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Auxiliary Heating and High β_p Equilibria in Strongly Shaped Tokamak Plasmas

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Auxiliary heating such as neutral beam injection (NBI) and radiofrequency heating (rf) in the early phase of plasma formation can save valuable volt-seconds in the ohmic transformer by lowering plasma resistivity and increasing bootstrap current. For low aspect ratio tokamaks, these early phase heating techniques will be particularly useful in the start-up and current ramp-up operations. However, the amount of heating which can be applied during the start-up phase is constrained by the β_p-equilibrium limit.[1,2] Previous theoretical studies have shown that $\varepsilon\beta_p < 1$ for circular cross-section plasmas in the limit of small inverse aspect ratio ε, and analytic model calculations have indicated that the upper bound could be increased with elongation. On the other hand, for strongly shaped plasmas at finite aspect ratio that upper bound has not been determined. In this work, we use the equilibrium code TOQ to construct a class of high β_p equilibria and examine the β_p limit. These equilibria are specified by a typical experimental L–mode pressure profile and a current density which is essentially constant when expressed in terms of the normalized poloidal flux. In the high β_p regime, these numerical equilibria possess many features similar to those of Cowley *et al.* high β equilibria.[3] In the full-size DIII–D configuration (aspect ratio of $A \approx 2.8$ and elongation of $\kappa \approx 2$), we have found that theoretical equilibria with $\varepsilon\beta_p \approx 3$ exist, which is about 50% higher than the experimental record value of β_p observed in DIII–D.[4] The β_p limit of this class of equilibria as a function of shape parameters and aspect ratio will be presented. The possibility of experimental realization of these high β_p equilibria will also be discussed.

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