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Simulation of the Pre-Thermal Quench Stage of Disruptions at Massive Gas Injection and Projections for ITER

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During disruption mitigation by massive gas injection (MGI) the thermal energy is expected to be radiated with high efficiency in order to prevent excessive heat loads to first wall and divertor PFCs. The energy loss will take place in two phases: a) the so-called pre-thermal quench phase that lasts from the arrival of the first gas to the onset of increased transport due to MHD activity during b) the second phase the thermal quench (TQ). Quantification of the duration of the pre-TQ phase is essential for the design of the ITER disruption mitigation system (DMS). The DMS has to be designed such that the impurity amount accumulated during pre-TQ stage should be sufficient for re-radiation of more than 90% of heat flux at subsequent TQ phase of ITER disruption.

The modelling with the code ASTRA together with ZIMPUR impurity transport and radiation code allows the description of the cooling process at the plasma edge, including the penetration of impurities and the shrinking of the current channel. Newly developed model for the gas flow at the end of delivery tube of MGI system well reproduce experimentally measured evolution. The validation of the simulation approach on available experimental data has demonstrated its ability to produce quantitative estimations of the pre-TQ stage duration and of the accumulated in the plasma amounts of Ar and deuterium under MGI.

The comparison of the simulation results with experiment will allow the identification of how the pre-TQ duration scales with plasma minor and major radius, plasma current, thermal energy, plasma density and temperature profiles on which an extrapolation to ITER can be based. Simulation results of the pre-TQ stage in reference ITER scenarios are presented. The ability of the ITER MGI systems to provide injection of necessary impurity amount during pre-TQ stage are discussed.

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