Handling Technology of Low Decontaminated TRU Fuel for the Simplified Pelletizing Method Fuel Fabrication System

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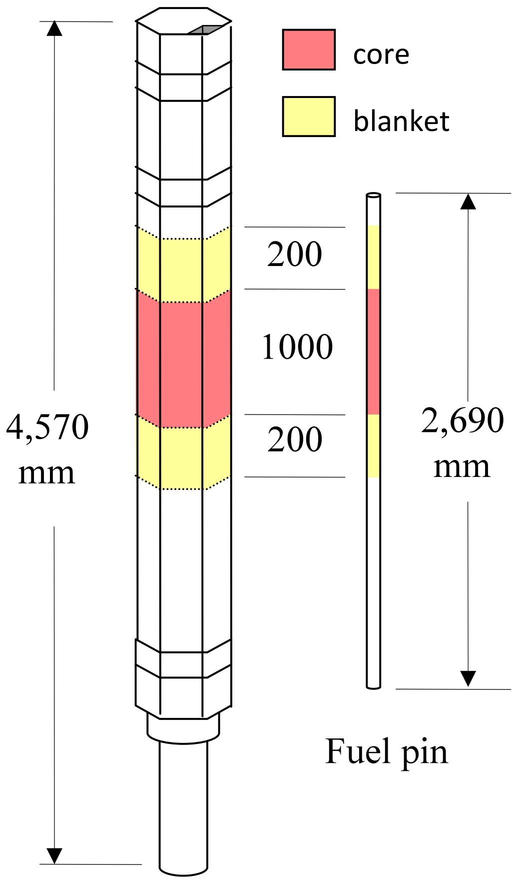
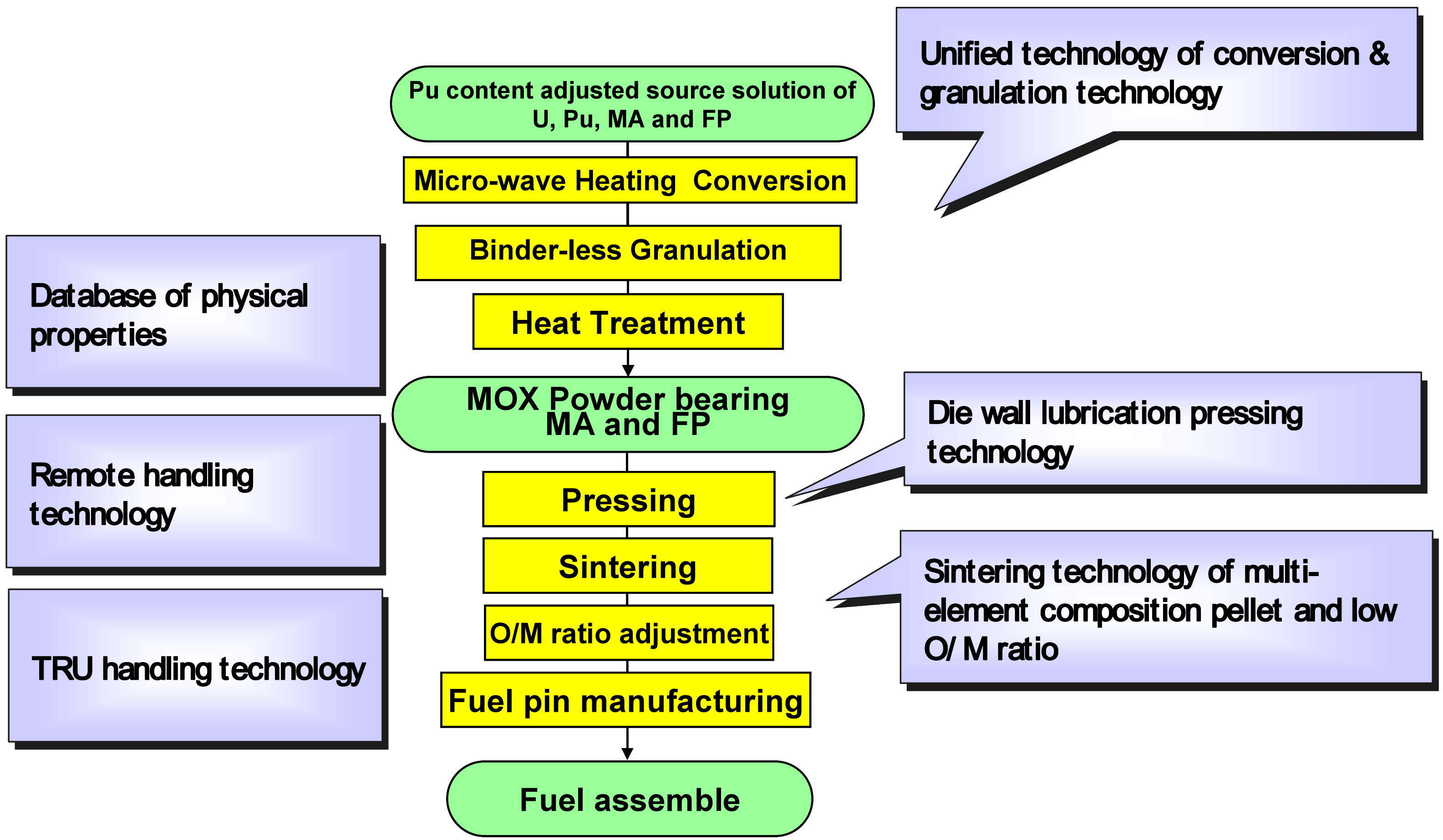
Specification of the Fuel on FaCT Project



Assembly (Core fuel)

- Specification of fuel
  - •Elements : 255pins/assembly
  - • Pu content : 18 wt% (inner core), 21 wt% (outer core)
  - • Pellet diameter : ϕ 8.74mm
  - •Density : more than 95 %TD
  - •O/M ratio: less than 1.97
  - •MA content : ～5.0 wt%
  - •FP content : 0.2 wt%
- Plant scale : 200t-HM/200days
- Operation days : 250 days/year (including casual maintenance)

Six Technical Issues of Fuel Fabrication Technology Development

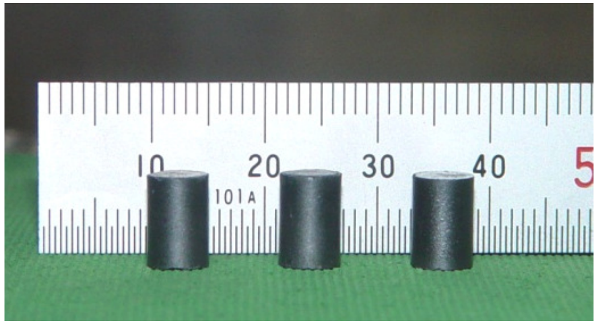


Issues for rationalizing present process and Issues for measures against MA and FP bearing are intertwined.

R&D Issues Specific on Low decontaminated TRU Fuel Fabrication

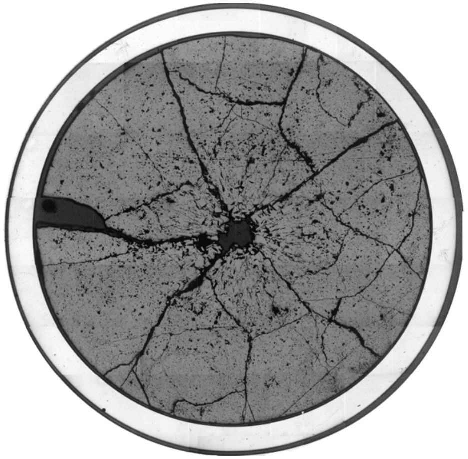
Feature	Affect	Required technology	R&D issue
MA,FP bearing	Pellet manufacture	Manufacturing condition	Sintering character control
	Fuel wellness	Fuel design	Physical property database Irradiation behaviour
High heat generation	Fuel manufacture	Measure against degradation	Non-organic additives Die lubrication Pressing
		Prevention of oxidation	Evaluation of change Storage
		Measure against heat	Cooling system
High radiation	Operation	In-cell equipment	Remote fabrication Feedstock containing
		Decontamination	Decontamination system Waste management
	Equipment	Measure against degradation	Irradiation resistance parts
		Nuclear material detection	Measuring technology Measuring equipment

Influence of Multi-element to Sintering & Irradiation behaviour

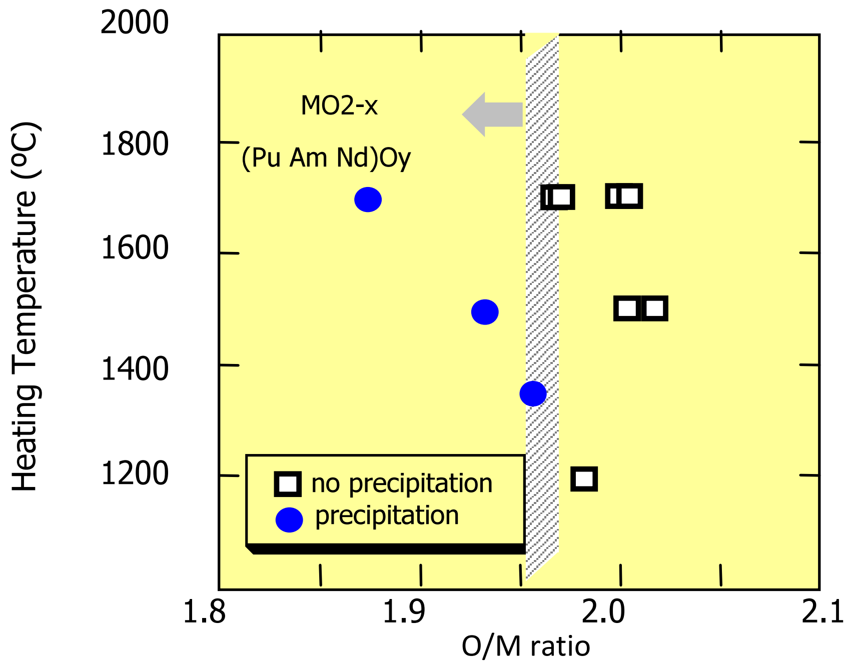


5%Am-MOX pellets for JOYO tests

2%Np/2%Am-MOX pellets for JOYO tests



5%Am-MOX、O/M=1.98 Irradiated for 10 min. in JOYO MK-III core



Precipitate with simulated FP ;
less than 10 μmφ

Specified MA and FP bearing fuel is expected to be feasible.

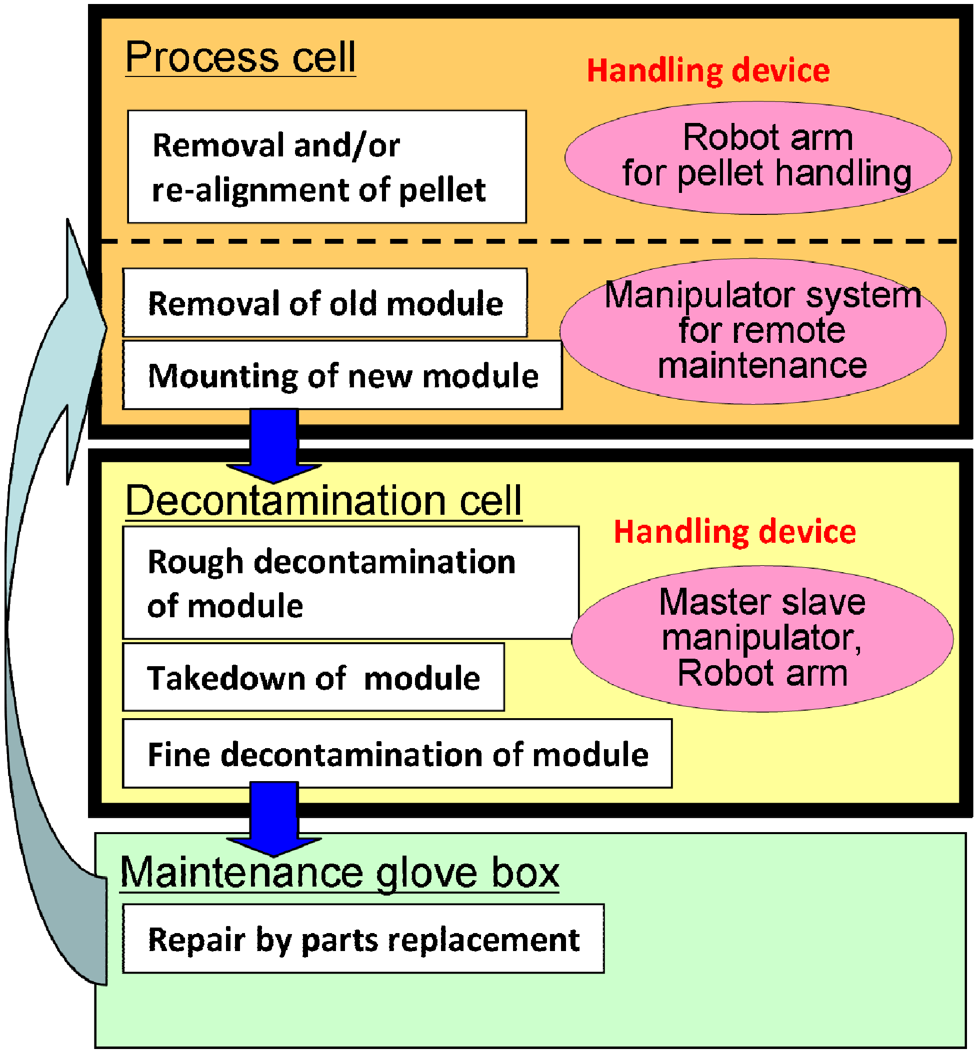
Fundamental Requirement for In-cell Equipment

	Requirment		Development Issue		
			Objective	Technology	
Remote fabrication	Compatibility to specification		Processing accuracy	Stability and homogeneity of process condition	
			Measurement accuracy	Measurement method	
	Automation	Intra-equioment material flow	Automatic transfer	Traqnsfer method	
				Transfer control	
		Inter-equipment material flow	Automatic control	Control logic	
		Process control	Automatic control	Operation control	
				Anomaly detection	Product anomaly detection
					Equipment anomaly detection
	Maintenance system	Equipment structure	Modularizing	Modularized equipment	Module structure
					Retaining mechanism
					Remote connection
					Confinement or ejection of fuel material
					Operation sequence
					Adjusment free positioning
		Remote handling	Easy handling	Module handling device	Control with good operationability
				Material handling device	

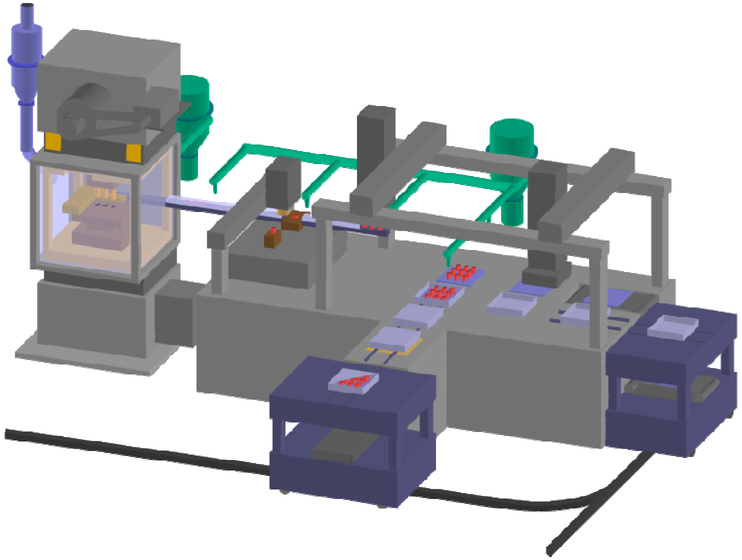
The technology can be developed

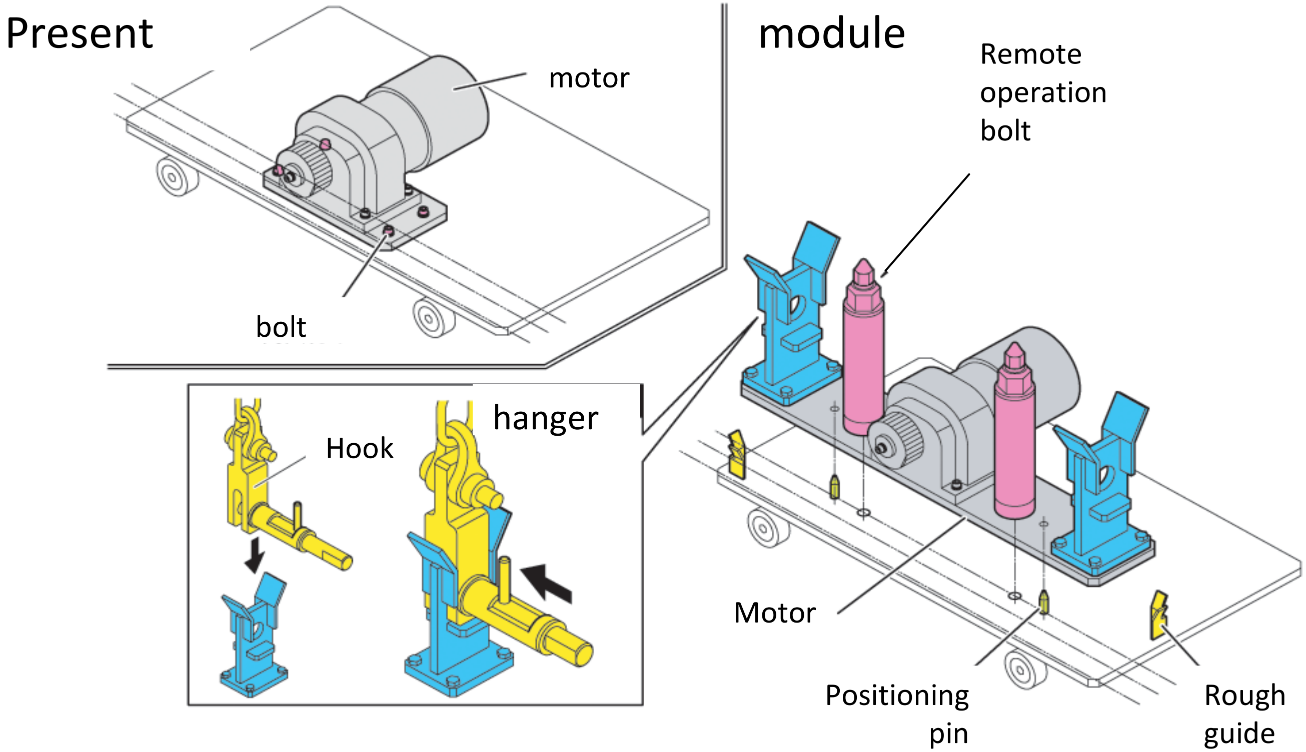
- **based on proven automation technology at present glove-box equipment**
- **considering balance of hurdle on each requirement ;**
  Compatibility to specification / Automation & Maintenance
  Automation / Maintenance

Optimum Concept for In-cell Equipment Maintenance



Fundamental Structure of Module





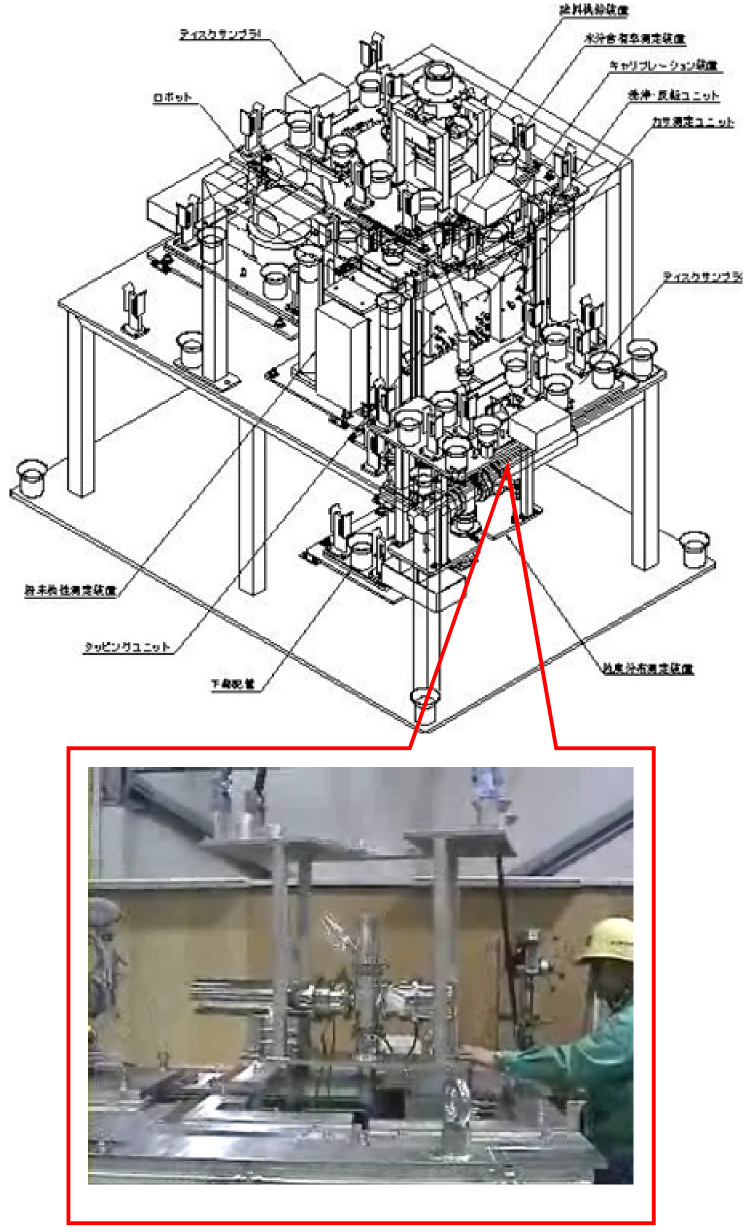
Modularized Pressing Machine

	Equipment composed	Composite module	Module
Pressing machine	Powder feeder	Powder feeder	Air knocker
	Press head	Press head	Press
			Press hesd
			3 other modules
	Pellet pushing rod	Pellet pushing rod	Stop sensor
	Pellet conveyer	Pellet conveyer	Pellet sensor
			Line sensor
	Inspection equipment	Inspection equipment	Pellet chuck
			Inspection device
	Pellet alignment equipment	Pellet alignment equipment	Pellet traverser
			2 Other modules
	Pellet transfer	Pellet transfer	Pellet transfer device
			Transfer stage
	Empty tray transfer	Empty tray transfer	Side roller
			Conveyer roller
	Pellet tray transfer	Pellet tray transfer	Side roller
			Conveyer roller
	Dust collector	Dust collector	Dust collector
			Collector head
			5 other modules
No. of modules		10	27

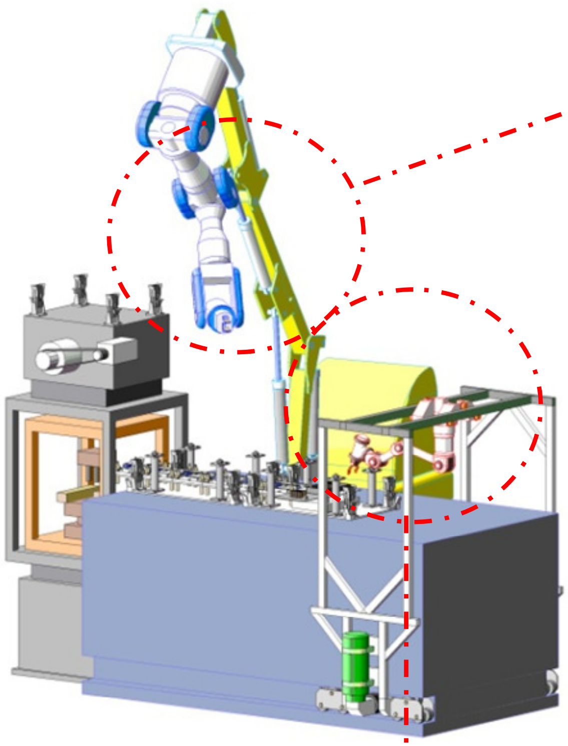
Modularizing for more precise equipment

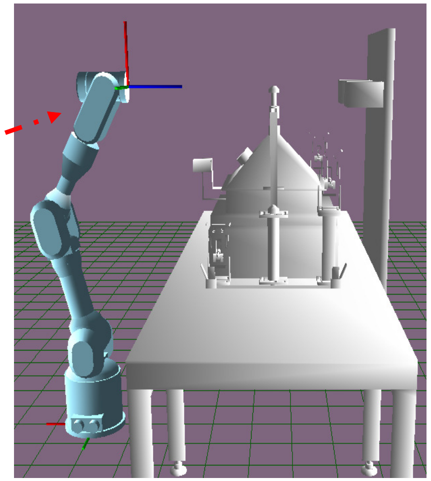
- **In-line analyzer for physical properties of MOX powder**
  - **moisture**
  - **grain size distribution**
  - **flowability**

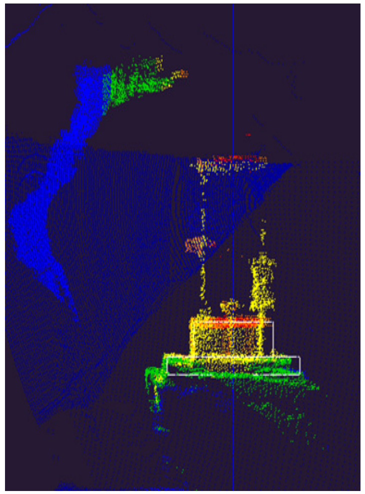
- **Pellet inspection equipment**



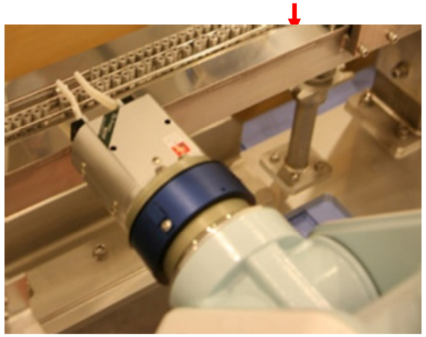
Handing Device & Man-Machine-Interface





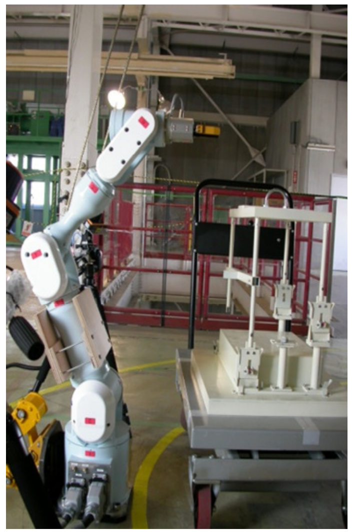


CG display calibrated by position data



Robot manipulation

MMI to reduce work load on an operator



Visual picture

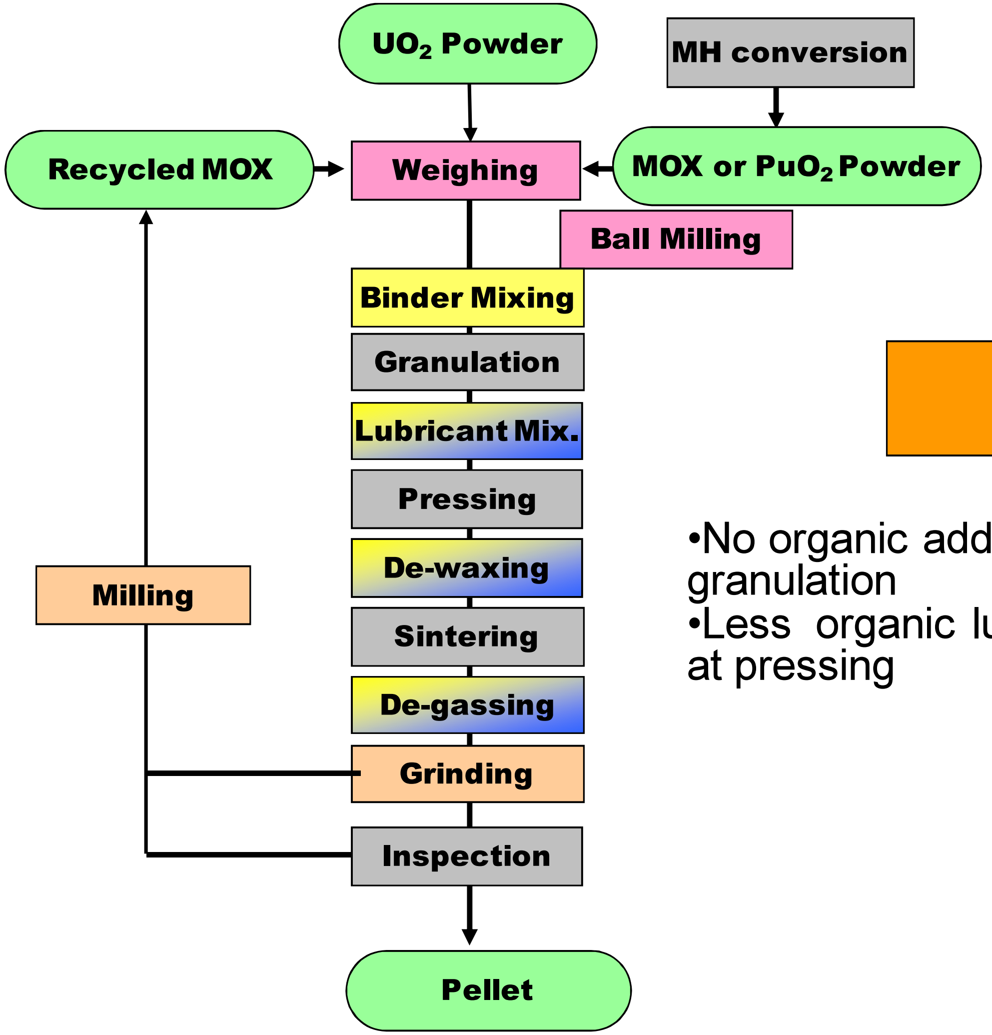
Measure against MA Decay Heat

- Maximum heat rate is substantially 20W/kgHM at 5wt% of MA bearing MOX (depend on recycle scenario)

- Undesirable effects to fuel production quality ;
  - degradation of organic additives
  - re-oxidation of source powder and pellet
  - oxidation of cladding
  - mechanical interaction between pin bundle and wrapper tube, etc.

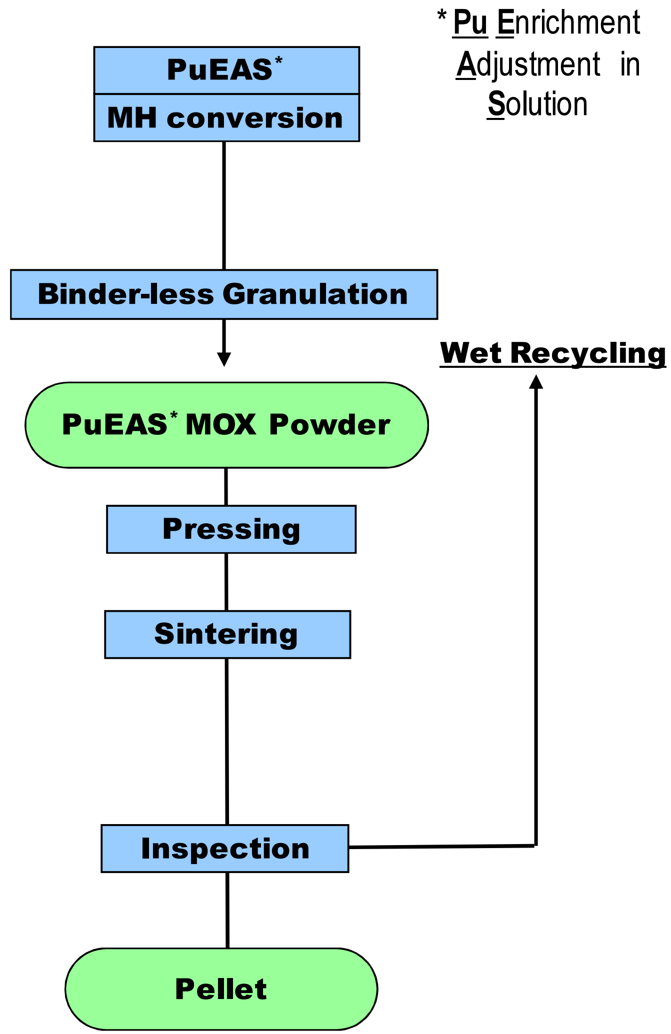
- Measures to reduce undesirable effects of heat generation of the MA-MOX ;
  - deconcentrate the source fuel (easy, but enhance equipment volume)
  - improve function of heat release (if possible)
  - prevent oxidation by surrounding inert gas (high cost)
  - forced cooling operation (reasonable), etc.

Advanced fuel fabrication process proves heat resistance du to MA decay



Present MOX Pellet Fabrication Process

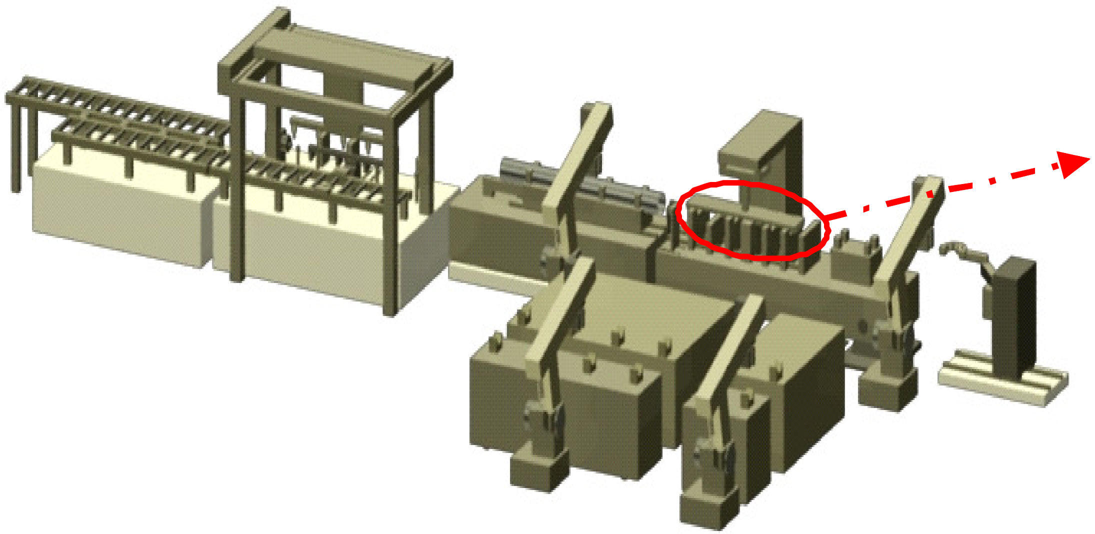
- No organic additives at granulation
- Less organic lubricant at pressing



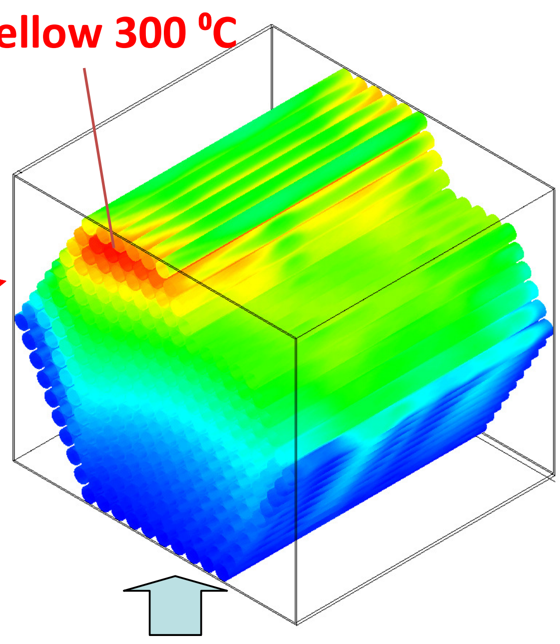
Simplified Pelletizing Method

Feasibility estimation of forced cooling by air blow on assembling process

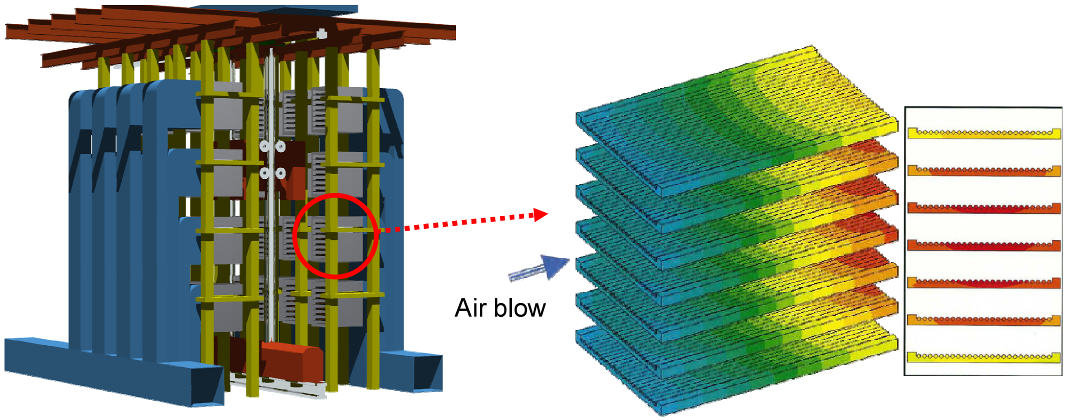
- **At assembling, the heat generation of max. 2.6 kW/assembly (130kgHM) might cause undesirable effects such as oxidation of cladding materials .**
- **Pin bundle without wrapper tube can be cooled down by air blow at right angle to pin bundle that is proven by full scale mock-up tests.**
- **So is pin bundle loaded into wrapper tube by air blow which is introduced belong its sodium coolant flow channel.**
- **Air blow shutdown test is going on.**



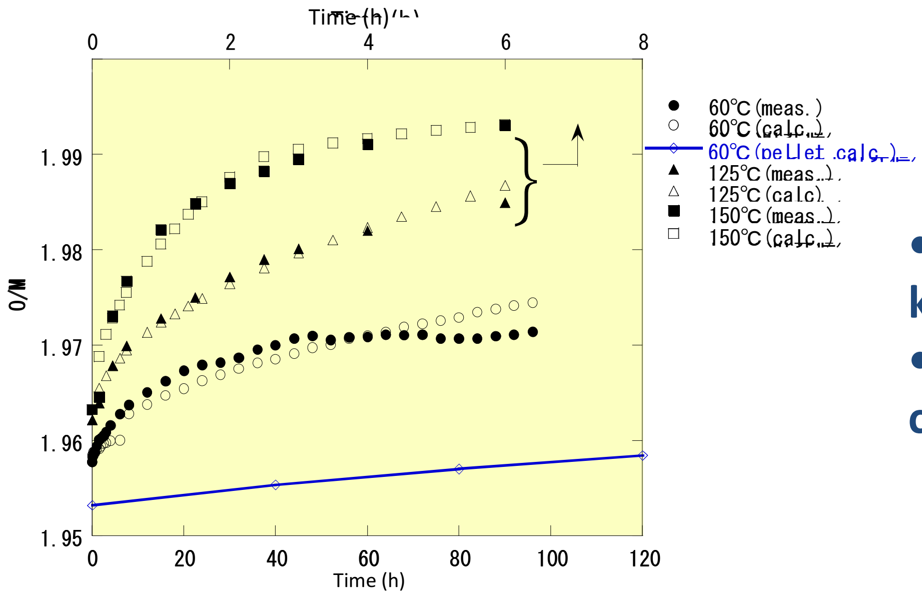
Fuel Assembling Equipment



Feasibility estimation of forced cooling by air blow on pellet storage



Design Specification:
1344 pellets/tray
7 trays /container
256 containers/ storage

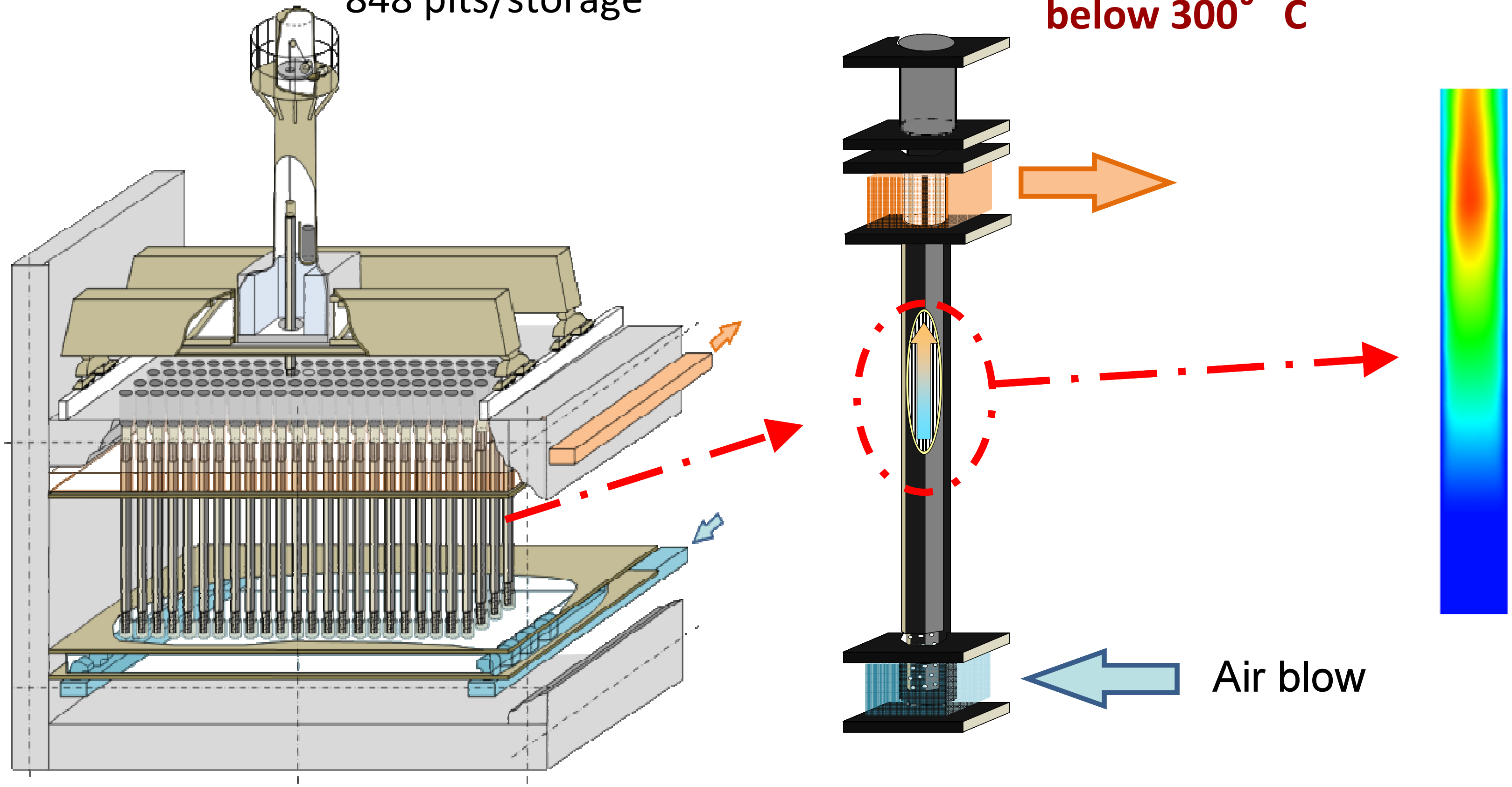


O/M ratio drift change of disk sample in air atmosphere

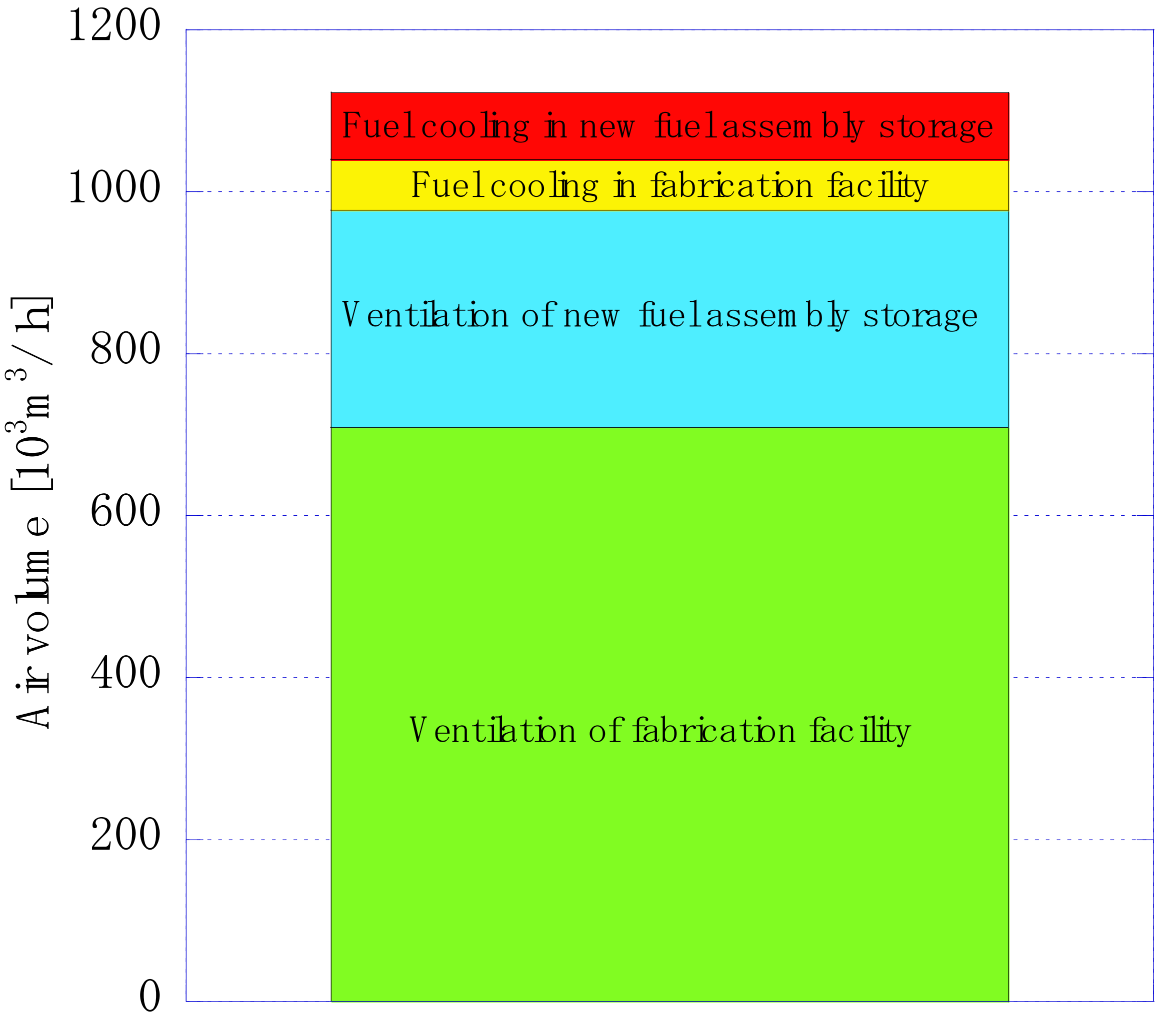
- **To prevent O/M drift , a pellet should be kept below 60°C .**
- **Air blow cooling system on the design condition is feasible.**

Feasibility estimation of forced cooling by air blow on new assembly storage

Design specification:
848 pits/storage



Estimation of Impact on Air ventilation



Concluding Remarks

- **R&D are going on toward a C&R in 2010 to decide the adoption.**

- **The interim summarizing by JAEA shows that in-cell remote maintenance system and MA decay heat removal system are generally expected to be feasible on a 200tH/y-scale plant.**