*Transactions of the Korean Nuclear Society Spring Meeting*
*PyeongChang, Korea, October 30-31, 2008*

# Design Variables that Affect the Crush Strength of a PWR Spacer Grid Assembly

Keenam Song [a*], S-B Lee [b], J-J Lee[c], and G-J Park[c]
[a]*Korea Atomic Energy Research Institute, P.O.BOX 105 Yusong, Taejon, KOREA*
[b]*University of Maryland, USA*
[c]*Hanyang University, KOREA*

[*]*Corresponding author: knsong@kaeri.re.kr*

## 1. Introduction

A fuel assembly in a Pressurized light Water Reactor (PWR) consists of spacer grids, fuel rods, a top nozzle, a bottom nozzle, guide tubes, and an instrumentation tube. Among them the spacer grid is one of the most important structural components in a PWR fuel assembly. The spacer grid, which supports the nuclear fuel rods laterally and vertically with a friction grip, is an interconnected array of slotted grid straps welded at the intersections to form an egg-crate structure as shown in Fig. 1. Dimples and springs are embedded into each grid strap to support the fuel rods. Zircaloy is prevailing as the material for a spacer grid because of its low neutron absorption characteristic and its extensive successful in-reactor use. The primary considerations are to provide a Zircaloy spacer grid with a crush strength sufficient to resist design basis loads, without significantly increasing the pressure drop across a reactor core. In this study, some design variables that effect the crush strength of a PWR spacer grid assembly are classified and their effects on the crush strength are investigated by a finite element analysis and a crush strength test.

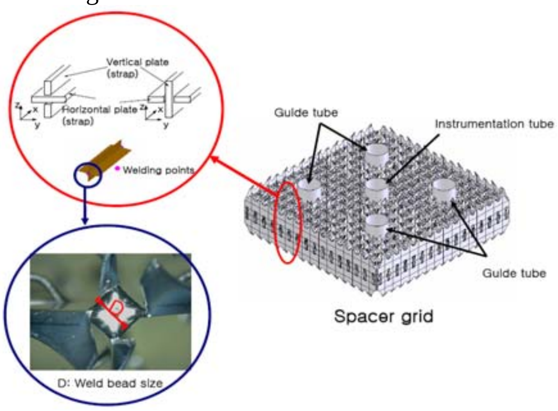


Fig. 1. Spacer grid

## 2. Classification of the Design Variables

### *2.1 Strap Thickness*

A grid strap's thickness has generally been considered as one of the main design variables in order to regulate the crush strength. Figure 2 shows the relations between a grid strap's thickness and crush strength, where the crush strength has a cubic relationship with a grid strap's thickness. However, this design variable for a spacer grid assembly is very closely related with the pressure drop of a coolant, its application to a spacer grid design is significantly restrictive.

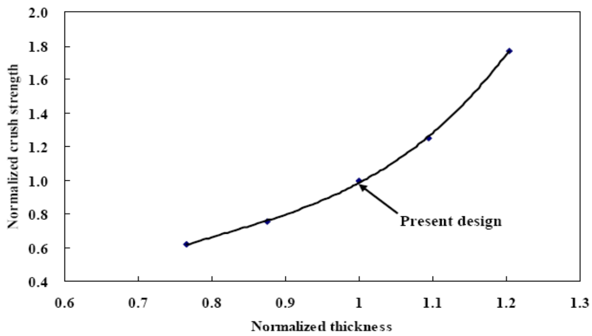


Fig. 2. Crush strength vs. strap thickness

### *2.2 Strap Height*

A total grid strap's height has generally been considered as one of the main design variables in order to regulate the crush strength. However, this design variable for a spacer grid assembly is also very closely related with the pressure drop of a coolant, its application to a spacer grid design is significantly restrictive. So, it could be very helpful for designing a spacer grid assembly, if a new design variable is deduced without affecting the pressure drop of a coolant, so much.

### *2.3 Increase the Weld Line Length*

The crush strength of a spacer grid assembly is strongly related to the buckling strength of the spacer grid straps constituting the spacer grid assembly. Based on the fact that the critical load ($P_{cr}$) is proportional to the moment of inertia ($I$), $P_{cr}$ can be enlarged by increasing the plate thickness ($t$) and the effective height ($B_e$) of a strap as shown in Fig. 3 and Eq. 1. $B_e$ refers to the part in a strap where a load passes, which is smaller than the height of a strap ($B_1+G+B_2$).

$$p_{cr} \propto \frac{EI}{L^2} \propto B_e \bullet t^3 \qquad (1)$$

Fig. 3 shows a simple case where there are no dimples and springs, and we can improve $P_{cr}$ by increasing $B_e$ or reducing the slit (gap) length ($G$). Therefore, increasing the effective height including the weld line length by maintaining the total height of the grid straps, could increase the bucking strength of the grid straps, consequently, also the crush strength of the spacer grid assembly without increasing the pressure drop of a coolant.

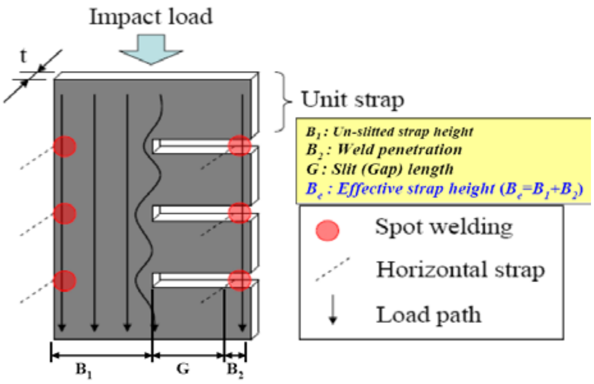


Fig. 3. Effective height for a grid strap

Figs. 4 and 5 show the results from a finite element analysis and a test for a crush strength enhancement with a larger effective height by increasing the weld line length.

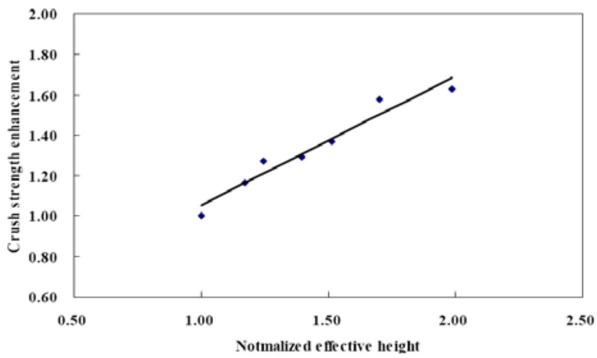


Fig. 4. Crush strength enhancement vs. effective height from a finite element analysis

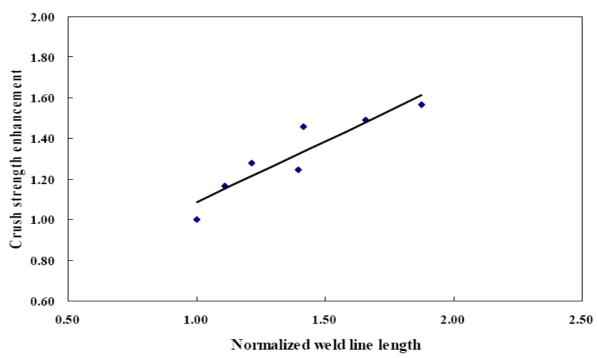


Fig. 5. Crush strength enhancement vs. effective height from a crush strength test

*2.4 Optimization of Dimple Location*

Recently, it was reported that a dimple location is also a design variable that effects the crush strength of a spacer grid assembly [1, 2]. Figure 4 shows the design variables for an optimization of a dimple location, where the spring length and the total height of a grid strap maintain constant values. The crush strength enhancement of a spacer grid assembly was reported in Ref. [3, 4].

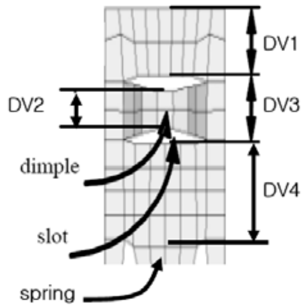


Fig. 4. Design variables for optimization of dimple location

## 3. Conclusions

Design variables to effect the crush strength of a spacer grid assembly were classified and their effects were investigated by a finite element analysis and a crush strength test. Among the design variables, an increase of the weld line length and a relocation of a dimple position are better ways to enhance the crush strength of a spacer grid assembly without significantly increasing the pressure drop of a coolant.

**Acknowledgements**

This project has been carried out under the nuclear R & D program by MEST (Ministry of Education, Science and Technology in Republic of Korea).

## REFERENCES

[1] H. A. Lee, C. K. Kim, K. N Song, and G. J. Park., Design of a Nuclear Fuel Spacer Grid Considering Impact and Wear, Trans. of KSME, 31(10), 2007.
[2] S. H. Lee, J. Y. Kim, and K. N. Song., Design Improvement of an OPT-H Type Nuclear Fuel Rod Support Grid by Using an Axiomatic Design and an Optimization, J. of Mech. Sci. and Tech., Vol. 21, 2007.
[3] S. B. Lee and K. N. Song., Suggestions to Enhance the Crush Strength of a LWR Spacer Grid Assembly, Trans. of the KNS Spring Meetings, Gyeongju, Korea, May 29-30, 2008.