§55. Modular Heliotron Reactor (MHR) Ignition Design

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A new helical system ("Modular Heliotron") with modular coils compatible with efficient closed helical divertor is proposed[1]. The physics[2] and engineering[3] optimization of this system has been carried out, and the effectiveness of this new coil concept is clarified.

Ignition conditions of D-T burning plasmas in LHD-type Helical Reactors are studied using zero-dimensional power balance equations with profile corrections based on several empirical confinement scalings (LHD, gyro-reduced Bohm or Lackner-Gottardi scalings) and neo-classical ripple loss model (combined model of $1/\nu$, $\nu^{1/2}$ and ν regime). The magnetic configuration and coil-divertor clearance are evaluated by using systematic scalings[4]. This analysis is applicable to the Modular Heliotron Reactor (MHR). The system studies including helical coil design are also carried out to fit the ignition plasma condition using these simplified scalings. Figure 1 shows the popcon plot for MHR with major radius of 16.5m, magnetic field strength of 5T. In this case auxiliary heating power of 80 MW leads to ignition of MHR.

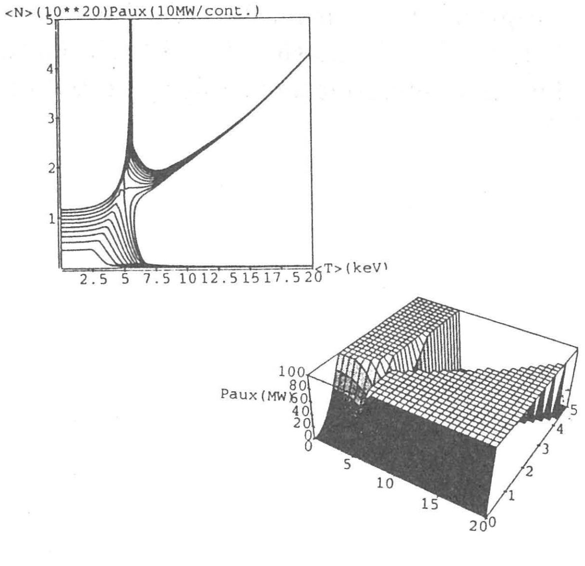

Fig. 6 POPCON plot for MHR standard design

The reference magnetic configuration adopted here is based on LHD physics concept with closed helical divertor. The maximum magnetic field (B_{max}<16T) with coil current density (~30A/mm^2) is allowed for Nb_3Sn superconducting coil systems. Neutron wall loading (L_n<3MW/m^2), the coil-divertor clearance (Δ_{dc}>1m) for blanket space, and the coil stress limit (σ_{coil} < 250MPa) should be required. The conditions of total fusion thermal power (P_{fusion} >1GW) and coil magnetic energy (W_{mag} < 500GJ) should be within the criteria. The confinement enhancement factor of 2 and density limit factor of 2 (during startup phase only) are assumed in LHD scaling . To reduce neoclassical ripple loss, the averaged effective helical ripple should be less than 5 % which is attainable in MHR by means of inward shift of the plasma column and the coil pitch modulation to the so-called transport-optimized stellarator. Among these criteria we found a design window for MHR as shown in Fig.2.

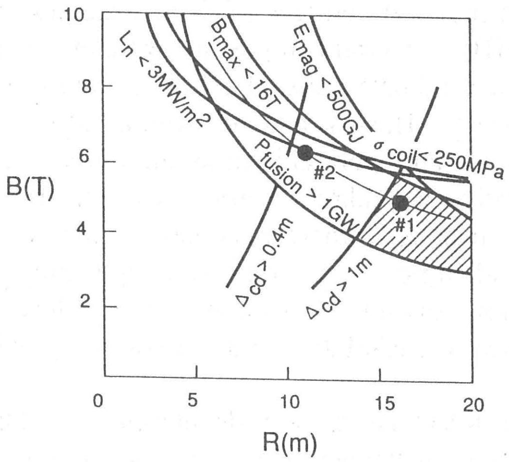

Fig.7 Design window for MHR

References

1) K.Yamazaki, J. Plasma & Fusion Research, 70 (1993) 281.
2) K.Yamazaki and K.Y.Watanabe, Research Report NIFS-279 (1994) (to be published in Nuclear Fusion)
3) K.Yamazaki et al., Transactions of Fusion Technology 27 (1995) 260.
4) K.Yamazaki et al., Fusion Technol.,21 (1992)147-160.