO THE JT-60U TOKAMAK

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The recent experiments in the JT-60U aim at the extension of the plasma performance towards high normalized beta (β_N), high bootstrap current fraction in the long pulse operation (65sec). The width of the EC wave (ECW) pulse (110GHz, 4 x 1MW Gyrotron) is extending and the ECW contributes as an important active control tool in the experiments to pursue the performance improvement. Recent topical experimental results which required the ECW are presented.

As is well known, the feature of the ECW is the strong power deposition to the electrons in the narrow specified region determined by the EC resonance (ECR) condition. The feature of ECH/ECCD [1] is utilized in the following studies.

1. Neoclassical tearing mode (NTM) suppression: The NTM degrades the β_N below the ideal beta limit. The suppression of the NTM ($m/n=3/2$) contributed to achieve higher β_N . It was found that localized ECCD as large as the bootstrap current was required [2] for the suppression. The feedback technique to apply the ECW by moving the antennas was demonstrated.
2. Profile control: The capability of controlling the core current profile (safety factor profile) by the ECW is typically seen in the sawteeth control which is useful for physical studies..
3. Transport study: Applying the perturbation by ECW, a complicated nature of the transport is studied [3]. Capability of the rapid power modulation of the ECW contributes to such purpose. ECW is also applied to study the role of electron heating to the internal transport barrier (ITB)[4].
4. Current hole study in the strong negative shear plasma: ECW was used to find the stiffness of the current profile when the current hole grew at the core [5], and to investigate a proposed equilibrium structure of the magnetic axis in such a plasma.

The another features of the ECW is a good matching to the vacuum or to the low density plasmas and good access to the resonance layers. The features are effectively utilized in the following studies.

5. Tokamak start-up without center solenoid (CS) : For the low aspect ratio (fat) tokamak reactor, the design difficulty is much reduced if we can build up the plasma current without the inductive loop voltage produced by the CS [6] . Plasma current ~100kA was generated by ECW with the help of the ramp-up of the vertical field. It was found that even without the null point in the vessel, this scheme works if enough EC power is applied.
6. Start-up assist and shut-down assist of the discharges by ECH were found to avoid disruptions and then reduce the need for the discharge cleaning (TDC), and therefore routinely used in JT-60U.

References [1] T.Suzuki et al., "Investigation of EC current drive in a high electron temperature plasma in JT-60U", in Proc. **EC-13** (2004).[2] A.Isayama et al., Phys. Plasmas **12**, 056117 (2005), Nucl. Fusion **43**, 1272 (2003).[3] S.Inagaki et al., Nucl. Fusion **46**,133 (2006).[4] S.Ide et al., Nucl. Fusion **44**,87 (2004) [5] T.Fujita et al., Phys. Rev. Lett. **95**, 075001 (2005). [6] M Ushigome et al, Nucl. Fusion **46**, 207(2006) .