CRUD deposition characteristics on the fuel cladding surface in Korean PWR

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1. Introduction

CRUD is important because it influences various fuel behavior. CRUD is very porous (porosity of about 80%) [1]. The pore (a kind of crevice) in CRUD can be enriched in B (neutron poison which induces AOA) or Li^+ (the corrosion enhancing species of Zircaloy) if boiling occurs. Moreover, the boiling of the solution inside CRUD may decrease its hydrogen concentration. The oxidizing species, like H_2O_2, may be concentrated in the CRUD and the corrosion would be accelerated. In addition, the CRUD on cladding behaves as a thermal barrier. And the activated CRUD would increases the radiation dose rate. The purpose of this study is to investigate the CRUD characteristics in Korean power plants.

2. Methods and Results

2.1 CRUD Analysis Method

CRUD samples from Several Korean PWRs (mainly from U-b, Y-a) were investigated. Crud samplings were carried out by various methods such as taping, smearing, and scraping of cladding surface. Some claddings were cross-sectioned to observe the micro-structural variation along the thickness of CRUD. The CRUD samples were analyzed by SEM, EDS and EPMA. The data of CRUD shown in this paper are the collected results from various scattered sources in Korean institutes. Some samples were prepared from the CRUD collected in filtering system after an ultrasonic cleaning of fuel assembly in U-b plant.

2.2 Morphology and Composition of CRUD

The cross section of the CRUD in the upper part (at 3300mm from bottom) of cladding in U-b plant is shown in Fig. 1. At about 3300mm (Fig. 1), CRUD is usually deposited uniformly around the cladding tube surface as shown in Fig. 2. The CRUD thickness at 3300mm is about 10~15 μm. The CRUD layer was mixed with large sharp-edge particles and small particles.

The cross section of the fuel cladding in Y-a unit at 2975 mm is shown in Fig. 3. CRUD is deposited around the fuel cladding in this unit also. The thickness of the CRUD is measured about 5~15 μm.

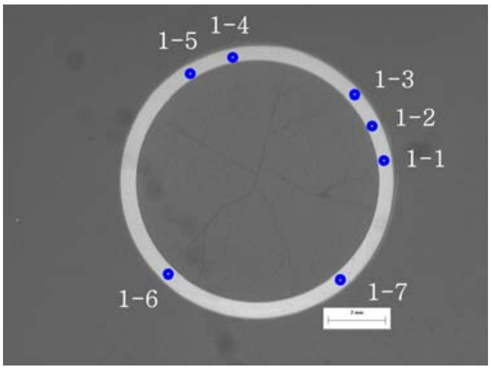


Fig. 1 Cross section of the fuel cladding in U-b unit. (at 3300mm from bottom)

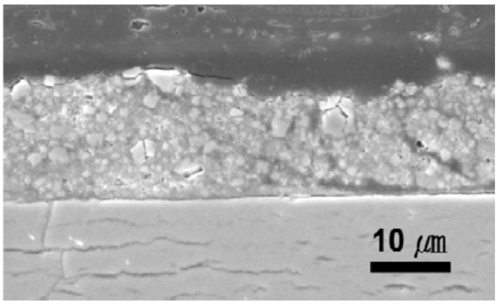


Fig. 2 CRUD at the location(1-2) in Fig. 1.

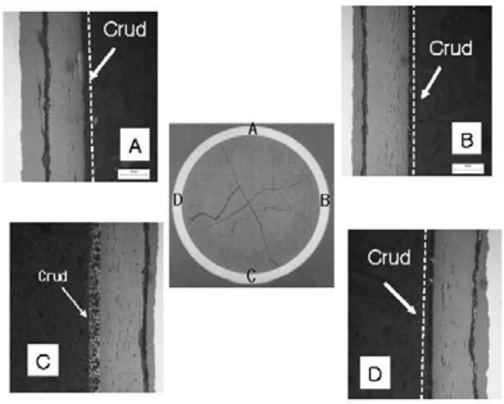
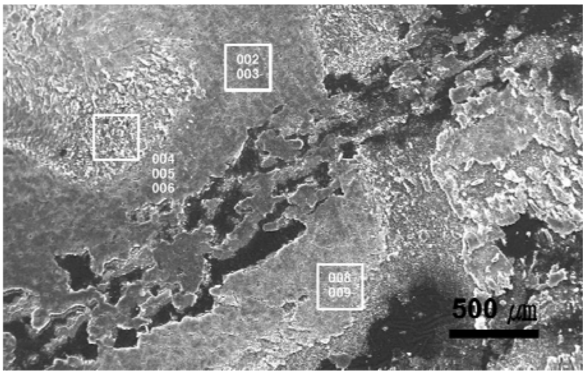
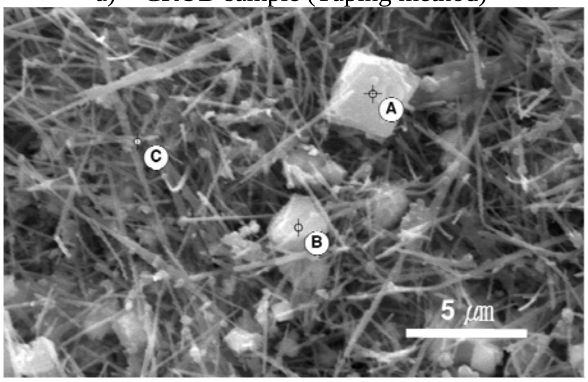


Fig. 3 The cross section of the fuel cladding at 2975 mm in Y-a plant.

The morphology and composition of the CRUD from U-b sampled by taping method is shown in Fig. 4. The CRUD from U-b has many needle-shape crystals mixed with relatively large grains.



a) CRUD sample (Taping method)



b) Morphology of CRUD (at location 009)

Element	Wt % (A/B/C)	At % (A/B/C)
Ni	45.74/46.68/53.41	44.44/45.36/51.97
Fe	52.46/51.03/41.53	53.58/52.13/42.48
Cr	1.18/2.29/5.05	1.98/2.52/5.55
Total	100/100/100	100/100/100

c) Composition of CRUD

Fig. 3 The morphology and the composition of the CRUD at 3300 mm in U-b plant.

The CRUD from Y-a unit is quite different with the CRUD from U-b unit. The CRUD from Y-a unit has mainly crystals of pyramid shape. The CRUD of Y-b also has needles. But the numbers are very few. Based on the composition (c of Fig.3), the needle is Ni rich phase. Some reports [4, 5] suggested that the needle is NiO whisker. To convince if the morphology difference between the two CRUDs (from U-b and Y-b) is typical or not, we need more experimental CRUD analysis data. And (I think) that the difference can be the clue to understand the different AOA behavior of various PWRs.

3. Summary

The characteristics of the CRUD deposited in Korean nuclear power plants were investigated in this paper. Several units in Korea PWRs have CRUD (thickness: ~10um) in the upper part of fuel rod. The morphology and composition of the CRUD in domestic PWRs are various according to the plant's condition. To understand the different AOA behavior of various PWRs, it is necessary to have enough CRUD analysis data.

REFERENCES

[1] M. Foucault et al., Int. Con. Water Chemistry in nuclear reactors systems, Avignon, France, April 2002.
[2] Byers, W. A., et al. In Proceedings of Int. Conf. on Water Chemistry of Nuclear Reactor Systems., 2006, Jeju, Korea
[3] EPRI, EPRI Palo Alto, CA and ENUSA, Madrid, Spain, 1013423, 2006