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Measurement of Cell Size of Fuel Assembly Grids in IMEF

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1. Introduction

The grid-to-rod fretting wear is still one of the main causes of fuel failure [1,2]. Fretting is a wear phenomenon occurring between two surfaces having oscillatory relative motion of small amplitude [3-5]. The coolant flowing around the fuel rods induces vibration of the rods at small amplitude, and the lack of grid-to-rod positive contact force due to relaxation of spacer spring causes fretting wear. The grid-to-rod gap size is one of key parameters to predict the fretting damage. Thus, it is important to know the change in size of grid cells during the fuel residency in reactor core by irradiation-induced stress relaxation and creep. The IMEF at KAERI has installed an apparatus for dimensional measurement in a hot cell, and carried out measuring cell size of grids which took from a fuel assembly after 3-cycles operation in PWR.

2. Experimental

The measuring system of dimension in an IMEF hot cell is consisted of a specimen holder, an X-Y moving table, a CCD camera, a digital displayer, and a PC (Fig. 1). A linear scale is attached at the X-Y moving table, and it reads X and Y coordinates of the position of the CCD camera. Dimension is calculated from the reading values of the linear scale.

Fig. 1 System of dimension measurement

In order to measure the cell size of a grid, a grid is fixed on the X-Y table using a special holder which is designed to keep a grid horizontally and vertically (Fig. 2). A reticle of the CCD camera places the focus on a spring or a dimple of a grid cell, and the position of the reticle is read by the linear scale (Fig. 3-4).

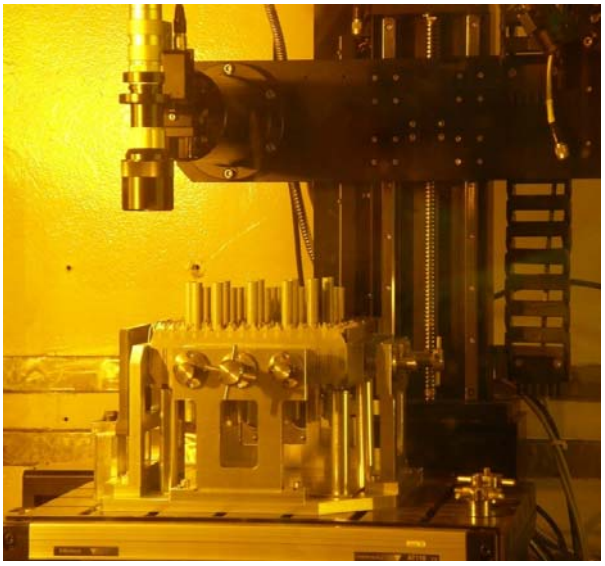

Fig. 2 Positioning of a grid on a X-Y moving table

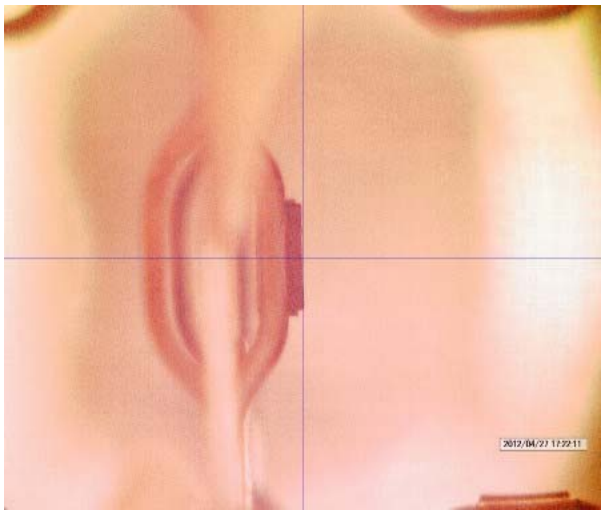

Fig. 3 CCD camera focusing on a grid spring

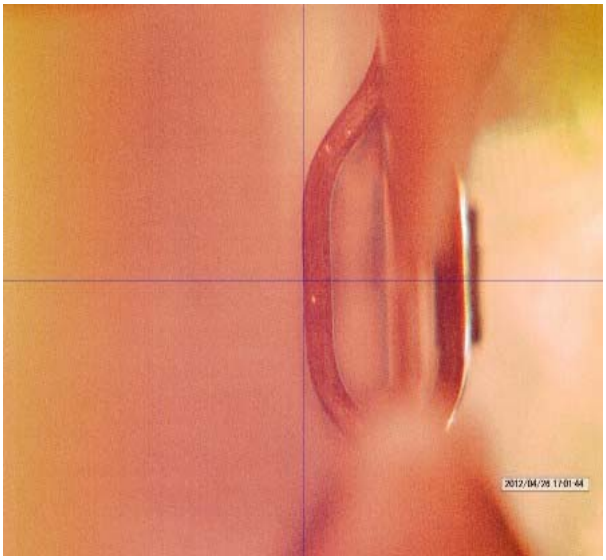

Fig. 4 CCD camera focusing on a grid dimple

Each cell size of a spacer grid, which is a distance between a cell spring and a cell dimple, is measured both horizontally and vertically.

3. Results

Grid-to-rod gap size of grid cells after 3-cycle operation in PWR is summarized in table 1. The gap size is defined as a value of a cell size minus an initial rod diameter. A positive value means existence of a gap, and a negative value means no gap with contact. The size of grid cells was initially smaller than a rod diameter to keep a spring force for grasping a fuel rod tightly[1,2]. During operation, the grid cells enlarged, and the increment of the size was different with zone of position. For instance, at a zone of 4/4, the cells deflected over a rod diameter to make a grid-to-rod gap.

Table 1 Grid-to-rod gap size of grid cells

Cell Number		A - I	J - Q
10 - 17	Horizontal	-0.13	+0.04
	Vertical	-0.09	-0.09
1 - 9	Horizontal	-0.13	+0.04
	Vertical	+0.03	+0.03

A main cause of grid cell enlargement was compression of a grid spring. The deflection of a grid spring may be caused by irradiation-accelerated creep and relaxation. In general, spring force of grid cells is designed not to form no gap during operation for prevent the grid-to-rod fretting wear. This result, in which an increment of cell sizes was different at each zone, indicates that the enlargement of cell size should be explained some other reasons such as a self-excited spacer grid assembly vibration besides of spring relaxation.

4. Conclusion

One of key parameters to predict the fretting damage of fuels is to know the change in size of grid cells due to irradiation-induced stress relaxation and creep during the fuel residency in reactor core. The IMEF at KAERI has installed an apparatus for dimensional measurement in a hot cell, and carried out measuring cell size of grids which took from a fuel assembly after 3-cycles operation in PWR. During operation, the grid cells enlarged, and the increment of the size was different with zone of position. At a partial zone, the cells deflected over a rod diameter to make a grid-to-rod gap. A main cause of grid cell enlargement was compression of a grid spring, which may be caused by irradiation-accelerated creep and relaxation.

REFERENCES

[1] K-T Kim, “A study on the grid-to-rod fretting wear-induced fuel failure observed in the 16x16 KOFA fuel,” *Nucl.Eng. & Des.*, vol. 240, pp. 756-762, (2010).
[2] K-T Kim, “The study on grid-to-rod fretting wear models for PWR fuel,” *Nucl.Eng. & Des.*, vol. 239, pp. 2820-2824, (2009).
[3] Y-H Lee and H-K Kim, “Effect of spring shapes on the variation of loading conditions and the wear behaviour of the nuclear fuel rod during fretting wear tests,” *Wear*, vol. 263, pp. 451-457, (2007).
[4] M.H. Attia, “On the fretting waer mechanism of Zr-alloys,” *Tribology*, vol. 39, pp. 1320-1326, (2006).
[5] S. Kovacs, J. Stabel, M. Ren and B. Ladouceur, “Comparative study on rod fretting behavior of different spacer spring geometries,” *Wear*, vol. 266, pp. 194-199, (2009).