§38. First Application of Membrane Pumping System to Plasma Devices

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Divertor pumping is indispensable in order to realize a fusion reactor by a magnetic confinement device. Recent experimental results on production of high performance plasma indicate that wall conditioning (recycling and impurity control) is very important. However, the wall treatment such as boron coating etc. is not capable of long pulse or steady state operation. Active particle control in the peripheral plasma region is essential for magnetic fusion reactors.

We develop a new divertor pumping system using a superpermeability of hydrogen atoms through a special metal membrane. In order to study the applicability of membrane pumping system to plasma devices, we have designed and fabricated a membrane pumping test device for the JFT-2M tokamak. Figure 1 shows a installation of the membrane unit in JFT-2M. Two Nb membrane tubes with the diameter of 15 mm and the thickness of 0.2 mm are placed near the divertor region. The membrane tubes are connected to a pumping system through stainless steel pipes and insulation couplings. The temperature of membrane is controlled by heating with an alternating current through the membrane tubes. In order to distinguish the permeation flux through the membrane between with and without plasma exposure, the membrane tubes are covered with a cylindrical shield case which can be rotated by a rotary feedthrough.

The permeation flux through the membrane is measured by gas flow changes with a diaphragm of conductance of 2.6 l/s and an ion gauge. The membrane is resistively heated up to ~850 °C by the alternating current of 150 A and the current is turned off during the excitation of toroidal magnetic field. As a result, the membrane temperature during plasma discharge is about 600 °C. First of all, we confirm that the outlet pressure does not change in the case of closing the shield. When the membrane window is opened, the pressure goes up quickly with switching on the heating current and goes down slowly. In this way, we can distinguish the membrane pumping of hydrogen atoms produced by the divertor plasma. The permeation flux is calculated from the integration of gas flow, for example, 5.5 x 10^{16} atoms/s for the discharge with the average plasma density of 2 x 10^{13} cm^{-3} and the duration of 0.5 in the lower divertor configuration. In the preliminary experiment, we obtain only the dependence of the permeation flux on the pressure in the divertor as shown in Fig. 2. The permeation flux increases with increasing the divertor pressure. We can observe no permeation flux without plasma in the divertor region (upper single null divertor operation).

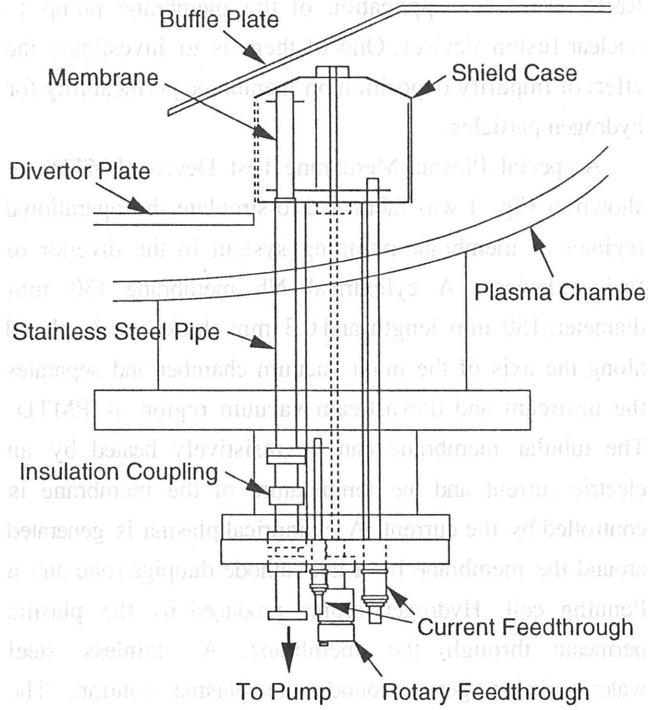

Fig. 1 Installation of membrane pumping unit in JFT-2M

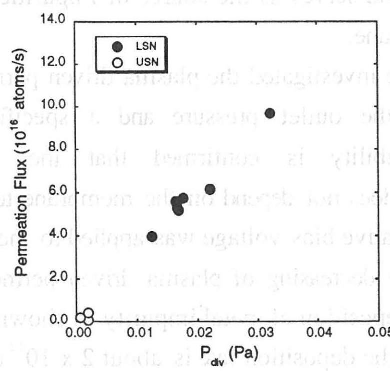

Fig. 2 Dependence of permeation flux on divertor pressure