Extrapolation of physics performance needed for a compact tokamak DEMO reactor

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System parameters and an optimal radial build and of a tokamak DEMO reactor with an aspect ratio, A = 2.5 - 4.0 were found by utilizing a simulation method which couples a conventional tokamak plasma analysis and a neutron transport analysis. Plasma physics and tokamak engineering constraints, which were extrapolated from the ITER model were self-consistently incorporated, together with neutron impacts on shielding and tritium breeding capability. For the given A and fusion power, the desired plasma performance (β_N, q_e, n_e/n_G, ripple etc.) determine the dependence of the major radius, R_0 on B_T, and locations of the inboard and outboard toroidal field (TF) coil. The minimum R_0 decreased as β_N and n_e/n_G increased. However, they increased as q_e increased. P_{aux} decreased as β_N and q_e, increased, but it decreased as n_e/n_G increased.

The neutronic requirements on shielding, tritium breeding and magnetic field at the TF coil determine the minimum R_0. As the aspect ratio increased, the contribution to tritium breeding from the inboard blanket increased and the minimum R_0 and the system size increased as the inboard blanket thickness increased to meet the requirements for tritium self-sufficiency. The TF coil bore radius also increased to meet the requirements for the magnetic flux density at the TF coil and thus the space for a central solenoid to provide volt-second for a plasma current ramp-up increased.