Comparison of a Impact Characterization of a Spacer Grid by using the Cross Spot Welding and Through Grid Welding Methods

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1. Introduction

KAERI has devised 16 kinds of spacer grid shapes and has designed/manufactured unique spacer grid models since 1997, i.e. one is the spacer grid with an optimized H-shaped spring[1] and the other is a doublet-type spacer grid[2] that are assumed to be the most powerful candidates for the spacer grid of the next generation nuclear fuel assembly. To evaluate the performance of the newly devised space grids, KAERI has conducted a number of experiments such as a spring characterization test, vibration characterization test, fretting wear test, impact test, etc.

The spacer grid has an important function of preventing a lateral impact force by a seismic and LOCA blowdown and maintaining the fuel rod space under accidental and operational loading conditions. General roles of the spacer grid assembly are providing a lateral and vertical support for the fuel rods, promoting the mixing of the coolant and keeping the guide tubes straight so as not to impede a control rod insertion under any normal or accidental conditions. To evaluate the impact characteristics of a SG such as the impact velocity, critical strength and duration time, a number of impact tests for the KAERI designed/ manufactured SGs have been conducted. The measured critical strength has to be bigger than the severe condition, i.e. 0.3g (4500lb≒20,000N).

The SG consists of inner straps to support the fuel rods and outer straps to cover them.[3] The inner straps are composed of horizontal straps and vertical straps, which are crossed to form an egg crate-like structure. Usually, to form the unit strap, a spot laser welding at two cross points(cross spot welding method) is used as illustrated figure 1.

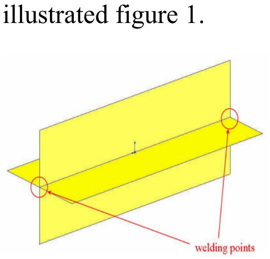

Figure 1 Cross spot welding

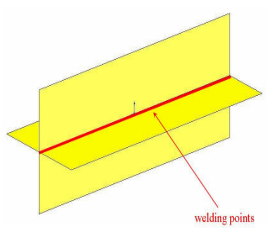

Figure 2 Through welding

In this work, a new welding method is proposed to form the unit strap. The dynamic impact parameters of a grid structure such as the critical impact acceleration, impact force and buckling mode, etc., are increased by using the proposed welding method(through grid welding method) without any design change or material change. In this paper, the characteristics and the method of a through grid welding are described in detail and the impact test results by using each welding method are carefully compared and discussed.

2. Through grid welding method

Through grid welding is the method which welds through the four intersection lines of a horizontal strap and a vertical strap shown in figure 2. Although this method(through grid welding) takes more time than pre-selected method(cross spot welding) because all the four intersection lines except for a few center zones are welded. It can be reduced by minimizing the welding zone which satisfies a severe condition.

3. The Pendulum impact test

A pendulum type shock machine, as shown in figure 3, is used to perform the impact test of the spacer grid structure.[4] It is intended to simulate the type of load and impact velocities anticipated under a seismic disturbance. This shock machine is composed of a structural body, impact hammer, and a data acquisition system. The impact hammer consists of a sphere type impact tip for a dynamic loading, three sensors for gathering the dynamic data, which are two force transducers and one accelerometer. The impact hammer moves with the guidance of the four guide rods. An angular transducer is attached at the hinge point located at the end of one guide rod. This is for detecting the initial angle of the hammer and continuous data on the angle of it. The impact hammer is made of mild steel, in which its mass corresponds to the mass of one span of the nuclear fuel assembly and the length of a guide rod matches the length of one span. For example, in the case of a 16by16 fuel assembly SG, the mass of hammer is 90kg and the length of one span is 540mm. The furnace is for the impact testing under room temperature and that a high temperature condition, which corresponds to the operating temperature in the core. This furnace is able to ascend the operating temperature of the core. The grids are rigidly clamped to the holding plate which is also placed by a clamping fixture in the furnace. The grids are fixed to the holding fixture by two screws. The impact hammer is held by a magnetic holder and releases the hammer as a release signal on the controller is activated. If some grid cells experience a local buckling, the duration time is longer than that before the buckling state. This means that the stiffness of the grid structure after a buckling is much smaller than that before the buckling phenomena.[5]

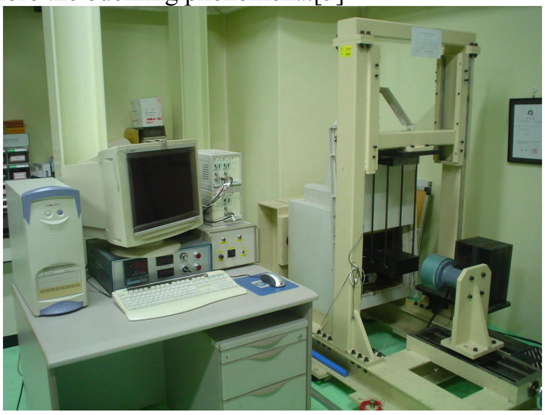

Figure 3 Pendulum impact test device

4. Experiment specimens

The test specimen has a 7by7 cell grid structure with optimized H type grid springs. The impact test of the grid structure is established with the same 8 specimens by each welding method i.e. total 16ea, due to the unevenness of the specimen, and a non-linearity of the test condition. This specimen is made of Zircaloy-4 with a 0.46mm thick inner strap, and a 0.67mm thick outer strap. The pendulum impact test has been conducted with a initial velocity of 201mm/sec.

5. Experiment Results

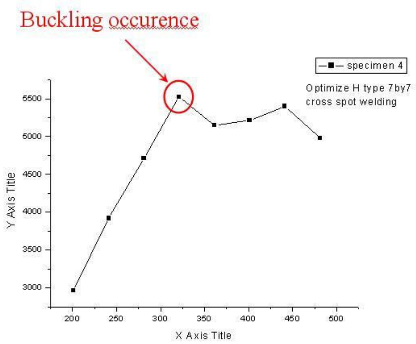

Figure 4 Initial velocity vs. impact force of 7by7 with cross spot welding

Figure 4 is the dynamic impact characterization curves for specimen 4 by using a cross spot welding. The impact force continually increases until a buckling of a grid cell occurs. A local buckling only occurs at the point where the impact force decreases. A local buckling usually occurs around the upper and lower cells of the grid.

The test results demonstrated that the critical impact force ranged between 4547.99 and 6141.91N in the case of a cross welding, between 7119.51 and 9287.24N in the case of a through welding. The test results are summarized in Table 1.

Table 1 Impact test results of optimized H type 7by7

	Critical buckling load(N)	
specimen	cross welding	through welding
1	5377.85	9287.24
2	5086.02	9265.99
3	5648.82	7162.02
4	5523.76	6694.47
5	6141.91	6992.00
6	5674.36	7140.76
7	5185.55	7140.76
8	4547.99	7119.51
average	5398.28	7600.34

6. Conclusion

The impact tests of optimized H type 7by7 spacer grids by using two kinds of welding methods were conducted. The comparisons of the results show that

1. The critical buckling load of a SG welded the through intersection line is increased by about 40.8% more than the cross spot welding method.
2. The critical impact load becomes higher without any design change or material change.
3. The welding time can be reduced by optimizing the through welding zone for satisfying the severe condition.

ACKNOWLEDGEMENTS

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