COMPARISON OF DIFFERENT PELLET INJECTION SYSTEMS FOR ELM PACING

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ELM control in ITER is important to avoid the rapid erosion of plasma facing components (PFC) and core plasma pollution. Pacing and mitigation of ELMs can be achieved by injection of cryogenic deuterium pellets into the plasma. Successful control relies on precisely timed reliable delivery of pellets with reasonable size and velocity. To minimize unwanted fuelling constraints high speed and small pellet size seems of advantage. Efforts to develop pellet launcher systems optimised for pacing purposes have been undertaken, basing on both major accelerator types, the centrifuge and the gas or blower gun.

Experimental results:

The high frequency (up to 143 Hz) blower gun developed at ASDEX Upgrade [1] was modified reducing the pellet size drastically (cylindrical shape with Ø = l = 2.0 mm to 1.0mm). It was found the initial high reliability (> 0.9) dropped significantly to about 0.25 due to pellet fragmentation during acceleration and transfer. Observed mass deviation is most probably due to heat transfer from the propellant gas to cryogenic pellet and friction induced abrasion. The velocity distribution showed two broad maxima correlated to the two acceleration channels of the shuttle (moving tic-tac like and firing in turn). Using only a single channel decreases the velocity scatter but also halves the repetition rate. Using both channels requires a system with perfect thermal and geometrical balance to achieve a single maximum in the velocity distribution. In the experiments, so far a velocity scatter of ± 17 % was observed. Taking into account the low pellet speed of about 200 m/s and transfer tube length in the order of 20 m, pellet trains launched with frequencies of about 50 Hz arrive in the plasma with already significantly distorted timing. For ITER operating a pacing system e.g. at 55 Hz could result in a temporal pellet separation of 18 ± 16 ms. Reason for the scatter is the statistical nature of gas drag acceleration being a force closure principle (non-positive locking) which is accompanied by some slip. Using a centrifuge with stop cylinder at ASDEX Upgrade and JET show much better accuracy concerning velocity scatter and efficiency [2]. The centrifuge accelerates pellets due to form closure (positive locking) very precisely, there is no slip on principle and velocity scatter below 0.3% is achieved [3]. Contrary to the gas gun, the cryogenic system is not part of the acceleration system enabling changes in pellet size and species by using different pellet sources. This disconnection as well suppresses heat transfer to cryogenic pellet. As a consequence, ASDEX Upgrade now aims to adapt the centrifuge launcher for pacing requirements. Following also the improved set up of JET centrifuge system, operation beyond already achieved repetition rates (83 Hz) is envisaged. Projected aims and status of this project will be presented as well.

Conclusions:

The paper will report on results from the ASDEX Upgrade blower gun system using large and small pellets, indicating resulting problems in the pacing regime. A dedicated comparison to a centrifuge system not yet fully optimized for pacing purposes will be demonstrated. Considerations will be presented comparing potential and limitations of both principles with respect to ELM control, indicating the centrifuge has major advantages.

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