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EX/P2-10:Non-inductive Plasma Start-up in NSTX Using Transient CHI

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Transient Coaxial Helicity Injection (CHI) in the National Spherical Torus Experiment (NSTX) has generated toroidal current on closed flux surfaces without the use of the central solenoid. When induction from the solenoid was added, CHI initiated discharges in NSTX achieved 1 MA of plasma current using 65% of the solenoid flux of standard induction-only discharges. In addition, they have lower density, which is difficult to achieve by other means in NSTX, and a low normalized internal plasma inductance of 0.35, which is consistent with broad current profiles expected for high performance NSTX-U discharges. The Tokamak Simulation Code (TSC) has now been used to understand the scaling of CHI generated toroidal current with variations in the external toroidal field and injector flux. These simulations show favorable scaling of the CHI start-up process with increasing machine size. Tokamaks and spherical tokamaks have generally relied on a central solenoid to generate the initial plasma current. The inclusion of a central solenoid in a steady-state tokamak to provide plasma startup limits the minimum aspect ratio and increases the device complexity. For reactors based on the ST concept, elimination of the central solenoid is essential, making alternate methods for plasma start-up necessary. CHI is implemented in NSTX by driving current from an external source along field lines that connect the inner and outer lower divertor plates. The NSTX is now undergoing a major upgrade (NSTX-U) to increase the capabilities of its toroidal and poloidal field coils and to add a second neutral beam line. Analysis of the NSTX results shows that the amount of closed-flux current generated by CHI is closely related to the initially applied injector flux. On NSTX-U the available injector flux is about 340 mWb, considerably exceeding the 80 mWb in NSTX. Simulations with the TSC projects that it should be possible to generate 500 kA of closed-flux current with CHI in NSTX-U. At this current, the second more tangentially injecting neutral beam should be capable of providing sufficient current drive to ramp-up the plasma current. The results from TSC simulations show that CHI could be an important tool for non-inductive start-up in next-step STs. This work was supported by U.S. DOE contracts DE-FG02-99ER54519 and DE-AC02-09CH11466.

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