§32. Comparison of Neutral Beam Heating Characteristics between Co- and Counter-injection

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In LHD, two neutral beam lines are installed tangentially in opposite direction (fig. 1). It should be tangential because passing ions must be made for avoiding helical ripple loss of fast ions. It should be balanced injection because net-current-free condition is required. In the figure, the beamline #1 correspond to counter-injection which is defined as that the fast ion current decreases the rotational transform. The beamline #2 corresponds to co-injection in opposite direction. Then the question arises whether there is any difference between co- and counter-injection on heating efficiency.

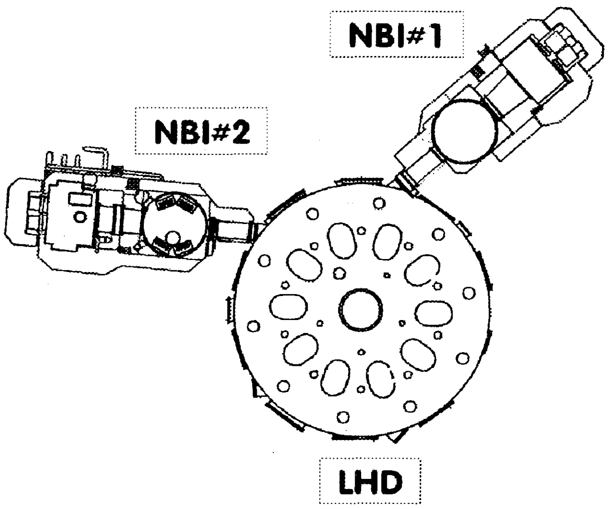

Fig. 1 Arrangement of neutral beam lines.

In tokamaks, some counter-injected ions run toroidal banana orbits, hit the inner vacuum vessel, and are lost. In CHS, where the plasma is closely bounded by the vacuum vessel, the efficiency of counter injection was slightly lower than that of co injection. However in LHD, intrinsic magnetic divertor configuration exists, and orbit calculation shows that the shift of the drift surface is not large in the outer region of plasma. One of the reason is that the magnetic field becomes strong in the outer region of the plasma closing the helical coils. Therefore, similar heating efficiency can be expected for counter-injection except under very low magnetic field strength.

We tried to compare the heating efficiency between co- and counter-injection using one of two neutral beamlines. Figure 2 shows experimental results. In the experiments, one beam (ctr) was injected during the other beam (co) sustained plasma, and compared the results when the role was exchanged between co- and counter-. The beam conditions were almost the same for both beams (90-100 keV, 1.6-1.7 MW port through). All other experimental conditions including gas puff were the same. The magnetic field strength was 1.5T. From the figure, we can see no difference between co- and counter-injection both in achieved stored energy and density. From the figure, we can see that not only the buildup of stored energy and density after first beam injection but also the increment after second beam was the same. The sudden drop of stored energy during beam injection corresponds to the short termination of the beam due to breakdown of the ion source.

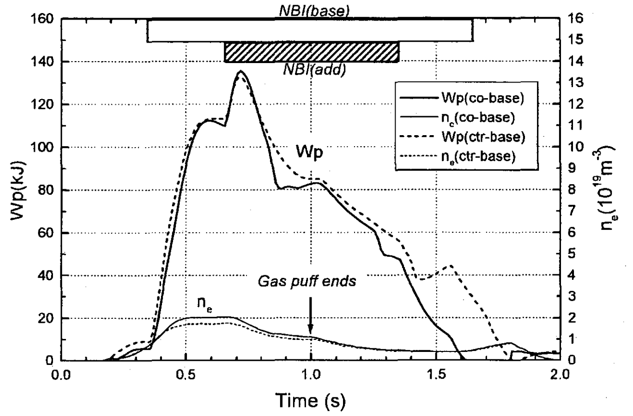

Fig. 2 Comparison of heating efficiency between co- and counter- injection.

Although we can conclude that the global heating efficiencies are almost the same between co- and counter-injection, there is slight difference in electron temperature profile measured by Thomson scattering, where the profile looks broad in counter-injection. This result is consistent with the fact that the birth profile of the fast ions is broad in counter-injection. This difference may become more apparent under lower magnetic field strength. This will be studied in more detail in the next experimental campaign.