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SUPERSONIC GAS INJECTOR FOR PLASMA FUELING

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Gas puffing is a common technique used for plasma density initiation, sustainment and diagnostic gas injection in present day high temperature plasma devices. A supersonic gas injector (SGI) has been developed for fueling and diagnostic applications on the National Spherical Torus Experiment (NSTX) following a successful demonstration of the enhanced fueling efficiency and reduced gas-wall interaction with the SGI on the HL-1M tokamak [1] and other facilities. The SGI design and operation principle are based on diverse physics fields including gas-dynamics, compressible fluid mechanics, neutral gas transport, and magnetized plasma physics. A high density expansively cooled gas jet penetrates through the plasma scrape-off layer perpendicular to the magnetic field, ionizes in the separatrix region and creates a localized plasma region of high pressure. This plasmoid region expands along field lines, cooling and locally fueling the edge plasma. The NSTX SGI is comprised of a nozzle, a modified commercial piezoelectric gas valve, and a diagnostic package mounted on a movable probe at a low field side midplane port location. The diagnostic package consists of a Langmuir probe, thermocouples and pick-up coils for measuring toroidal, radial and vertical magnetic field components at the location of the SGI tip. Supersonic gas jet profiles and SGI parameters have been measured in a laboratory facility, and in-situ in NSTX experiments. The converging-diverging Laval nozzle yields a gas flow rate of up to 4×10^{21} particles/s, comparable to the conventional gas injectors. The nozzle operates in a pulsed regime at room temperature, gas pressure up to 0.27 MPa, Mach number of about 4, and deuterium jet divergence half-angle of 5° - 25°. The focus of NSTX experiments is to study SGI fueling characteristics, compatibility of the pulsed supersonic gas jet fueling with an H-mode pedestal, edge localized mode stability, and high harmonic fast wave (HHFW) heating scenarios in high power density long pulse plasma regimes. Laboratory work is aimed at optimization of gas jet fueling parameters by using axisymmetric nozzles of different shapes and operating regimes. This work is supported by U.S. DOE under Contracts No. W-7405-Eng-48 and DE-AC02-76CH03073.

[1] L. Yao, et. al., *Nuclear Fusion* 44, 420, 2004.