JAEA’s Efforts for Reduction of Radioactive Wastes

February 17, 2016

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Activities in reprocessing spent fuels and utilizing the nuclear fuel cycle further enhance nuclear power characteristics of being excellent in supply stability.

- Enhancing the energy security of Japan
- Reducing waste generation and potential hazard of HLW

The Nuclear Fuel Cycle Policy

Strategic Energy Plan (Apr. 2014)

- To promote nuclear fuel cycle that reprocesses spent fuels and effectively utilizes the plutonium recovered as a basic policy of Japan for reduction of the volume and radiotoxicity of radioactive wastes

The 5th Science and Technology Basic Plan (Jan. 2016)

- To address the establishment of innovative technologies, ex. nuclear fusion, and the nuclear fuel cycle technologies, being important for future
Business Outline of JAEA

R&D related to dealing with the Fukushima Daiichi NPS accident  
【Sector of Fukushima R&D】
Decommissioning etc.

R&D on fast reactor  
【Sector of Fast Reactor R&D】
Monju
R&D for establishment of demonstrated technologies of fast reactors

R&D on reprocessing, fuel fabrication and treatment/disposal of radioactive wastes  
【Sector of Decommissioning and Radioactive Waste Management】
Reprocessing/fuel fabrication
Technologies for HLW disposal
Volume/radiotoxicity reduction
Decommissioning

R&D for safety improvement of nuclear use and activities contributing to non-proliferation/nuclear security

Technical assistance for nuclear safety regulatory administration through safety research  
【Sector of Nuclear Safety Research and Emergency Preparedness】

Enhancement of industry/academia/government cooperation and activities to secure reliability from society
Technology Transfer, Innovation  
Nuclear Operator Support  
International Cooperation

Basic & Foundation Research,  Development of Human Resources  
【Sector of Nuclear Science Research】
Basic Foundation Research to Support Nuclear Use
Advanced Nuclear Science Research  
R&D of HTGR
Quantum Beam Research  
J-PARC

R&D on nuclear fusion  
【Sector of Fusion R&D】
Promotion of ITER plan
R&D expanding BA activities

R&Ds for the establishment of nuclear fuel cycle are underway in 3 sectors
R&D in JAEA for reduction of the volume and radiotoxicity of radioactive wastes (1/2)

**Fast Reactor (FR) Cycle Type**

- Partitioning and transmutation technology using nuclear power generation reactors
- Recycle MA together with Pu
- Conduct nuclear transmutation of Minor Actinides (MA) in a nuclear power reactor (**Fast Reactor (FR)**)
- MA content in fuel: up to 3 - 5%
- Major candidate: Sodium-cooled Fast Reactor (SFR) with the MOX fuel

**Accelerator-Driven System (ADS) Type (Hierarchical Type)**

- Incorporate a transmutation cycle to a nuclear power generation cycle
- Confine MAs in a compact cycle
- Transmutation dedicated system (**accelerator-driven system: ADS etc.**)
- MA content in fuel: 50 % or more (fuel without uranium)
- Major candidate: Lead-cooled Fast Reactor (ADS) with the nitride-fuel

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**Concept of SFR with MOX fuel**

- Core
- Primary main circulation pump
- Secondary main circulation pump
- Steam generator
- Steam generator
- Primary main circulation pump

**Concept of ADS with nitride fuel**

- Core
- Proton beam duct
- Steam generator
- Primary main circulation pump
As two fields have many research items in common (ex. MA partitioning technology, MA fuel technology, two sectors are implementing R&Ds in cooperation.
R&D Facilities for reduction of the volume and radiotoxicity of radioactive wastes

Plutonium Fuel Development Facility (PFDF)

Prototype Fast Breeder Reactor (Monju)

Japan Proton Accelerator Research Complex (J-PARC)

Material Monitoring Facility (MMF)

Featured Facilities:
- Irradiated fuel assemblies
- Test fuel pins
- Fuel for irradiation

To further clarify:
- Fuel assemblies
- Fuel assemblies containing MA fuel pins (Planned)
- Irradiated fuel assemblies
- Test fuel pins
- Irradiated fuel assemblies (incl. re-loaded)

Facilities Overview:
- Monju
- Tokai Pu Facilities
- Oarai Fuel & material facilities
- Joyo
- Tokai Cycle Facilities
- Experimental Fast Reactor (Joyo)
- Fuel Monitoring Facility (FMF)
- Alpha-Gamma Facility (AGF)
- Chemical Processing Facility (CPF)
- Nuclear Fuel Cycle Safety Engineering Research Facility (NUCEF-BECKEY)
R&D roadmap of FR systems

- **International Collaboration (ex. ASTRID collaboration)**
  - Design Assessment
  - Collaborative Research
  - etc.

**Monju Research Plan**
(FR Cycle Research Plan)
- Improvement of the safety of fast breeder reactors
- Reduction in volume/toxic level of radioactive waste
- Compiling the result of the FBR development

- **Establishment of Demonstration Technology**
- Reviewing "Safety standards" as a result of Fukushima Daiichi NPP accident
  - Irradiation data of pin scale test
  - Irradiation data of pin bundle test
  - Safety Design Criteria/ Guideline

- **Outcome**
  - Basic performance of fast reactor core
  - Operating characteristics of sodium components
  - Basic performance of Sodium loop system

- **Outcome**
  - Performance of large-scaled core
  - Performance of MA burning core
  - Demonstration of SFR power plant (System and Design methods)

- **Outcome**
  - Basic performance of middle-scaled core
  - Operating characteristics of SG installed in SFR
  - Experience of SFR power plant

- **Base Technology Development / Basic Research**
  - Reactor Physics, Thermal-hydraulics, Safety, Component & Material, Instruments, Fuel material, In-service inspection, Maintenance (Facilities: AtheNa, MELT, SWAT, PLANDTL, HTL, FMF, MMF, AGF, Sodium-Engineering Research

- **Monju**
  - Performance of large-scaled core
  - Performance of MA burning core
  - Demonstration of SFR power plant (System and Design methods)

- **Joyo**
  - Performance of large-scaled core
  - Performance of MA burning core
  - Demonstration of SFR power plant (System and Design methods)
Research projects of FR cycle technologies

- Improvement of the flexibility in Pu use, verification of MA partitioning and transmutation technologies, etc. are necessary for obtaining technological perspective on the reduction of the volume and radio-toxicity of radioactive wastes.

Reprocessing:
- Development of MA partitioning process and performance evaluation
- Establishment of feasible process concepts

Fuel Fabrication:
- Remote MA-bearing MOX fuel fabrication technology
- Determination of fuel composition range applicable

Fuel Development & Irradiation Test:
- Systematic irradiation tests of MA-bearing MOX fuel, High Pu-contents MOX fuel

Reactor Characteristics & Reactor system:
- Feasibility confirmation of FR plant technologies
- Acquisition of characteristics of MA-containing core

Comprehensive system evaluation:
- Integration of information in each area & narrowing prospective system concepts
- Verification of effects on reduction of the volume and radiotoxicity of radioactive wastes

Evaluation of volume reduction, etc. by utilization of FR cycle
<System outline>

- Transmutation cycle is attached to commercial cycle: **Double-strata**
- **Accelerator Driven System (ADS)** is used as dedicated transmutation system

<Characteristic>

- MA can be confined into a small cycle and transmuted efficiently.
- Both commercial fuel cycle and transmutation cycle can be optimized according to their purposes, respectively.

**ADS: Accelerator Driven System**

- Proton beam from superconducting LINAC is introduced to spallation target.
- Generated fast neutrons keep the chain reactions of MA fuel in sub-critical system.
- Fission energy is used for power generation.
<ADS>
◆ Super-conducting proton LINAC — Liquid Pb-Bi target — U-free MA fuel, Pb-Bi coolant
◆ R&D items: Accelerator, Beam window, Pb-Bi handling, Measurement and control of sub-critical system, etc.

<MA fuel cycle>
◆ Partitioning: MA recovery by solvent extraction method from HLLW generated in commercial fuel cycle
◆ MA fuel: Nitride is the first candidate
◆ MA fuel reprocessing: Pyrochemical process with molten salt and liquid metal

It is necessary to establish technological basis which can give required data for the judgement of the realizability and practicability.
International cooperation for FR and ADS

International Cooperation is significant to R&D for verification of technical feasibility of SFR and ADS. Key issues of these cooperation:
- **SFR**: verification of effectiveness in reducing environmental burdens and establishment of safety technology of FR system
- **ADS**: R&D for engineering feasibility of subcritical system with high power accelerator

- **France**
  - Reactor & advanced nuclear energy system
  - Advanced fuel cycles
  - Prototype/demonstration reactor (incl. ASTRID)
  - Operation/Maintenance

- **Russia**
  - Vibro-compacted fuel
  - ODS cladding irradiation

- **Kazakhstan**
  - Re-criticality elimination mechanism (EAGLE project)

- **U.S.A.**
  - CNWG activities
  - Fast reactor technology
  - Fuel cycle technology
  - Waste management

- **EU**
  - Partitioning and transmutation technology
  - Experimental ADS and irradiation tests (MYRRAH project)

- **IAEA**
  - INPRO (Scenario study)
  - TWG-Fast reactors
  - TWG-Nuclear fuel cycle options
  - Coordinated research activities (CRPs)

- **OECD/NEA**
  - NI 2050
  - Innovative fuels

- **Japan**
  - SFR (Advanced fuel, Component Design &BOP, Safety and Operation, Safety Design Standard)
  - Trilateral Collaboration
    - Design goal and high level requirement for prototypes goals
    - Safety principles and infrastructure needs
    - Irradiation test of MA bearing fuels (GIF GACID project)
Thank you for your attention!