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Radiation profile and impurity line emissions on TPE-RX

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1. Introduction

We present a discussion about the radiation profile and the impurity line emissions on TPE-RX (minor radius, a is 0.45 m, and major radius, R is 1.72 m). We show the dependence of the ratio of the radiation power to the Ohmic power, P_{rad}/P_{oh} on the I_p/N value. The behavior of the impurity line emissions (e.g. molybdenum, iron and chromium) is presented. We also show the behavior of Dα line emissions.

We measure the radiation profile using bolometer arrays at two toroidal sections, and calculate the radial profile of the radiation and the total radiation loss. Dα line emissions are measured at 15 toroidal sections. The toroidally asymmetry of Dα line emissions is corrected by integrating the toroidal distribution. We also measure fore impurity lines at one toroidal section. We study the dependence of the radiation and the impurity line emissions on the I_p/N values. To control the I_p/N value, we change the operating conditions (e.g. I_p scan, Gas puffing discharges and Pulsed Poloidal Current Drive, PPCD).

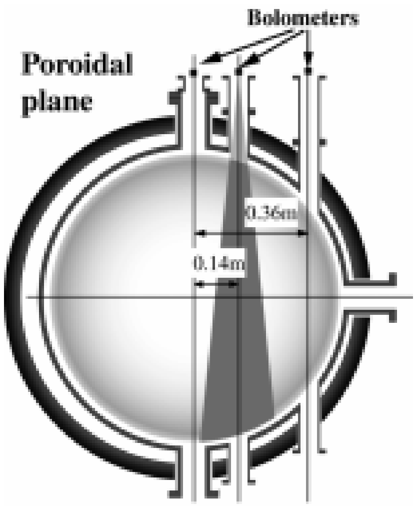


Figure 1. Experimental setup. Three housing metal foil bolometers are installed on the vertical ports

2. Radiation profile measurement

To perform the radiation profile measurement, three housing metal foil bolometers are installed on the vertical ports as shown in Fig. 1. These detectors were absolutely calibrated using green laser light. The radial profile of the plasma emissivity $\varepsilon(r)$ (W/m^3) can be obtained from the brightness measurements by these detectors. The power impinging on a detector is defined as the line integral of the emissivity along the chord times a geometrical factor. Limited the measurements to only three chords, it was assumed that the emissivity has both poloidal and toroidal symmetry and depends only on the radial coordinate. $\varepsilon(r)$ is assumed to be a forth order polynominal expression of the form $\varepsilon(r)$ =

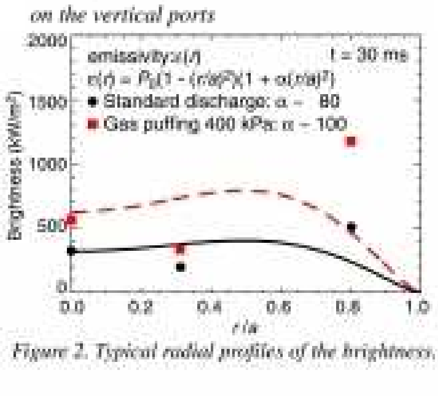


Figure 2. Typical radial profiles of the brightness.

$P_0[1-(r/a)^2][1+\alpha(r/a)^2]$. Typical radial profiles of the brightness are shown in Fig. 2. The symbols indicate the experimental results for standard discharge (solid circles) and for gas puffing discharge (solid squares). The broken and solid lines are obtained from fitting function $\varepsilon(r)$. The brightness at the edge chord is usually larger than at the center chord in standard and gas puffing discharges. In gas puffing discharge, ratio of the brightness at the edge chord to at center chord increases two times. Although three chords are not sufficient to provide an accurate reconstruction of the radial profile of emissivity, the measurements indicate a hollow profile for the emissivity. To perform I_p/N ($N = 2\pi\ a^2N_c$) scan, I_p is changes to 400 kA from 250 kA, and plasma density is changed by gas puffing technique. In figure 3, typical waveforms of plasma current I_p, reversal parameters $\Theta = B_{polo}(a)/\langle B_{toro}\rangle$ and $F = B_{toro}(a)/\langle B_{toro}\rangle$, total radiation power P_{rad}, Ohmic power P_{OH}, and plasma density N_c. P_{rad} is calculated by integration of the emissivity along the radial coordinate. The solid lines indicate the waveforms in the standard discharge, and the broken lines indicate the waveforms in the gas puffing discharge. The gas puff is triggered at 20 ms. N_c increases after the gas puff trigger, and has maximum value at 30 ms. The quantities of P_{rad}, of P_{OH} and of N_c depend on the fueling gas pressure of the puffing. The discharge parameters are controlled so that the reversal parameters F and Θ have the same value both in the cases of the standard discharge and in the case of the gas puffing discharge. Radiation flaction P_{rad}/P_{OH}, is plotted versus I_p/N and N_c in Fig. 4. N_c in TPE-RX is the range from 2 to 20 10^{18}m^{-3} due to use SUS vacuum vessel and Mo limiter. The gas puffing technique realizes

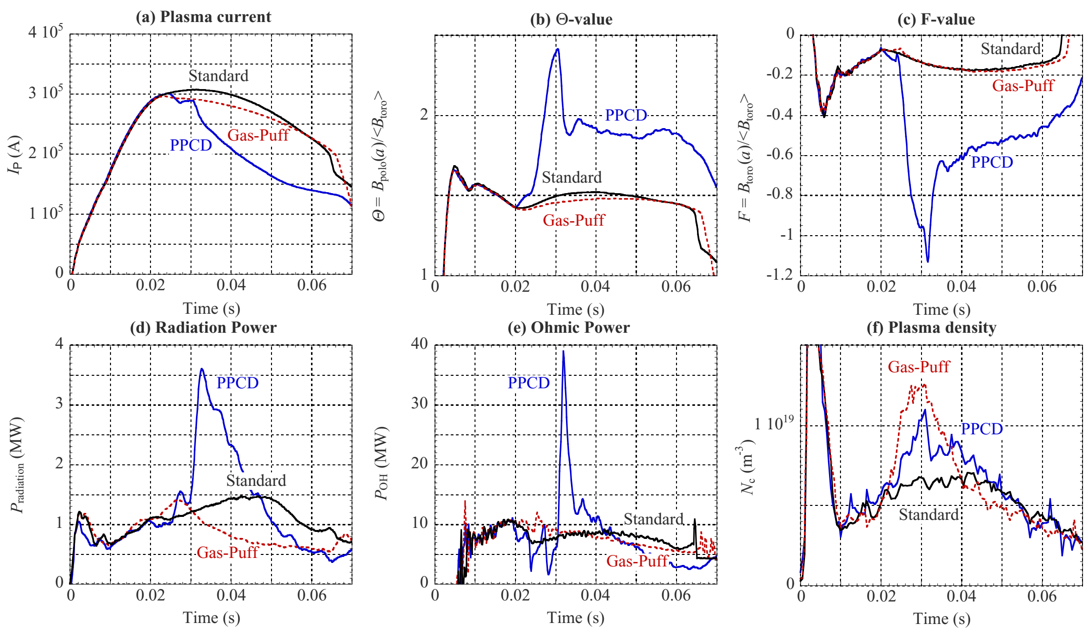


Figure 3. Typical waveforms of plasma current Ip, reversal parameters $\Theta = B_{polo}(a)/\langle B_{toro}\rangle$ and $F = B_{toro}(a)/\langle B_{toro}\rangle$, total radiation power P_{rad}, and Ohmic power P_{OH}.

the discharge in higher N_c, and in lower I_p/N. P_{rad}/P_{OH} is from 10 to 20 % in I_p/N range from 5 to 10 10^{-14}Am. As I_p/N decreases towards its lower limit (2 10^{-14}Am for TPE-RX data), P_{rad}/P_{OH} increases to 50 % and the amount of scatter in the measured values increases. P_{rad} in PPCD is also observed. In this experiment, PPCD phase is from 20 to 30ms. In PPCD discharge, the reversal parameters F and Θ change rapidly as shown in Fig. 3. P_{rad} increases during PPCD phase.

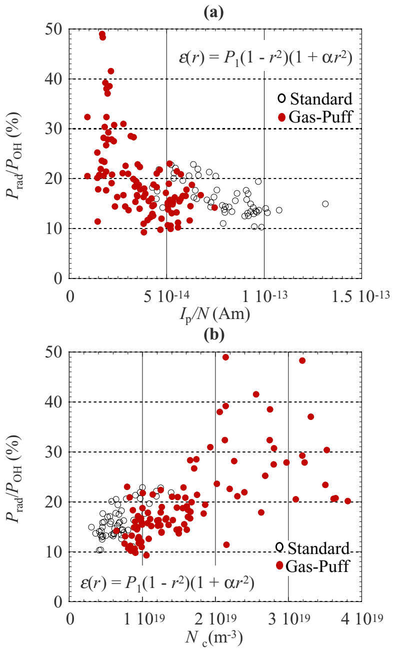


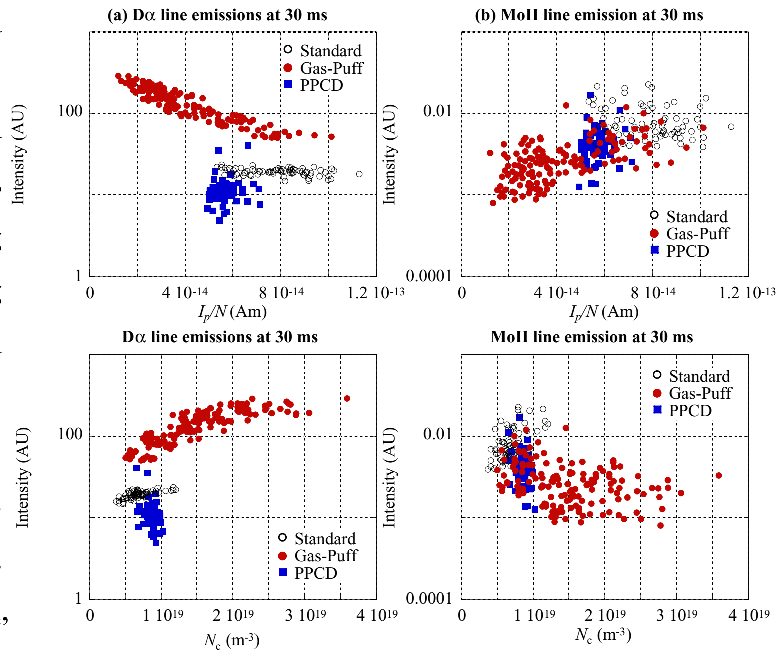
Figure 4. Radiation flaction.

3. Dα line and impurity lines

Behavior of Dα line emission and of the impurity line emissions (e.g. molybdenum, iron and chromium) is observed. Dα and MoII line emission intensities are plotted versus I_p/N in Fig. 5. In this experiment, carbon line emissions are not observed clearly. Line emissions of the wall materials (iron and chromium) and MoII line emissions are similar in the temporal behavior and in I_p/N dependence. Dα line emission increases with I_p/N decreasing. MoII line emission decreases with I_p/N decreasing. Dα line intensity in gas puffing discharge is larger than in standard discharge for same I_p/N. MoII line intensity in gas puffing discharge is smaller than in the standard discharge for same I_p/N. Gas puffing technique reduces the plasma wall interactions and improves the plasma purity. In PPCD discharge, Dα and impurity lines emissions decrease. N_c is increasing without auxiliary gas puffing in PPCD phase as shown in Fig. 3.

4. Summary

Ratio of the brightness measured at the edge chord, P_{edge} to at the center chord, P_c, is more than 1. It can be seen



Figurer 5. Dα line and impurity lines emissions in standard, gas puffing, and PPCD discharge at 30ms. (a); Da line 6561Å. (b); MoII line 3272Å.

that radial profile of the emissivity is hollow. This result is similar with the results of MST [1] and RFX [2], but it is different from the results of T2R [3]. In gas puffing discharge and PPCD, the brightness increases and P_{edge}/P_c increases to 2. P_{rad}/P_{oh} increase with increasing N_c and with decreasing I_p/N value. P_{rad}/P_{oh} is from 10 to 20 % in the I_p/N range from 5 to 10 10^{-14}Am and increases to 50 % in the low I_p/N range from 1 to 5 10^{-14}Am. The lower limit of I_p/N is about 2 10^{-14}Am. These results are similar with other three devices (MST, RFX and T2R) [1-3]. P_{rad}/P_{oh} in the Gas puffing discharge is smaller than in the standard discharge for the same I_p/N and N_c. The Dα line emission increases with I_p/N decreasing. The MoII line emission and the other line emissions of the wall materials decrease with I_p/N decreasing. The Dα line and the impurity line emissions decrease in the PPCD. The increasing rate in the gas puffing discharge is smaller than in the standard discharge. Impurity line emissions decrease and Dα line increases after gas puffing. The plasma purity is improved, and the plasma effective charge Z_{eff} may decrease after gas puffing.

5. Conclusion

Gas puffing allowed the discharge of TPE-RX wide I_p/N operation range from 2 to 10 10^{-14}Am. We study the dependence of the radiation and the impurity line emissions on the I_p/N values. In the gas puffing discharge, the radiation fraction is smaller than in the standard discharge. The Dα line emission is transposed for the Mo line emission and for the other line emissions of the wall materials. The gas puffing technique controls the plasma-wall interaction. The plasma purity is improved, and the plasma effective charge Z_{eff} may decrease after gas puffing. In the PPCD discharge, the Dα line and the impurity line emissions decrease. The plasma density increases with the decrease of the Dα line emission. The particle confinement is improved.

References

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