Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 25-26, 2012

The Fuel Cladding Oxide Measurement at Ulchin Unit 1 Cycle 17

Son Jin-Won, Kim Ki-Young, Bae Seong-Man
Korea Hydro & Nuclear Power Co., Ltd. 1312, Yuseong-daero, Yuseong-Gu, Daejeon, Korea, 305-343
[*]*Corresponding author:moonligh@khnp.co.kr*

1. Introduction

Adding zinc to the reactor coolant system of PWR is performed to reduce ex-core radiation fields and to mitigate primary stress corrosion cracking (PWSCC). The initial work to qualify zinc was performed at Ulchin Unit 1 in Korea. Zinc was added during Cycle 17, and the crud characteristics and cladding corrosion were measured after each cycle. No negative effects were observed from adding zinc.
So, Oxide thickness measurement has been carried out in order to compare the result before and after zinc injection at Ulchin unit 1

2. Examinations and Results

2.1 Oxide Thickness Measurement

The oxide thickness measurement of the fuel rod was taken using the ECT equipment where the ECT sensor moved horizontally between the fuel rod on the outside of the assembly and the 2nd fuel rod. In order to measure oxide thickness of fuel rod, the measurement was taken for the first and second row fuel rods from the outside of the assembly considering the interference with the guide tube and inspection time due to the characteristics of the ECT equipment. Fuel rod oxide thickness was measured in 2 stages. In the 1st stage, the oxide thickness was measured per each span of the grid as in Figure 2-1 for the entire length of the fuel rod for the outside fuel rods of FACE 2 which has maximum burn-up in order to figure out the oxide thickness on the axis direction of fuel rod. In the 2nd stage, the oxide thickness for the fuel rods was measured at the span 6B where the maximum oxide thickness is measured from the results of the oxide thickness measurement according to the axis direction in 1st stage.Table1. LTA Irradiation Data and Information

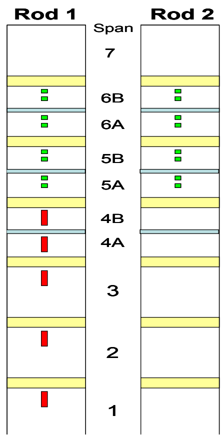

Figure 2-1. Crud Scraping Point per Fuel Span

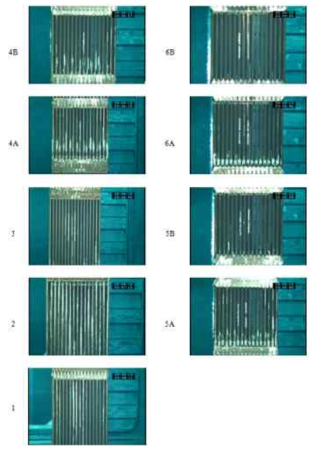

Figure 2-2. V. Inspection of S50 fuel Face 3, 1-6B

2.2 Oxide Measurement Results

2.2.1 Fuel Assembly List for Oxide Measurement

[Table2-1 Fuel Assembly List]

I.D	Assembly Average Burn-up (MWD/MTU)				Cycle	Note
	EOC14	EOC15	EOC16	EOC17		
R26		24,263	44,902		15,16	Compared fuels (non zinc injected fuel)
R56		24,039	44.379		15,16	
Q24	21,909	40,109	54,942		14,15,16	
Q01	22,607	41,918	50,036		14,15,16	
S64			24,702	45,879	16,17	Zinc-injected fuels
S42			24,584	45,586	16,17	
R19		19,919	40,692	48,444	15,16,17	
Q23	21,909	40,109		55,133	14,15,17	

2.2.2. Measurement Results

The average M/P ratio and standard deviation for non zinc injected fuel and zinc-injected fuels were compared, and as the result, the oxide thickness evaluation program conservatively predicts the oxide thickness within the appropriate distribution range. Thus, current oxide thickness evaluation program is available. (Fig. 2-3 and 2-4)

[Table2-2 Fuel Assembly List]

Item	Design Value	Compared Fuels (Non Zinc Injected Fuels)	Zinc-Injected Fuels
Average M/P Ratio[1]	1.00	0.86	0.86
Standard Deviation (σ)	0.62	0.32	0.31

1) M/P Ratio: Measurement Value /Prediction Value Ratio

2.2.3. Evaluation of Zinc Injection Effect

As a result of comparing the oxide thicknesses (OT) of fuels before & after zinc injection, the OT of Q23, S42 & S64 fuels were similar to those of Q24, R56 & R26 fuels that did not experience zinc injection while having similar burn-up history. So, zinc injection is analyzed not affecting the OT of Q23, S42 and S64 fuels.[Fig. 2-3] In the case of R19 fuel, OT was somewhat greater than Q01 fuel that did not experience zinc injection, but showed a tendency of OT similar to Q23 (zinc) and Q24 fuels which are the same thrice burned fuels. Also, R19 fuel showed that the oxide thickness after burning of 16th cycle which is before zinc injection tended to be greater than Q23 fuel of 17th cycle which is after zinc injection as shown in fig. 2-6, but the OT of R19 measured after burning of 17th cycle after zinc injection was similar to the oxide thickness of Q23 measured after zinc injection which is thrice burned fuel. Therefore, zinc injection is analyzed not affecting the oxide thickness of R19 fuel. After all, since the measured values of oxide thicknesses before and after zinc injection consist within the applied limit of design code, zinc injection have no effect of oxide thicknesses to fuels.

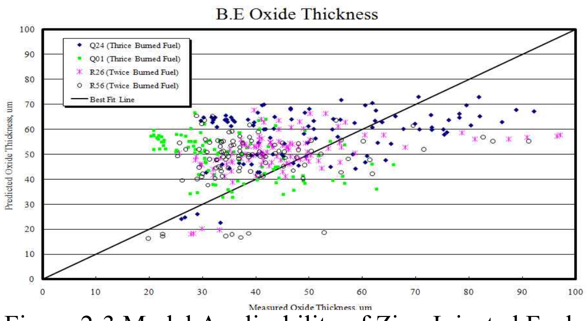

Figure 2-3 Model Applicability of Zinc-Injected Fuel

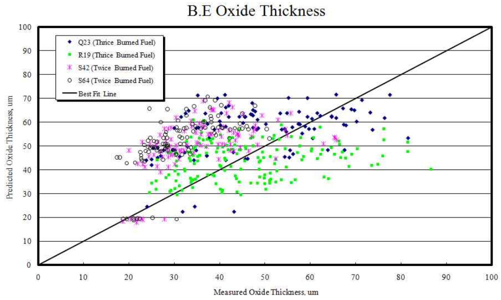

Figure 2-4 Comparison of Oxide Thickness

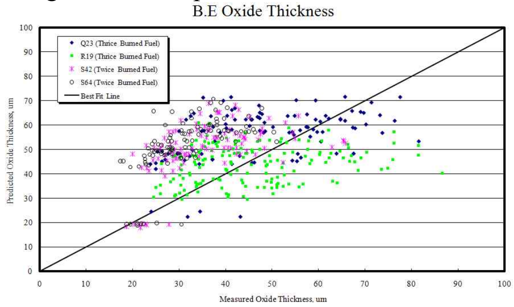

Figure 2-5 O. T. before & after Zinc Injection

3. Conclusions

According to the comparison of M/P ratios and standard deviations for the measured values of oxide thickness, it is valid to apply present design code for the evaluation of the oxide thicknesses before and after zinc injection. Since the oxide thickness of the fuel that experienced zinc injection was similar to the oxide thickness of fuel that did not experience zinc injection, zinc injection was found not affecting oxide thickness.

As the measured value of the oxide thickness of fuel that experienced zinc injection consist within the limit of design code, zinc injection is judged to have barely any effect on oxide thickness

REFERENCES

[1] Evaluation of Fuel Cladding Corrosion and Corrosion Product deposits from Vandellos 2 Cycle 15: interim Report Following First Cycle of Zinc Addition: 2008, 1016615.

[2] Jin-Won, Son et al., "Analysis of CRUD Flake by Shielded EPMA" proceedings, Korean Nuclear Society Autumn Meeting, Korea(2011)

[3] J, Deshon, Boron-induced Offset Anomaly (BOA) Risk Assessment Tool, Version 3.0, 1021227, EPRI (2010)

[4] Evaluation of Fuel Cladding Corrosion and Corrosion Product deposits from Ulchin unit 1 Cycle 17: Final Report : 2011.12, 1022898.