1-17 Viewing Inside an Irradiated Fuel Assembly

— Development of a Non-Destructive Post-Irradiation Examination Technique Using High-Energy X-ray Computer Tomography —

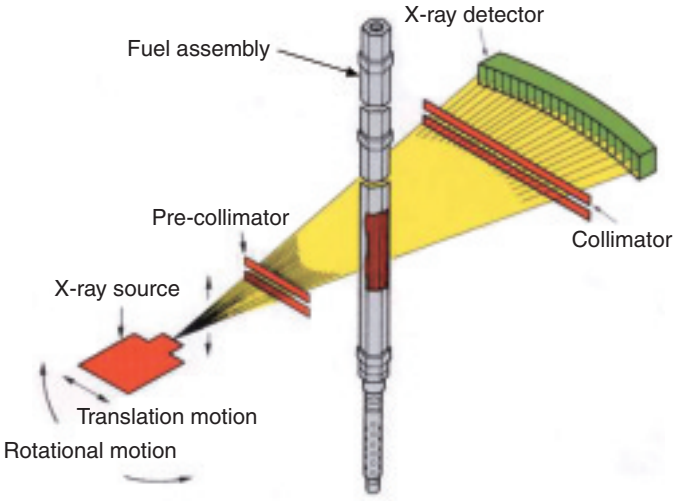

Fig.1-43 Outline of X-ray CT system
X-rays generated by the accelerator are collimated in front of specimen. An X-ray detector measures the intensity of X-ray transmitted through the specimen.

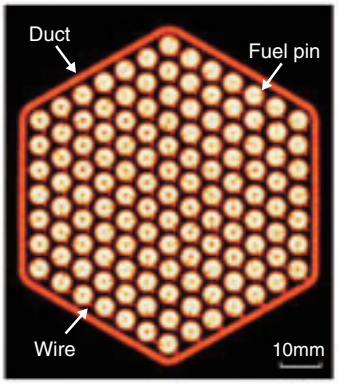

Fig.1-44 X-ray CT image of irradiated fuel assembly
The wrapper tube, cladding, fuel pins and wrapping wire can be distinctly seen in this figure.

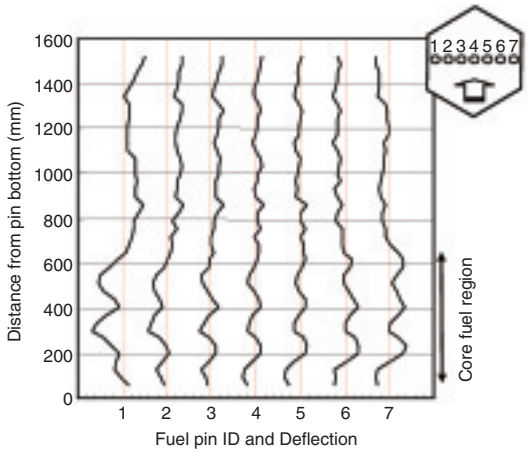

Fig.1-45 Longitudinal deformations of fuel pins
This figure shows the longitudinal deformations of an irradiated fuel assembly. The deformations of the core fuel region are significant.

In order to develop the fuels and materials to be used for a fast breeder reactor which has economic efficiency and high reliability, it is very important to confirm the irradiation performance by a Post Irradiation Examination (PIE). Non destructive PIEs for the fuel assemblies irradiated in the "JOYO" reactor are performed in the Fuel Monitoring Facility (FMF). An X-ray Computer Tomography (X-CT) apparatus was installed in the FMF in order to observe the inner condition of an irradiated fuel assembly.

In this study, the X-CT technique developed in the medical field was established to apply to the inspection of the irradiated fuel assembly (Fig.1-43). This was the first attempt at applying this technique to PIE in the world.

In order to reduce the effect of γ -ray from an irradiated fuel assembly, a high energy X-ray was selected, and the detection period of X-rays passing through the irradiated fuel assembly is synchronized the generated pulse of high energy X-rays, using $CdWO_4$ as the material of the scintillation detector because of its high sensitivity for high-energy photons.

As a result, a clear cross sectional CT image (Fig.1-44) of the fuel assembly irradiated to high burn up can be obtained. Analyzing this image enables measurement of the displacement of fuel pins in the assembly and the change of sodium flow area.

Fig.1-45 illustrates the longitudinal deformations of 7 fuel pins located in the center line of the fuel assembly. As shown in this figure, the deformations of fuel pins at the core fuel region are significant compared with the deformations of fuel pins at other regions. This behavior was caused by the irradiation creep of the core. Evaluation of the temperature effects on the fuel assembly will be aided using these data.

Reference

Katsuyama, K. et al., Application of High-energy X-ray Computer Tomography Technique for Checking Irradiated Nuclear Fuel, Proceedings of 4th World Congress on Industrial Process Tomography, Aizu, Japan, 2005.