§76. Material System Design for FFHR

Matsui, H. (IMR/Tohoku Univ.)
Motojima, O., Sagara, A., Muroga, T.,
Kohyama, A. (Kyoto Univ.),
Tanaka, T., Terai, T.(Univ. Tokyo)

Force-Free Helical Reactor has a remarkable feature of reduced mechanical load on helical coils, in addition to the outstanding advantages inherent to helical confinement systems. The support structures of helical coils can be greatly simplified and the rather large spacing between support beams enables easy access to the components within the plasma chamber. Combined with the choice of liquid breeding material, i.e. FLiBe, the enhanced accessibility increases the availability of the reactor, and helps reducing the cost of electricity.

The structural material chosen in the reference design is reduced activation ferritic steel, JLF-1 featuring mainly the industrial maturity of this class of materials. One of the greatest concern using this material, in addition to the rather limited temperature window, is the disturbance on the magnetic field caused by the ferromagnetism of ferritic steels. Rather detailed examination on this issue has been conducted in the present activity. As a result, several issues from the viewpoint of plasma confinement and its control have been identified and the basic principles for their remedy have been proposed.

The compatibility of JLF-1 and FLiBe is another issue discussed extensively in this group activity. FLiBe itself, if very pure, is not corrosive to ferritic steels while hydro-fluoric acid TF generated from decomposed free fluorine always exists in FLiBe especially in environments exposed to radiation. A method to reduce TF by adding beryllium has been proposed. The leakage rate of tritium through coolant tubing would be rather high if no countermeasures are exerted because of the high equilibrium tritium pressure over FLiBe. Tritium leakage must be minimized from points of view of tritium economy and public safety. A double wall coolant tube configuration with sweeping gas flowing in the gap between the double wall is proposed to reduce tritium leakage rate to an acceptable level.

High-Z materials have been examined for plasma facing component applications in FFHR. A series of molybdenum alloys added with TiC compounds, MTC, have been developed which have outstanding ductility compared to existing commercial molybdenum alloys, e.g. TZM. Because of the excellent thermo-mechanical properties of this alloy, one of the alloys has been adopted for FFHR application. However, the long lived radioisotopes generated from molybdenum has been a major concern from waste management view points. The protection wall made of MTC, which was originally placed in front of the first wall, has been eliminated in the revised design. There is even some gain in TBR by removing this protection wall, and the detection of coolant leakage would be done by monitoring the vacuum exhaust.

Tungsten does not have long lived radio isotopes and is considered as a substitute for MTC. Although the development stage of tungsten alloys, WTC, produced in a process similar to that used for MTC is relatively early, promising advance has been reported recently. Thus, it is likely that high heat flux components in FFHR is made of WTC.

By far the most important experiment needed to develop materials for FFHR is irradiation using fusion neutrons, which is still to be constructed. Detailed examination on the necessary features of fusion neutron sources has been made. In parallel with the IFMIF facility, the necessity of a small-scale d-Li neutron source called "MIRAI" has been emphasized.