§3. Development of Cluster Beams for Fueling

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1. Introduction

We defined the basic parameters of a cluster beam injection system, aiming at the future application of the cluster beams as an alternative fueling system. In addition, we experimentally tested the directivity of the beams from a pulsed nozzle with simple geometry.

2. Basic parameters of the cluster beams

We propose the following parameters of the cluster beams for a proof-of-principle experiment on LHD and future applications on fusion reactors.[1)]

	LHD	Reactor
Cluster size (atoms/cluster)	1,000	10,000
Beam Energy (MeV/cluster)	0.1	1
Number of nozzles	1	15
Fueling rate ($Pa \cdot m^3/s$)	6	100

It should be noted that all these parameters can be realized with small extrapolations from the present technology. Here we consider the fueling to the plasma region just inside of the outermost magnetic surface. There is the discussion that deeper penetration may be expected in the case of cluster beams than in the case of atomic beams.[2)] We need further study to obtain exact deposition profile of the cluster beams.

3. Experimental Result

We fabricated a movable device for a nozzle as shown in Fig. 1 and measured jet distributions from the orifice of the nozzle under several experimental conditions. The diameter of the orifice was 0.8 mm, and no further tube, such as Laval tube, was attached. Jet distributions were estimated from the pressure increase of the vacuum vessel at the downstream of the fixed skimmer with diameter of 0.8 mm.

Typical examples of the jet distributions are shown in Fig. 2. Argon gas with pressure of 2 atm was fed to the nozzle. We found that the jet divergence was as large as about 45°, as expected for the simple cylindrical nozzle. We observed the beam divergence was slightly improved as the pressure of argon gas was increased. This indicates the partial formation of clusters, because it is known that the cluster beam divergence is generally smaller than the atomic beam divergence. Several types of tubes are planned to be attached to the nozzle and tested in order to optimize the nozzle geometry for the generation of cluster beams.

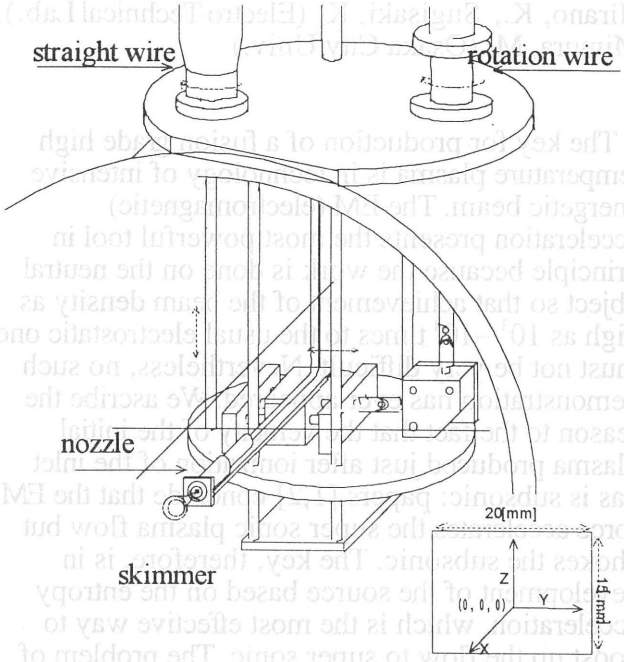

Fig. 1. Moving device for a nozzle

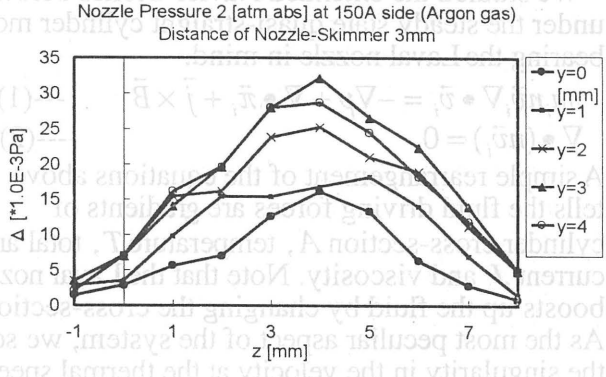

Fig. 2. Jet distribution from the nozzle.

References

1) Matsuoka, M., "Recent Progress of Cluster Beams and Its Applicability to Fueling", presented at US/Japan Workshop on Advanced Fueling, Lawrence Livermore National Laboratory, Dec. 2-3, 1997.

2) Bottiglioni, F., Coutant, J., Fois, M., "Plasma Heting by Cluster Injection: Basic Features and Expected Behavior", ASSOCIATION EURATOM-CEA, EUR-CEA-FC-848 (1976).