§5. Design Windows Analysis based on a Cost Model of Helical Reactor (HeliCos)

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The LHD type helical reactors are characterized by a large major radius but slender helical coil, which give us different approaches for power plants from tokamak reactors. For searching design windows of helical reactors and discussing their potential as power plants, we have developed a mass-cost estimating model linked with system design code (HeliCos), thorough studying the relationships between major plasma parameters and reactor parameters, and weight of major components.

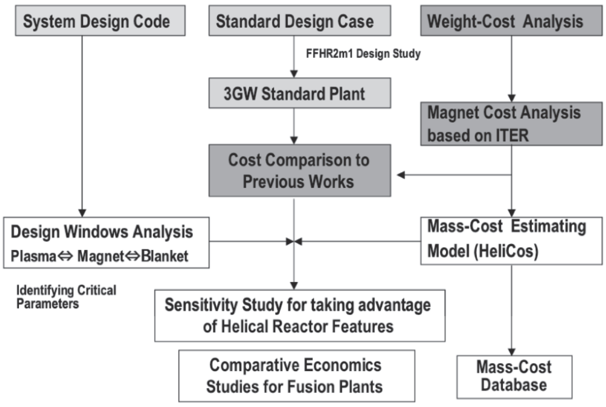

Fig1. Tasks for developing HeliCos (System Design and Mass-Cost Estimating Model) and studying design windows- of Helical Reactor.

To compare the magnet cost between tokamak and helical reactors, we estimated weights and cost of super conducting strands, conduits, support structures, and winding, through the ITER and FFHR-2m1 design basis.

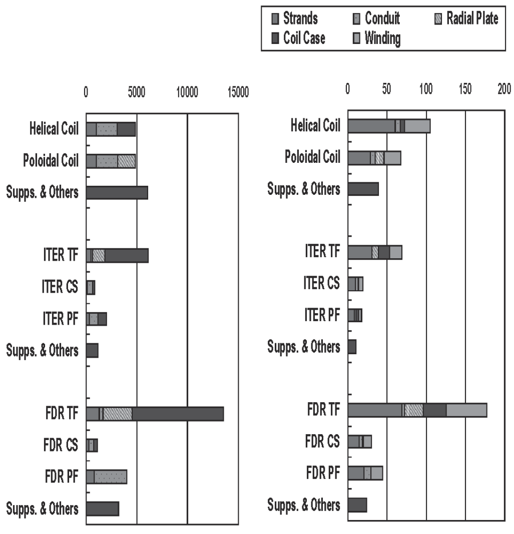

Fig2. Magnets weight and cost of Tokamak and Helical Reactor based on ITER data and FFHR-2m1 design.

Based on FFHR2m1 deign we considered a typical 3GWth helical plant (LHD type) with the same magnet size but increasing plasma densities. We evaluated the weight and cost of magnet systems of 3GWth helical plant, 16,000ton and 210BYen, which are similar values of tokamak reactors (ITER 2002 report, and FDR1999, Fig.2). The costs of strands and winding occupy 70% of total magnet costs. The design windows analysis on helical reactor to identify dominant parameters such as γ, β, B_0, and blanket space Δd are carried out with HeliCos.

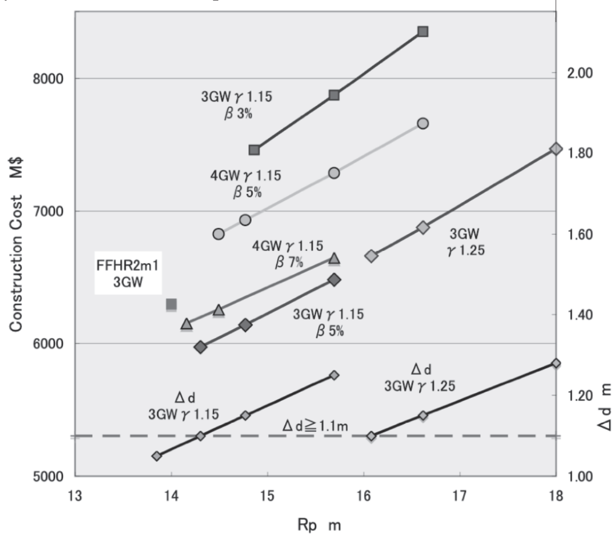

Fig.3 Construction Cost of helical reactors, depending on γ, β (3,5,7%), Pf, and Rp, with d (j=26A/mm2, coil width height ratio W/H=2) constraints.

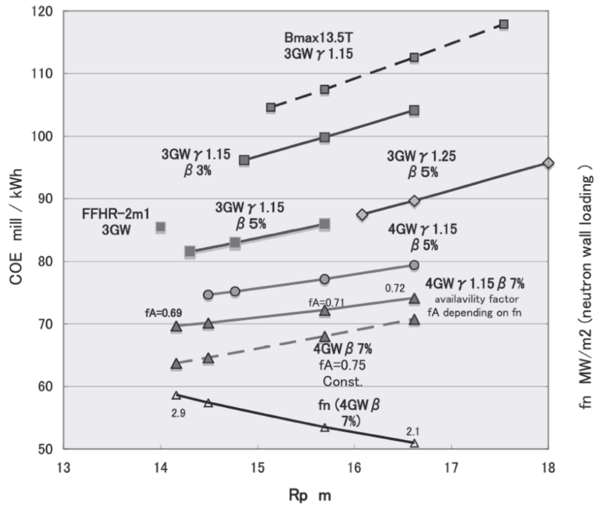

Fig. 4 COE of helical reactors, depending on γ, Pf, β (adding a Bmax 13.5T constant case as an upper bound), considering the availability factor decrease with the neutron loads increase. The lower COE in the higher β cases are obtained by decreasing Bo and the magnet cost.

Figs.3, 4 show the design windows of helical reactors are mainly given by γ-Rp-β (B_0) relationships, fusion output, blanket space constrain, and neutron wall loading. Analysis on the required H factors and density profiles in high β cases are the issues in the next studies.

References

1) A. Sagara et al., Fusion Eng. Design, 81(2006) 2703.
2) S. Imagawa et al., Ann. Rep. NIFS (2005-2006), 274.