# Characterization Test of the Optimized H Type Grid Spring under the In-grid Boundary Condition

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## 1.Introduction

This paper is dealing with the simplified method for the characterization test. In reality, the spring should be tested with the test specimen of spacer grid assembly itself (assembly-based test). But the available space for loading is very small due to the dimples and the spring of the adjacent straps, much care should be necessary in conducting the assembly-based test. Test results are compared with the previous test results [1] for checking the usability of the assembly-based test.

## 2.CharacterizationTest

### *2.1 Spring Specimen*

The springs for the characterization test are made of Zircaloy-4. The optimized H type grid spring is tested, which is shown in Fig. 1. On the other hand, the outer spring for the outer strap and the inner spring for the inner strap were consisted. So, the length of spring B is shorter than A to accommodate the dimples. The widths and length of spring B is differentiated with spring A. The difference of the width between the springs of the inner and outer straps is regarded as negligible compared with that of the length. Two types of characterization test are conducted such as the strap-based test and the assembly-based test. The specimen for the assembly-based test is a whole spacer grid assembly and that of the strap-based test is the spring with the strap cut from the grid assembly as shown in Fig. 1 [2].

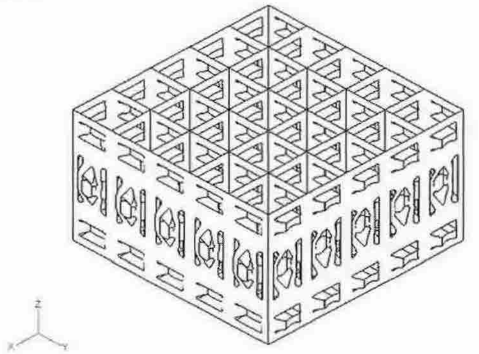

Fig. 1 Schematic diagram of the 5×5 cell Optimized H type spacer grid.

### *2.2 Apparatus*

Universal tensile testing machine (UTM) is used for applying the compression on the spring [3]. Data acquisition system and a personal computer are used for logging the load and the displacement on line. For the strap-based test, the fixture for the specimen and the loading bar are specially designed. The fixture clamps both side edges of the strap specimen, and the loading bar is inserted into the fixture and presses the spring. The loading bar has the cylindrical shape, which is simulated the actual fuel rod [4].

For the assembly-based test, a different fixture and loading bar are designed. The fixture clamps four outer surfaces of the grid assembly and put on the lower crosshead. The loading bar passes through a specified test location (cell) of the grid assembly and presses the spring. And the four circumferential rod cells are inserted with each fuel rod of 100mm length. Fig. 2 presents the test setup for the assembly-based test.

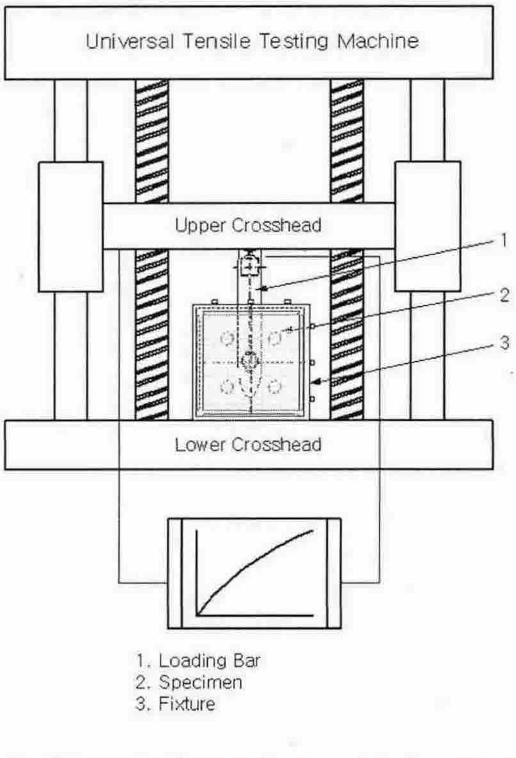


Fig. 2 Schematic diagram for assembly-based test.

### 2.3 Test Condition

The characterization test (i.e., the assembly-based test) is conducted in room temperature condition. Crosshead speed is set to be 0.5 mm/min for this test. Sampling rate is five points per second. Five specimens of the assembly-based test are tested repeatedly for one displacement value.

### 2.4 Characterization Test Results

Typical results of the characterization tests are given in Fig. 3, which are the results of the spring and dimple, respectively. In Fig. 3, the plots of the assembly-based test are averaged from five specimens at each displacement. For comparing the results of the strap-based test with those of the assembly-based test, the plots are overlapped. Each averaged plot of the strap-based test shows the scatter of the data at several specified displacements with so called error bars. At a glance, the test results show almost the same. The range of the data scatter enables us to reach a conclusion that the assembly-based test, which provides an easier and time saving method for obtaining the characteristic curves.

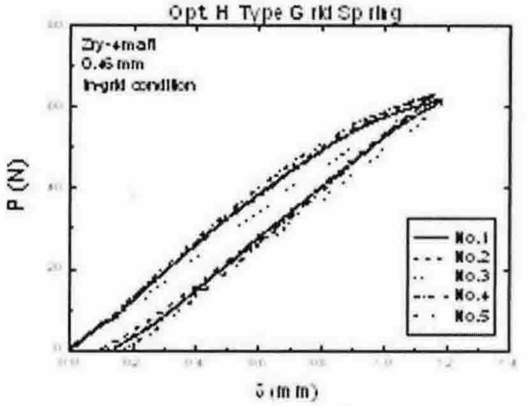


Fig. 3 Characteristic curve of the Optimized H type 16×16 cell grid spring by characterization Test.

For the spring characteristics satisfying the foregoing proposed design requirements, the stiffness of the spring is selected as a performance evaluation. The stiffness is computed by the ratio of the reaction force developed at the final load step and the prescribed displacement. The linear range of the stiffness is also selected as a performance measure. The stiffness is related to the maximum stress in a model with nonlinear material property. The average stiffness of the opt. H type grid spring is 64.1 N/mm, and the maximum load is about 62 N. In addition to these, the plastic set is about 0.11 mm after 1.2 mm loading. These results much differentiated compared to the strap-based test.

## 3. ComparisonandDiscussion

## 4.

The characterization test results by the present method were compared with that of the previous results [1]. It has a little differentiated about 3.2 %, which were summarized in Table 1. The characteristic behavior of assembly-based condition has nearly linear curve till 1.0mm displacement in this method. Above discrepancy was caused by test error of the mechanical properties of the loading bar material.

Table 1 Comparison of the test results with Ref. [1]

| Average stiffness | | | |
|---|---|---|---|
| Inner spring (N/mm) | | Outer spring (N/mm) | |
| present | Ref. [1] | present | Ref. [1] |
| 98.8 | 98.4 | 161.6 | 156.6 |

## 5. ConcludingRemarks

## 6.

A assembly-based test method for characterizing the spacer grid spring is studied to satisfy the intrinsic boundary condition of the grid assembly. Consequently, the developed test method for obtaining the characteristic curve under the in-grid boundary condition is verified. Therefore, the present assembly-based characterization test can be adopted as a simplified test method under the in-grid boundary condition.

## Acknowledgement

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## References

[1] K. T. Kim et al., Development of Advanced Nuclear Fuel for Korea Standard Nuclear Plants, (2002).

[2] K. H. Yoon et al., Spacer Grid for Nuclear Reactor Fuel Assemblies with Grid Springs Maintaining Conformal Contact with Fuel Rods and Enlarged Elastic Range, US Patent No. 6707872, (2004).

[3] W. G. Kim and D. W. Kim, Tensile Test Procedure of INSTRON 4505, NMTD-RI&DB-TECHMEMO001/1999, Rev. 00, (1999).

[4] K. H. Yoon et al., Analysis of the Optimized H Type Grid Spring by Characterization Test and Finite Element Method under the In-grid Boundary Condition, KSME 04MF26, (2004).