§5. Particle Exhaust in CHS with the LID

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Particle Balance with Plasma. In general, the global particle balance in a magnetic fusion device can be described as $\Phi + R\frac{N}{\tau_P} - \frac{N}{\tau_P} = \frac{dN}{dt}$ where Φ is the external fueling source, N is the total number of electrons in the main plasma and τ_p is the global particle confinement time. R is the recycling coefficient. With particle exhaust $R \rightarrow R_o - \varepsilon$, where ε is the exhaust efficiency. It is also convenient to define an average particle lifetime $\tau_p{}^* = \frac{\tau_P}{1-R}$ or $\frac{\tau_P}{1-R+\varepsilon}$' for the non-pumped or pumped cases, correspondingly.

For Shot 55495, the gas puff turns off at 0.11s, but the NBI continues to 0.13s. For that period of time, Φ~0 and $\tau_P{}^*$ can be determined from the density decay rate: $\tau_P{}^* = 153$ ms with B-pert. In the case of Shot 55490, $\tau_P{}^* = 200$ ms without B-pert. Therefore, $\frac{1-R+\varepsilon}{1-R} = \frac{200}{153}$, i.e. ε is a strong function of the recycling coefficient. We estimate that $\tau_P = 2$ ms for the type of discharges in the March 5,6 experiments, and derive R=0.99. [1] This results in ε = 0.3%.

Particle Balance without Plasma. Gas puff experiments were also performed with magnetic field, but without plasma. These are most useful for the evaluation of pumping speeds and conductances, which are parameters in the set of coupled differential equations that describe the evolution of the neutral pressures p_L and p_V in the two reservoirs (CHS vessel and LID chamber, respectively) that are connected via the LID throat:

$$V_L \frac{dp_L}{dt} = p_V \cdot C - p_L \cdot C - p_L \cdot S_L \quad \text{and}$$

$$V_V \frac{dp_V}{dt} = G - p_V \cdot S_V - p_V \cdot C + p_L \cdot C,$$

where V_L, V_V are the volumes of the LID (400 l) and CHS vessel (2000 l) respectively. G is the gas puff (for 0-30ms only), C is the conductance of the throat and S_L, S_V are the pumping speeds of the LID and the vessel respectively.

These equations were solved numerically for many choices of the parameters. Best results are seen in Figs. 1 and 2 (lower curve corresponds to the case with the LID pump on):

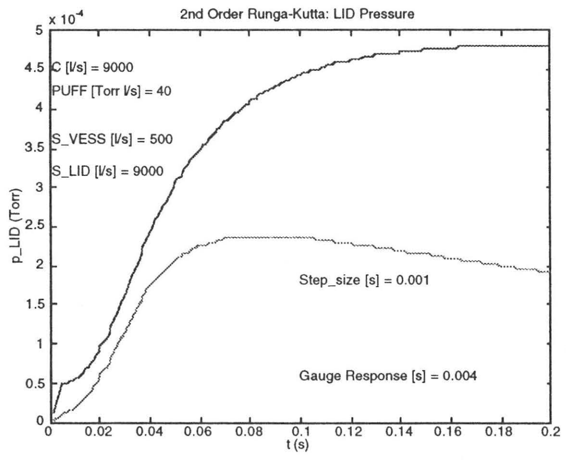

Fig. 1. Simulated LID neutral pressure.

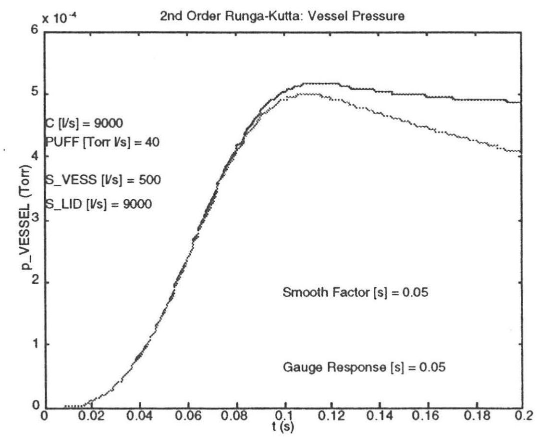

Fig. 2. Simulated vessel pressure.

Exhaust efficiency from particle balance in the LID. Using these best parameters, ε can be estimated. For a pump limiter, $\varepsilon = \mathbf{f} \cdot \varepsilon_t$, i.e., the product of the exhaust fraction and the trapping efficiency [2].

With plasma, in equilibrium, the ion flux into the throat $\Gamma_{in} = p \bullet (C+S)$ and $\varepsilon_t = \frac{p \bullet S}{\Gamma_{in}}$; $f = \frac{\Gamma_{in}}{N/\tau_P}$. Note that, ideally, for the LID concept, **f** --> 1. Analysis of the throat Langmuir probe data, coupled with H_α images which will define the footprint of the ion flux into the LID should allow for an estimate of Γ and subsequently the trapping and exhaust efficiencies.

Reference

1) Morita, S., *et.al.*, Trans. Fus. Technol, **27** (1995), 239.
2) Post and Behrisch, NATO ASI (1984).