Contribution ID: **222** Type: **Poster**

FTP/P7-34: Multifarious Physics Analyses of the Core Plasma Properties in a Helical DEMO Reactor FFHR-d1

Friday, 12 October 2012 08:30 (4 hours)

Theoretical analyses on the MHD equilibrium, the neoclassical transport, and the alpha particle transport, etc., are being carried out for a helical fusion DEMO reactor named FFHR-d1, using radial profiles extrapolated from LHD. FFHR-d1 is a heliotron type DEMO reactor of which the conceptual design activity has been launched since 2010. It is possible to sustain the burning plasma without auxiliary heating (i.e., self-ignition) in FFHR-d1, since there is no need of plasma current drive in heliotron plasmas. The device size is 4 times enlarged from LHD, i.e., the major radius of helical coil center is 15.6 m, the magnetic field strength at the helical coil center is 4.7 T, and the fusion output is ~3 GW. One of the distinguished subjects in FFHR-d1 compared with the former FFHR design series is the robust similarity with LHD. The arrangement of superconducting magnet coils in FFHR-d1 is similar to that of LHD, except a pair of planar poloidal coils omitted to maximize the maintenance ports. This makes reasonable to assume a similar MHD equilibrium as observed in LHD for FFHR-d1, as long as the beta profiles in these two are similar. In FFHR-d1, radial profiles of density and temperature are determined by multiplying proper enhancement factors on those obtained in LHD, according to the DPE (Direct Profile Extrapolation) method. The enhancement factors are calculated consistently with the gyro-Bohm model. Therefore, the global confinement properties as expressed in ISS95 or ISS04 are kept in FFHR-d1. A large Shafranov shift is foreseen in FFHR-d1 due to its high-beta property. This leads to deterioration in the neoclassical transport and alpha particle confinement. Effectiveness of plasma position control and/or magnetic configuration optimization has been examined to solve this problem and to check the validity of extrapolated profiles. According to these analyses, it is concluded that the self-ignition condition can be achieved in FFHR-d1 by mitigating the Shafranov shift. Plasma position control by the vertical magnetic fields is effective for the Shafranov shift mitigation and will improve both the neoclassical transport and alpha heat deposition properties.

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Session Classification: Poster: P7

Track Classification: FTP - Fusion Technology and Power Plant Design