PIE Burnup Measurement & Analysis of LEU Silicide Fuel Plates Irradiated in RSG GAS Multipurpose Reactor (MPR-30)

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Abstract Non-destructive and destructive PIE burnup measurements of LEU silicide fuel plates irradiated in the Indonesian RSG GAS multipurpose reactor (MPR-30) have been successfully conducted. Burnup verification analysis by SRAC2006 code and JENDL-3.3 library showed good agreement with the measured values.

Keywords: LEU silicide fuel, RSG GAS multipurpose reactor, PIE, burnup measurement & analysis, non-destructive & destructive methods

1. Introduction

At the end of 1990s, the RSG GAS (30 MWth, Be-reflected, water-cooled pool tank reactor) core conversion program from oxide to silicide fuel with higher ^{235}U loading per fuel element (FE) was initiated in the Agency's Center for Multipurpose Reactor to optimize the reactor utilization. The RSG GAS core conversion program is being coordinated and fully supported by similar programs in the Nuclear Fuel Element Center (NFEC) and Radio-Metallurgy Installation (RMI) for acquiring and establishing the technology to fabricate U_3Si_2 dispersion fuel as well as to conduct non-destructive and destructive post irradiation examination (PIE). Here, the PIE activity, i.e. burnup measurements and analyses of LEU silicide fuel plates (19.75 w/o enrichment, 250 gram ^{235}U/FE loading) fabricated and irradiated (six consecutive core cycles i.e. Core IV to Core IX) in the Agency is reported (FE identification: RI-SIE2; 12th (central) and 20th (outer) plate identification: IDA0036 and IDA0045; FE averaged declared burnup: approximately 50 % loss of ^{235}U (IAFUEL in-core fuel management code)).

2. Burnup Measurements and Analyses [1,2]

Non-destructive burnup measurement was conducted by gamma-ray spectroscopy with burnup indicator ^{134}Cs/^{137}Cs activity ratio to obtain the axial distribution of relative burnup, its average values, burnup peak values and peak locations for each fuel plate, as well as the burnup difference between central and outer plates. Destructive (absolute) burnup measurement was conducted by radiochemical technique on a sample taken from the IDA0045. The amount of ^{235}U fissile material left and the ^{137}Cs fission product were selected as the burnup indicators and measured by alpha spectrometry and gamma-ray spectroscopy methods, respectively. Burnup verification analysis was conducted using SRAC2006 and JENDL-3.3 library with a PIE dedicated detail burnup chain.

3. Results

The burnup measurement and verification results are shown in the table below. The measured burnup values of the sample were 72.4 and 78.6 % loss of ^{235}U based on the amount of ^{235}U left and ^{137}Cs, respectively. The amount of ^{137}Cs showed slightly larger value since it was assumed that all fissions originated from ^{235}U thermal fissions. Burnup verification result combined with non-destructive burnup measurement results on the plate wise and axial distribution of ^{134}Cs/^{137}Cs activity ratio produced burnup value of 75.0 loss of ^{235}U which agreed well with the measured values.

Evaluated parameters	Calculation (C)		Nondestructive Gamma Spectrometry Measurement (E)		Destructive Absolute Burnup Measurement by Radiochemical Analysis (A Sample taken from IDA0045)	
	SRAC2006	IAFUEL	IDA0036	IDA0045	U-235 burnup indicator	Cs-137 burnup indicator
FE-averaged burnup (% loss of U-235)	50.6	50.29	−	−	−	−
Average Cs-134/Cs-137 activity ratio	0.502	−	0.473	0.494	−	−
C/E for average activity ratio	−	−	1.06	1.02	−	−
Axial peak factor of activity ratio	−	−	1.36	1.45	−	−
Peak location (from bottom) (cm)	−	−	25.7	28.8	−	−
Absolute burnup at sample location on IDA0045 fuel plates (% loss of U-235)	75.0 ∓ 5.0 (SRAC2006+Nondestructive Measurement)				72.4 ∓ 4.5	78.6 ∓ 5.0%

References

[1] Peng Hong Liem, Siti Amini, Antonio G. Hutagol, Tagor M. Sembiring, *Annals of Nuclear Energy* **56** (2013) pp. 57-65.

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