Investigation of radial distribution of atomic hydrogen flow to the plasma facing components in steady state tokamak operation

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Hydrogen recycling in fusion devices is one of the main unsolved problem. The processes, including interaction of neutral particles, even with low energies, with plasma facing components (PFCs) may play a significant role \([1]\). Among such particles, the atomic hydrogen (H) is of the most concern, because even in PFCs, not directly exposed to plasma interaction, the H flux to the wall may remain significant, of an order of \(10^{18}\) H m\(^{-2}\) s\(^{-1}\) \([2]\). To complete the hydrogen recycling models \([3,4]\), the atomic hydrogen flux to the walls needs to be measured in-situ. The duration of steady-state pulses in QUEST tokamak \([4]\) allows us to use a permeation probe for this purpose \([2,5]\).

The radial distribution of atomic H was measured only in non-confined annular plasma \([2]\). In the present work we measured the radial distribution of atomic H in inboard limiter plasma configuration using the same reciprocate permeation probe as in \([2,5]\). A reciprocate Langmuir probe was used to measure the ion flux at the same location. As in the case of annular plasma, in confined plasma the atomic H flux inside the port does not decrease to zero, while the ion saturation current of the Langmuir probe does. The atomic H flux is in the range of \(10^{14}\)-\(10^{16}\) H m\(^{-2}\) s\(^{-1}\) for radial positions \(R = 1.1-1.4\) m. The atomic H density in plasma in similar discharges, estimated from hydrogen spectroscopy, is \(10^{15}-10^{16}\) m\(^{-3}\) for \(R = 0.3-0.7\) m. To calculate this incident atomic flux, a diffusion problem is solved, and the unknown recombination coefficient is scanned to fit the measured permeated flux. The surface conditions of the metal membrane strongly affect this parameter, and to get a reliable absolute value for the incoming H flux a proper calibration of the process is now being developed.

A bench-test device to develop such calibration consists of two separate vacuum chambers, one with a plasma and atomic hydrogen source to irradiate the membrane, and another to measure the permeation hydrogen flux through the membrane. The incident atomic H flux is calculated using two approaches. First, the atomic H density is calculated from spectroscopic observations of the plasma and the Langmuir probe data. Second, the hydrogen flux is calculated from the measured permeation flux by solving the diffusion equation. These two approaches are independent and will allow to develop the required calibration for the tokamak probe.