

Inspection of TRISO-Coated Particle Fuel for the Irradiation Test at HANARO

Woong Ki Kim, Yeon Ku Kim, Kyung Chai Jeong, Sung Ho Eom, Young Woo Lee, Bong Goo Kim,
Young Min Kim and Moon Sung Cho

Korea Atomic Energy Research Institute, 150 Dukjin-Dong, Yuseong, Daejeon, wkkim@kaeri.re.kr

1. Introduction

The first irradiation test of TRISO-coated particle fuel for a HTGR (high temperature gas-cooled reactor) will be carried out at the HANARO reactor in 2013. Two batches of TRISO-coated particle fuel were fabricated for the irradiation test. TRISO-coated particle fuel is composed of a nuclear fuel kernel and outer coating layers [1-3]. The kernel was made of UO₂ with an enrichment of 4.5 % U-235. The coating layers consist of buffer PyC (pyrolytic carbon), inner PyC (I-PyC), SiC, and outer PyC (O-PyC) layers. The quality of the coated particles was inspected under the inspection procedures. The diameter of the coated particles was measured by a PSA (particle size analyzer). The thickness of the coating layers was measured by a microstructure analysis. The density of the coating layers was measured by a density gradient column. The optical anisotropy factor of I-PyC and O-PyC layers was measured by a polarized optical system [4-7].

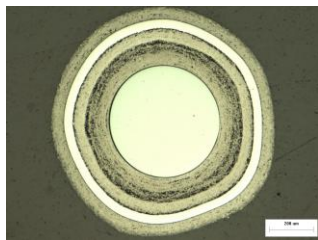


Fig.1. Microstructure of a TRISO-coated particle.

2. Inspection of TRISO-coated particle fuel

UO₂ kernels with a diameter of 480 μm were used to fabricate TRISO-coated particle fuel through TR275 and TR277 fabrication batches. The diameter of the coated particles was measured by a PSA. The mean of the diameters of the coated particles can be measured in a short time by PSA. The averaged diameter was 942 μm for TR275, and 964 μm for TR277, respectively.

The thickness of the coating layers was measured through a microstructure analysis instead of an X-ray in this study. The buffer thickness was 93 μm , the thickness of the I-PyC layer was 40 μm , the thickness of the SiC layer was 36 μm , and the thickness of the O-PyC layers was 43 μm for the TR275 batch. The buffer thickness was 113 μm , the thickness of the I-PyC layer was 41 μm , the thickness of the SiC layer was 36 μm , and the thickness of the O-PyC layers was 49 μm for the TR277 batch.

The density of the coating layers was measured by a density gradient column as shown in Fig. 2. The density of the SiC layer was 3.181 g/cc, the O-PyC layer density was 1.754 g/cc for the TR275 batch. The density of the SiC layer was 3.183 g/cc, the O-PyC layer density was 2.006 g/cc for the TR277 batch. The buffer layer density and I-PyC layer density were measured during the coating technology development processes TR207 and TR220. The buffer layer density was 1.052 g/cc for the TR207 batch, and the I-PyC layer density was 1.910 g/cc for the TR220 batch.



Fig. 2. Density gradient column for density measurement of O-PyC coating layers.

The optical anisotropy factor (OPTAF) of I-PyC and O-PyC layers was measured by a polarized optical measurement system as shown in Fig. 3 and Fig. 4. The OPTAF of the I-PyC layer was 1.017, which means 1.055 as of BAF. The OPTAF of the O-PyC layer was 1.020, which means 1.064 as of BAF for the TR275 batch. The OPTAF of the I-PyC layer was 1.016, which means 1.051 as of BAF. The OPTAF of the O-PyC layer was 1.018, which means 1.058 as of BAF for the TR277 batch.

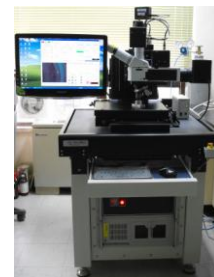


Fig. 3. OPTAF measurement system.

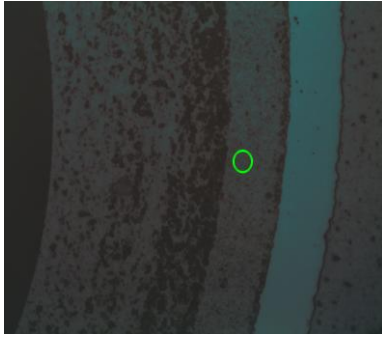


Fig. 4. OPTAF measurement of I-PyC layer.

Table 1. Inspection of TR275 TRISO-coated particles.

		Measurement	Specifications	Measurement method
Particle Diameter (μm)		941.64	900 ± 100	Particle size analyzer
Coating Layers Thickness (μm)	Buffer	93.0	95 ± 45	Microstructure analysis
	I-PyC	40.02	40 ± 20	
	SiC	35.93	35 ± 10	
	O-PyC	43.25	40 ± 20	
Coating Layers Density	Buffer	1.052	1.0 ± 0.1	X-ray
	I-PyC	1.910	1.85 ± 0.20	Density column
	SiC	3.181	≥ 3.18	Density column
	O-PyC	1.754	1.85 ± 0.20	Density column
Optical Anisotropy (OPTAF)	I-PyC	1.017	≤ 1.030	Optical anisotropy by photometer
	O-PyC	1.020	≤ 1.030	

Table 2. Inspection of TR277 TRISO-coated particles.

		Measurement	Specifications	Measurement method
Particle Diameter (μm)		964.36	900 ± 100	Particle size analyzer
Coating Layers Thickness (μm)	Buffer	112.82	95 ± 45	Microstructure analysis
	I-PyC	41.08	40 ± 20	
	SiC	36.23	35 ± 10	
	O-PyC	49.35	40 ± 20	
Coating Layers Density	Buffer	1.052	1.0 ± 0.1	X-ray
	I-PyC	1.910	1.85 ± 0.20	Density column
	SiC	3.183	≥ 3.18	Density column
	O-PyC	2.006	1.85 ± 0.20	Density column
Optical Anisotropy (OPTAF)	I-PyC	1.016	≤ 1.030	Optical anisotropy by photometer
	O-PyC	1.018	≤ 1.030	

3. Conclusion

In this study, the diameter of the coated particles, the thickness of the coating layers, the coating layer density and the optical anisotropy factor of the PyC layers were inspected under specified inspection processes for the first irradiation test at the HANARO reactor. The experimental results are as follows.

- Inspection procedures as well as the inspection and test plan were developed to qualify TRISO-coated particle fuel for the irradiation test at HANARO.
- The diameter of the coated particles was measured by a PSA (particle size analyzer).
- The thickness of the coating layers was measured by a microstructure analysis.
- The density of the coating layers was measured by a density gradient column.
- the optical anisotropy factor of I-PyC and O-PyC layers was measured by a polarized optical system.
- The experimental results met the specifications for the irradiation test at HANARO.

Acknowledgement

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