§25. Gas-Puff System of LHD

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Gas-puff system of LHD is capable of fuelling ultra-high purity Hydrogen or Helium gas into the vacuum vessel, and is also capable of injecting a large amount of Argon gas to extinguish the plasma and avoid the production of runaway electron that causes hard X-ray emission in case of the current quenching of super conducting magnetic coils of LHD. This system contains two purifiers for Hydrogen and Helium, which can be operated continuously. After the purifier, the impurity level of the gas is below 100ppb. Gas is injected into LHD through a manifold set at 3.5L port as shown in Fig. 1. This manifold is equipped with five different pressure gauges to cover a broad pressure range (10^{-7}~10^{5}Pa). Five fast piezo-valves of three different maximum flow rate (1, 5, and 50Pa·m^3/s(H_2)) are set on the manifold, for Hydrogen or Helium puff. And two fast piezo-valves of maximum flow rate 100Pa·m^3/s(H_2) are installed for Argon puff. The response time of these fast piezo-valves are less than 1msec. For discharge cleaning or continuous operation, we prepared two types of mass-flow controllers of large flow rate 5-1,000 mℓ/min (0℃, 1atm) and small flow rate 0.1-5mℓ/min (0℃, 1atm).

Although we have already tested the piezo-valves to study about their time response or flow rate and certified their performance using small test chamber, we thought it is important to test the system as a whole by filling up the LHD vacuum vessel (V.V.) with Hydrogen gas through the piezo-valves of the gas-puff system. The time trace of the pressure in LHD V.V. during the test puffing is depicted in Fig. 2. The pressure is measured by Penning gauge that is installed on the gas-puff manifold shown in Fig. 1. The spikes seen in Fig. 2 indicate the time at where piezo-valves are triggered. In this case, we used two piezo-valves of the same maximum flow rate of 5Pa·m^3/s(H_2) simultaneously. After the large increase of the pressure in gas-puff manifold, the gas diffuses into LHD V.V. and the pressure becomes steady in time. The amount of the gas inflow is controlled by changing the control voltage $V_{control}$ and the pulse length of puffing. From the difference of the pressure before and after gas-puffing, we can obtain the relation between $V_{control}$ and flow rate, as shown in Fig. 3. This agrees well with the result already obtained for each piezo-valves, and one can see the good linearity between them.

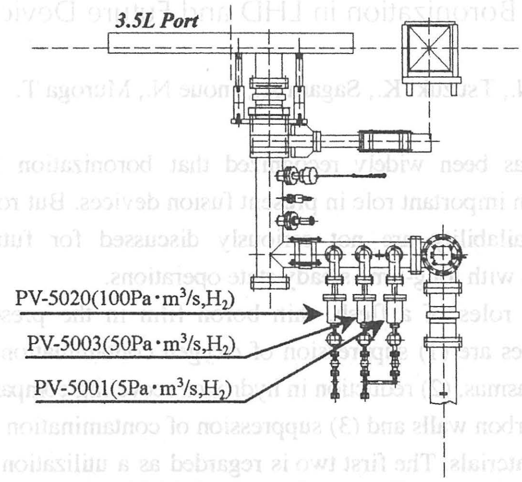

Fig. 1. Manifold layout of gas-puff system installed under 3.5L port of LHD.

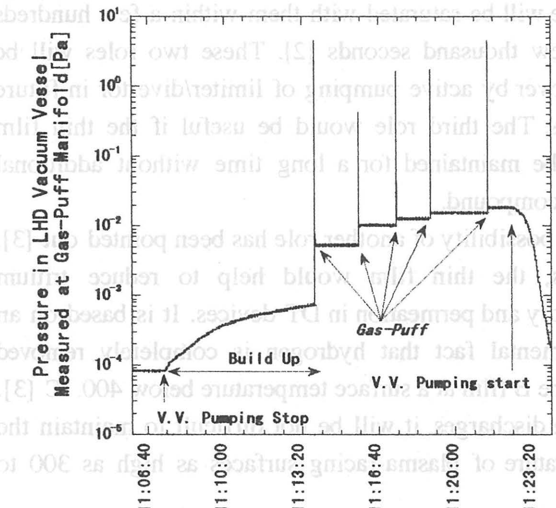

Fig. 2. Time trace of the pressure in LHD vacuum vessel measured at gas-puff manifold during test puffing.

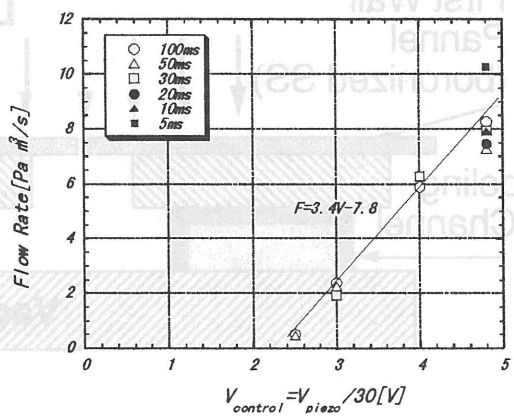

Fig. 3. Calibration between the control voltage $V_{control}$($= V_{piezo}$/30) and the flow rate in the case of gas-puffing using two piezo-valves of 5Pa·m^3/s(H_2) max. flow rate.