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Shattered Pellet Injection as the Primary Disruption Mitigation Technique for ITER

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The shattered pellet injection (SPI) technique has demonstrated disruption thermal quench (TQ) and current quench (CQ) control that scale to meet ITER disruption mitigation requirements. This innovative technique was tested for the last few years on DIII-D and showed improved results when compared to massive gas injection (MGI) technique in comparable conditions. Major disruptions on large tokamaks such as ITER are expected to generate deleterious heat loads during the TQ, mechanical stress during the CQ and multi-MeV runaway electron (RE) beams. Thus the mitigation of these disruptions is critical to reliable operations of ITER. SPI showed significant improvements on DIII-D when compared to equivalent MGI in identical plasma targets. The particle delivery efficiency to the plasma characterizes the potential effect of SPI and MGI on RE formation since the RE formation by avalanche is expected to be mitigated if the electron density is high enough. The fraction of injected particles observed in the plasma was doubled for SPI and observed to be significantly faster. The fast delivery of radiative impurities by SPI is expected to reduce the peak heat load by radiating the thermal energy on the entire surface of the wall instead of being funneled by conduction to the divertor. SPI shutdowns yielded 20% lower divertor heat load than equivalent MGI shutdowns on DIII-D. The compatibility between TQ mitigation and acceptable CQ timescale was tested through a new technique using mixed D2/neon SPI on DIII-D. This technique enabled the demonstration that the mitigation of the TQ heat loads improves continuously for small neon contents on DIII-D and that acceptable TQ mitigation and CQ decay time on ITER may be compatible in a limited range of D2/neon fraction. Although early SPI injections could have an effect on RE avalanche during the CQ, the formation of RE beam may occur. Thus this technique was studied for the mitigation of existing RE beam on DIII-D. The SPI was compared to equivalent MGI. These results showed that both neon SPI and MGI dissipate part or all of the RE current. The effect of pure D2 SPI on RE was opposite to neon with a significant drop in the effective resistivity of the RE beam and background plasma electron density. This work was supported by the US DOE under DE-AC05-00OR22725, DEFC02-04ER54698, DE-FG02-07ER54917 and DE-AC52-07NA27344.

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