# Modeling penetration and plasma response of a dense neutral gas jet in a post-thermal quenched plasma

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**Abstract**. This paper is about the dynamics of gas jet injection and propagation into the cold, current quench discharge following the thermal quench (TQ) phase of a disruption event. Understanding the processes involved in the interpenetration between a dense, fast-moving supersonic gas jet and a magnetized plasma is fundamental to the solution of the disruption mitigation problem using massive gas injection. An analytical model was developed that provides the penetration depth of the jet in the CQ discharge. The model developed incorporates the injector, the vacuum space between injector and plasma, and the low beta current quench plasma through which the jet penetrates. The radially moving gas stagnates at some point inside the plasma by formation of a "bottle shock", resulting in a certain penetration depth. Consistent with experimental findings, it is shown that high fueling efficiency $> 70\%$ and good penetration beyond the $q = 2$ surface is possible in such plasma discharges, but in normal (unquenched) plasma discharges penetration of dense gas jets will be quite poor. The paper also sheds light on how the external plasma responds to allow interpenetration of perfectly insulating gas jet through a strong magnetic field $B^2/2\mu_0 >> \rho u^2$. The paper also develops semi-analytical models for the response of the cold, high-current, collision-dominated plasma to the insertion of a dense neutral jet: the propagation of cooling waves out along the magnetic field lines, the heated and ionized surface layer which also expands outward along the magnetic field lines, and the electrical breakdown of the neutral gas within the jet volume. Although good penetration in the ITER post-TQ discharge can be achieved, the plasma resistivity is only marginally enhanced. This may render repetitive gas inject ineffective, as the concept requires a sizable resistivity enhancement to initiate a current profile contraction, and resulting kink-tearing activity to suppress runaway avalanching.

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