An Analytical Model for Resistive Wall Modes Stabilization

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The importance of the resistive wall modes (RWMs) reside from the fact that in advanced tokamaks the RWMs have been predicted to limit the maximum plasma performance (in terms of the plasma normalized beta) to less than half the performance achievable with a perfectly conducting wall.

In order to understand the physics of resistive wall mode stability, the Fitzpatrick model [1] has been considered and generalised: a large aspect-ratio, low beta, circular cross-section tokamak plasma surrounded by a thin, nonuniform resistive shell (gaps) and with feedback and detector coils placed around the tokamak plasma. A rotation of a thin inertial layer (governed by non-ideal magnetohydrodynamics) at the surface of the plasma [1] has been considered as a stabilizing mechanism of the RWMs by means of dissipation via viscosity and by decoupling the RWMs from the eddy-currents induced in the passive shell. For the moment, dissipation via anomalous viscosity has been treated only – the Landau damping mechanism will be considered in a further step. We sought to find the necessary rotation which, combined with an appropriate distance passive shell - plasma surface, can decouple the kink modes from the eddy currents in the shell, leading to the stabilization of the RWMs. Another important destabilizing factor of the RWMs we have investigated was the coupling between a RWM and its sideband or adjacent modes. The inhomogeneity of the passive shell and the presence of the discrete active feedback system are coupling the plasma modes in such a way that the RWM becomes more unstable.

We have found that with the detector coil placed below the passive shell the stabilization of the RWM is improved, but the neighboring plasma modes begin to increase their growth rates. Another result we have obtained was that the angular extent of the feedback coils is important in order to stabilize the RWM, in the sense that the extent of the coil must equal the half-integer multiple of the wavelength of the plasma mode for the case when feedback coils are located symmetrically. Our results showed also that the coupling between RWM and adjacent plasma modes is smaller when the above condition is fulfilled.

A destabilizing effect by approaching the radius of the resistive shell to the critical Newcomb radius and especially to the critical Newcomb radius with no rotation of the edge plasma has been found. If the radius of the shell is placed above the critical Newcomb radius with no rotation of the plasma edge, the mode cannot be stabilized, its frequency preserving the value of the rotation of the plasma edge itself. The stabilizing effect of placing the sensor coil of the active feedback system as near as possible to the passive shell surrounding the plasma has been also investigated.

References

[1] R. Fitzpatrick, and A.Y. Aydemir, Nucl. Fusion, **11**, 36 (1996).