Re-assembling procedure of the fuel assemblies for the nuclear power ship “Mutsu”

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The first and only nuclear power ship in Japan
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  In-cell transportation device, Upper nozzle cutting device, Fuel rod drawing device

• Re-assembling procedure

• Summary
The fuels were loaded in the reactor

The reactor attained criticality

When the reactor test in the pacific ocean, there was a minor leak of neutrons and gamma rays from the reactor shielding

Various modifications were made to the reactor shield of the “Mutsu”

First voyage using nuclear power

After research voyages, the decommissioning work was started

The irradiated fuel assemblies transported to the Reactor Fuel Examination Facility (RFEF)

The fuels were re-assembled for reprocessing
For the decommissioning of “Mutsu”, fuel should be reprocessed in the JAEA’s reprocessing plant.

**Requirement from reprocessing plant**

- **Power Plant fuel assembly**

  **Dimensional request**
  - Same size as PWR type assembly

  **Average enrichment of assembly**
  - Less than 4%
**Objective of Re-assembling**

<table>
<thead>
<tr>
<th></th>
<th>“Mutsu” Fuel Assembly</th>
<th>Acceptable specifications of reprocessing facility (Power Plant fuel assembly)</th>
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</thead>
<tbody>
<tr>
<td><strong>Enrichment</strong></td>
<td>3.24 % and 4.44%</td>
<td>Less than 4%</td>
</tr>
<tr>
<td><strong>Length of Assembly (mm)</strong></td>
<td>1,431(L) × 167.7(W) ×167.7(W)</td>
<td>3,620(L) × 214(W) × 214(W)</td>
</tr>
<tr>
<td><strong>Alignment of rods</strong></td>
<td>11 × 11</td>
<td>15 × 15</td>
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“Mutsu” fuel assemblies were re-assembled in order to adjust the acceptable specifications of reprocessing plant.
Transportation of the “Mutsu” fuel

Thirty-four irradiated fuel assemblies of “Mutsu” were removed from the reactor in 1993 and transported to the Reactor Fuel Examination Facility (RFEF) in 2001.
Reactor Fuel Examination Facility (RFEF)

Main Activities

PIEs of reactor fuels
PWR, BWR and ATR (Advanced Thermal Reactor) fuel assemblies (20 in Total) and fuel rods.

Nuclear Fuel Safety Research
PIEs of nuclear fuels safety research such as RIA and LOCA simulating experiment.
Loading of fuel assembly into hot cell

Top Loading
- Load assembly from cell roof-gate
- Not required to decontaminate cask
- Reduce costs and save time

Storage Pool
- Contamination of cask by pool water
- Requires to decontaminate cask
- Pull out assembly from cask
- Spends a lot of time and money
- Lift it up to hot cell

Notation:
- 34 "Mutsu" cask in total
- "X" indicates an unfavorable condition
The “Mutsu” cask was unloaded from a carrier.

The “Mutsu” assembly was extracted from the “Mutsu” cask and lifted up to the handling cask.

The handling cask was transported to the cell No.4 with a crane.
Lift down the assembly into the cell No.4

Insert the assembly to the basket

Visual inspection

Transport to the cell No.3
Re-assembling procedure

1. Cut the upper nozzle
   - *Upper nozzle cutting device*

2. Draw fuel rods
   - *Fuel rod drawing device*

3. Insert fuel rods
Cutting procedure of upper nozzle

Upper nozzle
Fuel assembly
Positioning plate
Cutter head
Chucking device
Handling cage
Fuel assembly
After cutting
Cutting Device

Cutting Position: 168.5 mm (7 mm)

Handling cage
Chucking device
Cutter head
Positioning plate
1. Cut the upper nozzle
   • Upper nozzle cutting device

2. Draw fuel rods
   • Fuel rod drawing device

3. Insert fuel rods
To improve operation efficiency

The air valve is controlled from Operation Area.

The clamping head is equipped with an indicator rod which inform a fuel clamping.

The clamping head structure remains closed at all times which prevent a fuel rod from dropping accident.
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The clamping head is equipped with an indicator rod which informs a fuel clamping.

The clamping head structure remains closed at all times which prevent a fuel rod from dropping accident.

Fuel rod drawing device
1. Cut the upper nozzle
   - Upper nozzle cutting device

2. Draw fuel rods
   - Fuel rod drawing device

3. Insert fuel rods
   - Adjust assembly enrichment
   - Insert fuel rods
Adjustment of assembly enrichment

Identifying mark: A or B

Enrichment:
- A: 3.24%
- B: 4.44%
- ≤ 4%

Grid of skeleton

Top view of skeleton

Skeleton of assembly

Fuel rod

Bottom

Top
1) Insert the fuel rod
2) Confirmation of the inserted position
3) Slide down the fuel rods
4) Attach the upper nozzle
5) Observation test
   Weight measurement

**Re-assembled fuel assembly**

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<table>
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<tbody>
<tr>
<td>In the spacer grid</td>
<td>612 rods</td>
</tr>
<tr>
<td>In the thimble</td>
<td>24 rods</td>
</tr>
<tr>
<td>Total</td>
<td>636 rods</td>
</tr>
<tr>
<td>Enrichment (assembly)</td>
<td>3.98 %</td>
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**Insertion procedure of fuel rods**
Re-assembling

“Mutsu” Fuel Assembly

Re-assembled fuel composed of approx. 5.6 assemblies of “Mutsu” Fuel

Re-assembled Fuel (15x15 PWR type power plant fuel)

Finally 34 fuel assemblies were re-assembled as 6 PWR type fuel assemblies
Several devices were developed for re-assembling work.

Re-assembling work for “Mutsu” fuel assemblies was performed in RFEF and finished in 2007, successfully.

Re-assembled fuels will be transported to reprocessing plant in JAEA near future.
Thank you for your attention
Re-assembling process
Identifying marks
Structure of re-assembling fuel

- Upper nozzle
- Spacer
- Control rod guide thimble
- Guide thimble with screwed end
- Hold pipe for fuel rod