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Comparison of Strains Measured on Spacer Grid and Fuel Rod Caused by External Load

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1. Introduction

The Korea Atomic Energy Research Institute have been evaluated the integrity and retrievability of fuel for transportation and long-term dry storage of spent nuclear fuel. Spacer grid (SG) is one of the structural parts of the fuel assembly. The SG must be enough strong to protect the fuel rod from external loads issued by earthquake and transportation. To evaluate the integrity of the SG, pendulum type impact tests have been performed. Conventionally, the studies were focused on the behavior of a SG, not the fuel rods. However, the behavior of the fuel rods are also as important as the plates. Therefore, in this study, the pendulum type impact test of the SG was performed. The strain data at the plate of the SG and the fuel rod were obtained and compared.

2. Method and Results

2.1. Pendulum type impact tester

Fig. 1 shows the schematic drawing of the pendulum type impact tester. The impact hammer was fixed and rotated by the motor. The specimen was fixed with a force of 15.7 kgf using air pressure.

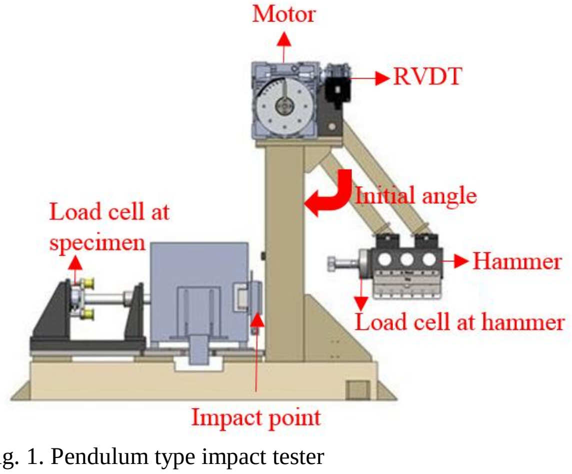

Fig. 1. Pendulum type impact tester

2.2. Specimen

A test specimen was 14OFA spacer grid fabricated with Zircaloy-4 material as shown in Fig. 2 (a). The fuel rods were inserted into every fuel rod slots at a SG as shown in Fig. 2 (b).

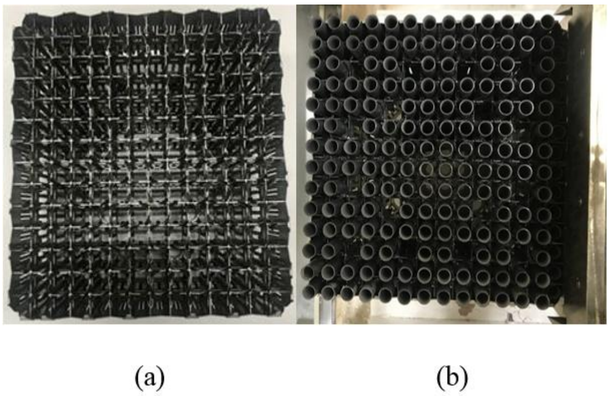

Fig. 2. Photograph of a 14OFA Space Grid (a) and SG with Fuel Rods (b)

2.3 Test conditions for impact test of SG

As shown in Fig. 3 unidirectional strain gauges were attached to the plates and the fuel rods of a SG at front, middle and bottom position, respectively. The strain gauges attached to the plates are located at same elevation as hammer`s impact point. But the strain gauges attached to the fuel rods are located at the upper elevation as hammer`s impact point due to avoiding the interference of springs and dimples. The resistance of the strain gage is 120 ohms and the gauge factor is 2.0. By controlling initial angle as shown in Fig. 1, impact energies transmitted to the plate and rod could be controlled. The length of the arm is about 0.88 m and the mass of the hammer is about 38 kg. The initial angle of the hammer was 9 ˚ and it was increased by 2 ˚ until 31 ˚.

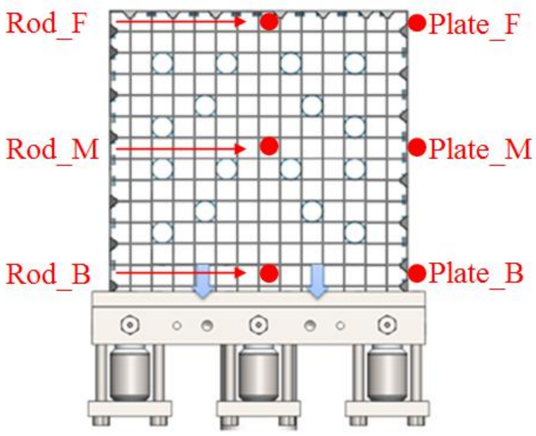

Fig. 3. Positions of strain gauges

2.4 Test results

The impact test data are summarized in table 1. The maximum impact forces of the hammer and specimen are 33.762 kN and 36.554 kN at the 27 and 29 degrees, respectively.

Table. 1. Impact test result

Angle (deg.)	Impact force		Impact energy
	Hammer (kN)	Specimen (kN)	(J)
9	10,452	13,217	4.14
13	15,384	19,169	8.62
17	19,656	25,057	14.69
21	20,600	25,973	22.34
25	31,765	33,980	31.51
27	33,762	34,129	36.66
29	33,583	36,555	42.17
31	27,862	30,812	48.03

The maximum strain results of the plates and fuel rods are shown in Fig 4 and Fig 5. After initial angle is 25 ˚ , strains on Plate_M and Rod_M are suddenly increased. It seems that buckling has occurred in this angle.

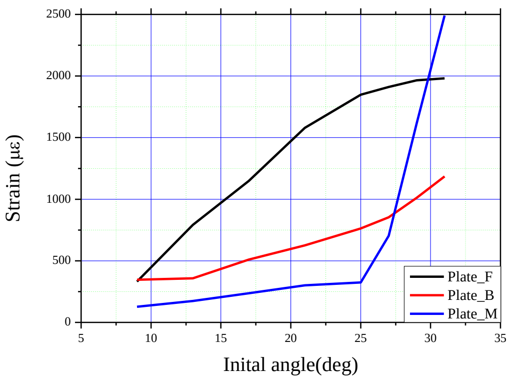

Fig. 4. Maximum strain results of plates according to initial angles

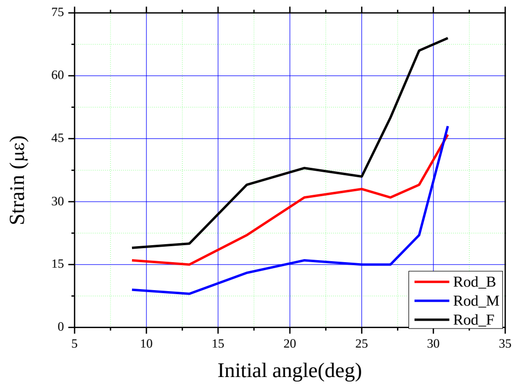

Fig. 5. Maximum strain results of rods according to initial angles

Table. 2 shows the measured strain data at the middle position. Also, it shows the strain ratio of rod to plate according to various initial angles. Through these results, it is considered that most of the external impact load was absorbed by SG, because the impact force acting on the fuel rods was very small.

Table. 2 Strain ratio of rod to plate with different angles at middle position

Angle (deg.)	Plate_M (με)	Rod_M (με)	Rod/Plate (%)
9	146	10	6.849315
13	204	16	7.843137
17	267	20	7.490637
19	301	19	6.312292
21	404	48	11.88119
23	325	15	4.615385
25	703	15	2.133713
27	1614	22	1.363073
29	2491	48	1.926937
31	4302	58	1.34821

3. Conclusion

A pendulum impact test was carried out to evaluate integrity of the SG and fuel rod during impact. It seems that rod received only an impact force about average 6% of plate. After buckling it lessens average 2%. It seems that SG absorbed more energy after buckling.

For the future work, various impact tests with more fuel rods attached strain gauge in a column will be conducted. To do this, the strain gauge will be attached inside the fuel rod on the same elevation as hammer`s impact point.

ACKNOWLEDGEMENTS

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