Behavior of high-pressure gasses injected to vacuum through a fast solenoid valve for supersonic cluster beam injection

A. Murakami, J. Miyazawa[a], T. Murase[a], K. Yasui[a], H. Tsuchiya[a], and H. Yamada[a]

The Graduate University for Advanced Studies, 322-6 Oroshi-cho, Toki 509-5292, Japan
[a]National Institute for Fusion Science,322-6 Oroshi-cho, Toki 509-5292, Japan

e-mail murakami.akiyoshi@LHD.nifs.ac.jp

A new fueling method of supersonic cluster beam (SSCB) injection is being developed for Large Helical Devise (LHD). In SSCB, high-pressure gas cooled to less than 77K by a GM refrigerator will be injected to the fusion plasma through a fast solenoid valve. SSCB is an improved version of Cluster Jet Injection (CJI) developed in Chinese tokamak HL-2M, where liquid nitrogen is used for gas cooling [1]. Before applying SSCB to LHD, the solenoid valve for SSCB has been tested at the room temperature in a test vacuum chamber to investigate the basic characteristics. Experimental setup is shown in Fig. 1. The valve is set inside the test chamber. The pressure is measured by a baratron gauge set at the opposite side of the valve. Various gases of hydrogen, helium, methane, neon, and argon are used in the experiment. Typical waveforms are depicted in Fig. 2, where argon is used as the working gas and the plenum pressure is increased from 0.5 to 5.0 MPa. After the valve is open, the gas flow directly reaches the pressure gauge with the speed of sound. Unexpected peaks appear when the plenum pressure is increased to above 3 MPa in the case of argon. Similar peaks are also observed in the experiments with other gases except helium. It is difficult to explain this phenomenon by formation of shock waves, since it does not take place in the case of helium. It is also difficult to attribute the cause of this phenomenon to clustering, because the room temperature condition in this experiment is far from the clustering condition described by the "Hagena parameter" [2]. Nonetheless, these peaks, which enable a large amount of gas injection within a short pulse, might be favorable from the point of view of fueling, as in the case of pellet injection.

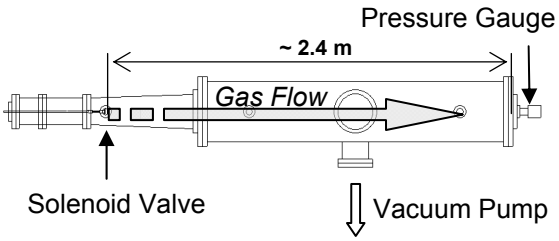

Fig. 1. Schematic of the experimental setup. The distance from the solenoid valve to the baratron pressure gauge is ~2.4 m. Inside the chamber is pumped to less than 10^{-4} Pa.

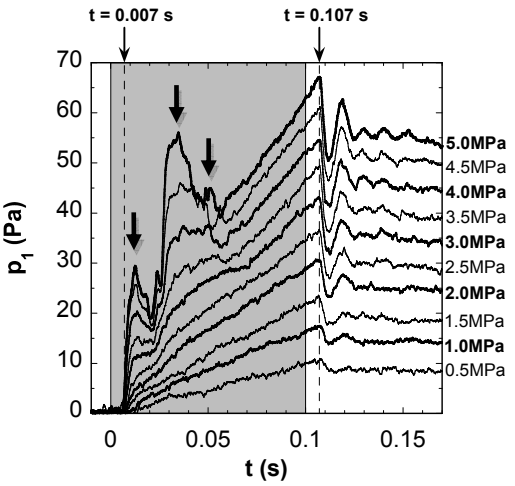

Fig. 2. Typical waveforms of argon gas puff experiment. The plenum pressure is scanned from 0.5 MPa to 5.0 MPa, while the gas puff pulse length of 0.1 s (t = 0 — 0.1 s) is kept unchanged. The pressure begins to increase at t ~ 0.007 s and reaches the maximum at t ~ 1.007 s. The delay time of ~0.007 s corresponds the time expected from the sonic speed of argon. Large peaks are marked with arrows.

[1] L. Yao *et al*. Nucl Fusion **47** (2007) 1339.
[2] R.A.Smith *et al.* Rev Sci Instrum **69** (1998)3798