

§15. Particle Control by an End Plate in GAMMA-10

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It is well known that particle recycling from plasma-facing components in magnetic fusion devices can affect core confinement performance. This can best be described by the Supershot confinement regime discovered in TFTR, where particle recycling from the graphite bumper limiter was reduced by thermal degassing and/or helium discharge conditioning prior to confinement discharges [1]. As can be seen in Fig. 1, the energy confinement time in TFTR increases with decreasing edge D_α intensity, a measure of particle recycling. Similar reduced recycling effects have been observed in a number of toroidal fusion devices over the past several decades even as the physics behind these effects is not thoroughly understood.

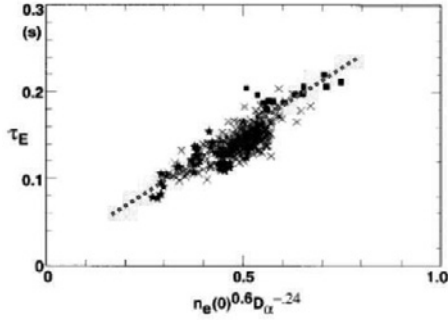


Fig. 1 TFTR energy confinement database¹⁾.

The present work is intended to investigate if such wall recycling effects can be observed in a linear device, where, however, there are no plasma-facing components of the definition used for toroidal devices except that the confinement loss particles flow into the end cells, being neutralized. One believes that the effect of neutral particles recycling can be observed, using an end plate which separates the end cell from the central cell.

Generally, the heat flow along the magnetic field line is considered to be the sum of convection and conduction effects such that:

$$q_{||} = q_{||\text{conv.}} + q_{||\text{cond.}} \quad (1)$$

Here, it is extremely important to point out that the SOL collisionality ν_{SOL} plays a key role in determining the heat loss mechanism to the plasma-facing component. Also, for the same plasma temperature and density, ν_{SOL} is linearly proportional to connection length.

If $\nu_{\text{SOL}} < 10$, the heat loss will be sheath-limited to be given by²⁾:

$$q_{||} \approx q_{||\text{conv.}} = \left\{ \frac{1}{2} m_i v^2 + \frac{5}{2} k(T_e + T_i) \right\} n v \quad (2)$$

As opposed to that, if $\nu_{\text{SOL}} > 20$, the heat loss will become conduction-limited to be expressed as²⁾:

$$q_{||} \approx q_{||\text{cond.}} \approx -\kappa_{0e} T_e^{\frac{5}{2}} \frac{dT_e}{dx} \quad (3)$$

Because mirror machines are inherent with short connection lengths, the heat flow is expected to be sheath-limited in which case the edge density plays an important role, as indicated by eq. (2).

A schematic diagram of the end plate prepared for this purpose is shown in Fig. 2. Employed as the end plate materials are titanium and tungsten, completely different in hydrogen recycling characteristics. Titanium is well known to form hydride (TiH_2), keeping the recycling coefficient: $R_e \ll 1$ for a typical pulse length of 100ms in GAMMA10, whereas although it is implanted with energetic hydrogen to a certain extent, tungsten essentially reflects hydrogenic species, meaning that $R_e \sim 1$ ³⁾. These two materials can be interchanged in-situ by flipping the end plate. Also, a sheet heater (see Fig. 3) is inserted in between these end plates, so that post-exposure TDS can be done in a vacuum chamber, valve-separated from GAMMA-10.

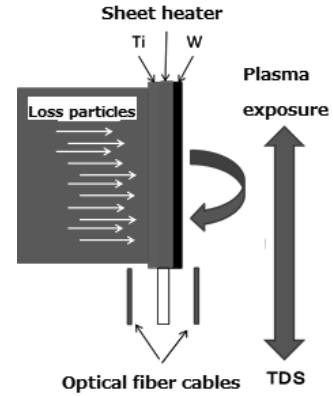


Fig. 2 A schematic diagram of the experimental set up.



Fig. 3 A photo of the sheet heater for the end plate.

- 1) Strachan, J. D., Nucl. Fusion **39**(1999)1093.
- 2) Stangeby, P. C, "The plasma boundary of magnetic fusion devices", IoP (2000).
- 3) Post, D. E. and Behrisch, R. "Physics of plasma-wall interactions in controlled fusion" Plenum Press (1986).