§35. Proposal of High Efficient Discharge Cleaning Using Local Island Divertor

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A new method of high efficient discharge cleaning using Local Island Divertor (LID) in LHD was proposed as one of optional merits of LID. This method drastically shortens the discharge cleaning time required in wall conditioning to remove main impurities such as oxygen on the surface of plasma facing components. According to the following estimation, very fast conditioning in less than one hour can be expected even in a large machine like LHD, which usually needs more than a few weeks to sufficiently reduce plasma impurities with conventional methods of discharge cleaning.

This method is mainly made up of three features as schematically shown in Fig.1; the first is efficient pumping of gaseous particles such as CO and H_2 using LID, which has localized divertor configuration with a proper pumping system under high magnetic field in steady-state operation, the second is the use of graphite materials for ion neutralizer in the LID head, which enhances the oxygen recycling ratio by CO production, and the third is the use of toroidally distributed H_2 gas puffing to enhance oxygen release rate from the wall surface.

The conditioning time with this method in LHD is estimated : supposing the plasma edge temperature of 5eV with the heat flux of 250kW onto the LID head and 250kW onto the first wall with charge exchanged H^0 neutrals under the 500kW ECH input to a hydrogen plasma containing 1% oxygen impurities, which is usually a sufficient level as a goal of cleaning procedure and not needed to be reduced any more, the particle flux of hydrogen Γ_H and oxygen Γ_O are about 5×10^{22}/s and 5×10^{20}/s, respectively. Here O^+ ions bombarding the graphite surface along with magnetic field lines can recycle as CO molecules with their production yield Y_{CO} of about 1 CO/O^+ [1]. When the particle removal efficiency $\varepsilon = 0.01$, which is achievable by a conventional TMP with a duct conductance larger than 1% of the back flow conductance of 14,000 l/s for CO (and 53,000 l/s for H_2) at the LID head having a 5cm opening width, oxygen removal rate

$\varepsilon Y_{CO}\Gamma_O \sim 5 \times 10^{18}$ CO/s .

Then the time required to remove one monolayer oxygen contaminants from the whole LHD vacuum vessel

$t \sim 1\times10^{15}/\text{cm}^2 \times 300\text{m}^2 / \varepsilon Y_{CO}\Gamma_O \sim 600$ s .

Consequently the cleanup procedure of multi-layer contaminants is accomplished in less than one hour.

If a higher removal efficiency, e.g. $\varepsilon = 0.1$, is needed, a titanium getter pump with a chevron baffle of ϕ26cm is promising. In this method a cryogenic pump is unfortunately not used due to the safety limit regarding hydrogen burst, but a hydrogen permeation membrane pump is also promising in combination with the titanium getter pump for CO.

This method can be tested in actual plasma devices using a graphite limiter located near a pumping duct in a fairy long discharge operation with a proper plasma heating and H_2 gas puffing under a high magnetic field.

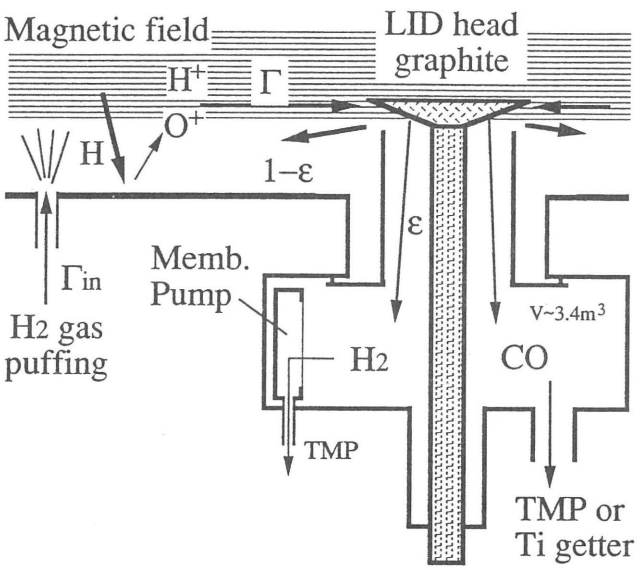

Fig.1 LID discharge cleaning method.

Reference

1) E. Vietzke, J. Nucl. Mater. 145-147 ('87) 425.