12-6 Neutronic Evaluation for Irradiation Tests of JMTR

－Accurate Evaluation of Tritium Production－

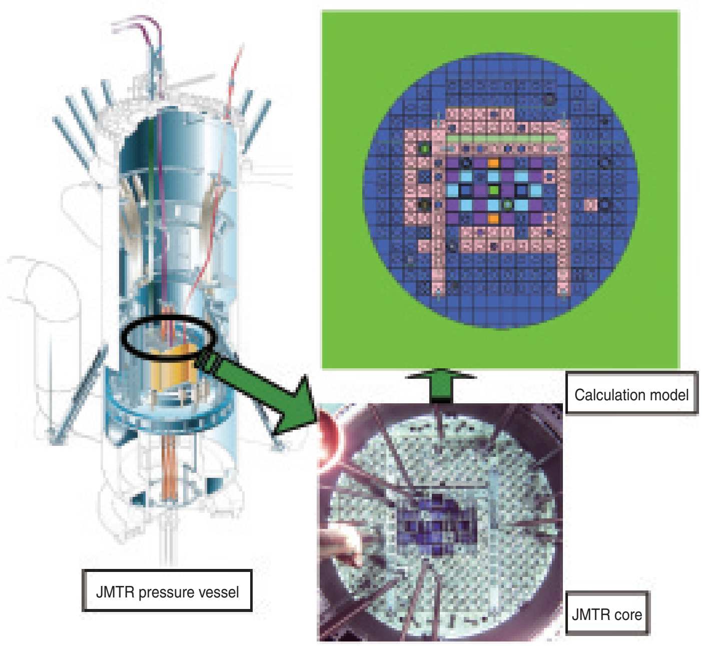

Fig.12-13 Calculation model of JMTR
The JMTR is a tank-in-pool type reactor with thermal power of 50MW and maximum neutron fluxes of $4\times10^{18}m^{-2}s^{-1}$. Test pieces were installed in the JMTR core and were irradiated. Neutronic analyses are conducted using MCNP. The whole 3-D JMTR core was modeled in detail. Irradiation parameters of neutron flux/spectrum, γ dose, etc. are predicted, controlled and evaluated by the calculation model.

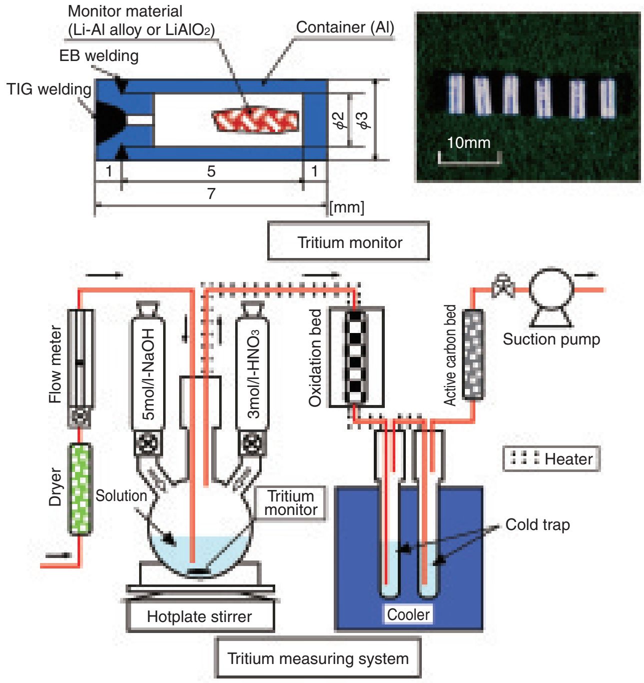

Fig.12-14 Tritium monitor and its measuring system
A tritium monitor consists of monitor material (Li-Al alloy or $LiAlO_2$) and its container. Tritium monitors are installed in irradiation capsules and irradiated in the JMTR. Irradiated tritium monitors are dissolved in tritium measuring system. Almost all the tritium produced in the tritium monitor is trapped in the flask and cold trap. Trapped tritium is measured by a liquid scintillation counter.

Current irradiation research on aging of Light Water Reactor core internal materials, specifically Irradiation Assisted Stress Corrosion Cracking, tritium release of fusion blankets under neutron irradiation, etc. generally needs more accurate prediction, control, and evaluation of irradiation parameters such as neutron fluence, γ dose, and production of nuclear transformation products (Helium, Hydrogen, etc.).

An evaluation procedure using continuous energy Monte Carlo code MCNP with a calculation model of the whole 3-D JMTR core (Fig.12-13) has been therefore introduced to evaluate irradiation parameters. Detail analyses of irradiation parameters are conducted before irradiation using this procedure and there results are verified by comparing with the measured values.

Calculated neutron fluence was verified against measurements of irradiated fluence monitors (Iron and Aluminum-Cobalt wires). With regard to γ dose, calculated γ heating rates were verified against measurements of the nuclear heating evaluation capsule which was developed in order to measure nuclear heating rate (generated from interaction between materials and neutrons or γ -rays). As a result, it was confirmed that the calculated fast and thermal neutron fluence agreed with measurements within ±10%, ±30%, respectively, and the calculated γ dose agreed within -3 to +14%.

Amounts of different products of nuclear transmutation, caused by interaction between neutron and nuclide, must be verified individually because they vary depending on the neutron energy spectrum. In the present study, a tritium monitor and a specialized tritium measuring system (Fig.12-14) were developed for verification of tritium production. Tritium measurement experiments to verify the calculated amount of tritium were conducted using the tritium monitors irradiated in the “JMTR”. As the result, it was confirmed that the calculated tritium matched the measurement within an error of -1% to +8%. This method is contributing to research and development of the fusion blanket materials.

Development of evaluation techniques of irradiation parameters will be conducted to aid in advanced irradiation research.

Reference

Nagao, Y. et al., Development of Tritium Production Measurement Method for In-Pile Tests of Fusion Blanket in the JMTR, Fusion Engineering and Design, vol.81, 2006, p.619-623.