§11. Comparative Design Analysis between Helical and Tokamak Reactors

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For comparative design studies of tokamak and helical reactors are carried out focusing on (1) advanced internal transport barrier (ITB) operation modes with pellet injection and (2) reactor system analyses including cost and CO_2 emission amount.

(1) ITB Formation in Helical and Tokamak Reactors[1-2)]

In the future fusion reactor, the plasma density peaking is important for the increase in the fusion power gain and for the achievement of confinement improvement mode. The density control and ITB formation due to the pellet injection have been simulated in tokamak and helical reactors using the toroidal transport linkage code TOTAL. Firstly, the pellet injection simulation is carried out including the neutral gas shielding model and the mass relocation model in the TOTAL code, and the effectiveness of the high field side (HFS) pellet injection is clarified. Secondly, the ITB simulation with the pellet injection is carried out with the confinement improvement model based on the ExB shear effects, and it is found that the deep pellet penetration is helpful for the ITB formation as well as the plasma core fuelling in the reversed shear tokamk reactor, but the deep pellet penetration is not effective in the helical reactor.

The figure 1 shows the operation scenarios of the tokamak reactor (reversed shear mode) in deep penetration case by HFS pellet injection. Alpha particle power and density are feedback-controlled by the adjustment of both heating power and fuelling. In this scenario, ITB is formed at 15 sec and plasma is ignited at 100 sec.

(2) Cost and Environmental Assessment[3)]

The need for new large scale electric power generating systems is increasing because of the global warming and finite fissile fuel crises, and the fusion reactor is expected to play an important role in electric power supply in the near future. To establish the fusion power plant there are many problem to solve. There are not only technical problems but also economical, safety and environmental problem et al.

We calculated the cost of electricity, CO_2 emission amount, energy payback ratio and radioactive waste volume for some combinations of fusion reactors with several blanket options. Fusion reactors considered here are Tokamak Reactor (TR), Spherical Tokamak Reactor (ST) and Helical Reactor (HR). The ratio of CO_2 emission amount per output electric power for various electric generation power plants including fusion systems are summarized in Fig.2.

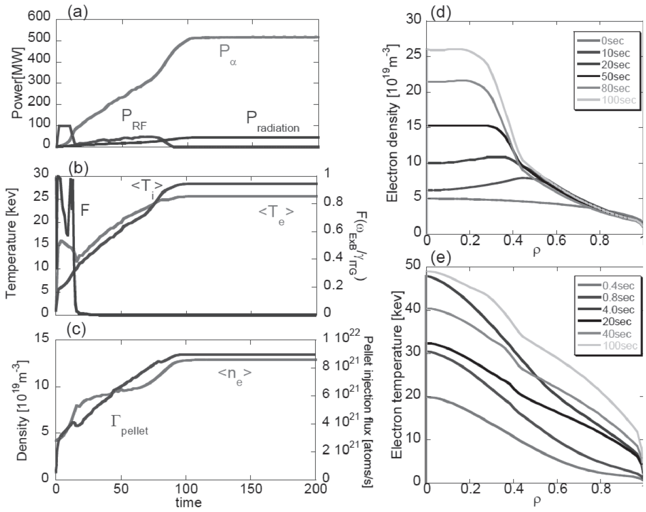

Fig.1. (a) ~ (c) operation scenarios of TR-1 (reversed-shear) with HFS pellet injection. The improvement factor $F(\omega_{ExB}/\gamma_{ITG})$ is the value at ρ=0.4. (d) ~ (e) time evolution of the electron density and temperature radial profiles[2)].

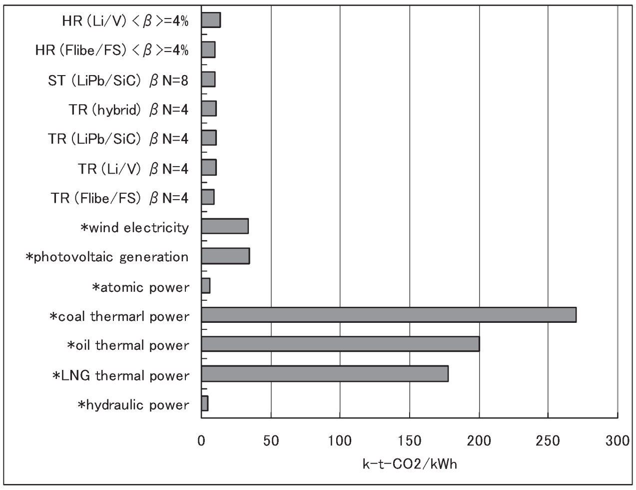

Fig.2. CO_2 emission amount per electric energy output[3)]
*) referred from Y. Uchiyama Socio-economic Research Center, Y94009, (1995)

1) Higashiyama, Y., Yamazaki, K., Garcia, J., Arimoto, H., Shoji, T., Proceedings of ITC/ISHW2007 (15-19 October 2007, Toki, Japan)
2) Higashiyama, Y., Yamazaki, K., Garcia, J., Arimoto, H., Shoji, T., Proc. 11th IAEA Technical Meeting on H-mode Physics and Transport Barriers (26-28 September 2007, Tsukuba, Japan)
3) Uemura, S., Yamazaki, K., Arimoto, H., Shoji, T., Proceedings of International Symposium on EcoTopia Science 2007, ISETS07 (23-25 November 2007, Nagoya Japan)