Recent Progress on Design and Development of the ITER Equatorial EC Launcher

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An electron cyclotron heating and current drive (EC H&CD) is an extremely necessary tool in ITER as the task of bulk heating, current profile control, suppression of MHD instabilities. In order to fulfill the tasks, the 170GHz, 24MW EC H&CD system, consisting of 24 gyrotrons, transmission lines and two kinds of launchers (equatorial and upper), will be equipped. Toroidal steering capability of 20MW incident rf beam and a necessary nuclear shielding to protect the launcher components and tokamak coils are required for the equatorial launcher. The launcher has two sections; a front shield and a port plug[1]. The front shield is segmented by fourteen modules and has three slots for rf beam injection. Three front steering mirrors, waveguide components, internal shields are installed in the port plug. Finally, torus diamond windows are attached at the plug end (outside) as tritium barriers. The design of the launcher components must endure over 20MW rf transmission and electromagnetic (EM) forces. In order to confirm the consistency of the shield module design, for instance, thermal and EM force analyses were carried out. It was verified that the design withstood incremental temperature and induced stresses while EM forces on some of the shield modules were revealed large and the support structure might not tolerate enough. Therefore, the application of a slit structure or a separable first wall has sufficiently being considered. Another critical component of the launcher is the steering mirror unit that consists of a movable mirror to reflect and steer rf beams, a spiral tube feed for the mirror cooling and a drive mechanism. It was found that the combination of the copper alloy plate (less than 30mm in thickness) and several stainless steal tubes (inner diameter of 12mm and flow speed of 4m/sec) can remove the expected heat deposition in the mirror and tolerate the EM forces. An ultrasonic motor that can be electronically controlled in high magnetic filed circumstance of the ITER is a promising candidate for the mirror unit. It is capable of $\geq$1N-m rotation torque and $\geq$2N-m holding torque, which is sufficient for the normal operation. The motor has been applied for the mock-up of the drive system for the unit. The study of the nuclear radiation proof for the motor is under going as well.

A counter (cnt) - ECCD from the equatorial port has recently being investigated[2]. The cnt-ECCD can contribute the formation of strong negative shear plasma and the control of q profile (or sawteeth) and may offer the opportunity to understand fusion plasma physics in ITER. Since having both co- and cnt-steering capability with one mirror is, however, not practical technically, the control of incident beam angle by one of three mirrors is possibly considered although the power of the co-injection is lost.

In this paper, the recent progress of the equatorial launcher design and development will be presented. In addition, the preliminary result and the technical issues of the design option for the cnt-beam steering will be discussed. The physics issues will be presented in ref [3].

References

[1] K. Takahashi *et al*, Fusion Sci. Tech. 47 (2005) 1-15.
[2] M. Henderson *et al*, Journal of Physics: Conference Series 25 (2005) 143-150.
[3] M. Henderson *et al*, at this workshop.