Fueling experiments with supersonic gas jet in NSTX

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Options for fueling future reactor-type tokamaks, such as ITER, include frozen fuel pellets or compact toroids for central and edge fueling, and conventional gas puffing for the initial plasma density build-up and edge density sustainment. A possible improvement to the gas puffing technique - a supersonic gas (SG) jet fueling - is studied in the National Spherical Torus Experiment (NSTX). The NSTX SG injector is comprised of a graphite converging-diverging Laval nozzle, a piezoelectric gas valve, and a diagnostic package (Langmuir probe, thermocouples and magnetic pick-up coils) mounted on a movable probe at a low field side (LFS) midplane port location. The nozzle operates in a pulsed regime at room temperature, reservoir gas pressure up to 0.33 MPa, Mach number of about 4, and a deuterium jet divergence half-angle of 5° - 40°. A high gas jet Mach number is an indicator of its directionality, high density and divergence. The SG jet has been used for fueling of both L- and H-mode plasmas. The injector was located at a distance 2-15 cm from the plasma separatrix in ohmically heated discharges, and 10-15 cm in 2-4 MW NBI-heated discharges to avoid interaction with lost orbit energetic particles. The fueling efficiency in the range 0.1 - 0.3 was inferred from the plasma electron inventory analysis. It was sensitive to the edge plasma pressure and edge intrinsic plasma perturbations, such as MHD modes and small ELMs. The fueling efficiency appeared to be a function of the SG jet pressure. In contrast to a conventional LFS gas injection, steady-state SG injection in the H-mode phase at a rate up to 4.5 x 10^{21} particles/s did not cause an H to L transition. The density pedestal height increased by up to 20 %, while lower divertor and midplane neutral pressures were obtained. The SG jet fueling is part of the NSTX density control program which also includes wall conditioning tools, in particular, the evaporated lithium coatings planned for the upcoming experimental campaign. This work is supported by U.S. DOE in part under Contracts No. W-7405-Eng-48 and DE-AC02-76CH03073.