Contribution ID: **41** Type: **Contributed Oral**

Pellet production and shattering studies in the ITER DMS support laboratory

Friday, 22 July 2022 09:50 (25 minutes)

The ITER disruption mitigation support laboratory is part of the ITER Disruption Mitigation System (DMS) Task Force programme to establish the physics and technology basis for the ITER DMS. The laboratory is located at the Centre for Energy Research, Budapest Hungary.
The aims include production, launching and shattering of 19x39 mm and 28.5x57 mm (d x L) H, D, Ne and mixture pellets, and diagnosing the fragment plumes resulting from shattering.

The pellets are desublimated in a stainless steel barrel cooled by liquid Helium evaporation to 5-12 Kelvin. The pellet production process can be monitored in detail by a camera looking along the barrel. The gas for the pellet is supplied through a precooler by a fully computer-controlled gas system capable of controlling the barrel pressure and/or gas feed rate using different algorithms. The finished pellets are launched by a propellant gas pulse injected by a specially built valve operating at up to 150 bar pressure and opening in 1.5 ms. After launch the pellet is diagnosed by two orthogonally viewing fast cameras. The propellant gas expands in a large vacuum volume and the pellet flies along a 60 mm diameter flight tube to about 4 m to the shattering head. This distance is identical to the injector-shattering head distance in the ITER SPI design. The shattering process is observed by a fast camera. The resulting fragments are diagnosed by a double laser curtain diagnostic. Each of them consists of a line laser illuminating a plane roughly perpendicular to the flight direction. To cameras view close to parallel to the flight direction and observe light scattered by the fragments. The two laser curtains operate at different wavelengths, therefore the cameras can operate in parallel and reveal the fragment size, velocity and flight direction information.

Up to now 19 mm diameter H, D, Ne and H-Ne mixture pellets were produced. At 5 K when the barrel pressure at the start of the pellet production process is raised to 50 mbar with a rate of about 10 mbar/min a thin dark layer (presumably snow-like) forms on the pellet-barrel interface. This enables launching of all pellet types, even Neon, with maximum 100 bar valve pressure, thus a punch mechanism is not needed to dislodge the pellet. The desublimation process for H and D pellets takes about 20-25 minutes, for Neon up to 45 minutes. These times agree well with results of a 2D pellet desublimation model.

It was found that all intact pellets reach the shattering head. The fragment clould was found to be highly asymmetric, about 3 times wider along the shattering plate then across it.

The results confirm that 19 mm H, D, and Ne pellets are suitable for the ITER SPI system. Experiments with the final 28.5 mm pellet diameter will start in June 2022.

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Session Classification: Mitigation Technology

Track Classification: Mitigation