IAEA Technical Meeting on the Management of Spent Fuel (Pebbles and Compacts) from High Temperature Reactors

DEMONSTRATION PLAN FOR HEAD-END PROCESS OF HTGR SPENT FUEL REPROCESSING IN JAPAN

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HTGR Project Management Office
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Background and Objective

Background

- Japan has promoted the nuclear fuel cycle by reprocessing spent fuel and effectively utilizing recovered plutonium from the perspective of resource as a basic policy.
- Japan, the U.S., etc., have performed R&D on the head-end process to remove coating layers of CFP to connect an LWR reprocessing to reprocess the spent fuel from HTGRs.
- Japan has investigated the basic concept of the head-end process and confirmed the feasibility of the elemental technologies through basic experiments.
- The head-end process must be demonstrated by using spent fuel, and Japan is planning the demonstration test using the spent fuel from HTTR.

Objective

- To overview of Japanese basic policy and back-end technologies for HTGR.
- To introduce the plan and the status of R&D for the demonstration test for head-end process using the spent fuel from HTTR.

Overview of Japanese basic policy and back-end technologies for HTGR

The Target of Fuel Cycle in Japanese Policy

Background of basic policy for nuclear energy

Time	Event	Purpose
1955	The revision of US-Japan Nuclear Cooperation Agreement	To introduce research reactor
1956	**Long range plan on the development and utilization of Nuclear Energy**	**"Reprocessing and breeder reactor" in the scope**
1956	Japan Atomic Energy Institute	To introduce LWR
1958	The revision of US-Japan Nuclear Cooperation Agreement	To introduce LWR
1958	The UK-Japan Nuclear Cooperation Agreement	To introduce Calder Hall reactor
1963	Starting operation of JPDR (GE BWR) in JAEA	To train the LWR operator
1966	Starting commercial operation of Toukai-daiichi NPP	Starting of Calder Hall reactor operation (the last one)
1970	Starting commercial operation of 1st unit of Tsuruga NPP(BWR), 1st unit of Mihama NPP (PWR)	Starting of LWR operation

Reprocessing was set to be target in the basic policy for resources in Japan.

History of Reprocessing Plant Development

History

Japan had developed the reprocessing technologies based on French technologies.

Time	France	Japan	Purpose
1958	UP1		Generate Pu for nuclear weapon
1966	UP2		Reprocessing Calder Hall reactor SF
1976	UP2		Update for LWR SF
1977		Tokai Reprocessing Plant	Reprocessing LWR SF, Negotiation with U.S.*
1989	UP3		Reprocessing LWR SF
2006		Rokkasyo Reprocessing Plant (RPP)	Reprocessing LWR SF

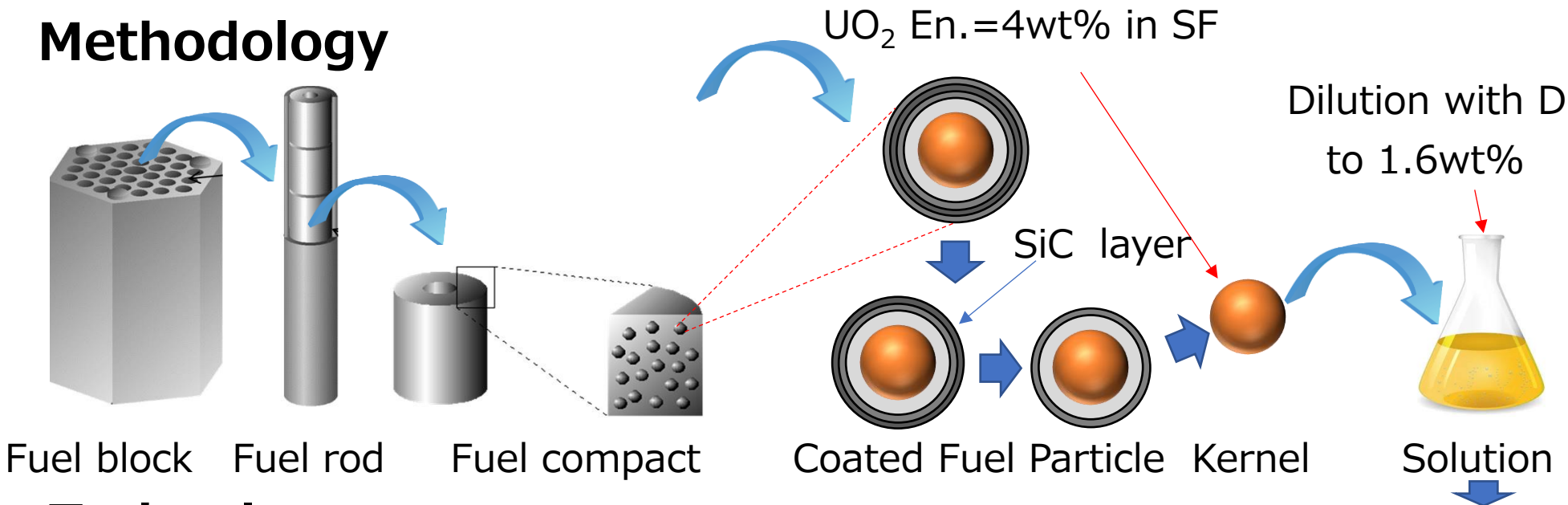
*Japan-U.S. reprocessing negotiation;

Japan, which is non-nuclear-weapon state, is accepted to extract Pu with same amount of U by U.S.

HTGR technologies had also been developed with assuming reprocessing in Japan.

Development of Head-End Process for HTGR

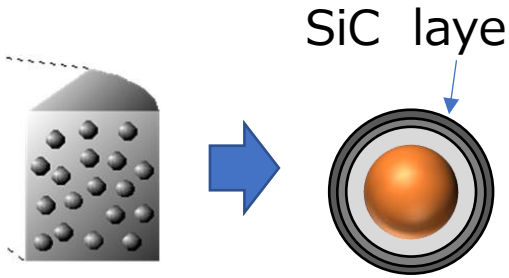
Methodology



Rokkasyo Reprocessing Plant

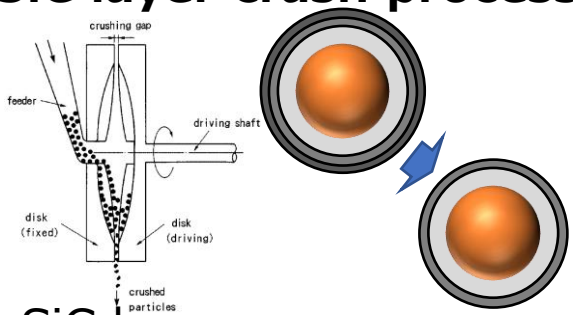
Technology

Burn process



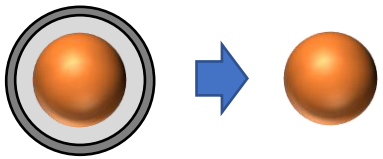
Carbon material is removed by burning.

SiC layer crash process



SiC layer is mechanically crashed.

Reburn process



Carbon layer is removed by burning.

Nuclear Fuel Industries, Ltd. have used these technology to recover uranium from failure products.

Advantage of Japanese Head-End Process

IAEA-TECDOC-1645 concludes that HTGR spent fuel reprocessing is challenging by referring Dr. Greneche's opinion.

Ref.: Greneche, D., Masson, M., Brossard, P., "The Reprocessing Issue for HTR Fuels: An assessment of Its Interest and Its Feasibility", Global 2003 Conference, New Orleans, LA November, 2003.

He referred to **Oak Ridge grinding technology**, which crashes **whole fuel block**.

The waste amount is increase and recovery ratio become worse.

Fuel block

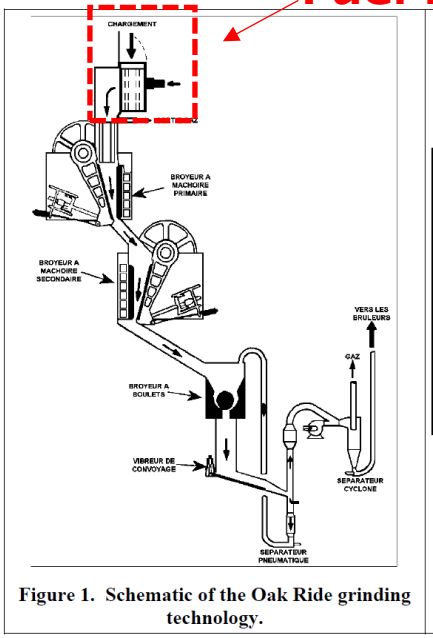


Figure 1. Schematic of the Oak Ride grinding technology.

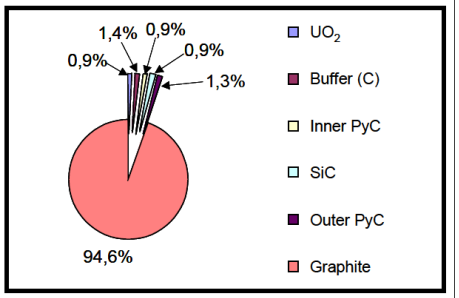
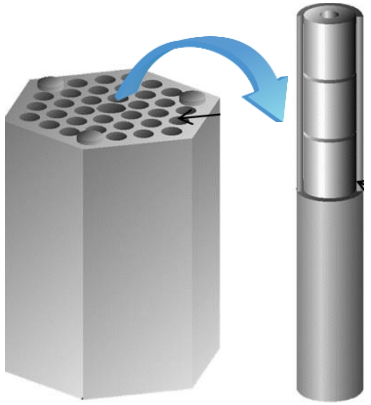


Figure 2. Elementary composition of one GTMHR compact (in % vol.)

Oak Ridge grinding technology

To conquer this problem,

Japan select the pin-in-block type fuel.



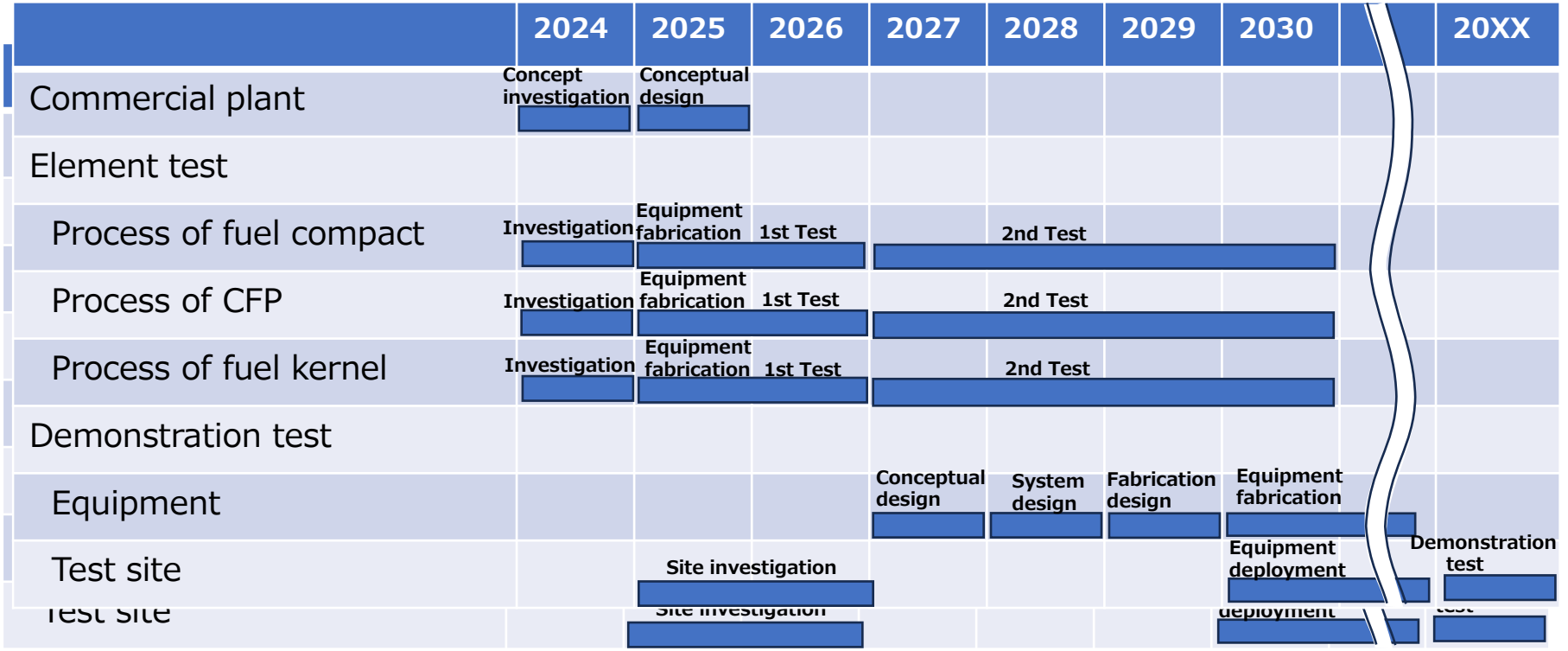
Pin-in-block type fuel

Japanese head-end process reduces waste amount with high recovery ratio.

Plan and status of R&D for the demonstration test for the head-end process using the spent fuel from HTTR

Plan for the Demonstration Test using the Spent Fuel from HTTR

The R&D have been performed as the part of demonstration HTGR plan in GX (Green Transformation) policy of METTI.



R&D and test equipment fabrication will be completed in 2030.
The year of the demonstration depends on fuel reloading of HTTR, and it is not determined yet.

Result of Technology Review for Head End Process

To confirm suitability for commercial use, the feasibility for each element technology for the head end process was investigated.

Part		Process	Target				
			Compact	OPyC	SiC	IPyC/Buffer	Kernel
Fuel Compact Process	Base	Burn (Atmospheric env.)	△ Waste Amount	△ Waste Amount	–	–	–
	Base	Burn (CO_2 Env.)	○	○	–	–	–
	Alt.	Electrical Disintegration (Pulse)	△ Few Example	–	–	–	–
	Alt.	Electrical Disintegration (Constant Current)	○	–	–	–	–
CFP Process	Base	Mechanical Crush (Hard Desk Crusher)	–	–	△ Remote Control and Maintenance	–	–
	Alt.	SiC Burn (Air env.)	–	–	△ Control of Env.	–	–
	Alt.	SiC Burn (Halogen env.)	–	–	× Selection of Material	× Selection of Material	–
	Base	Re-burn	–	–	–	○	–
	Alt.	Molten Salt Electrolysis	△ Large Amount	△ Demonstration of Principle	△ Demonstration of Principle	△ Demonstration of Principle	–
Kernel Process	Base	Dissolution	–	–	△ Effect to Dissolution	–	○
	Base	Recovering Residue Clarification	–	–	△ Deference of Density	–	○

○ Feasible

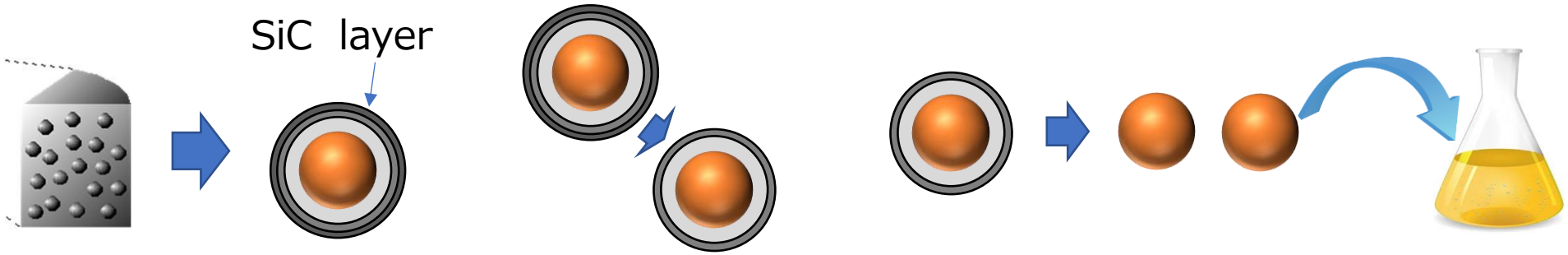
△ Subjects to be solved

×Not Feasible

Even in the hard desk crasher used in NFI, there is subjects to be solved for spent fuel processing.

Candidates of Head End Process

Now, JAEA have developed equipment for demonstration using HTTR spent fuel.
The candidates the head end process to be demonstrated in order to the priority:



1st:	Burn	Hard disk Crasher	Re-burn	Dissolution
2nd:	Burn	Molten Salt Electrolysis		Dissolution
3rd:	Burn	SiC burn	Re-burn	Dissolution

JAEA will develop the most suitable process of the head end process, and demonstrate it in 2030's.

Summary

JAEA introduced the status of R&D of back-end technologies of HTGR and the plan for the demonstration test to using HTTR spent fuel.

For R&D of back-end technologies of HTGR:

- Japanese basic policy for fuel cycle is reprocessing from resources.
- Japan had completed the reprocessing for LWR.
- Head-end process of reprocessing for HTGR had also completed, and applicability to RRP had been also confirmed.

For R&D of demonstration test using HTTR spent fuel:

- JAEA started the R&D in 2024 with the GX budget from METI as a part of HTGR demonstration program.
- The candidates of head-end processes are a hard disk crasher process, a molten salt electrolysis process, and SiC burn process.
- JAEA will develop the most suitable process and demonstrate it in 2030's.