Proficiency Testing Schemes of a Fuel Assembly Performance Method by Comparing of Measurement Results of Two Tester

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1. Introduction

The purpose of this work is to establish the proficiency testing schemes of a fuel assembly for non-standard test method case. As the nuclear regulatory guide [1], "the testing and inspections to be performed to verify the design characteristics of the fuel system components, including clad integrity, dimensions, fuel enrichment, burnable poison concentration, absorber composition, and characteristics of the fuel, absorber, and poison pellets, should be described. ~". In this guide, the fuel assembly test method is as that, the lateral and axial stiffness, lateral vibration, lateral and axial impact and the rotational stiffness test [1]. These method cases are very important for the license service and providing some input data for the accident analysis model of FA. Therefore, all of these tests have to be executed as the authorized standard, for example, Korea Laboratory Accreditation Scheme (KOLAS) [2]. Unfortunately, the performance tests of a FA did not certified by the KOLAS.

In order to receive the authorized test scheme, the proficiency testing schemes is most important item. For non-standard test case, the most of these tests be normally executed through the inter-laboratory comparisons [3]. However, there is no standard, no certified reference material (CRM) for pressurized water reactor (PWR) fuel assembly. In this case, the most important point is that how to verify the validity of the performance test method of a fuel. Therefore, the inter-personnel testing scheme is proposed for this.

For the proficiency testing of a fuel assembly performance test, the lateral bending test of a fuel assembly (FA) is executed using FAMeCT. The FAMeCT is a tester of a versatile function for a mechanical characterization of an actual size FA.

Because of the absence of the CRM, the t-test method was selected. Null and alternative hypotheses were assumed and then t-value was evaluated as these hypotheses.

2. Fuel assembly bending test

The lateral bending test of a fuel assembly was executed using FAMeCT as shown in Fig. 1.

The static displacements were applied by screw jack at the 6[th] grid position [4 & 5]. The maximum displacement and increment value was 40 mm and 2 mm, respectively. At the opposite side of the loading point, two linear transducers were mounted for measuring. All sensors for measurement were calibrated at the national calibration laboratory at every other year cycle.

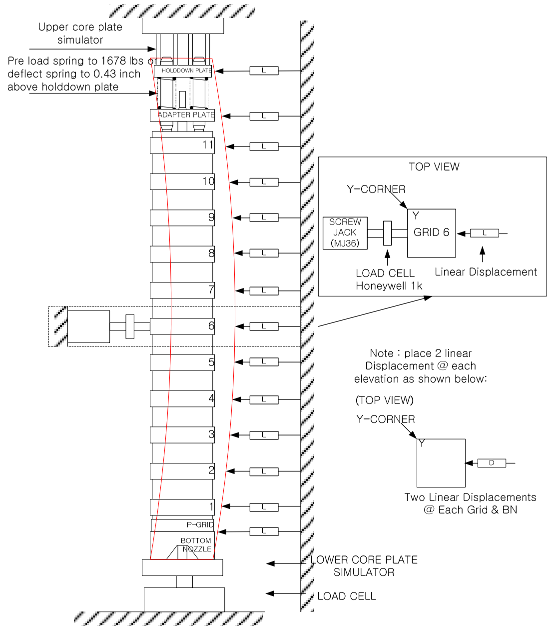

Fig.1 Schematic drawing for the lateral bending test using FAMeCT

Table 1: Bending test results for inter-personnel testing scheme

mm	SG6(mm)-1		SG6(mm)-2	
	1st	2nd	1st	2nd
2	1.91	1.93	1.92	1.93
4	3.86	3.86	3.9	3.92
6	5.82	5.85	5.86	5.88
8	7.78	7.79	7.84	7.88
10	9.74	9.78	9.81	9.85
12	11.68	11.71	11.77	11.83
14	13.65	13.69	13.75	13.79
16	15.63	15.65	15.74	15.78
18	17.58	17.63	17.7	17.74
20	19.53	19.58	19.7	19.75
22	21.51	21.56	21.69	21.72
24	23.46	23.5	23.69	23.73
26	25.45	25.49	25.66	25.72
28	27.39	27.42	27.67	27.7
30	29.37	29.42	29.66	29.7
32	31.33	31.35	31.66	31.71
34	33.3	33.36	33.62	33.66
36	35.25	35.3	35.63	35.67
38	37.23	37.29	37.61	37.63
40	39.2	39.22	39.6	39.63

The lateral displacements from the linear transducer are summarized in Table 1. And these measured data from static lateral bending test are compared in Fig. 2. The characteristic of this test show that the applied lateral displacement by screw jack is larger, and the accumulative deviation from linear sensor is larger. The maximum deviations occurred at the largest displacement and the range showed about 0.4 to 0.8 mm from two testers. Therefore, the statistical procedure for the proficiency testing is advisable thing for 40 mm applied case.

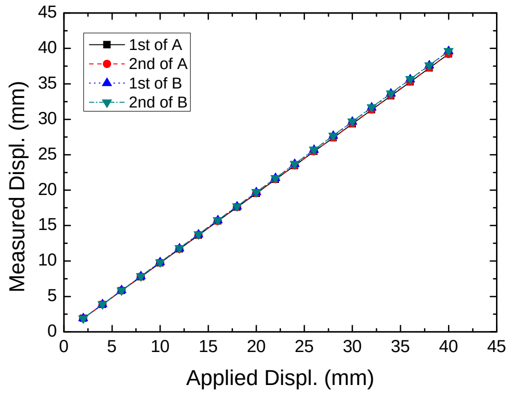

Fig.2 Comparison of the measured data from tester A and B

3. z tests and confidence intervals

Here this method to problem situations involving the means, of two different population distributions. Test hypotheses about difference between true average breaking strengths of two different types of two testers. One such hypothesis would state that $\mu_1 - \mu_2 = 0$; that is, that $\mu_1 = \mu_2$. Alternatively, it may be appropriate to estimate $\mu_1 - \mu_2$ by computing a 95% confidence interval. The average of tester A and B is 39.4 and 39.425 mm, respectively. And the number of tests is two times and the degree of freedom is one. In Table 2, the statistical values for the proficiency testing are computed by Excel program and summarized.

Table 2: t-value for two population variances from the lateral bending test

	Tester A	Tester B
mean @ max. displacement	39.4	39.425
variance	0.08	0.08405
number of data	2	2
pooled estimator	0.082025	
hypothesis average	0	
degrees of freedom	2	
t-value	-0.08729	
P(T<=t) for one-sided	0.469197	
t rejection region for one sided	2.919986	
P(T<=t) for both sides	0.938394	
t rejection region for both sides	4.302653	

This lateral bending test case, sample size is small and the population variances have unknown values. The resulting two-sample t test and confidence interval, which are not as broadly applicable as are the two-sample z procedures, are based on the following assumptions [6]. Both populations are normal, so that X_1, X_2,…,Xm is a random sample from a normal distribution and so Y_1,…,Y_n. And the values of the two population variances $\boldsymbol{\sigma_1^2}$ and $\boldsymbol{\sigma_2^2}$ are equal, so that their common value can be denoted by $\boldsymbol{\sigma^2}$.

Here, t-value for small population is computed equation (1).

$$\mathbf{t} = \frac{\bar{X}-\mu}{s/\sqrt{n}} \qquad (1)$$

The t-value for 95% confidence level is -0.08729 and the t rejection region for one side and both sides is 2.919986 and 4.302653, respectively. The t-value is less than the rejection region for both cases. So, the null hypothesis is satisfied. Therefore, there is no difference between two personnel tester.

Of course, the both sides value case is reasonable for the lateral bending test.

4. Conclusion

The proficiency testing schemes for KOLAS is proposed. All of the performance tests of a FA are non-standard case. And a representative FA is not certified reference material for inter-laboratory proficiency testing schemes. Therefore, the lateral bending test is executed two times by two personnel tester. Inter-personnel test results are compared and evaluated as statistical procedure for small data case. The mean deviation of two personnel had no shown, so the null and the alternative hypotheses were satisfied. Because of these results, the t-test as a best test was established.

ACKNOWLEDGEMENTS

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REFERENCES

[1] Safety Review Plan for Nuclear Power Plants, KINS Document, Rev. 2, 1999.
[2] Guidelines for the Proficiency Testing, KOLAS Document No. KOLAS-R-003, 2007.
[3] Introducing the Concept of Uncertainty of Measurement in Testing in Association with the Application of the Standard, ISO/IEC 17025, 2002.
[4] Fuel Assembly Bending Test, KNFC Document No. MDR-PT-07001, 2007.
[5] Test Manual, KAERI Document No. TCI-LF-01, 2006.
[6] Jay L. Devore, Probability and Statistics for Engineering and the Sciences, 3rd ed., Duxbury Press, 1990.