CO3-1 Development of In-reactor Observation System Using Cherenkov Light (VI)

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INTRODUCTION: The surveillance system which can visualize and quantitatively evaluate reactor statuses will contribute to reactor operation management. We started the development of the on-line reactor core imaging system using Cherenkov light[1] in 2009. Previously, the total reactor power of the KUR can be estimated using the CCD camera by the method of dissolving the total image brightness to the RGB brightness components[2]. In this study, the correlation between the reactor power and the image brightness of the Cherenkov light from a specific fuel element was evaluated in an effort to evaluate the output power of each fuel element.

EXPERIMENTS: The CCD camera (AEC-100ZL, Q·I Inc.) was inserted into core-observation pipe of KUR during increasing the reactor power from 1 to 5 MW. The output of the CCD camera was collected by an image recorder. The Cherenkov light from the target fuel element shown in fig. 1 was analyzed. The brightness signal of the output image from the CCD was dissolved to RGB color signals (R:700nm, G:546.1nm, B:435.8nm)[3]. The R component without halation was used to correct the total image brightness.

RESULTS: Figure 2 shows the results of the analyses of the Cherenkov light from the TC and D2O sides of the target fuel element. Although the averaged brightness changes at an almost same rate as that of the total output power, at the TC and D2O sides of the fuel element, the change rates of the brightness are larger and smaller than that of the total output power, respectively. The difference in the change rate between the TC and D2O sides is thought to be due to an inhomogeneous distribution of output power, resulting in the difference in the amount of the Cherenkov light. On the other hand, the absolute value of the brightness of the TC side was smaller than that of the D2O side at from 1 to 2 MW. A possible explanation is that the shadow of the control-rod guide tubes and the other irradiation equipment were included in image of the CCD camera. To suppress the effect of the shadow on the analyses of the brightness, the observations of the Cherenkov light from various positions using a number of cameras might be required.

CONCLUSION: As part of the development of the visible on-line core surveillance system, the Cherenkov light at the core of KUR observed by a CCD camera was analyzed on the correlation between the image brightness of the Cherenkov light and the output power about a specific fuel element. The results indicate that the inhomogeneous distribution of output power and the shadow of the control-rod guide tubes and the other irradiation equipment have significant effects on the brightness of the Cherenkov light. These effects could be suppressed by using a number of cameras located at various positions.

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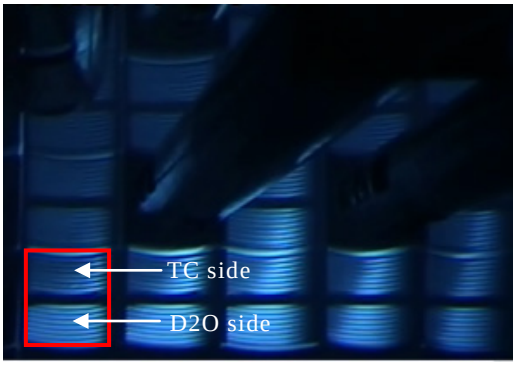

Fig. 1. The array of the fuel elements at the core of KUR. The red boxed fuel is the target one. The black band at the middle of the fuel element is the handle.

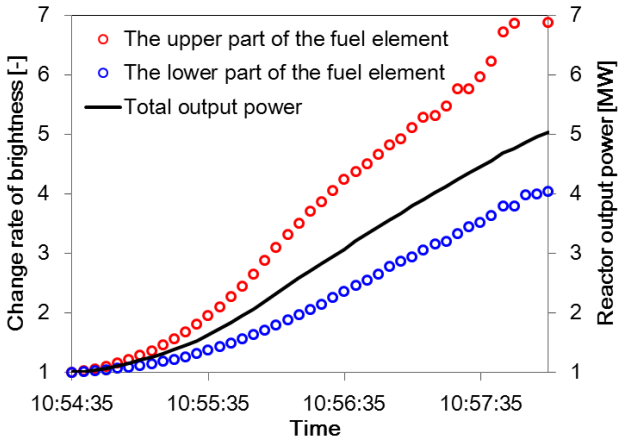

Fig. 2. The change rate of the brightness of the Cherenkov light from the target fuel element with the reactor power.

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CO3-2 Neutron Irradiation Effect of High-density MoO_3 Pellets for Mo-99 Production (2)

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INTRODUCTION: As one of effective applications of the Japan Materials Testing Reactor (JMTR), JAEA has a plan to produce ^{99}Mo by (n, γ) method ((n, γ)^{99}Mo production), a parent nuclide of ^{99m}Tc [1]. In this study, preliminary irradiation test was carried out with the high-density molybdenum trioxide (MoO_3) pellets in the hydraulic conveyer (HYD) of the Kyoto University Research Reactor (KUR) and the ^{99m}Tc solution extracted from ^{99}Mo was evaluated.

EXPERIMENTS: The high-density MoO_3 pellets were fabricated by the Plasma Sintering Method [2]. Dimension and density of MoO_3 pellets were ϕ18×10 mm and about 92.5%T.D., respectively. The MoO_3 pellets were irradiated in the HYD of the KUR. Before the irradiation test, neutron flux in the HYD was measured with the dosimeters (In foil and In-Ni foil with Cd canning). Table 1 shows the irradiation conditions of MoO_3 pellets in the HYD. After the irradiation tests, the irradiated MoO_3 pellets were transported from KUR to JMTR-HL. The irradiated pellets were dissolved with 6M-NaOH solution in the Lead Cell and the ^{99m}Tc was extracted from the Mo solution by the solvent extraction method using methyl ethyl ketone (MEK).

Table 1 Irradiation conditions of MoO_3 pellets

Items	Values
Thermal power	1 MW
Thermal neutron flux	$1.82 \times 10^{17} \pm 4.18 \times 10^{15}$ m^{-2}s^{-1}
Epithermal neutron flux	$7.08 \times 10^{16} \pm 2.29 \times 10^{15}$ m^{-2}s^{-1}
Fast neutron flux	$7.13 \times 10^{16} \pm 1.85 \times 10^{15}$ m^{-2}s^{-1}
Irradiation time	3.2 h
Irradiation temperature	below 90°C

RESULTS: After the irradiation test, all of the diffraction peaks corresponding to the orthorhombic crystal structure (α-MoO_3) were assigned to MoO_3 appeared in the irradiated MoO_3 pellet. The Grain sizes of MoO_3 pellet before/after neutron irradiation were almost identical (approx. 1μm). The results suggest that No change of crystal structure and grain size was observed in the MoO_3 pellets irradiated at low temperature and low fluence.

After the dissolution of irradiated MoO_3 pellets and extraction of ^{99m}Tc solution, ^{99}Mo and ^{99m}Tc activities were measured in the Mo solution and ^{99m}Tc solution by the germanium detector. From the result of the γ-ray spectrum of Mo solution and ^{99m}Tc solution, the ratio of measured value and calculated value (M/C) was 1.05 and it was confirmed that the calculated ^{99}Mo marched the measured one within an error of ±5% by the previous method [3]. On the other hand, ^{92m}Nb observed in the Mo solution as impurities. ^{92m}Nb was not measured in the ^{99m}Tc solutions. Table 2 shows the result of ^{99m}Tc recovery rates from the Mo solution. The recovery rate of the 1st and 2nd runs achieved the target values (>80%). The 3rd and 4th runs were less than 60%. In this experimental, different MEKs were used for the extraction tests and it seems that the ^{99m}Tc recovery rate affected purity of MEK.

Impurities such as Al, Mo and MEK, radiochemical purity and radionuclidic impurity were measured with the ^{99m}Tc solution in the 1st run and the high purity ^{99m}Tc solution was obtained by this method.

Table 2 Result of ^{99m}Tc recovery rates from the Mo solution

No.	Activity of ^{99m}Tc (Bq)	Recovery rate (%)
1st run	1.09×10^9	82.3
2nd run	8.53×10^8	95.7
3rd run	3.09×10^8	56.5
4th run	2.41×10^8	55.1

CONCLUSION: After the irradiation test of the high-density MoO_3 pellets in the KUR, ^{99m}Tc was extracted from the Mo solution and the recovery rate of ^{99m}Tc achieved the target values. The ^{99m}Tc solution also got the value that satisfied the standard value for ^{99m}Tc radiopharmaceutical products by the solvent extraction method.

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