CORE STRUCTURE MATERIALS SURVEILLANCE AND NEUTRON FLUENCE EVALUATION IN THE EXPERIMENTAL FAST REACTOR JOYO

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In the sodium cooled experimental fast reactor JOYO, high fast neutron dose and irradiation temperature affect the integrity of core and structural components. In addition to the reactor vessel as is the case in light water reactors, it is important to evaluate the core support plate due to axial neutron streaming. The surveillance tests are conducted in JOYO to confirm the integrity of these components.

Surveillance specimens of reactor vessel and core support plate materials such as type 304 and 316 stainless steels are irradiated in the reflector region, in-vessel storage rack, where neutron flux is higher than the actual core structure positions, and material irradiation rack near the reactor vessel.

The neutron flux at the positions away from core center is evaluated with transport calculation code “DORT”, and calculated flux is adjusted by the measured reaction rates of multiple foil activation method. The neutron fluence and relevant irradiation parameters such as dpa and helium production are evaluated with the adjusted neutron spectrum. Temperature of surveillance specimens during irradiation is approximately 410 - 450 °C.

In post irradiation examinations, the integrity of the irradiated surveillance specimens is confirmed by the tensile strength test, charpy impact test and metallography test. Creep test and fatigue test are conducted for the part of the specimens.

As an example of JOYO surveillance test results on the core support plate are as follows;

1. The fast neutron fluence ($E \geq 0.1$ MeV) on the core support plate has reached $1.0 \times 10^{21}$ n/cm$^2$ at present and will be reached $2.6 \times 10^{21}$ n/cm$^2$ at the end of design life.
2. The maximum fast neutron fluence on the surveillance specimen of the core support plate amounted to $5.9 \times 10^{21}$ n/cm$^2$.
3. As a result of the post irradiation examination tests, tensile strength and 0.2% yield strength increased slightly following an increase neutron fluence. It was confirmed that material hardening and decreasing the ductility caused by the irradiation were small, and the strength of structure material was satisfied the design criteria. From the results, the integrity of the core support plate at the end of design life was confirmed.