

Evaluation on the measurements of Grids for PWR's Spent Fuel in IMEF

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1. Introduction

A 3-D measuring apparatus[1], which is designed to measure the dimensional of grids for the spent fuel of PWR, was developed and carried out the performance test at the M5a hot cell of IMEF[2,3,4] in 2009. By using this equipment, four(4) grids were successfully measured to get cell sizes of grids which were burned about 3 cycles in the core of a reactor.

In general, to minimize the standard deviation to the mean, a grid is to be set on the fixing jig for maintaining the stable position by master-slave manipulators mounted on the hot cell wall of M5a. The data were collected in MS-Excel sheet, calculated by VBA (visual basic for application) program, and analyzed.

The analyzed data were observed a little shifted to both left and right sides as well as both top and bottom sides from the center of a grid. The results were also evaluated by conventional statistics analysis to understand the dimensional properties as well as integrities of grids.

2. Experimental & Results

2.1 Grids for the Spent Fuel of PWR

Total four Grids, which are two middle grids (Grid-mid-1 & -2), a top grid (Grid-top-1), and a bottom grid (Grid-bot-1) for the spent fuel of PWR, were dismantled in the pool of PIEF(Post-Irradiation Examination Facility) and transported to IMEF by a shipping cask. The fuel assembly was burned about 3 cycles in the core of a reactor. Through the pool of IMEF, these were transferred to M5a hot cell by a bucket elevator.

2.2 Experiment

A 3-dimensional measurement apparatus consists of a measurement part, a controller part, and a PC & DB system as shown in a figure 1, and the specification of it is as follows.

- Movements of working table both X-direction and Y-direction : 250 mm.
- Movements of Z-direction with a touch sensor : 250 mm.
- Measurable depth : up to 100 mm under condition of 10 mm x 10 mm in cell size
- Measurement accuracy : ± 0.001 mm

- Tolerance of both perpendicularity and horizontality : ± 1.0 mm.
- The grooves for various kinds of clamps are machined on a working table.
- Coordinators for each axis were installed

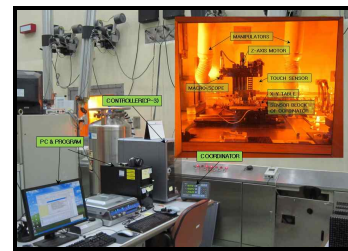


Fig. 1. The appearance of a 3-dimensional measurement apparatus at M5a hot cell in IMEF.

2.3 Setting a grid on the fixing jig

The grid must be set on the fixing jig for maintaining in stable position to minimize the standard deviation to the mean, by master-slave manipulators mounted on the hot cell wall of M5a. Therefore, as shown in figure 2 the fixing jig was installed on the X-Y table of a 3-D measurement apparatus and the level was also checked by using dial gauge within the tolerance ± 100 μm .

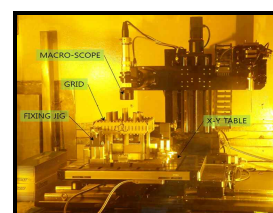


Fig. 2. The appearance of a grid on the fixing jig.

2.4 Test results

Total four Grids, which are two middle grids (Grid-mid-1 & -2) and a top grid (Grid-top-1) and a bottom grid (Grid-bot-1) were tested to get the cell sizes as shown in table 1 and figures from 3 to 6. From a figure 3 to a figure 6, the data are summarized as follows.

1) The cell sizes of Grid-mid-1 from column A to column H are smaller than the other columns. Therefore, this grid seems to be declined from left to right.

2) The cell sizes of Grid-mid-2 from row 1 to 8 are larger than the other rows. Therefore, this grid seems to be declined from bottom to top.

3) The tendency of Grid-top-1 is very similar to Grid-mid-1.

4) The tendency of Grid-bot-1 is very similar to Grid-mid-2.

Table 1: Test results for four grids

ID	Measured data (unit : mm)		Re- marks
	Direction-1	Value	
Grid-mid-1	Hori. (1-16) aver.	9.479±0.004	k ≈ 2.12 (95% confidence level, dof=15)
	Ver. (A-S) aver.	9.489±0.028	
Grid-mid-2	Hori. (1-16) aver.	9.478±0.037	
	Ver. (A-S) aver.	9.503±0.007	
Grid-top-1	Hori. (1-16) aver.	9.343±0.006	
	Ver. (A-S) aver.	9.342±0.034	
Grid-bot-1	Hori. (1-16) aver.	9.356±0.017	
	Ver. (A-S) aver.	9.366±0.019	
Designation			

- * Hori. : Horizontal length
- * Ver. : Vertical length
- * aver. Average

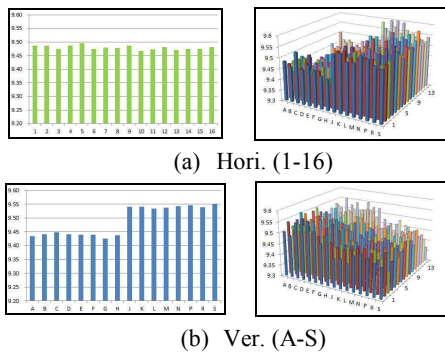


Fig. 3. Test result for Grid-mid-1.

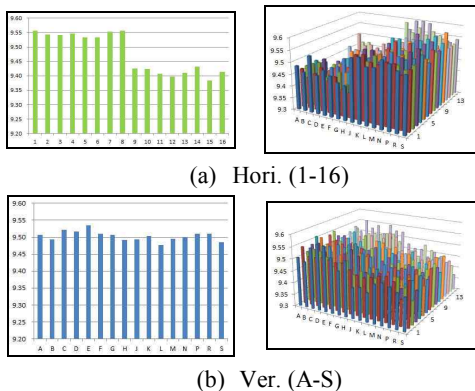
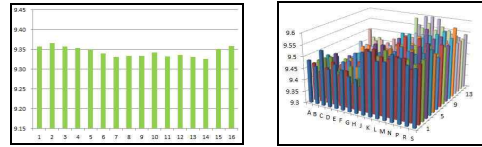
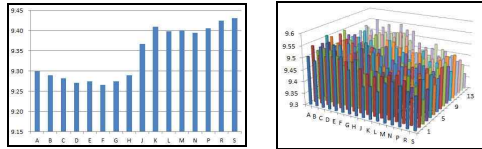


Fig. 4. Test result for Grid-mid-2.

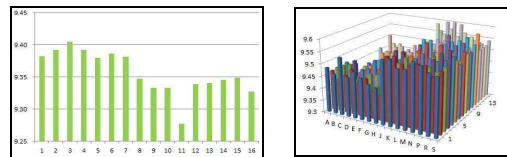


(a) Hori. (1-16)

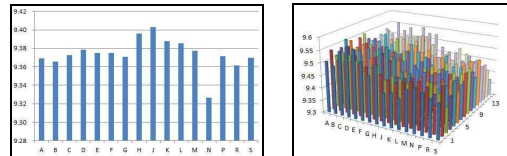


(b) Ver. (A-S)

Fig. 5. Test result for Grid-top-1.



(a) Hori. (1-16)



(b) Ver. (A-S)

Fig. 6. Test result for Grid-bot-1.

3. Conclusions

The developed 3-dimensional measurement apparatus was applied to measure the cell sizes of four grids, and the acquired data were also evaluated by conventional statistics analysis. As a result, the evaluated data seems to be very close to the mean of population, but they show a peculiarity which is to be studied the reason. Therefore, the stepped pin gages, which were used by Westinghouse, should be applied to compare or confirm the acquired data later.

REFERENCES

[1] Y.S Choo et al., "Development of a 3-D Measurement Apparatus for Measuring Cell sizes, Spring and Dimple pitches of Grids for PWR's Spent Fuels", Proceeding of KNS Autumn Meeting, Oct. 27-28, 2011.
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