2D distributions of current and floating potential at the target surface in Pilot-PSI

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Introduction

Pilot-PSI is a magnetized linear plasma device designed to study plasma surface interaction (PSI) at ITER relevant parameters [1]. This device is also the smaller forerunner of MAGNUM-PSI, a high-flux linear plasma generator. One important aspect of experimental investigations is the diagnosis of Pilot-PSI plasma column. Plasma parameters as electron density, electron temperature and plasma angular rotation were determined by optical methods [2]. Electrical probes were recently used to evaluate plasma potential, radial electric field, electron/ion saturation currents and plasma fluctuations [3, 4].

The present work reports on the experimental investigation of the time-space distribution of two important parameters measured by a multi-channel analyzer placed in the centre of Pilot-PSI target: plasma current drawn by the grounded collectors and the potential of the floating collectors.

Experimental set-up

The scheme of Pilot-PSI device is shown in Fig. 1. The plasma source is a cascaded arc [5] which exhausts into a vacuum vessel of 1 m length and 0.4 m diameter (~ 0.1 Pa background pressure). Five magnetic coils distributed along the vessel are used to create rather uniform magnetic field inside the vacuum chamber. The maximum available magnetic field strength is 1.6 T. A water-cooled solid target is installed inside the vacuum vessel, opposite to plasma source. Usually carbon or tungsten is used as target material. To study plasma currents and potential distributions at the target surface a multi-channel analyzer with 61 collectors was installed in the centre of the target. A front view of the multi-channel analyzer is shown in Fig. 2. The analyzer consisted of a cylindrical ceramic plate in which 61 collectors (tungsten wire, ϕ = 1 mm) were inserted. The collectors were symmetrically distributed over four concentric circles, the radii of the circles being multiples of 2.5 mm. A carbon plate could optionally be placed in front of the analyzer to protect the ceramic surface from melting in case of high plasma fluxes.

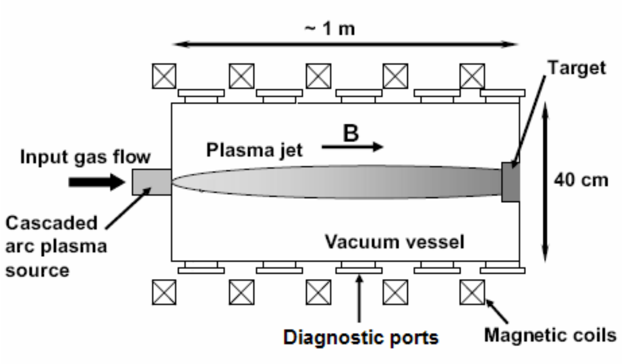


Fig. 1. General scheme of Pilot-PSI set-up

Fig. 2. Front view of multi-channel analyzer

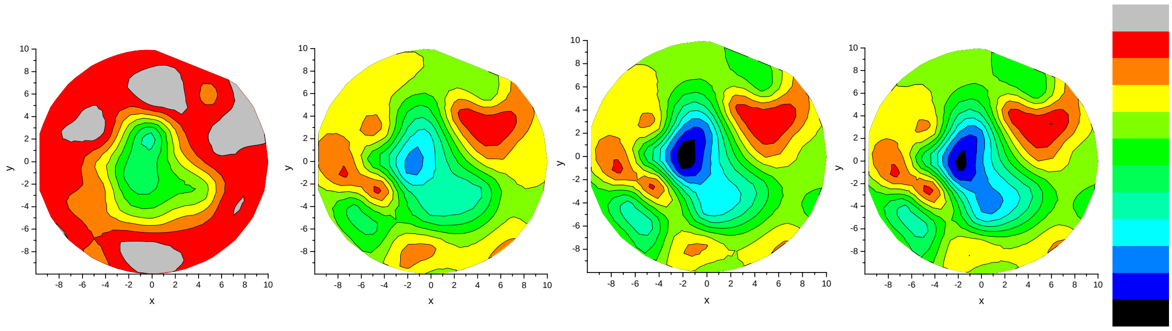
A data acquisition system with 64 analog input channels was used for simultaneous measurements on all 61 collectors. Plasma source was operated in hydrogen with a gas flow of 3 slm (1 slm ~ 4.48×10^{20} molec/s) and a discharge current I_d of 80 to 140 A. The gas pressure in the vessel was in the range of 3 ÷ 5 Pa and the measurements were performed for two magnetic field strengths, namely 0.4 and 0.8 T. The target was positioned at 56 cm from the cascaded arc plasma source.

A simple electronic circuit was used for current and floating potential measurements. The current flowing to the ground through each collector was measured as the voltage drop on a resistor of 0.2 Ω. The floating potential was measured using a resistive divider 1/100. The time-dependence of the signals was acquired at a sampling rate of 50 KHz.

Results and discussions

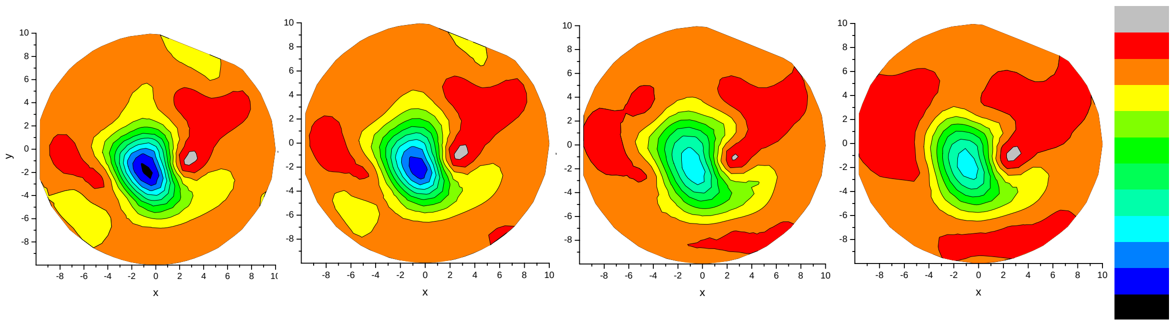
The experiments were focused to obtain the 2D distributions of the plasma current (drawn by the grounded collectors) and floating potential at the target surface. The 2D current distributions obtained in a magnetic field of 0.4 T are plotted in Fig. 3, for different discharge currents (I_d = 80, 100, 120 and 140 A). The negative values of the measured currents are related to the electron dominated current received by the grounded collectors. A strong radial gradient of the current can be noticed in all four cases. Although at higher radii the plasma column presents angular inhomogeneity, yet the core of the plasma seems to be cylindrically symmetric. The symmetry is more obvious at stronger magnetic fields (Fig. 4). The measured currents increase with the discharge current. The maximum of the current distribution is recorded almost in the center of the target.

The same 2D current distributions obtained in a magnetic field of 0.8 T are plotted in Fig. 4. The increase of the magnetic field creates a better plasma confinement, reflected in a strong amplification of the measured electric current intensity and steep radial gradients. The current drawn by the grounded target in the central area decreases with the current from the plasma source. The maximum values of the measured currents were ~ 0.5 A at 0.4 T and ~ 5 A at 0.8 T, in the center of the plasma column.



I_d = 80A 100A 120A 140A

Fig. 3. 2D current distributions, at the target surface, obtained for a magnetic field of 0.4 T

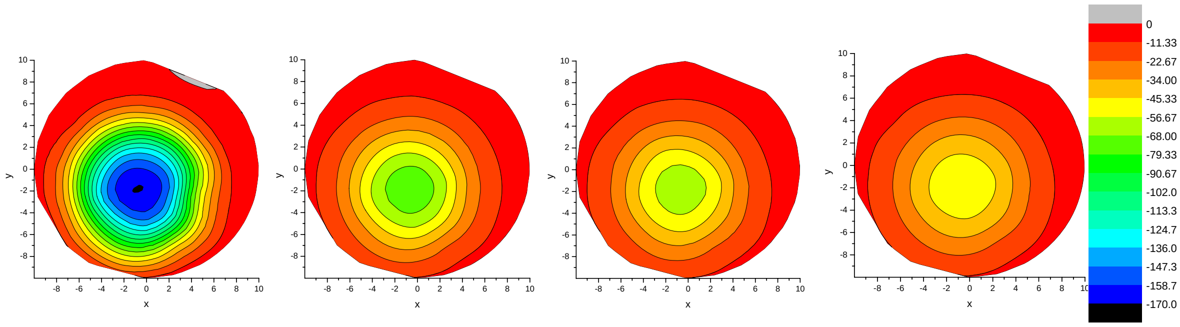


I_d = 80A 100A 120A 140A

Fig. 4. 2D current distributions, at the target surface, obtained for a magnetic field of 0.8 T

Measurements with floating collectors indicated that these currents were driven by strong potential gradients in the plasma column. The 2D floating potential distributions measured in a magnetic field strength of 0.8 T are plotted in figure 5. All distributions show a very good radial symmetry. The measured floating potential ranges between ~ 0 V at the side of the beam and -70 V at 0.4 T (not shown) up to -165 V at 0.8 T in the centre of the plasma column. The axis of the plasma column was not precisely enough aligned with the center of the analyzer, but the plasma column seems to maintain its position independently of the discharge current.

An increase of the total discharge current was observed to decrease the floating potential at the target. The magnetic field dependence is explained by a decreasing cross field conductivity.



I_d = 80A 100A 120A 140A

Fig. 5. 2D floating potential distributions obtained for a magnetic field of 0.8 T

Conclusions

Experimental investigations on the 2D distributions of the plasma current reaching the grounded target and the floating potential at the target surface have been reported for the plasma column of Pilot-PSI device. The measurements were performed by a multi-channel analyzer placed in the centre of target. Floating potential distribution has a good radial symmetry while current distribution presents angular inhomogeneity at higher radii. The density of the electric current received by the grounded collectors increased strongly with the magnetic field strength (from ~ 64 A/cm^2 at 0.4 T to ~ 575 A/cm^2 at 0.8 T in the center of the plasma column). An increase of the total discharge current was observed to decrease the floating potential at the target.

Acknowledgements

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