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Evaluation of Fuel Rod Retention Force by Louver on Debris Filtering Bottom Grid

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1. Introduction

Fuel failure due to debris is one of the most common causes of failure in PWR fuel assembly. As a remedy for failure induced by in-core debris, the DFBG(Debris Filtering Bottom Grid) was newly developed in KEPCO NF.

The DFBG is made of nickel alloy straps, which is located directly above the bottom nozzle to support the bottom of fuel rods. The primary function of the DFBG is to filter debris flowed up through a flow hole of bottom nozzle and support the bottom of fuel rod to minimize the risk of fretting damage. The perspective view of DFBG with fuel rod and bottom nozzle is shown in Fig. 1. A side strap of the DFBG's one cell consists of two dimples, spring with louver and debris filtering arches. The DFBG is designed to be used in conjunction with the long solid end plug to prevent the wear damage by trapped debris. Also, the S-shaped debris filtering arches were formed in the lower region of the strap and effectively divided the corner space of one cell to minimize the passable debris size.

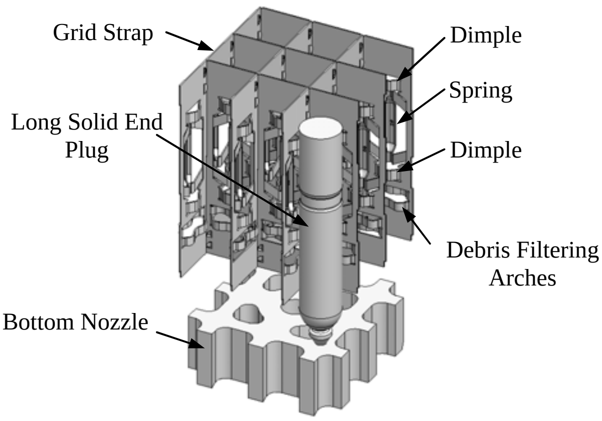


Fig. 1. Debris Filtering Bottom Grid with Solid End Plug

To maintain the debris filtering performance of DFBG, the springs stably support the long solid end plugs so that the fuel rods are not allowed to move through the cell axially. If the long solid end plugs move up and the ends of solid end plug fillet are positioned above the debris filtering arches, the debris passable size could become large so that the DFBG could not filter foreign material effectively. Accordingly, The DFBG was designed to prevent uplift of fuel rods by the spring with louver. The louvers are formed at the center of springs and inserted into the groove of a circumferential surface of the long solid end plug, as Fig. 2 illustrates.

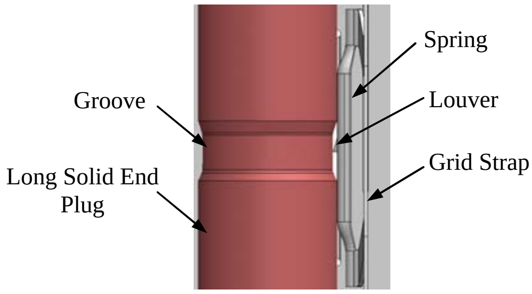


Fig. 2. Spring with Louver and Long Solid End Plug

The louvers of DFBG have been applied to grip the fuel rods firmly in the fuel assembly as these add drag force. In this paper, the effect of louver will be discussed through single rod drag test and the statistical analysis of test results.

2. Single Rod Drag Test

The purpose of the test is to evaluate the difference of the drag forces with and without louver.

2.1 Test Configuration

The configuration of the single rod drag test is shown in Fig. 3. The test consisted of a grid fixture, two test grids and simulated rods. Two test grids were used to evaluate the effect of louver. One had springs with louvers and the other had springs without louvers. To simulate rod loading condition, the solid end plugs were inserted into every cell of the grids except the cells for drag test. The simulated fuel rods welded with long solid end plugs were used to measure the drag force at the test cells.

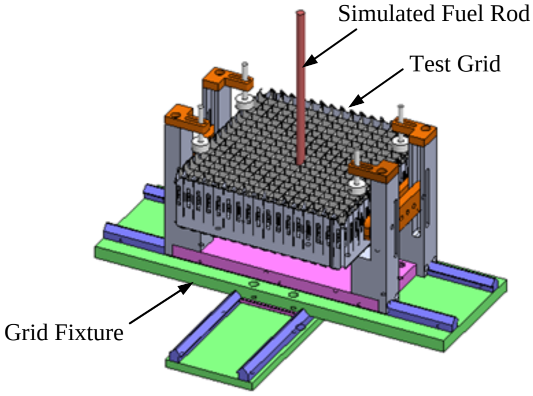


Fig. 3. Single Rod Drag Test Configuration

2.2 Test Performance

The test was performed at room temperature in air condition utilizing the Instron Universal Testing Machine. The test setup is shown in Fig. 4. The drag force as a function of axial movement was measured during the removal of the simulated fuel rod.

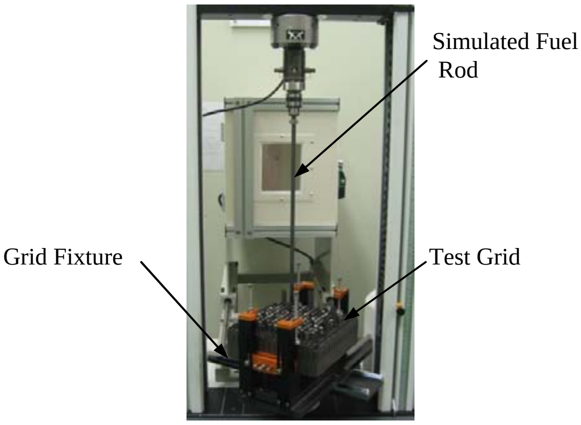


Fig. 4. Single Rod Drag Test Set Up

3. Analysis of Test Results

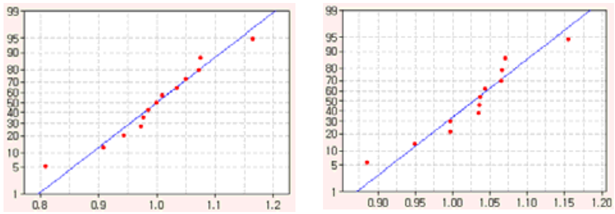
The difference of drag force between grids with and without louver can be estimated by statistical method using the popular statistical software package, Minitab. The two-sample t-test is a method of comparing two population means if the populations have normal distributions[1]. Table I shows the two-sample t-test results of the drag force increment. In this analysis, the calculated p-value was below 0.05, which represent the level of the significance of their result. If the p-value is below the common cutoff value of five percent, 0.05, the average of populations will be statistically significant, and so each average population of tests will differ from each other.

The drag force of grid with louver is significantly higher than the grid without louver, because the p-value is below the traditional cutoff value of 0.05. The percentage increment of the drag force is between 42.2% and 59.6%, and the estimated nominal value is 50.9%.

Table I: Two-sample T-test Results

Drag Force Increment(%)		
Min.	Nom.	Max.
42.2	50.9	59.6

Furthermore, the validity of the statistical results from t-test must be checked whether the sample distribution is normal or not[2]. Fig. 5 shows the normal probability plot of the drag forces of the two grids to check the normality. Since the p-values for these tests are above the traditional cutoff value of 0.05- not small enough for us to reject normality, the two samples have a normal distribution[1].



(a) Force with louver (p-value: 0.730)
(b) Force without louver (p-value: 0.212)

Fig. 5. Normal Probability Plot of Normalized Drag Force(=Drag force/Average of Drag Force)

4. Conclusions

The DFBG was newly designed to retain the fuel rod so that the debris passable size could remain stable for anti-debris ability. In this study, the effect of DFBG's louver has been discussed through the single rod drag test to evaluate the additional drag force.

The difference of drag force was estimated by the two-sample t-test method using Minitab. The Two-sample t-test is a statistical method to detect difference between the two population means. The two-sample t-test results of single rod drag test showed that the percentage increment of the drag force is between 42.2% and 59.6%, which is a 95% confidence interval.

Based on the results of the test, it is concluded that the interaction between louver and fuel rod groove increases the drag force, and the figures of louver and groove used in the test will be a good guide line for optimizing drag force.

Acknowledgement

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REFERENCES

[1] Ryan, Joiner and Cryer, Minitab Handbook, 5th Ed., Chapter 9, Thomson brooks/cole, 2005.

[2] William Mendenhall and Terry Sincich, Statistics for engineering and the sciences, 4th Ed., Chapter 8, Prentice-Hall International, Inc., 1995.