Seminar

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Institute for Plasma Research

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Title: Development of a New Filament-Based Pre-Ionization System and Analysis of Observed Hα Emission Peaks in Aditya-U Tokamak

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Venue: Committee 3, IPR

Abstract

Filament pre-ionization is a method used in tokamaks to increase the initial electron density to facilitate the gas-breakdown for the main plasma operation. The success of the breakdown depends on several key conditions: the electric field-to-pressure (E/p) ratio, a suitable toroidal electric field, a sufficient presence of neutral particles, and an adequate number of available free electrons. For increasing the number of free electrons, a simple hot filament is used to create the initial electron density. The filament is placed outside the limiter radius so as it will not interact with the main plasma. However, in presence of magnetic field in tokamak, the filament-produced electrons do not penetrate far inside the vessel, hence limiting their participation in the breakdown process occurring in the interior of the vessel. Furthermore, as these filament-produced electrons remains near the vessel wall, probability of their loss to the vessel wall remains high. To obtain higher density of free electrons in the interior of the vacuum vessel, a new design of filament system is proposed. In this system, an electric field is produced in a suitable direction near the filament location, which gives an E x B drift to the electrons utilizing the toroidal magnetic field of the tokamak. This additional electric field in a suitable direction guides the thermionically emitted electrons toward the vessel center through E×B drift. The electric field is produced using specially designed electrodes placed near the filament. The dimension and shape of the electrodes are optimized to obtain enhance the pre-ionization performance through COMSOL simulations of electric field.

Along with this designing work, the Hα emission peaks that are observed during the ramp-up phase of ADITYA-U discharges are analyzed for understanding their origin. These peaks, during the plasma current-ramp phase, are typically observed when the current ramp-up rate slows down, particularly during the plasma column's outward movement and occur at frequencies around 0.5 to 1 kHz. Further investigation reveals that the edge density also shows simultaneous peaks. These indicate that the observed Hα emission peaks may be generated by either periodic increase in electron density or periodic increase of neutral concentration due to plasma's outward movement. The periodic increase in electron density may be due to some instabilities, such as ionization instability. These instabilities, combined with charge-exchange processes involving neutral atoms from the wall may be generating the Hα emission peaks. Further investigation is ongoing to pinpoint the cause.

Apart from the above a computer routine has been developed to identify probe positions (r, θ, φ) and provides a graphical overview with corresponding active channel numbers for specific plasma shots for data mining in ADIYTA-U. Additionally, a separate GUI has been created for recording and standardizing data entry, and further modifications are ongoing.