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Suggestions to Enhance the Crush Strength of a LWR Spacer Grid Assembly

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1. Introduction

A spacer grid is one of the most important structural components in a LWR fuel assembly. The spacer grid, which supports 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 stamped 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 the reactor core. A Zircaloy grid strap's thickness and height have generally been considered as the main design variables in order to meet the above considerations. However, since the above design variables for a spacer grid assembly are very closely related with the pressure drop of a coolant, their application to a spacer grid design is significantly restrictive. Therefore, it could be very helpful for designing a spacer grid assembly, if new design variables are deduced without affecting the pressure drop of a coolant so much. In this study, new design variables to enhance the crush strength of a spacer grid assembly are deduced and their validity is confirmed by applying them to a spacer grid design and performing a crush strength test and a finite element analysis.

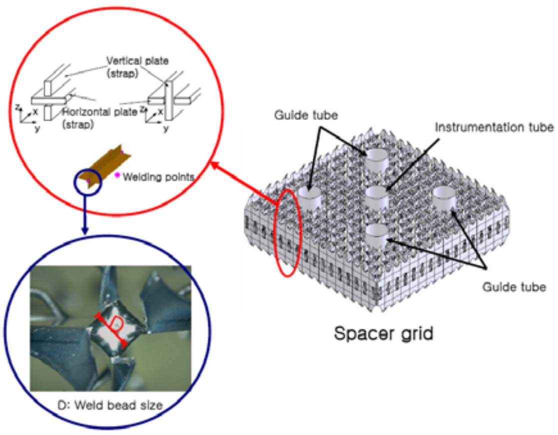

Fig. 1. Spacer grid

2. New Design Variables

2.1 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 the strap as shown in Fig. 2. Increasing both the plate thickness and the total height (B_t) of the grid straps are not the best schemes to enhance the crush strength because it will increase the pressure drop of the coolant significantly. 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 the coolant. As shown in Fig. 2, effective height (B_e) refers a substantial part in a strap where a load passes.

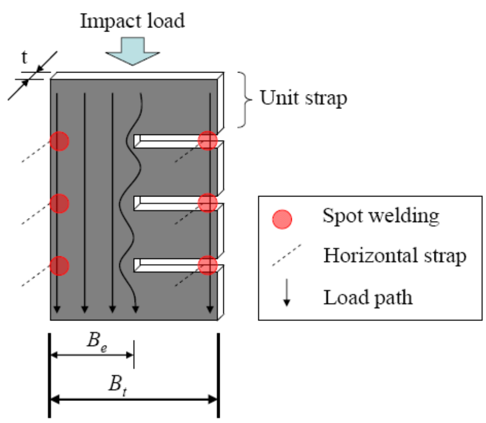

Fig. 2. Effective height for a grid strap

2.2 Optimization of Dimple Location

Recently, it was reported that a dimple location is also a design variable that affects the crush strength of a spacer grid assembly [1, 2]. Fig. 3 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.

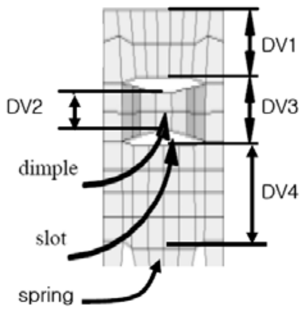

Fig. 3. Design variables for optimization of dimple location

3. Confirmation Results

3.1 Increase the Weld Line Length

We carried out a crush strength test on several spacer grid specimens with different weld line lengths. Figs. 4 and 5 show the test results for the 7x7 sub-sized spacer grid specimens and the 16x16 full-arrayed spacer grid specimens, respectively. Enhancement of the crush strength with an increase of the effective height of the grid straps can be confirmed from Figs. 4 and 5.

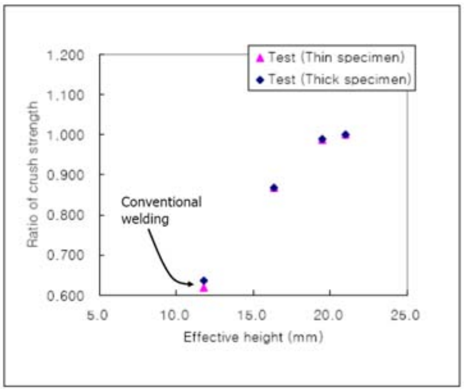

Fig. 4. Enhancement of the crush strength vs. the effective height for the 7x7 sub-sized spacer grid specimens

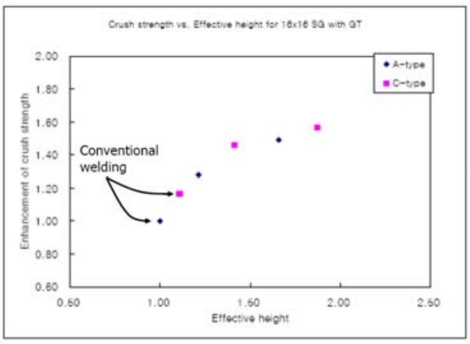

Fig. 5. Enhancement of the crush strength vs. the effective height for the 16x16 full-arrayed spacer grid specimens

3.2 Optimization of Dimple Location

We carried out a crush strength analysis on several spacer grid specimens with different dimple locations. Fig. 6 shows the analysis results for the 3x3 sub-sized analysis model. Enhancement of the crush strength is also confirmed from Fig. 6.

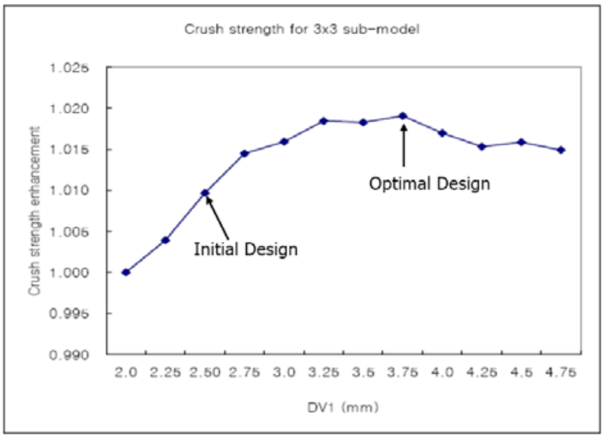

Fig. 6. Enhancement of crush strength vs. dimple location for 3x3 sub-sized analysis model

4. Conclusion

Two new design variables to enhance the crush strength of a spacer grid assembly were deduced without increasing the pressure drop of the coolant significantly. These new design variables are as follows; first, an increase of the weld line length; second a relocation of a dimple position.

Acknowledgements

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REFERENCES

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[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.