Nuclear Technology of Fuji Electric
1. Main products and history in Nuclear field

<table>
<thead>
<tr>
<th>Field</th>
<th>70’s</th>
<th>80’s</th>
<th>90’s</th>
<th>00’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Reactor</td>
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<tr>
<td>Tokai Reactor</td>
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<tr>
<td>Advanced Reactor</td>
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<td>HTGR</td>
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<td>FBR</td>
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<tr>
<td>ATR</td>
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<tr>
<td>Nuclear Fuel Cycle (MOX fuel fabrication Reprocessing)</td>
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<tr>
<td>Radioactive waste treatment plant</td>
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</tbody>
</table>

2. Feature of FES’ s Nuclear Technology

Key Technology and FES’s experience

1. Remote-handling and Transfer Technology
   - Fuel Handling and Storage System for Nuclear Plant
   - Remote dismantle of the Nuclear Reactor
   - MOX Fuel Fabrication Facility

2. Radioactive Waste Treatment Technology
   - Waste Treatment System for Nuclear Plant
   - Reprocessing Waste Treatment
   - Dismantling Waste Treatment

3. High Temperature Gas Cooled Reactor Technology
   - HTTR (High Temperature Engineering Test Reactor)

<Map & Supplied System>
Features of FES’ Fuel Handling and Storage System as the Remote Handling and Transfer Technology are follows.

<Feature>

(1) FES supplied the full set of the Fuel Handling and Storage System for the following new reactors in Japan.

* "JOYO": The Experimental Fast Breeder Reactor
* "MONJU": The Prototype Fast Breeder Reactor
* "FUGEN": The Prototype Advanced Thermal Reactor
* "HTTR": The High Temperature Engineering Test Reactor

(2) The fuel handling and storage system for these plants are realized to the fully automatic operation for remote handling rather than that of LWR.

(3) Spent fuel transfer and storage technology in the water pool such as FBR "JOYO", FBR "MONJU", and ATR "FUGEN", is directly applicable to the LWR plant.

The following shows our experience with fuel handling and storage systems in Japan.

Reactor dismantling and MOX fuel manufacturing facility are also shown as an other experience of our remote-handling and transportation technology.

4. Experimental Fast Reactor ‘JOYO’
4.1 ‘Joyo’ Fuel Handling and Storage System

- Customer: JAEA
- Output power: 100MWth
- Main products:
  - Fuel handling and storage system
  - Spent fuel storage facility
  - Radiation monitoring system
  - Electrical power supply system
  - General purpose maintenance facilities
  - Radioactive waste treatment system
  - Instrument and plant control system

4.2 ‘Joyo’ Spent Fuel Storage Facility

- Spent fuel handling and storage technology is directly applicable to the LWR plant.

**Feature**
- The number and direction of fuel assembly which is underwater can be checked and dealt with by ITV.
- Fuel transfer can be remotely-operated from the outside of a radiation controlled area.

<table>
<thead>
<tr>
<th>Main Specification</th>
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</thead>
<tbody>
<tr>
<td>Water cooling Pond</td>
</tr>
<tr>
<td>Retained water</td>
</tr>
<tr>
<td>Lining</td>
</tr>
<tr>
<td>Fuel transfer machine</td>
</tr>
<tr>
<td>Water cooling purification system</td>
</tr>
<tr>
<td>ITV for check</td>
</tr>
</tbody>
</table>
5. Prototype Fast Breeder Reactor ‘MONJU’

* FES supplied the full set of fuel handling and storage system for ‘MONJU’
* Spent fuel handling and storage technology is directly applicable to the LWR plant.

- **Customer:** JAEA
- **Thermal Power:** 280MW
- **Main Facilities Supplied by FES**
  - Fuel handling and storage system
  - Radioactive waste treatment system
  - General purpose maintenance facilities
  - Radiation monitoring system
  - Instrument and plant control system

5.1 ‘MONJU’ Fuel Handling and Storage System

* Fuel handling and storage of “MONJU” can be fully operated automatically for remote handling.

Ex-vessel Transfer Machine

Ex-vessel Fuel Storage Tank
5.2 ‘MONJ U’ Spent Fuel Storage Facility

*Spent fuel handling and storage technology in a water pool is directly applicable to the LWR plant.

**Feature**
- The fuel which exists underwater can be dealt with.
- Fuel transfer can be remotely-operated from the outside of a radiation controlled area.

**Main Specification**
- Fuel transfer machine: Handling load capacity 475kg
- Water cooling Pond: W 11.5m X L 23m X D 14m
- Lining: SUS304

6. Advanced Thermal Reactor ‘FUGEN’

*FES supplied the full set of fuel handling and storage system for ATR ‘FUGEN’*

- Customer: JAEA
- Electric Power: 165MW
- Main Facilities Supplied by FES
  - Fuel handling and storage system
  - Radioactive waste treatment system
  - Engineered safety protection system
  - Reactor Seal Plug
  - Radiation Monitoring System
  - Instrument and plant control system

**"FUGEN" Fuel handling and Storage System**

Bird's Eye View

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Fuji Electric Group
6.1 ‘FUGEN’ Spent Fuel Transfer Machine

- Spent fuel handling and storage technology is directly applicable to the LWR plant.
- Feature:
  - Fuel is transferred to the spent fuel rack in the pool by the spent fuel transfer machine.
  - Fuel handling machine can be operated remotely and automatically from the central control room.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Main Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run Span</td>
<td>3.3m</td>
</tr>
<tr>
<td>Lifting height</td>
<td>20m</td>
</tr>
<tr>
<td>Lifting load</td>
<td>600kg</td>
</tr>
<tr>
<td>Driving unit</td>
<td>Wire drive system</td>
</tr>
<tr>
<td>Gripper</td>
<td>Solenoid opening and shutting type</td>
</tr>
<tr>
<td>Main material</td>
<td>Stainless steel</td>
</tr>
</tbody>
</table>

Customer: The Japan Atomic Power Company
Output: 166MWe
Start operation: July 1966  Stop operation: March 1998

7. Gas cooled reactor ‘Tokai Power Station’

- FES engaged in the construction of the Tokai No1 nuclear plant, the first commercial nuclear plant in Japan. At present FES is studying the reactor dismantling method for Tokai No1 using one of our key technology.

Customer: The Japan Atomic Power Company
Output: 166MWe
Start operation: July 1966  Stop operation: March 1998

Full view of Tokai Power Station
Reactor vessel, internals and primary cooling system (Drawing by 3D CAD for dismantling simulation)
8. MOX Fuel Manufacturing Facility (1/2)

* MOX fuel manufacturing facility is another example of FES's remote handling and transfer technology.

- Main Equipment Supplied by Fuji Electric Systems
  - Pellet Grinding and Inspection Equipment
    - Pellet size and density inspection system
    - Density measuring Device
    - Equipment to inspect the Grinded Pellet
    - Grinding machine
    - Pellet surface inspection equipment
    - Inspection Machine of Fuel Assembly
    - Automatic Storage Facility of Uranium

- Features
  - Simplification of the system by the function integration
  - High Speed Processing
  - Minimum hold up
  - Improved maintainability
  - Remote & Automation

Photograph of Glove Box
(Pellet Inspection Equipment)
Presented by JAEA

8. MOX Fuel Manufacturing Facility (2/2)

- Grinding Machine
  - Major Spec.
    - Method: Dry type center-less grinding method
    - Function: Grinding of the pellet periphery

- Pellet surface inspection equipment
  - Major Spec.
    - Method: 3 ITV camera imaging
    - Spec.: Equipment check the surface of both end and the body of pellets

- Pellet size and density inspection system
  - Major Spec.
    - Method: Size measurement by laser instrument
      - Weight measurement by electromagnetic balance type
    - Function: Quality check by measurement of size and weight of the pellet and computing density
9. Feature of FES’s radioactive waste treatment system

Features of FES’s radioactive waste treatment system are follows.

<Feature>

(1) FES supplied the radioactive waste treatment system for the following new reactors.
   * The Prototype FBR “MONJU” (Gaseous and Liquid Waste Treatment System)
   * The Experimental FBR “JOYO” (Liquid Waste Treatment System) etc.

(2) The performance of these facility is superior to that required in LWR plant.

(3) FES is developing the spent resin volume reduction stabilization process equipment.

(4) FES can supply radioactive waste treatment system and / or equipment in response to the users' requirement.

The following shows our experience with radioactive waste treatment systems in Japan.

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9.1 Liquid Waste Treatment System for the experimental FBR “JOYO”

Liquid Waste Treatment System for “JOYO”

- Major Components
  - Receiver tank
  - Evaporation & Condensation equipment
  - Glassification equipment using microwave
  - Concentration conditioning tank
  - Concentrated solution tank
  - Control system

![Liquid waste treatment process](image1)

Microwave glassificator
9.2 Gaseous Waste Treatment System for the prototype FBR “MONJU”

Gaseous Waste Treatment System for “MONJU”

- Major Spec.
  - Processing Capacity
    - Peak processing : 70Nm³/h
    - Continuous processing : 10Nm³/h
  - Noble gas hold up time
    - Xe : over 30 days
    - Kr : over 40h

9.3 Liquid Waste Treatment System for the prototype FBR “MONJU”

Liquid Waste Treatment System for ”MONJU”

- Major Spec.
  - Treatment Capacity : 2m³/h
  - Major equipment
    - Natural circulation type evaporator for liquid waste
    - Demineralizer
    - Transfer pump
9.4 Fuji Resin Reducer

<IC plasma spent resin volume reduction stabilization process equipment>

- High volume reduction
- Small size unit type system
- Cost reduction for final disposal
- Lower environmental impact
- The residuum is easy to mix cement
- Module type system
- Stabilization process

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume reduction method</td>
<td>Inductively coupled plasma Low pressure oxygen</td>
</tr>
<tr>
<td></td>
<td>Plasma: 0.15 - 0.73psi (10 - 50hPa)</td>
</tr>
<tr>
<td></td>
<td>Temperature: 750 – 1290°F (400 – 700°C)</td>
</tr>
<tr>
<td></td>
<td>Low carry-over (&lt;10^-4 as Co)</td>
</tr>
<tr>
<td>Dealing material</td>
<td>Spent Resin, Charcoal</td>
</tr>
<tr>
<td>Capacity</td>
<td>13.2gal (50wet-liter) / day·unit</td>
</tr>
<tr>
<td></td>
<td>353ft³ (10m³) / year</td>
</tr>
<tr>
<td>Volume reduction</td>
<td>More than 95% (1/20 of volume reduction)</td>
</tr>
</tbody>
</table>

10. HTGR (High-temperature Gas Cooled Reactor) technology

<Feature>

- FES supplied the reactor internals for HTTR (High Temperature Engineering Test Reactor), the first HTGR in Japan.
- FES supported the JAEA’s nuclear / thermo hydraulic design and safety analysis for HTTR.
- FES also supplied the full set of fuel handling and storage system for HTTR. HTTR fuel is handled in helium atmosphere and fuel handling machine is operated automatically for remote handling.
10.1 High Temperature Engineering Test Reactor ‘HTTR’

- Customer: Japan Atomic Energy Agency (JAEA)
- Output Power: 30MWth
- Outlet coolant temperature: 850°C / 950°C
- Main products: Reactor internal structures, Fuel handling & storage system
- Core design, Safety analysis: in cooperation with JAEA

Reactor internals (top view, outer dimension 4.25m)

10.2 ‘HTTR’ Fuel Handling Machine

- Feature:
  - Fuel handling machine is used for charging/discharging of fuel blocks into/out of nuclear reactor and is used for transfer of fuel blocks between spent fuel storage facilities and fresh fuel storage facilities.
  - A series of refueling operations and positioning to the fuel block is performed remotely and automatically.

- Main Specification:
  - Design pressure: 88kPa
  - Design temperature: 100 °C
  - Dimensions: H 11m
  - Weight: 150ton
  - Inside atmosphere: Helium gas
  - Handling load capacity: 200kg
11. Certification

- We operate
  ISO 9001 (certification for quality management system)
  & ISO 14001 (certification for environmental management system).

- Currently ASME NQA-1 QA program is under development.

Overseas Subsidiaries

- Fuji Electric FA Europe GmbH
- Fuji Electric Device Technology Europe GmbH
- Fuji Electric (Shenzhen) Co., Ltd.
- Hong Kong Fujidenki Co., Ltd.
- Fuji Electric (Asia) Co., Ltd.
- Fuji Electric Device Technology Hong Kong Co., Limited
- Atai Fuji Electric Co., Ltd.
- Fuji Electric Dalian Co., Ltd.
- Fuji Electric Motor (Dalian) Co., Ltd.
- Fuji DE Drives (Wuxi) Co., Ltd.
- Shanghai Fuji Electric Switchgear Co., Ltd.
- Fuji Electric (Shanghai) Co., Ltd.
- Fuji Electric Taiwan Co., Ltd.
- Fuji Electric FA Taiwan Co., Ltd.
- Fuji Electric Singapore Private Ltd.
- Fuji Electric FA Singapore Pte., Ltd.
- Fuji Electric (Malaysia) Sdn. Bhd.
- Fuji Electric Philippines, Inc.

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