§15. Installation of ASDEX Type Gauge and Measurement of Neutral Compression Effect in LHD

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In the magnetically confined fusion reactor, compression of neutral particles in the divertor region is one of the most important issues for divertor optimization in terms of the effective pumping of fuel particles and He ash. Loss of the effective pumping leads to the loss of the density control and also the reduction of fusion output power due to the fuel dilution. The LHD divertor has been upgraded with the installation of closed divertor structure at the two toroidal sections out of total 10 sections, i.e. 20% coverage [1)]. The first experiment has been conducted in the 14th experimental campaign, the purpose of which is to obtain the data base of neutral compression in the closed divertor [2)]. While the present divertor system has no pumping unit, the database gives the basis to estimate the pumping efficiency for future upgrade of the closed divertor with pumping system.

The ASDEX-type neutral pressure gauge consists of filament, control grid, acceleration grid and ion collector. These electrodes are arranged along an axis, such that the Larmor motion has no effect on the collection of ion current by placing the axis parallel to magnetic field. Fig.1 shows the gauge head with each electrode indicated. The electrons emitted from the filament, which is heated by electric current of about 16A, are accelerated by the potential gradient between the acceleration grid and the filament. The ions produced by the ionization of neutral gas are collected with the ion collector. The electron flux from the filament to the acceleration grid is chopped by sweeping the control grid potential with high frequency, during which the offset due to the background plasma (if any) is measured. The offset is subtracted from the ion collector current in order to obtain net ion current from neutrals only. The ion collector current normalized with the emission current measured at the acceleration grid can be used as a measure of number of neutral particles at the gauge, i.e. neutral pressure. The calibration has been done with the magnetic field activated by the helical coils at about 3 Tesla.

Fig.2 shows the schematic of the closed divertor system and the location of the neutral pressure gauge. The "vertical" divertor plates are installed from the bottom to top of the torus along the helical coil, and the dome structure is situated in-between the two divertor plate arrays, as shown in Fig.2 (a). The three neutral pressure gauges are installed under the dome as shown in Fig.2 (b) and each of three is located at bottom, mid-plane and in-between top and mid-plane of the dome array, respectively (Fig.2 (a)). The obtained neutral pressure is shown in Fig.3 for the closed and open divertor together with the outboard side region (outside of divertor). In LHD, the particle flux tends to concentrate at the inboard side of the torus, and thus the neutrals pressure becomes high there. This is the reason for the higher pressure at the open (inboard) divertor than at the outboard side, by a factor of ~10. Is it also found that there appears clear compression effect at the closed divertor region, where the achieved maximum pressure is around 0.7 Pa, which is larger than at the open divertor region by a factor of ~ 10. It is estimated that the pressure of the order of 0.1 Pa is reasonable one for obtaining sufficient pumping capability for future upgrade of the divertor.

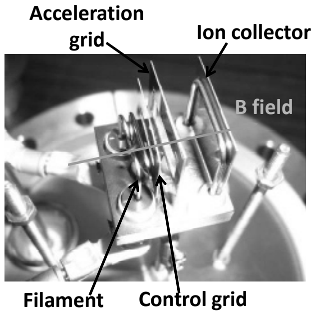

Fig.1. The gauge head of the ASDEX-type neutral pressure gauge.

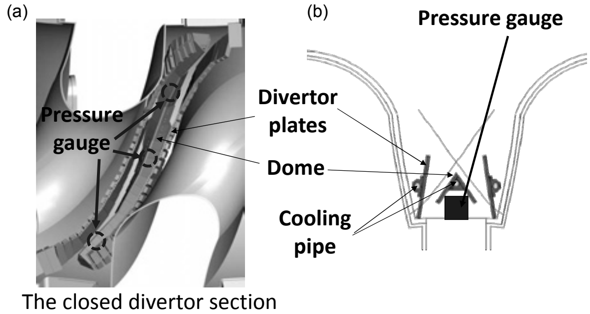

Fig. 2. Schematics of (a) the view from outboard side of the closed divertor and (b) the cross section along helical coil, for divertor configuration and neutral pressure gauge location.

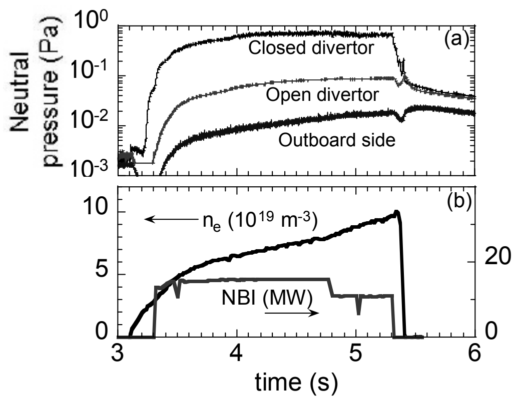

Fig. 3. Time traces of (a) neutral pressure at closed (inboard) divertor, open (inboard) divertor and outboard side (outside divertor), (b) line averaged density and NBI input power.

1) Masuzaki, S. et al. : Fusion Eng. Des. **85** (2010) 940.
2) Masuzaki, S. et al. : Plasma and Fusion Research, Rapid Communications **6** (2011) 1202007.