Safety and environmental research and development are important to design and construction of a future nuclear fusion reactor and to secure sufficient safety. Major issues are as follows.

(1) Fundamental concept to secure safety in fusion reactor.
It includes studies of radiation protection considering radiation generating devices and radioactive materials in a nuclear fusion reactor.
Safety analysis presuming a helical type power reactor had been made considering engineering safety systems, functions, and sequential schemes presuming abnormal events.

(2) Safety consideration of tritium fuel cycle.
The fusion reactor system includes large amount of tritium in the vacuum vessel and fuel cycle. So safety handling technology and robust confinement system are required. Major safety issues are to prevent tritium release accident and to recovery of the tritium released to a radiation control room. Also research of tritium behavior in the environment and its biological effect is important considering radiation protection for occupational health hazard.

(3) Biological shields and radiation monitoring.
Much induced radioactive materials are produced in a nuclear fusion reactor. Shielding analysis of neutron and radiation from the radioactive materials are required. Also radiation measurements and monitoring are important for radiation protection.

(4) Radioactive waste management.
Waste management of tritium containing gas, liquid and contaminated solid are important problems. Major issues are recovery of tritium, decontamination or volume reduction of the wastes.

(5) Safety and public consent.
Comprehensive safety analysis and risk analysis should be made and the accountability is required.

Major safety issue specific for a future fusion reactor is to avoid the release accident of large amount of tritium. Fundamental safety of tritium processing would be secured by low tritium inventory, tritium dispersion to various partitioned components, and multiple protection systems.

Results of some collaborating studies are shown as follows. They will be useful not only for the DD experiment of LHD, but also for a future fusion reactor.

(a) Tritium behavior in cooling pipe of stainless steel

This basic study has been carried out as collaborations with Shizuoka University. It is known that the existence of oxide layer has an important role for the tritium retention in SS. Forms of hydrogen isotopes on/in SS-316 were studied by TDS (thermal desorption spectroscopy) and XPS (X-ray Photoelectron Spectroscopy). It has been elucidated that the implanted D was trapped by iron oxide with forming FeO-D and simultaneously, released with forming D_2O. It was expected, however, the trapping of D by iron oxide would be saturated around the fluence of 2.5×10^{21} D^+ m^{-2} and the D retention could be decreased by the release of D_2O.

(b) Hydrogen retention in deposition layers

The basic study about the hydrogen trapping behaviors in the re-deposition layer of SS316 has been carried out as collaborations with Kyushu University. In the present study, a deposition layer was formed from stainless steel by deuterium plasma and deuterium release behavior and retention were investigated by thermal desorption method. The observed release behavior is similar to that from a tungsten deposition layer. However, two order of magnitude smaller deuterium retention data were obtained. These facts suggest that more detailed investigations are required to elucidate the differences.

(c) Hydrogen isotope separation system in gas phase

Gaseous hydrogen isotope separation and purification system by pressure swing adsorption (PSA) has been carried out as collaborations with Kyushu University. The H2-HD-D2 three components experiments have been carried out. Obtained data suggest that a pressure and thermal swing adsorption process (PTSA) can be expected to realize a extremely high performance system of hydrogen isotope separation and enrichment.
As the next step, the theoretical simulation and the optimization of the PSA process have been carried out. It has been demonstrated that the experimental results show the mass balances consistent to the analytical estimation based on the static and kinetic adsorption characteristics of hydrogen isotopes onto the zeolites at the liquid-nitrogen temperature 77.4K.

(d) Hydrogen isotope separation system in liquid phase

Hydrogen isotope separation by a Combined Electrolysis Catalytic Exchange (CECE) is planning to apply in ITER for the tritium recovery from tritiated waste water. The purpose of the present study collaborated with Nagoya University is to demonstrate the efficient separation of tritium from hydrogen using the improved CECE device on the basis of the previous results for deuterium and hydrogen.
The column was a random-packed bed of hydrophobic Kogel catalysts and Dixon gauze rings with 25 mm internal diameter and 60 cm length.
Evaluations of optimum operating condition were performed with the originally developed model through analyses and experiments with hydrogen-deuterium system.

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