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Overview of SST-1 Up-gradation & Recent Experiments in SST-1 & Overview of Recent Experimental Results from Aditya Tokamak

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A. Steady State Superconducting Tokamak (SST-1) is a 'operational' experimental superconducting device since late 2013. Since last IAEA-FEC; SST-1 has been upgraded with Plasma Facing Components being installed and integrated in the vacuum vessel and is getting prepared towards long pulse operations in both circular and elongated configurations. The PFC integration has been completed in August 2015 and initial experiments have begun in SST-1 with circular plasma configurations. SST-1 offers a unique possibility of investigating long pulse discharges with large aspect ratio (> 5.5) compared to contemporary devices. Presently, SST-1 standard ohmic discharges are in excess of 100 KA with typical core density $\sim 2 \times 10^{19} \text{ m}^{-3}$ and core electron temperatures $\sim 500 \text{ eV}$ having duration in excess of 300 ms. A 42 GHz ECR pre-ionization source at $\sim 150 \text{ KW}$ in 1.5 T central field breaks down the gas, the current starts up at $\sim 1.3 \text{ MA/s}$ in 60-80 ms in an induced field of $\sim 0.3 \text{ V/m}$. These standard discharges demonstrate copious saw teething and MHD activities as the pulse progresses including NTM, mode locking and MHD characteristics. PFC equipped SST-1 has completed these basic experimental studies confirmed with simulations. These includes eddy currents influencing the NULL dynamics, field errors, equilibrium index evolutions, wall influencing plasma characteristics, plasma positions, plasma rotational and Tearing Mode characteristics including the island width and island growths etc. Presently, SST-1 is attempting at multi second long high aspect ratio plasma discharges by coupling the Lower Hybrid with the Ohmic plasma as well as with robust real time position and density controls.

SST-1 device has been upgraded with a pair of internal coil aimed at effective fast plasma control and a pair of segmented coil aimed at controlling some of the rotational aspects of plasma including the RMPs and ELMs. Supersonic Molecular Beam Injection (SMBI) from both high field and low field sides and Pellets Injection Systems have also been added with several edge plasma diagnostics aimed at both density control and edge plasma turbulence studies. The up-gradation details including the planned ones, salient early plasma characteristics in large aspect ratio PFC equipped SST-1 plasma and future experimental plans towards long pulse operations in SST-1 will be elaborated in this paper.

B. Several experiments, related to controlled thermonuclear fusion research and highly relevant for large size tokamaks including ITER, have been carried out in ADITYA, an ohmically heated circular limiter tokamak. Repeatable plasma discharges of maximum plasma current of $\sim 160 \text{ kA}$ and discharge duration beyond $\sim 250 \text{ ms}$ with plasma current flattop duration of $\sim 140 \text{ ms}$ has been obtained for the first time in ADITYA. The discharge reproducibility has been improved considerably with Lithium wall conditioning and improved plasma discharges are obtained by precisely controlling the plasma position. In these discharges, chord-averaged electron density $\sim 3.0 - 4.0 \times 10^{19} \text{ m}^{-3}$ using multiple hydrogen gas puffs, electron temperature of the order of $\sim 500 - 700 \text{ eV}$ have been achieved.

Novel experiments related to disruption control are carried out and disruptions, induced by hydrogen gas puffing are successfully mitigated using biased electrode and ICR pulse techniques. Runaway electrons are successfully mitigated by applying a short local vertical field (LVF) pulse. A thorough disruption database has been generated by identifying the different categories of disruption. Detailed analysis of several hundred disrupted discharges showed that the current quench time is inversely proportional to q_{edge} . Formation of current filaments are observed during most of the disruptions, which helps in identifying the cause of disruption. Apart from this, for volt-sec recovery during the plasma formation phase, low loop voltage start-up and current ramp-up experiments have been carried out using ECRH and ICRH. Successful recovery of

volt-sec leads to achievement of longer plasma discharge durations. In order to achieve better coupling of lower hybrid waves to the plasma, multiple gas puffs are injected prior to the launch of lower hybrid waves. The experiments showed considerable reduction in the reflection co-efficient indicating better absorption of LH waves in plasma. In addition to that Neon gas puff assisted radiative improved confinement mode has also been achieved in ADITYA. Further, the electrode biasing experiments have shown that during transition to better confinement mode, the Drift-Alfven fluctuations are suppressed and the current profile gets modified near the edge plasma region. In this paper, all the above mentioned experiments will be discussed.

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