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Non-destructive Tests for Irradiated Mini Fuel Plates in Hot Laboratory.

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1. Introduction

Aluminum fuel plate is useful for research reactors. The meat of plate are still being developed to enhance reactor performance. Currently, U_3Si_2/Al dispersion fuel have been used in research reactor as operating fuel with high enrichment, but U-Mo fuel is recommended and developed as new material in meat on fuel plate with low enrichment. Many irradiation of fuel plates(U-Mo/Al dispersion) have been performed to observe better effects with Mo-contents in Uranium and Si added in the Al matrix [1]. After irradiation of the mini fuel plate in HANARO research reactor, non-destructive test(X-ray inspection, 2-D gamma spectroscopy, 2-D thickness measurement, 2-D oxide layer thickness measurement and blistering test) was performed as well as destructive test. Non-destructive test for the mini fuel plates in IMEF (Irradiated Material Examination Facility[2]) were introduced in this paper.

2. Methods and Results

Several U-Mo/Al(5wt.Si) dispersion fuel plates with uranium loading density of 8.0 gU/cm^3 and plate size(width : 35mm, length : 130mm) were irradiated in HANARO research reactor [3]. The irradiation test was successfully completed achieving the local peak burnup of 66.2 U-235% and average burnup of 63.3 U-235% depletion. After irradiation, fuel plates were move to hotcell in IMEF and visual inspection was carried out to observe the surface of specimen.

2.1 X-ray Inspection[4]

450kV X-ray inspection showed fuel meat density profile due to dispersion of U-Mo particles on aluminum plate in manufacturing process as well as comparison to fuel meat in pre-irradiation as shown in Fig.1.

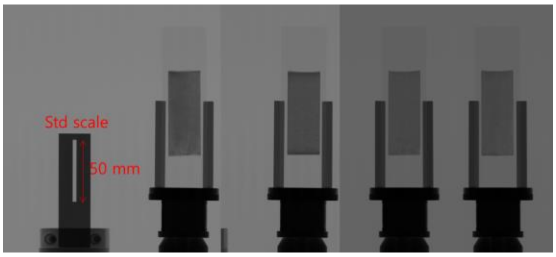


Fig. 1. X-ray pictures of four fuel plates with tungsten-scale

2.2 Gamma spectroscopy[5]

2-D relative burnup profile was useful to be compared with burnup calculation results. HPGe gamma detector was used to find peaks of Cs-137, Zr-95 and Nb-95 which are generated strong gamma peaks as shown in Fig.2.

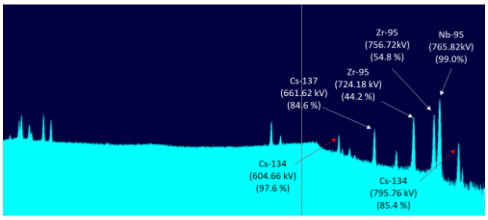
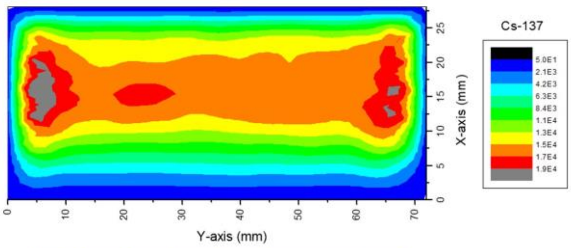


Fig. 2. Gamma peaks of fuel meat by gamma radiography

Several points on meat were set and gamma detection carried out on each point, then gamma peaks were shown on contour graph as shown in Fig.3.



Position (mm)	8	17	25	34	43	51	60
3	63.30%	60.40%	60.40%	60.50%	60.70%	61.90%	64.10%
9	61.70%	58.80%	57.60%	58.10%	58.30%	59.40%	61.50%
15	61.70%	59.40%	58.00%	58.70%	58.50%	58.60%	61.80%
22	64.00%	62.60%	61.60%	61.10%	61.00%	61.70%	63.60%

Fig. 3. Contour graph of gamma peaks of Cs-137(upper) and calculated local burnup at the position of fuel meat (bottom)

2.3 Measurement of thickness and oxide layer[6]

Device was developed to measure at each point on plate with LVDT and ECT probes. Two probes were set on each sides on plate and they move to x,y direction. Finally, thickness and oxide layer were obtained by LVDT and ECT probes, respectively as shown in Fig.4.

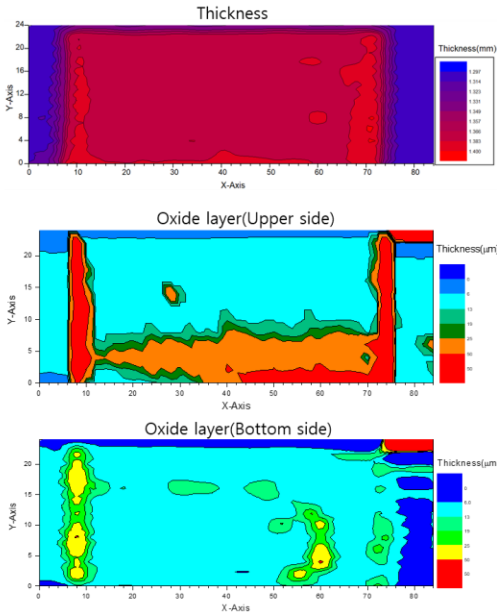


Fig. 4. 2-D thickness and oxide layer data

2.4 Blistering Test[7]

Fission gas release in fuel plate are main important factor with temperatures. Blistering before release is symptom at certain temperature. Therefore, the temperature which cause blistering on surface must be known by heating test. Temperature range were 350℃ ~ 550 ℃ and each temperatures were raised up by 25℃ and duration time was 20 minutes as shown in Fig. 5.

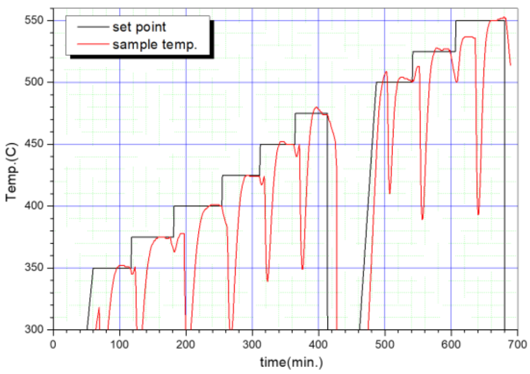


Fig. 5. Temperature profile for blistering test

After every heating temperature with 20min., fuel plate was withdrawn and take picture on both side to observe blister. In this test, blister was occurred at 470℃ and 500℃ as shown in Fig.6.

Fig. 6. Fuel plate with blister after heating

3. Conclusions

To develop fuel plate for research reactor, U-Mo fuel has been studied with low enrichment. Mini fuel plates were irradiated in HANARO Research reactor and moved to IMEF(hot laboratory) for PIE. For Non-destructive test, several devices were installed in M1 hotcell. Hotcell camera, X-ray inspection system, gamma spectroscopy system, 2-D dimensional measurement system and furnace for blistering test in one hotcell space were needed in this study. In this PIE, manufacturing condition of fuel meat was interesting with fuel density, homogeneity and burnup. So, that was the reason to perform 2-D observation on fuel meat. The results of 2-D gamma detection, thickness and X-ray inspection were agreed each other. Those results were informed to manufacturing process of fuel meat.

REFERENCES

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