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Development of a Systematic, Self-consistent Algorithm for K-DEMO Steady-state Operation Scenario

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A systematic, self-consistent process to find the K-DEMO operation scenario has been investigated. Recent progress on K-DEMO scenario study explored zero-dimensional operation regime and one-dimensional current density configurations with fixed safety factor profile [1]. However, previous researches do not contain confinement optimization process for stable equilibria. In this study, an optimum plasma kinetic profile determination process is addressed simultaneously self-consistently with equilibrium, stability, confinement, and heating/current drive scheme. To consider profile effect carefully, the inverse approach analyzes demo plasma performance starting from target plasma profile. Pressure profile with pedestal structure are investigated by changing its height, slope, and flatness. Parallel current density profiles are composed of bootstrap current and centrally peaked external contribution. Formation of stable equilibria is evaluated by solving Grad-Shafranov equation and checking linear core MHD stability. For the case of stable equilibrium profiles, necessary external heating distribution is calculated from power balance equation considering the conduction energy loss, alpha particle heating, and radiation loss. The external current drive profile is obtained by subtracting the bootstrap current profile from the total current profile. The highest Q value plasma equilibrium is chosen to reference target. Relevant heating configuration matching both required external heating and current drive distribution is parametrically scanned by varying heating/current drive control knobs. As a final step, electron/ion temperature and poloidal flux evolution are solved with the derived heating configuration to find its time derivative zero solution and achieve self-consistent plasma kinetic profiles. An economic K-DEMO steady-state target operation scenario would finally be presented through the designed algorithm considering self-consistency with equilibrium, stability, confinement, and heating/current drive.

[1] J. S. Kang et al, Fusion Eng. Des. (2016),
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