Transactions of the Korean Nuclear Society Autumn Meeting
Busan, Korea, October 27-28, 2005

Dimensional Measurements of Fresh CANDU Fuel Bundle

Ji Su Jun, Chang Keun Jo, Jong Yeob Jung, Dae Seo Koo and Moon Sung Cho
Korea Atomic Energy Research Institute, P.O.Box105, Yuseong, Daejeon, Korea 305-600
junjisu@kaeri.re.kr

1. Introduction

This paper intends to provide the dimensional measurements of fresh CANDU fuel (37-element) bundle [1] for the estimation of deformation of post-irradiated (PI) bundle. It is expensive and difficult to measure the fretting wear of bearing pad, the element bowing and the waviness of endplate at the two-phase high flow condition (above 24 kg/s) of out-of-reactor test [2]. So, it is recommended to compare the geometry of fresh bundle with that of PI bundle to estimate the integrity of fuel bundle in the CANDU-6 fuel channel [3] with two-phase flow condition. The measurement system [4] has been developed to provide the visual inspection and the dimensional measurements within the accuracy of 10 μm as shown in Figure 1. It is applicable in-air and underwater to the CANDU bundle as well as the CANFLEX bundle [5].

The in-air measurements of the 36 fresh CANDU bundles (S/N: B400892 ~ B400927) are done by this system from February 2004 to March 2004 in the PHWR fresh fuel storage building of KNFC. These bundles are produced by KNFC manufacturing procedure and are waiting for the delivery to the Wolsong-3 plant, and are planned to load into the proposed test channels [6]. The detail measurements contain the outer rod profile (including the bearing pad), the diameter of bundle, the bowing of bundle, the rod length and the surface profile of end plate (waviness).

2. Measurement Procedure

The setup of the measurement system is needed to calibrate all the LVDT sensors and compensate the mechanical error of the system with two reference bundles (Aluminum bundle and CANDU master bundle). The reference dimensions of these mockup bundles were measured by the authorization [4]. The preliminary tests are performed until ensuring the accuracy of the system by using the mockup bundle. The main measurements of fresh CANDU bundle are checked by the quality assurance (Q/A) list, which requires the detail test procedure to ensure the reliability, the repeatability and the consistency of the test. The measurements are performed by the following test procedures ; checking the serial number of bundle, setting the DAS (data acquisition system) program of the system, installing the bundle on the system, checking the position of LVDT, aligning the bundle, measuring the endplate waviness and the rod length, saving the measured data on the disk, measuring the rod profile, and saving the rod profile data and all the graphic files on the disk. All procedures are controlled remotely by the DAS program, while the bundle is installed manually on the system. The repeat tests of seven bundles are done to assure the credit of measurements.

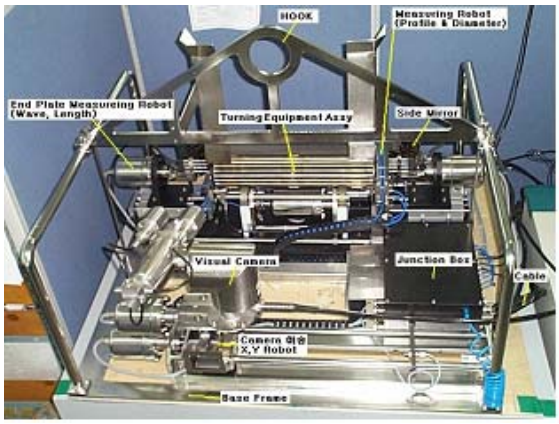

Fig.1 Dimensional Measurement System

3. Results and Discussions

All the fresh bundles were manufactured through the reference design [1]. So, the quality was already certified by KNFC manufacturing procedure prior to the test. It requires that the maximum height of bearing pads should be less than 1.385mm to be compatible to the pressure tube. The height is obtained by the outer rod

profile (distance between rod and bearing pad surface) as shown in Figure 2. The measured results for all the bundles show that the height is less than 1.30mm. The average height of bearing pads is measured by about 1.24mm. The design value of fuel rod length is 495.30 mm, which is including the end plate. The rod length is obtained by the endplate waviness data (distance between left LVDT and right LVDT). The data of the fuel rod length are distributed between about 495.10mm and 495.20mm as shown in Figure 3. It indicates that the measured value is slightly less (0.1～0.2mm) than the design value. It may be caused by that the length is measured at the welding point of the end plates. The profile of endplate shows a periodic waviness with the number of welding points through the ribs of endplate. That is, there are 18 waves at the outer ring, 12 waves at the intermediate ring and 6 waves at the inner ring, respectively. It is found that the outer rod of fresh bundle has a slight bowing as shown in Figure 2. Based on these profiles of 18 outer rods, the bowing of bundle is examined at the positions of 1/4, middle and 3/4 planes as shown in Figure 4. The bowing at the middle plane is slightly greater than other positions, but the maximum bowing is very small (less than 0.50mm). The measured data show reliable, repeatable and consistent through 36 bundle tests and 7 repeat bundle tests.

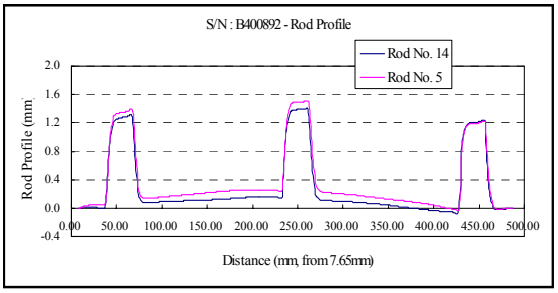

Fig.2 Outer Rod Profile of B400892 Bundle

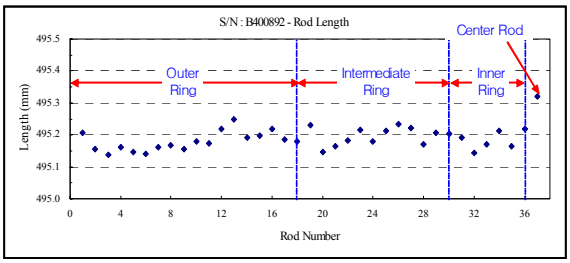

Fig.3 Length of B400892 Bundle

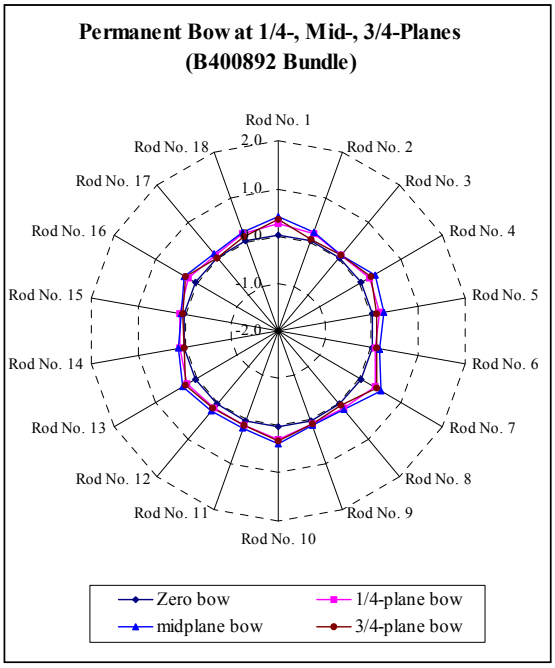

Fig.4 Bowing of B400892 Bundle

ACKNOWLEDGEMENTS

This work has been carried out under the Nuclear Research and Development Program of the Korea ministry of science and Technology.

REFERENCES

[1] I.E. Oldaker, “Fuel Design Manual for CANDU-6 Reactors”, AECL Internal Document DM-XX-3700-001, 1989. 2.

[2] Wolsong 2, 3 & 4 Final Safety Analysis Report, KEPCO, 1995.

[3] M.S. Cho, H.C. Suk, J.S. Jun, K.J. Park, C.K. Jo, D.S. Koo, J.Y. Jung, "Technology Development of Integrity Evaluation of Fuel Bundles and Fuel Channel in a Two-Phase Flow CANDU-6 Fuel Channel", KAERI/RR-2545/2004, 2005. 5.

[4] C.K. Jo, M.S. Cho, D.S. Koo, K.J. Park, J.S. Jun, J.Y. Jung, H.C. Suk, “Development of Fuel Inspection System for CANDU Fuel Bundles”, 2004 KNS Spring Meeting, 2004. 5.

[5] J.S. Jun, H.C. Suk, M.S. Cho, J.Y.Jung, C.K.Jo, C.J. Jeong, “The Design Manual of CANFLEX-NU Fuel Bundle for CANDU-6 Reactor”, KAERI/TR-2576/2003, 2003. 10.

[6] J.S. Jun, “The Test Channel Groups in the Wolsong-3 Reactor for the Evaluation of PHWR Fuel Integrity in the Two Phase Flow Condition”, KAERI/TR-2796/2004, 2004. 7.