ENERGY BALANCE, RADIATION AND STABILITY DURING RAPID PLASMA TERMINATION VIA IMPURITY PELLET INJECTIONS ON DIII–D*

D.G. Whyte,[a] T.E. Evans, A.G. Kellman, D.A. Humphreys, A.W. Hyatt, T.C. Jernigan,[b]
R.L. Lee, S.L. Luckhardt,[a] P.B. Parks, M.J. Schaffer, and P.L.Taylor
General Atomics, P.O. Box 85608, San Diego, CA 92138-9784

Injections of impurity "killer" pellets on DIII–D have demonstrated partial mitigation of undesirable disruption phenomena; namely reducing the convected heat loss to the wall, and the halo current's magnitude and toroidal asymmetry. However, the appearance of a runaway electron population and large magnetic fluctuations ($\tilde{B}/B_T \leq 1\%$) is coincident with the measured rapid loss of the plasma's thermal energy (≥1 MJ in 1 ms) due to impurity radiation. A time dependent numerical code, with flux surface averaged non-coronal radiation, energy balance, and ionization state balance, has been developed to model the plasma's response to large amounts of impurities deposited by the pellets. The code has been successfully benchmarked against numerous experimental measurements, including impurity line radiation, electron density and temperature from Thomson scattering, and the stored energy losses from magnetic reconstruction. It is shown from these calculations and experimental data that plasma instabilities during the pellet ablation may play a key role in determining both the effectiveness of the radiative thermal quench and the production of runaway electrons. Radial pressure gradients, caused by the rapid non-adiabatic cooling of the impurity, are identified as the probable source of these instabilities. These instabilities can lead to increased convective heat losses, and possibly the production of runaway electrons by transport of hot electrons into the thermally collapsed plasma, which contains an enhanced parallel electric field. Modeling indicates that non-Maxwellian effects in the cooling of the original energetic plasma electrons, due to their weaker collisional coupling, may also produce a tail population of electrons which runaway. The implication of these insights on designing safer disruption mitigation via impurity pellets is discussed. Results of a modeling effort to optimize pellet content and impurity species for the avoidance of instabilities and runaway electrons will also be shown.

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[a]University of California, San Diego, California.
[b]Oak Ridge National Laboratory, Oak Ridge, Tennessee.