Contribution ID: **383** Type: **Poster**

Shattered Pellet Injection Technology Design and Characterization for Disruption Mitigation Experiments

Tuesday 23 October 2018 08:30 (20 minutes)

The technology of forming high-Z cryogenic pellets mixed with D2 that are shattered upon injection into a plasma has been developed at ORNL for mitigating disruptions and has been selected as the basis for the baseline disruption mitigation system on ITER. In these shattered pellet injectors (SPIs), large pellets of neon and argon mixed with D2 are formed from gas and are shattered upon impact with a bent tube just before entering into disrupting plasmas in order to radiate the plasma energy to mitigate possible damage to in-vessel components [1].

In support of disruption mitigation research for ITER, SPI systems have been designed and fabricated for use on thermal mitigation and runaway electron dissipation experiments on DIII-D and JET. These systems have common features of 3 barrels of different size pellets that are formed in-situ and collimated into a single injection line. The shatter tubes are bent stainless steel tubes that are mounted inside the vacuum vessel of the tokamak. The large pellets are formed in-situ from the low pressure gas feed into the barrels that are cooled with liquid helium and held intact ready to fire until needed. Pressurized gas is also used to accelerate these pellets with gaps in the injection lines to remove as much of the gas as is practical to avoid influencing the plasma shutdown.

Solid pellets of argon in particular present a challenge to fire the pellet because of high shear stress, thus mechanical punches have been developed that can apply higher impact to release these pellets. Punches using high pressure gas and solenoid drivers have been developed. Tests of gas punches have revealed that argon can be released and achieve speeds up to 160 m/s for 8 mm size pellets. The slower pellet speeds achieved with a punch have been found to result in larger fragment sizes, which is appealing for deeper penetration in high performance plasmas. Higher speed pellets that are achieved with high pressure gas and high deuterium content in the same shatter tube result in finer particles and higher gas content in the resulting shatter material spray.

[1] N. Commaux, et al., Nucl. Fus. 50 (2010) 112001.
[2] L. R. Baylor, et al., Fus. Sci. Tech. 68 (2015) 211.

⊠ This work was supported by ORNL managed by UT-Battelle, LLC for the U.S. Department of Energy under Contract Nos. DE-AC05-00OR22725 and DE-FC02-04ER54698.

Country or International Organization

United States of America

Paper Number

FIP/P1-1

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Session Classification: P1 Posters

Track Classification: FIP - Fusion Engineering, Integration and Power Plant Design