3D Scanning System of Nuclear Fuel Assembly Detection

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1.Abstract

3D scanning system of nuclear fuel assembly could realize multiple beam of x-rays from different angle and different level exposure to the fuel components, and obtain projection data of the fuel component structure, transmit projection data to the image processing server, and complete tomographic image reconstruction through data processing and high speed calculation.3D scanning system is an important part of the non-destructive detection system of nuclear fuel assembly. Its performance directly affects the coordination of the whole system and the reliability of data acquisition, and finally affects the image quality of nuclear fuel assembly.

2. Scanning mode

3D scanning of nuclear fuel assembly includes stratified motion, graduated motion and interpolation motion. Stratified motion is the forward and backward movement along with the axis of fuel assembly, which is used to locate the cross-sectional position of scanning. Graduated motion is the rotation of the fuel assembly itself, which is performed after the tomography scanning positioning ,and is used to do multi-angle tomography scanning. Interpolation motion is the relative position adjustment motion between high-energy accelerator ray source and detector, through which more detection projection data could be obtained and system resolution could be improved. The detection scanning method is called "rotation" scanning.

In previous studies, the tomographic image of nuclear fuel assembly exists ring artifact and ghosting under the scanning mode of "rotation" ,which affects the defect analysis and assessment of the nuclear fuel components, the main reason of ring artifacts is that the energy response of each channel in the detector array is inconsistency, while performing back-projection calculation, the inconsistency signals of detecting channels result in plurality of rings centered on the rotation axis being formed at the fixed position of the reconstruction matrix. the ring is called ring artifact. In order to further improve the imaging quality of nuclear fuel components and restrain ring artifacts effectively , we are in the process of optimizing the 3d scanning system, translation motion was designed on the basis of the existing stratified motion, graduated motion and interpolation motion , translation motion move the fuel assembly into the field of detection view and execute a certain degree of rotation, this kind of scanning mode is called "translation - rotation" scanning(see figure 1) .The "translation-rotation" scanning mode could correct the energy response inconsistency of detector array from the perspective of original data, and could suppress the generation of ring artifacts effectively, thus the quality of tomographic image is improved .

3. 3D Scanning control system

3D detecting scanning system of nuclear fuel assembly consists of 3d detection scanning mechanism and 3d scanning control system. 3D scanning control system could realize translation-rotation of nuclear fuel assembly and the combination of relative movement between the radiation source and detectors ,complete control of the nuclear fuel assembly scanning , offer real-time feedback position information in the process of scanning , ensure the accuracy of the movement, and control ray source and data acquisition system synchronously to read the data in accordance with the set position, at the same time transmit batch data to graphics server in the process of setting to perform data processing and image reconstruction, if the accurate synchronization is not guaranteed between the combination movement of X-ray source-detector and "translation - rotation" of fuel assembly very well , the validity and accuracy of the acquisition data and the imaging quality of the whole detection system will be affected .On the basis of theoretical analysis and calculation, our research group are conducting scanning mechanism design and development tasks, and three-dimensional scanning control system are studying now.

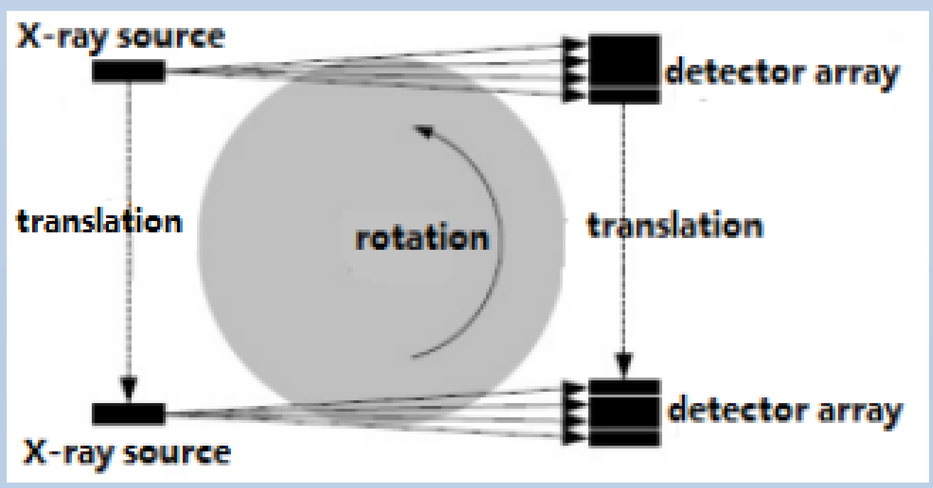

Figure 1. "translation - rotation" scanning mode.

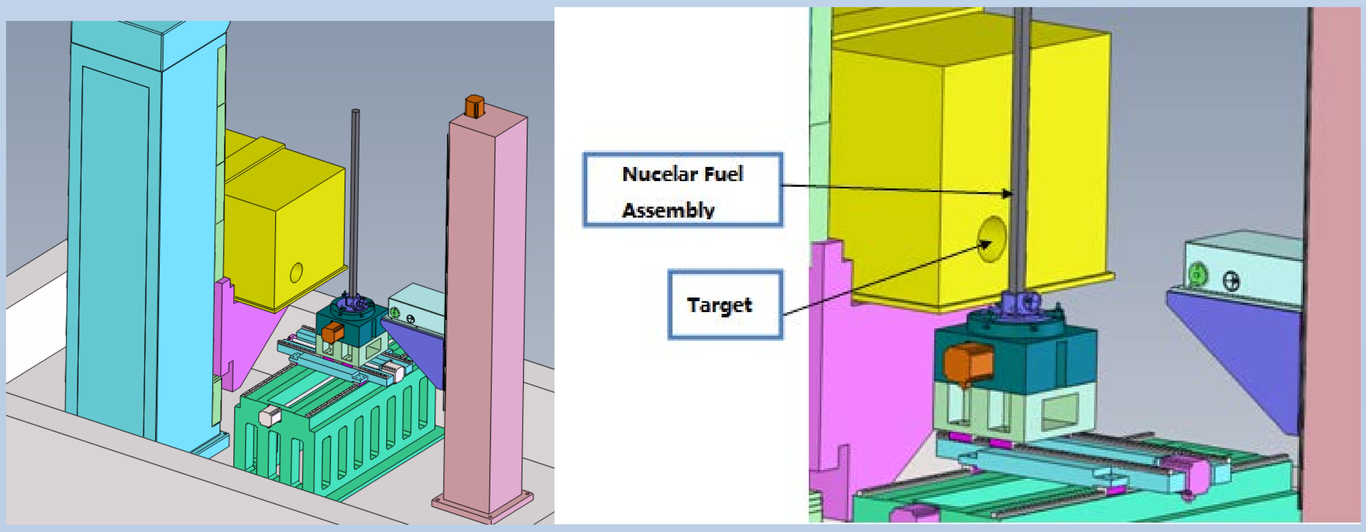

Figure 2 Schematic diagram of 3d detection scanning structure.

Figure 3.Facility for the detection of nuclear fuel assembly .

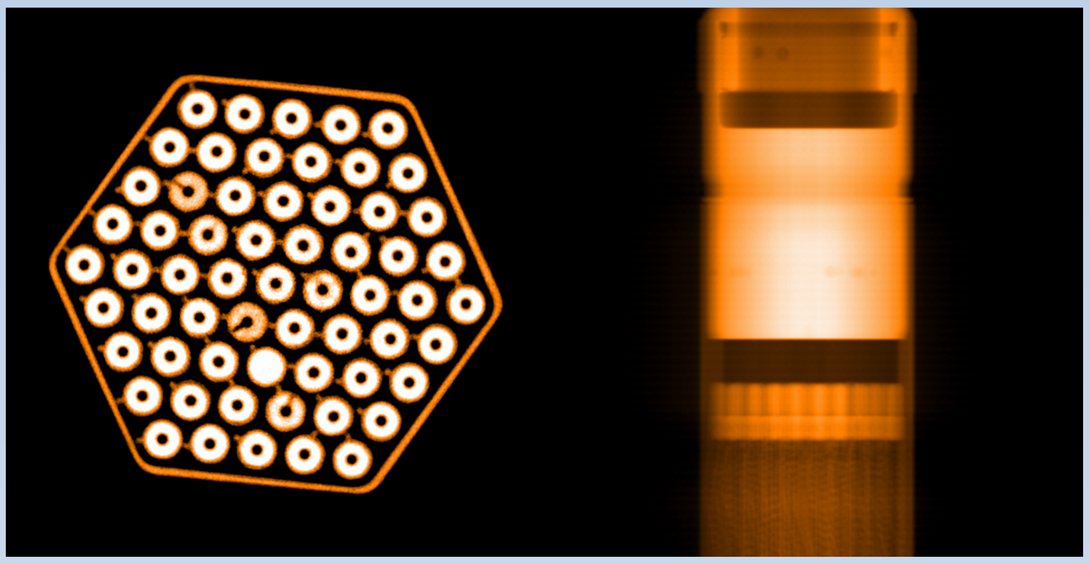

Figure 4.CT and DR test results of simulated fule assembly .