NEUTRAL PENETRATION AND FUELING OF ADITYA-U TOKAMAK PLASMAS BY GAS-PUFFS

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Efficient fueling is an important research area in tokamak as bigger machine size and higher electron density lead to lower penetration of neutral particle into the plasma. Various techniques, gas puffing from low and high field sides, supersonic beam injection and pellet injection have been developed and efficiency of these systems have been explored through the investigation of correlation between core plasma electron density and injected particle. It is also seen that neutral particle plays an important role in various edge phenomena such as multifaceted axisymmetric radiation from the edge (MARFE) and the low-to-high (L-H) mode transition [1]. Due to the importance of the determination of the neutral (atomic and molecular) density profiles, nearly every tokamak has developed techniques for their estimation. Yet, neutral densities are not a routine measurement. It is usually done through the passive emission from atoms excited by the background plasma. The 2D (or 3D) distribution of fuel atom density is derived using a suitable edge fluid or kinetic modeling in the tokamak.

In the ADITYA-U tokamak (major (R) and minor (a) radii, 0.75 and 0.25 m, respectively), hydrogen is routinely puffed into the plasma to regulate plasma density, to investigate gas puff induced sawtooth stabilization and to understand its effect on drift tearing mode [2, 3]. The gas is puffed into the plasma using a pulsed gas feed system having a piezoelectric valve. Here, applied voltage on the valve, pulse duration and gap between pulses are varied for carrying out various experiments. However, the fueling efficiency of gas puffing technique has not been investigated thoroughly in ADITYA-U tokamak. Since H_α radiation mainly come from excitation of neutral hydrogen before it gets ionize, its special distribution provides insight into the penetration depth and ionization dynamics. By analyzing modification of radial profiles of the H_α emission after gas puffing, one can determine edge ionization source and how effectively they contribute to the plasma fueling.

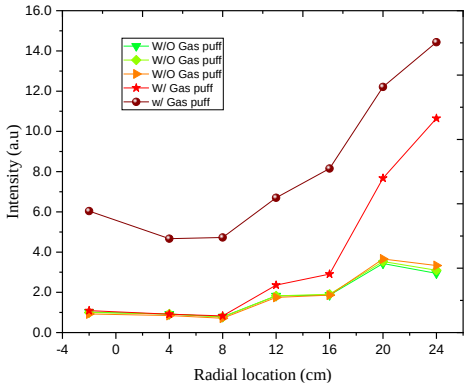

Fig.1 *Spatial profile of H_α Intensities with and without gas puff*

For this purpose, the spatial profiles of H_α intensity have been measured using space-resolved visible spectroscopic diagnostic. It consists of a high resolution 1.0 m multi-track spectrometer and sCMOS detector [4]. The spectral resolution of the spectrometer 0.025 nm at 50 μm entrance slit width. The spatial profile is obtained by viewing the plasma along 8 lines of sight spreading over almost outer half of the plasma for the discharges with and without gas puff. It clearly shows that H_α intensity is having peak at plasma edge, but its substantial

fraction reaches up to r = 16 cm. It is seen that H_α intensity is almost constant within 5 cm of limiter radius for the discharges without gas puff and then decreases gradually toward plasma inner region. This observation is corroborated through a theoretical calculation of the penetration of neutral hydrogen, which is ~ 5 cm for the

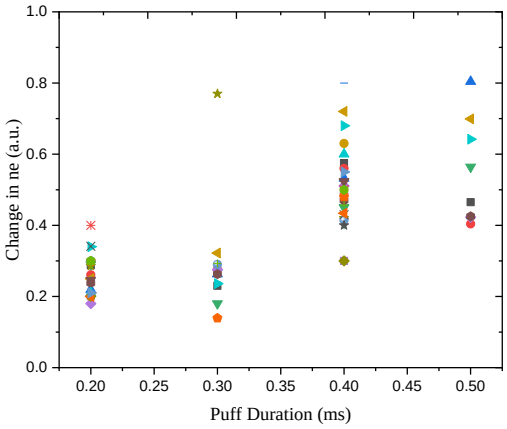

Fig.2 *Change in the ne with variation of gas puff duration*

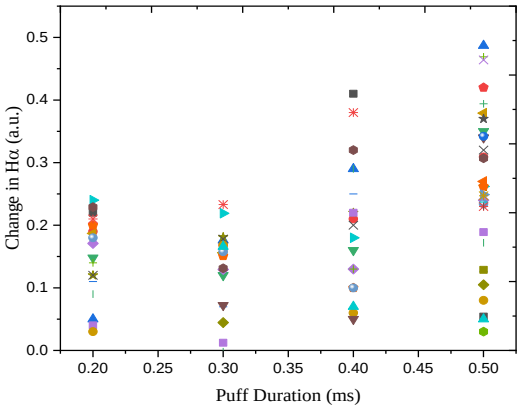

Fig.3 *Change in the Hα with variation of gas puff duration*

ADITYA-U edge plasma parameters ($n_{e,a}$ ~ 0.5 to 1.0 $\times 10^{18}$ m^{-3} and $T_{e,a}$ ~ 7 to 15 eV).

In addition to the investigation of neutral penetration, a correlation study between the increase in central chord averaged electron density and changes in H_α intensity and injected particle amount have been carried out for better understanding of the role of edge plasma in the fueling efficiency. The experiment has been done by changing the pulse duration indicating the variation of number of injected particles into the plasma and the background edge plasma properties. It has been found that an increase in the amount of gas puff leads to higher increments in chord averaged electron density and H_α emission. It is also seen that electron density rises nearly double, while change in the H_α intensity does not show any strong correlation with the amount of injected particle, which indicates edge plasma parameter influencing ionization source rate and location.

In summary it can be inferred that H_α intensity falls sharply within 8 cm of limiter radius for the discharges with gas puff indicating lower neutral penetration into the inner region of ADITYA-U plasma as compared to plasmas without gas puff. It is also seen that changes in the chord averaged electron density becomes double when puff duration changed from 0.20 to 0.50 ms, whereas modification in H_α intensity does not show any correlation with the changes in puff duration.

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