§67. Design Studies of Force-Free Helical Reactor FFHR

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The main feature of FFHR is force-free-like configuration of helical coils, which makes it possible to simplify the coil supporting structure and to use high magnetic field instead of high plasma beta. The other feature is the selection of molten-salt Flibe as a self-cooling tritium breeder from the main reason of safety[1].

Collaboration works based on the LHD project have made great progress in the reactor studies by focusing on engineering aspects of the high magnetic filed and Flibe system design. Our present activity is at the first stage in Phase 1 for the concept definition prior to the next stage for the concept optimization and the cost estimation.

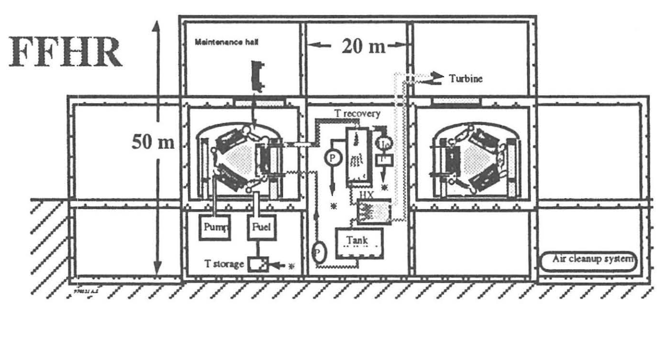
Encouraging positive results have been shown on MHD stability, ignition access, mechanical stress in coils supporting structures, improvement in the blanket system including materials selection and tritium recovery. Critical issues on fundamental safety analysis and maintainability of reactor components have been also investigated, and then key subjects have been pointed out as future works.

MHD equilibrium and stability analyses have shown that the 0.1m outward shift of the axis of the outer-most magnetic surface satisfies the condition $<\beta>$ of 0.7% required for ignition in FFHR-1. Around this condition the equilibrium limit for β_0 is found to be as high as about 4%.

Under the high magnetic field in FFHR-1, the way to access the ignition regime has been analyzed using the time dependent zero-dimensional power balance equation, including the H-mode power threshold.

As for the electromagnetic force between continuously winding helical coils, the averaged minor radius hoop force $<f_a>$ normalized by the product of B_0 and coil current I_H in FFHR-1 is reduced to 35% of the value in LHD. However, since the absolute value $<f_a>$ is 97 MN/m, about 10 times larger than LHD, preliminary structural design has been carried out.

In the previous design of double walled blanket with He flow, the first wall was covered with the protection wall of the Mo-TiC alloy, which has high resistance against neutron irradiation, or the W-TiC alloy, which is currently under development by replacing Mo with W in view of the long-life radioactive waste. However, we have found that, though the wall thickness is only 1 cm, the tritium breeding ratio TBR is very low in case of Mo mainly due to reduction of the epithermal neutron flux below 0.1MeV. On the other hand, thougn the (n, 2n) reactions of W are very effective, after the reactor operation with 0.3MWa/m^2 for instance, the dose rate on W is as high as 1 Sv/h/g for a few days, which makes immediate inspection very difficult. Furthermore, due to transmutation under neutron exposure, more than 50% of W changes to Re in about 10MWa/m^2, and finally to Os in 45MWa/m^2. Consequently we have withdrawen the double-walled concept on the first wall, because this concept is only important in out-vessel channels for the Flibe loop.



[1] A. Sagara, et al, Fusion Engrg. Design. 29 (1995) 51.