Contribution ID: **82** Type: **Contributed Oral**

RESISTIVE WALL TEARING MODE MAJOR DISRUPTIONS WITH FEEDBACK

Tuesday 3 September 2024 12:05 (25 minutes)

Resistive wall tearing modes (RWTM) are closely related to resistive wall modes (RWMs). RWTMs are tearing modes whose linear and nonlinear growth rate depend on the resistive wall penetration time.
The consequence for ITER, with wall penetration time of $250ms$, compared to $\sim 5ms$ in JET and DIII-D, is that the thermal quench
timescale could be much longer than previously conjectured.
Active feedback is another possible way to mitigate or prevent RWTM disruptions.
Simulations indicate that feedback can make the resistive wall behave effectively as an
ideal wall, preventing major disruptions.

Linear MHD simulations and theory [1,2] show that the RWTM growth time
is asymptotically proportional to
the wall penetration time, like a RWM. The $q = 2$ mode rational surface must be sufficiently close to the wall for a RWTM disruption to occur. This agrees quantitatively with a DIII-D locked mode disruption database [3],
in which disruptions require the $q = 2$ rational surface radius to exceed 0.75 of the plasma minor radius.
A nonlinear MHD simulation of a DIII-D locked mode equilibrium reconstruction shows a complete thermal quench in a time which agrees with experiment.
The Madison Symmetric Tokamak (MST) has a longer resistive wall time $(800ms)$ than ITER, and disruptions are not observed experimentally
when MST is operated as a standard tokamak. Simulations indicate that
the RWTM disruption time scale is longer than the experimental shot time.

A sequence of low edge current model equilibria [4,5] was produced from MST equilibrium reconstructions, with higher edge q and with wall distance 1.2 times the wall radius, similar to DIII-D. Nonlinear simulations showed that only minor disruptions occur with an ideal wall.
Major disruptions occur only for a resistive wall, and with
edge $q \leq 3.4$. This requires that the $q = 2$ minor radius is greater than 0.77 of the plasma radius,
as in the DIII-D database [3].
Simulations with resistive wall and feedback [5] are similar to an ideal wall. An ideal wall or resistive wall with feedback,
restricts the modes to moderate amplitude, producing only a minor disruption. With the same initial equilibrium and no feedback
the mode amplitude is large, causing a major disruption.
The feedback simulations are consistent with the findings of an
experiment in RFX - mod [6], in which feedback was applied to stabilize
equilibria with edge $q > 2$.

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Session Classification: Prediction & Avoidance

Track Classification: Prediction and Avoidance