A comparison of oxide thickness predictability from the perspective of codes

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1. Introduction

In nuclear safety, it is very important to analyze fuel cladding corrosion resistance and mechanical properties in reactor operating conditions. For the evaluation of corrosion in the irradiated fuel rod, it is generally accepted that PWR fuel rods retain their mechanical integrity during normal operation up to a oxide layer thickness limit 100μm.

In Korea, OPR1000 and Westinghouse type nuclear power plant reactor fuel rods oxide thickness has been evaluated by imported code A. Because of this, there have been multiple constraints in operation and maintenance of fuel rod design system. For this reason, there has been a growing demand to establish an independent fuel rod design system. To meet this goal, KNF has recently developed its own code B for fuel rod design.

The objective of this study is to compare oxide thickness prediction performance between code A and code B and to check the validity of predicting corrosion behaviors of newly developed code B. This study is based on Pool Side Examination (PSE) data for the performance confirmation. For the examination procedures, the oxide thickness measurement methods and equipments of PSE are described in detail.

2. Measurement Methods

PSE is performed in the spent fuel pool during the overhaul period and should usually be completed within the very limited time frame because of the tight overhaul schedule. Therefore, it is essential to have skillful engineers and automated measurement tools to complete the work within the given time. The oxide thickness is measured with ECT (Eddy Current Test) equipment.

The oxide thickness measurements are processed in two phases. In the first phase, oxide thickness is measured for all the most outer rods on the face with the highest burnup distribution among four faces of the fuel assembly over 11 axial positions to acquire axial distribution of cladding oxide thickness [1]. The configuration of the first phase is shown in Fig. 1 [3].

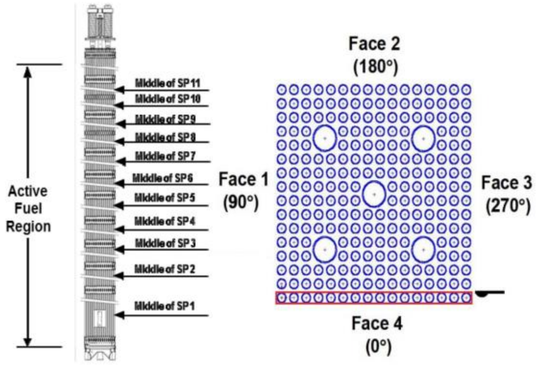

Fig. 1. The measurement of oxide thickness at axial position in fuel assembly

After determining the axial elevation which shows the peak oxide thickness, as a second phase, all targeted rods are measured at that elevation to obtain the maximum oxide thickness. In the second phase, the ECT prove inserts from outer specific face of fuel assembly into the space between the fuel rods at the axial elevation selected from the first phase, 10 mm higher, and 10mm lower than the selected location to secure the averaged value around approximately 1 inch height. Therefore, all the measured data from PSE in this study averaged value around approximately 1 inch height distance. For the more accurate average calculation, it is performed three time to acquire the oxide thickness data for the 360° angle of fuel rod during the second phase. And then, the maximum oxide thickness data are averaged from two position measurements of the fuel rod data [2]. The configuration of the second phase is shown in Fig. 2 [3].

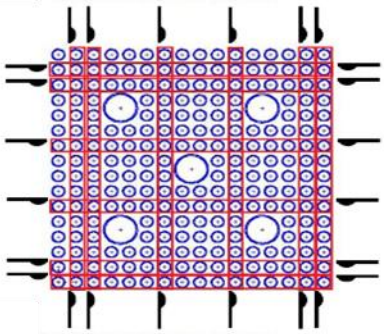

Fig. 2. Sectional drawing of oxide thickness measurement on the surface of fuel assembly by ECT apparatus

3. Comparison between PSE and code evaluation results for oxide thickness.

This study compares the predictability of existing code (code A) with code B regarding oxide thickness values from nuclear power plant A and plant B. In addition, the validities of two different codes in prediction of corrosion behaviors are checked by comparing the predicted results with the measured values from PSE. The comparative results for the measured and evaluated oxide thicknesses of fuel rods are shown in Figure 3.

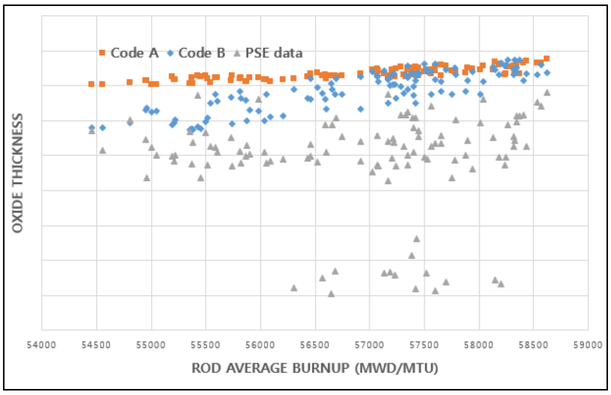

Fig. 3. Comparison of oxide thickness value from measured PSE data and prediction data from code A and code B for nuclear power plant A.

Fig. 3 shows that the measured oxide thickness varies during the normal operation because the heat flux and coolant temperature of the fuel rods vary with a change in rod average burnup. For the evaluation of corrosion in the irradiated fuel rod, it is generally accepted that PWR fuel rods retain their mechanical integrity during normal operation up to oxide layer thickness of 100µm. According to the generally accepted criteria, all the summarized data in Fig.3 are to be met within the criteria. As shown in Fig. 3, the maximum measured oxide thicknesses are found at about under 70µm in case of plant A but the predicted maximum oxide thickness from code A and code B were more than 70µm. It means that the code predictions show more conservative results than the measured. The summarized maximum data for measured and evaluated oxide thicknesses of fuel rods are shown in Fig.4.

The results from the current study is just an interim, but consecutive PSE is scheduled to perform again at plant B for comparison of the oxide thickness for different fuel assembly type. To evaluate corrosion characteristic and conservative prediction value for various cases, it is important to perform further researches on the corrosion mechanism with additional PSE and code confirming processes.

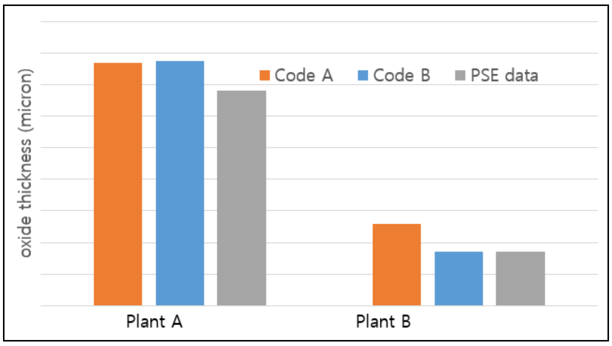

Fig. 4. Maximum oxide thickness data from PSE and codes for plants A and B

4. Conclusions

In this study, code B is confirmed conservatism and validity on evaluating cladding oxide thickness through the comparison with code A. Code prediction values show higher value than measured data from PSE. Throughout this study, the values by code B are evaluated and proved to be valid in a view point of the oxide thickness evaluation.

However, the code B input for prediction has been made by designer's judgment with complex handwork that might be lead to excessive conservative result and ineffective design process with some possibility of errors. Therefore the automatic program is under development for the purpose of efficient, accurate, and standardized PSE evaluation near future.

REFERENCES

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