§25. Development of Cluster Beam for Fueling

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Hydrogen cluster beams, which can be obtained by adiabatic expansion of hydrogen gas from nozzles followed by electrostatic acceleration, have been considered to be as an alternative method for fusion fueling. Recently, Chinese group reported encouraging data on fueling as well as on the improvement of plasma performance with fueling by supersonic molecular beams (SMB) in a small tokamak device.[1] Mechanism of the deep penetration of SMB into plasmas is the electron shielding by the outer part of the dense SMB.[2] They obtained SMB from a magnetic valve, which is same as the nozzle of a cluster beam system. Therefore, we decided to develop an SMB system for LHD, as a part of the development of cluster beam systems.

The valve must be positioned close to the target plasma to avoid formation of Mach disk, which destroys directional dense SMB. In the case of LHD, the valve should be positioned inside of the vacuum vessel and a valve of magnetic type is unlikely to be applied due to the existence of strong magnetic field of LHD.

Piezoelectric and pneumatic valves, which are insensitive to magnetic field, can be considered as an alternative. Here we excluded pneumatic valves for LHD. The reason is that conventional pneumatic valves require several hundreds of millisecond to open and close them, which is too long to control fueling for LHD experiments.

We modified a piezoelectric valve, which was commercially available, to obtain SMB. The modified valve was installed in a newly fabricated test chamber and the test was just started to obtain beam characteristics. Numerical simulations using a fluid code are also in progress.

The experiment of SMB in LHD will give us the information on the speed required to inject fuel into large, high-temperature plasmas. If faster speed is found to be indispensable, the cluster beam injection with electrostatic acceleration will be recognized as a more important alternative fueling method.

Figure 1 illustrates the planned geometry of SMB in LHD. Since the gas inlet position is movable and can cross a divertor leg, fueling efficiency from a private and a non-private region can be investigated in addition to verification of an intrinsic SMB advantage.

References

1) L.H Yao et al.,"Hydrogen Cluster-Like Behavior during Supersonic Molecular Beam Injection on the HL-1M Tokamak" 18th IAEA (2000).
2) X.M. Song et al, J. Plasma and Fusion Research 76, 282 (2000)

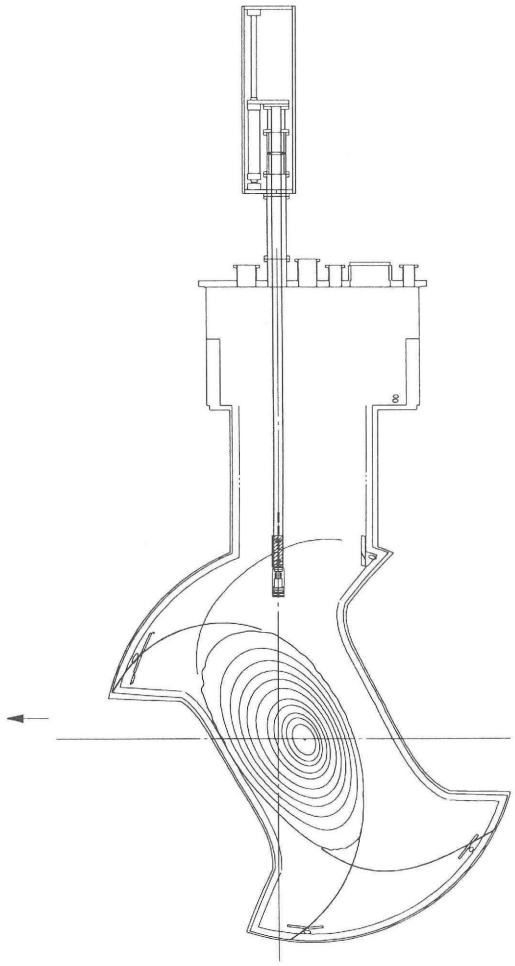

Fig.1 Schematic view of SMB arrangement in LHD