Development and operation of curriculum for evaluation of material aging in nuclear components

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***Keywords :** material aging, nuclear components, nuclear manpower, practical education, curriculum, evaluation,*

1. Introduction

The utilization rate and operating rate of domestic nuclear power plants began to decline in 2017, the beginning of the nuclear power plant policy, and in 2018, they were at their lowest levels at 65.9% and 66.5%. But they continued to increase from 2019 to 81.6% and 81.1% in 2022, and the emergency index per nuclear power plant decreased from 0.23 in 2021 to 0.16 in 2022[1].

Nuclear power generation has 1 billion won/day of shutdown loss due to failure and stop, so the reduction of failure and stop time can greatly contribute to reducing sales decline. According to the analysis of the contribution of the research sector to the increase in sales from 2010 to 2015, 71% of nuclear materials research, 20% of safety research, and 9% of convergence research were found[2].

Since mechanical defects during the operation of nuclear power plants are due to various material deterioration phenomena, it is necessary to continuously train experts in the field of evaluation of material aging in nuclear components to operate domestic and foreign nuclear facilities more safely and efficiently.

This study attempted to find ways to improve by analyzing the results of the post-educational survey of the evaluation of material aging in nuclear components curriculum developed and ran on a trial basis in 2019 and operated in 2023 by partially supplementing the educational content.

2. Methods

We formed a team of experts in Material Safety Technology Research Division, Post Irradiation Examination Division and Hanaro Utilization Divisionthe at Korea Atomic Energy Research Institute and developed a curriculum for evaluation of material aging in nuclear components and established detailed learning plans. We sent e-mail to 15 universities with nuclear engineering majors to recruit students as well as announcing them on the website of Nuclear Education and Training Center. We selected 22 graduate and undergraduate students to provide education.

A questionnaire was distributed to students who completed education to investigate their expectations for education, overall curriculum, instructors overall, learning achievement by subject, instructors and lecture contents, textbooks, learning methods, satisfaction with the educational environment, and opinions on good points and improvements, and the results of the survey were summarized and analyzed.

3. Results and Discussion

The evaluation of material aging in nuclear components consisted a five-day course of 10 theoretical education subjects, 9 practical education subjects, 2 technical tours, orientation, and education satisfaction survey.

10 theoretical education subjects are Codes and standards on aging degradation in nuclear component materials, Theory of positron annihilation spectroscopy, Stress corrosion cracking under high temperature water environment in NPP, Radiation effects on stress corrosion cracking, Surveillance testing of neutron irradiation embrittlement of nuclear reactor vessel materials, ntegrity assessment of nuclear components based on fracture mechanics, Operational theory of equipments for fracture mechanics testing, Theory of non-destructive examination of nuclear components, Theory of microstructure analysis for irradiated materials and Technology of non-destructive examination. 9 practical education subjects are Practice in positron annihilation spectroscopy, Practice in SCC crack growth rate tests under high temperature water environment, Practice in SCC crack initiation tests for ion-irradiated specimens, Practice in two-phase FAC (flow accelerated corrosion) testing of nuclear pipes, Practice in sludge deposit tests on steam generator tubes, Practice in fracture toughness testing in ductile-brittle transition temperature range (Cv, KJC), Practice in testing and evaluation of ductile fracture toughness (JIC), Practice in microstructure analysis of reactor materials and Practice in non-destructive examination. 2 technical tours consisted of visits of MEF (irradiated materials examination facility) for irradiated materials testing and HANARO research reactor.

Theoretical education was conducted first and then linked practical education was conducted to improve understanding. In order to enhance the effectiveness of practice and experiential education, two groups of 11

students were operated, with 12 graduate students and 10 undergraduates and graduates participating.

The educational satisfaction (out of 5) was 4.6 as shown in Figure 1, and the satisfaction level after education was higher than expected in all items with 4.6 overall education, 4.7 acquisition of new knowledge and skills, 5.0 recommendations to others, 4.9 instructors and lectures, and 4.7 educational environment.

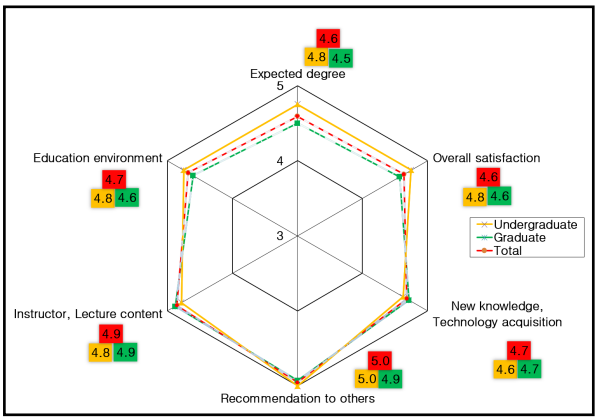

Fig. 1. Comparison of Educational Satisfaction between Graduate and Undergraduate Students

Comparing educational expectations and results satisfaction between graduate students, senior undergraduate students, and graduate groups showed higher expectations, overall education, recommendations to others, and satisfaction with the educational environment, while graduate students were higher in acquiring new knowledge and skills, instructors, and lectures, but overall satisfaction between the two groups was not significant.

The learning achievement (%) felt by trainees before and after practical training was based on a perfect score of 100, and the average score before training was 47 points and 80 points, which was 41%, which was not higher than other courses. I think this is because the percentage of graduate students is higher than that of undergraduate students.

When nuclear materials, which are related to the contents of major education and are difficult to access at school, are deteriorated, the learning process seems to have a higher understanding than other education because they are easy, well-organized, and properly mixed with theoretical learning and practice. Practical training using measuring equipment for evaluating deterioration of nuclear power plants, research materials testing facilities, and research reactor experience training were highly satisfactory to the trainees, and the lively practical experience and career advice of the practitioners were very helpful to the students.

It seems that satisfaction was high because they could see various equipment with their own eyes, hear explanations, and receive questions and answers immediately during the practice process. They learned about the properties of materials for each component of the nuclear power plant and the damage that occurs during operation. They also learned about various inspection methods for safe operation.

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Even without deep knowledge of the overall materials, the course was not very difficult for undergraduate students because the course was not difficult, but there was a difference in basic knowledge between graduate and undergraduate students, so the subjects were further subdivided and some said it would be good.

4. Conclusions

As a result of developing and operating the evaluation of material aging in nuclear components, both learning achievement and education satisfaction were high, indicating that the development and operation of a field-customized nuclear manpower training program were successful. Compared to 2019, when it was piloted, there were more applicants for education, the application for education was completed early. It is an encouraging phenomenon that the recommended items to others showed perfect scores and that more graduate students participated than undergraduate students.

Since the evaluation of material aging in nuclear components is an essential field to reduce the loss of shutdown of nuclear power plants, we plan to continuously provide on-site customized training by analyzing and supplementing the survey results.

Thank-you note

This study was conducted as the Nuclear Safety Research Professional Training Project organized by Ministry of Science and ICT.

REFERENCES

[1] 2023 Current Status and Trends of Nuclear Power Generation in the World, Korea Atomic Energy Industry Conference, 2023

[2] An analysis of industrial application and utilization effect of the nuclear R&D achievement, 83-88, Korea Atomic Energy Research Institute, 2016