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Ultrafast actuator development for shattered pellet injectors - fast, high pressure valve and ITER DMS Shutter

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The ITER Disruption Mitigation System (DMS) is based on Shattered Pellet Injectors (SPI), which accelerates a large protium, neon or mixture pellet with high pressure gas and shatters it prior to the entrance into the plasma, creating a plume of smaller pellet fragments. The ITER DMS Support Laboratory is part of the ITER DMS Task Force programme to establish the physics and technology basis for the ITER DMS. The laboratory is located at the HUN-REN Centre for Energy Research (HUN-REN CER), Budapest Hungary.
A key component of an SPI system is a fast, high-pressure gas valve which can release propellant gas with about 10 m3/s volumetric flow rate, within a few milliseconds after the arrival of the control signal. This necessitates the opening of a gas reservoir of approximately 1 litre volume, filled with gas up to 15 MPa pressure, which requires an ultrafast actuator capable of releasing ~20 kN force within a millisecond after the trigger. A fast gas valve, using eddy current principle has been developed fulfilling these requirements.
The propellant gas released by the fast valve can overtake the pellet, triggering an early disruption and deteriorating the disruption mitigation efficiency. A suppressor chamber is foreseen to be utilised in which most of the propellant gas can be retarded for some time, however, a certain fraction of the gas will still arrive at the shatter device exit ahead of the fragments.
An optional fast shutter is considered after the suppressor to block the path of the propellent gas when the pellet has passed. The piston of the valve must be accelerated to tens of meters per second to close the 40 mm orifice in a few milliseconds and decelerated after the closure to avoid high velocity impact at the end position. The device must survive several thousands of cycles because maintenance access will be limited. The setup needs to be compact due to space restrictions, to operate in 400 mT external field, to withstand a high neutron dose rate and be tritium compatible as it is a part of the ITER main vacuum system.
This contribution describes the development and the laboratory testing of the ITER DMS Support Laboratory fast gas valve and the ITER DMS Fast Shutter from the physics design, through the electromechanical prototyping and the model validation, including the final mechanical design and the laboratory test results.

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