§41. Survey of Optimum Tangency Radii for Neutral Beam Injection on QUEST (Q-shu University Experiment with Steady State Spherical Tokamak)

Osakabe, M., Takeiri, Y., Nagaoka, K.,
Zushi, H., Hasegawa, M., Sharma, S.K. (Kyushu Univ.)

The experiments on QUEST (Q-shu University Experiment with Steady state spherical Tokamak) have started since 2008. One of the main aims of this experimental project is to explore the steady state operations of high-beta plasmas with spherical tokamaks (ST). This includes the establishment of the current drive scenario which is suitable for sustaining the high-beta and high-performance ST plasmas.

The neutral beam (NB) injection is one of the most common methods in heating plasmas and in driving currents in various toroidal plasmas. This method is also applied for several ST plasmas[1,2]. On QUEST, the NB injection is also considered as a candidate for auxiliary heating methods. The NB-injector which is considered to be used is similar to that was used in CHS(Compact Helical System) at NIFS[3]. The injection energy of the beam is ranging from 30 to 40keV with Hydrogen, and its power is about 1MW.

As a design study of NBI-installation at QUEST, the optimum tangency radii for NB-injections are surveyed for the standard configuration of steady state operation in the second experimental phase, where the plasma current (Ip) of 100kA and toroidal field strength (Bt) of 0.25T are expected and the magnetic axis location is approximately at R=65cm. In the survey, the electron density profile of $n_e(0)*(1-(r/a)^8)$ and temperature profile of $T_e(0)*(1-(r/a)^2)$ are assumed. In Fig.1, NB-deposition rate ($\eta_{dep.}$) and Fast-ion confinement rate ($\eta_{fast-ion.}$) are shown with the change of central electron densities, where η_{dep} and $\eta_{fast-ion}$ are the ratio of the number of ionized NB particles and that of confined fast-ion to the number of injected NB-particles to the plasma. In the calculation, the central electron temperature of 300eV and beam injection energy of 40keV are assumed. The center line of beam is placed on the mid-plane and the beam stopping cross sections in the ADAS-database are used in the calculation [4]. The beam is injected to co.-direction to the plasma current in the figure. As shown in the figure, the η_{dep} is higher at the inboard side tangency radii, but the $\eta_{fast-ion.}$ is maximized at R_t=80cm. Therefore, it is better to place the tangency radius at outboard side of the plasma axis on QUEST Ip=100kA configuration. This is due to the weak poloidal field with the low plasma current. We also made calculations for counter-NB injection cases, but it turned out that almost all of the deposited particles are lost to the vacuum vessels with counter-NB injection.

The results shown here is consistent with the simple previous analysis [5] and confirms that the optimum tangency radius of NB-injection locates at around R_t=80cm on QUEST.

This work is supported by a NIFS-universities collaboration program (NIFS08 KUTR011).

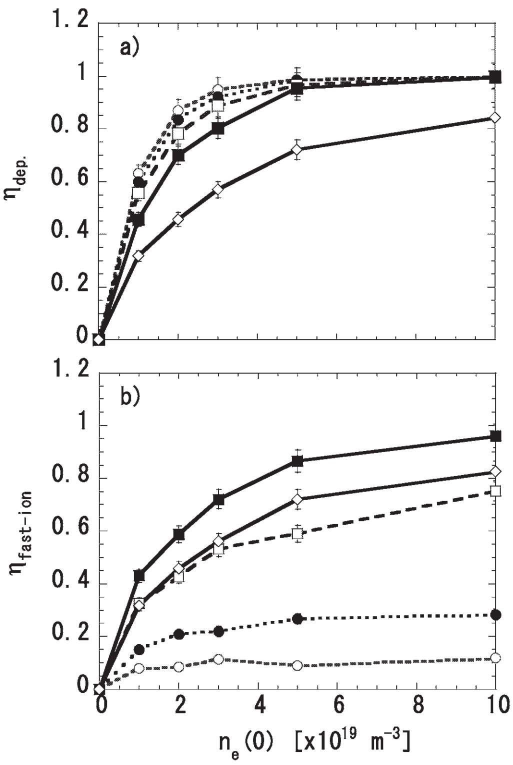

Fig. 1. Tangency radius dependence of (a) NB-deposition rate and (b) confinement rate of ionized fast-ions to the injected NB-particles. The open circles with dashed lines, closed circles with dashed lines, open squares with dashed lines, closed squares with solid lines and open diamonds with solid lines show the calculated result for R_t=50cm, 60cm, 70cm, 80cm and 90cm, respectively.

[1] Akers, R.J.,, *et.al.*, Nuclear Fusion, Vol.42, pp.122-135 (2003).
[2] Heidbrink, W.W.,, *et.al.*, Nuclear Fusion, Vol. 43, pp.883-888 (2003).
[3] Kaneko, O., *et. al.*, Proceedings of 13th IEEE Symposium on Fusion Engineering, Knoxville, Tennessee 1989, Vol. 2, p. 1455 (unpublished).
[4] Summers, H.P., (2004) The ADAS User Manual, version 2.6 http://adas.phys.strath.ac.uk
[5] Osakabe, M., *et.al.,* NIFS Annual Report, April 2007-March 2008, p.535