§6. Economic and Environmental Assessment of Helical and Tokamak Reactors

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Fission and fusion reactors are expected as abundant electric power generation systems reducing global warming greenhouse gas (GHG) emission amounts. Different from fossil-fuel thermal power plants, the fuel cost fraction of nuclear plants is small. However, fission reactors with oversea gaseous diffusion uranium-enrichment system lead to rather high GHG emissions in comparison with those of domestic centrifuge enrichment system, because of its large electricity consumption. Here, we investigate the effects of the tritium fuel cycle system on the cost of electricity (COE) and the life-cycle CO_2 emissions in fusion reactors.

The system design assessments[1-4)] of magnetic confinement fusion (MCF) and inertial confinement fusion (ICF) reactors schematically shown in Fig.1 have been performed using PEC (Physics Engineering and Cost) system code. In the physics design, the reactor plasma performance can be determined by fusion output power, beta limit, density limit and so on. As for engineering design, important parameters to realize compact DT fusion reactors are the MCF maximum magnetic field strength or ICF driver energy, the blanket and shield thickness, the neutron wall loading, etc.

The cost accounting analysis is based on unit cost per weight or power, and life-cycle GHG emissions are evaluated using the input-output table. The unit cost of helical coil is assumed 25% higher than those of toroidal and poloidal coils. The cost of superconducting toroidal coil with weight W_{TFC} is assumed as $0.114W_{TFC}$(t) [M$]. The other main detailed cost accounting values used here are described in Ref. 4.

D^3He reactor assessment has been done using TOTAL equilibrium-transport code[5)] and PEC system code focusing on bootstrap current fraction which is strongly related to reactor economics.

The present economic and environmental assessments show the advantage of high-beta tokamak reactors in COE and the advantage of compact spherical tokamak in lifetime CO_2 emission reduction. Especially, new scaling formulas for the reference TR, HR and IR plants are introduced. The parameter dependence of CO_2 emission rate is rather weak than that of COE, except for beta, maximum field strength and thermal efficiency of HR on GHG emission rate. The favorable electric power dependences of COE and CO_2 emissions are also clarified.

By comparing fusion reactors with other electric power generation systems from the view point of COE and CO_2 emission amount, we confirmed that COE of fusion reactors is two times higher than that of coal-fired electric plant and that of fission power plant. On the other hand, the life-cycle CO_2 emission amount from fusion reactor is slightly less than that of fission power plant. The fusion-fission hybrid reactor and advanced D^3He reactors are evaluated, and their future advantages are clarified.

When the carbon tax of around 3,000 yen/t-CO_2 is introduced, the COE of fusion reactor might be same level on that of coal-fired electric power plant and 1.5 times lower than that of oil-fired electric power plant. Even if the CCS technology is applied to new fossil power plants, both magnetic and inertial fusion energy rectors are expected to be advantageous against global warming.

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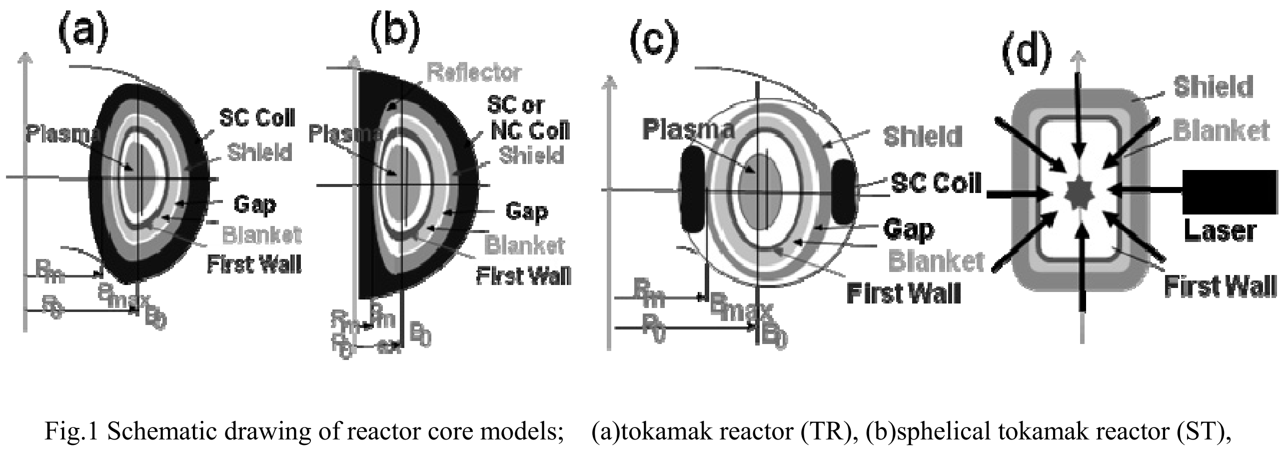

Fig.1 Schematic drawing of reactor core models; (a)tokamak reactor (TR), (b)sphelical tokamak reactor (ST), (c) helical reactor(HR), and (d) inertical fusion energy reactor (IR).