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Development of a fast-opening repetitive magnetic valve for gas injection in spherical tokamaks

Experiments have been performed on the MAST spherical tokamak that the gas puffing in the high-field side (HFS) will improve the plasma confinement. Considering the limited space and short discharge duration of SUNIST spherical tokamak, a fast and compact valve is necessary for gas injection. A new fast magnetic valve has been developed for the gas injection research on SUNIST. The open state of the valve is shorter than 1ms by the IGBT switching device used in the power supply. Besides, the valve is capable of repetitive operation during one shot of plasma discharge at the frequency of over 100 Hz. The piston made of aluminum in the valve is activated by eddy currents, and the diameter and height of which are 70 mm and 30 mm respectively, so the valve can be reliably operated on the high field side for inboard gas puffing. The flow speed of the gas can be increased to 2000 m/s in the de Laval nozzle installed on the gas outlet and the gas outflow become supersonic molecular beam injection (SMBI). The throughput which is 0.1 Pa m^3 typically for hydrogen, is adjustable by changing the pressure in the back chamber, the pulse length, and the voltage of capacitors. The fast valve has been installed and operates successfully in SUNIST. In comparison with gas puffing in the low-field side, experiments have shown that the fueling efficiency is higher in the HFS. And the SMBI can increase the electron density more rapidly than the usual gas puffing method. The influences of fast valve gas injection on the MHD activities and runaway current are also observed in the experiments.

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