Representation of Process Design Rationale for Change Management

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Back Ground

- The process safety management system intends to realize process safety through the plant life cycle by applying the mechanism of the MOC (Management Of Change).
- All the changes except for RIK (Replacement In Kind) to the process, plant, operation and chemicals should be managed by the MOC process.
- Many major accidents are caused by the changes of which they were judged being RIK.
- Because, the judgement of RIK has been made by considering just the results of process and/or plant design.
- To overcome this problem, it is necessary to judge RIK based on not only the design results but also the process design rationales

Motivation and Approach

- There exist many researches on the design rationale system.
- For industrial design, IBIS (Issue Based Information System) has been applied.
- However, the design process assumed in IBIS is different from the process design process in the chemical industry.
- IBIS cannot be applied for the management of change.
- We focus on the conceptual process design, which is closely related to the inherently safer process design, here.
- In this study, we explicitly clarify the conceptual process design process.
- The purpose of this study is developing a method to represent the conceptual process design rationale consistent with the process design process.

Process Design Stages

Reaction Path Design, Process Synthesis (Research &Development)

The technology is transferred

Process Lifecycle

Plant Lifecycle

Conceptual Process Design (Design for Chemical Processing)

- BFD (Block Flow Diagram) Level Design
- PFD (Process Flow Diagram without BPCS) Level Design

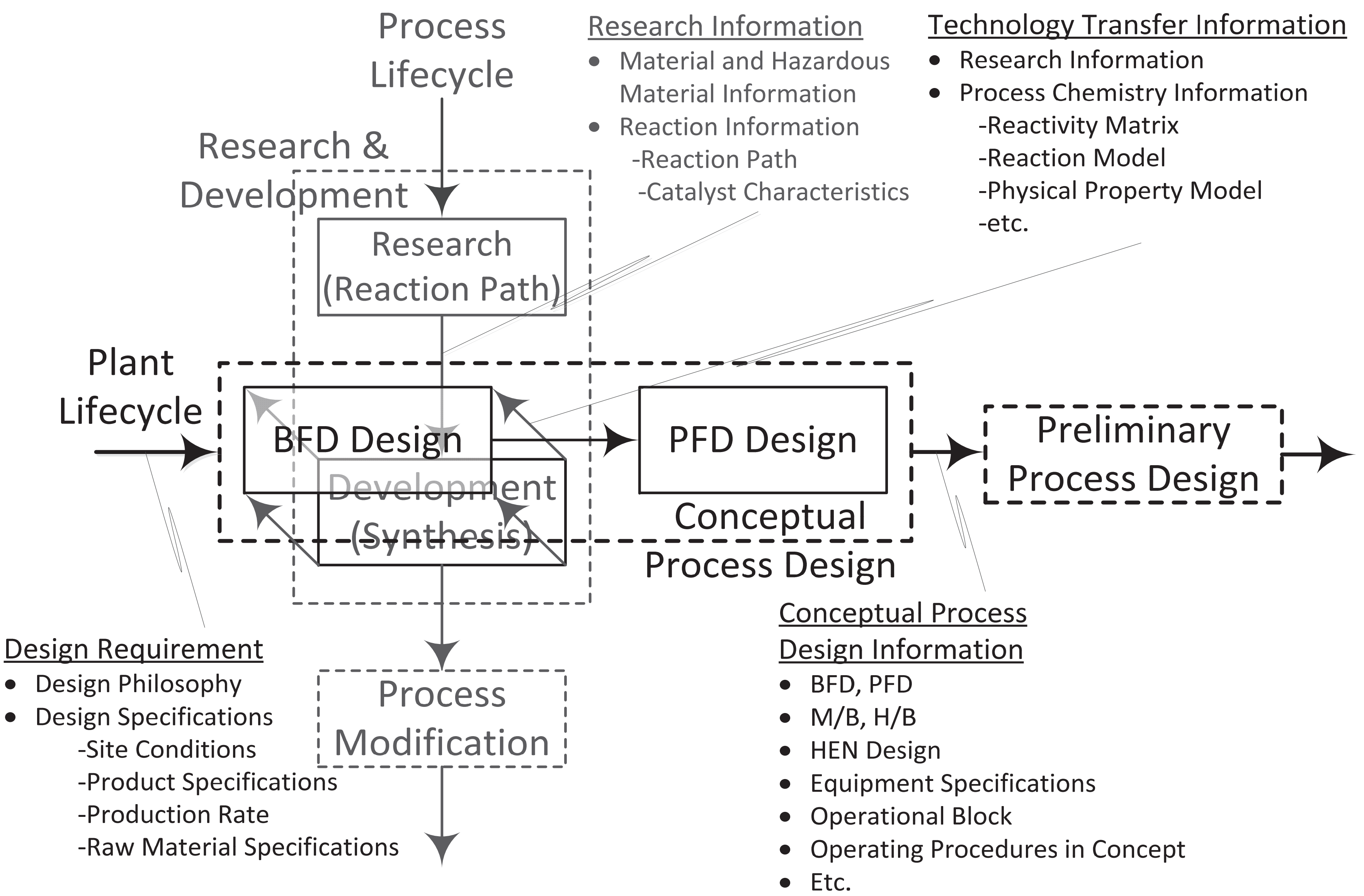
Preliminary Process Design (Process Operational Design)

- PFD with BPCS
- P&ID (Piping and Instrumentation Diagram) AFP, AFD
- Process Sketch, Data Sheet

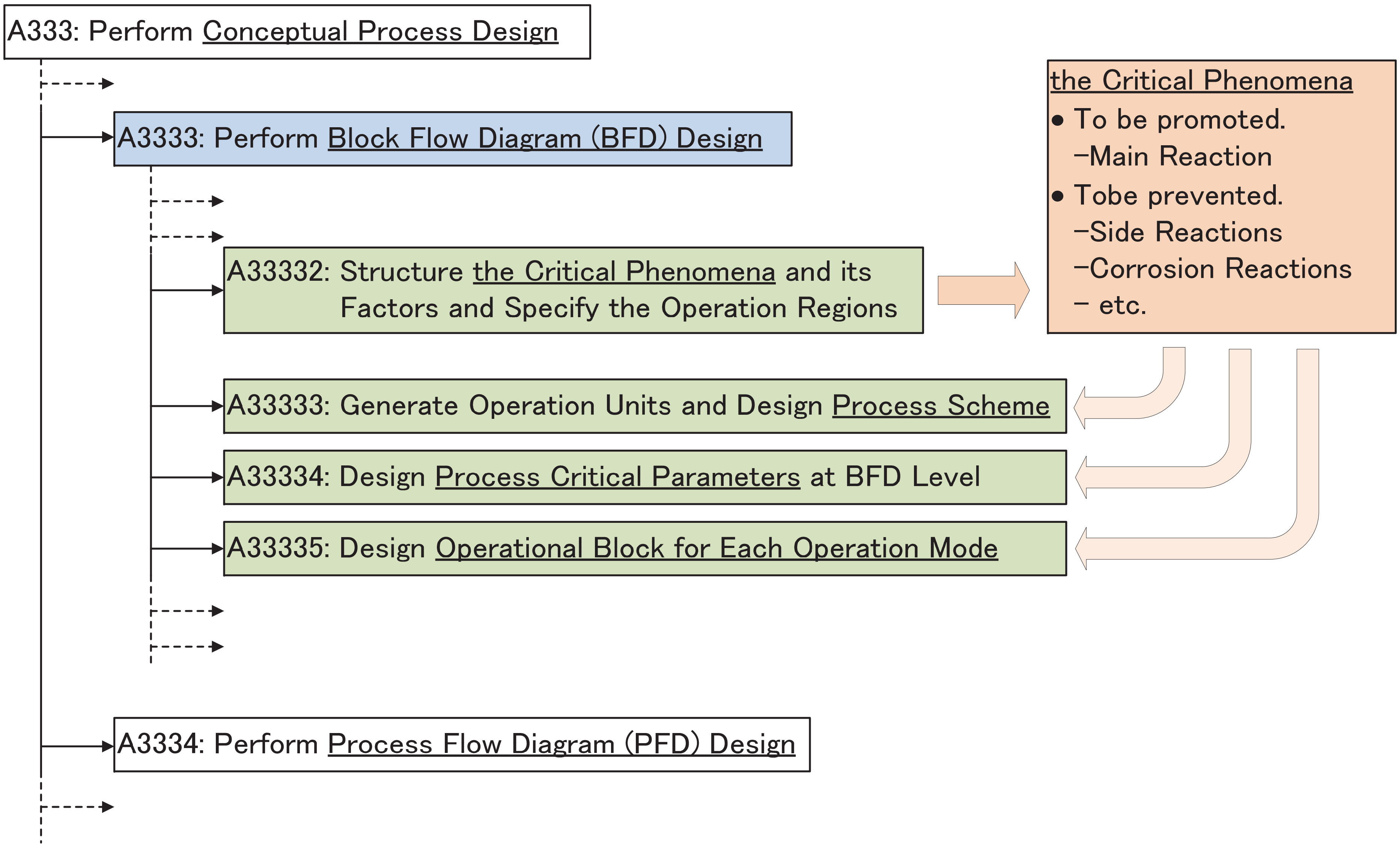
Detailed Process Design (Dynamic Operation Design)

- P&ID AFC
- Interlock Diagram, SOP (Standard Operation Procedure)

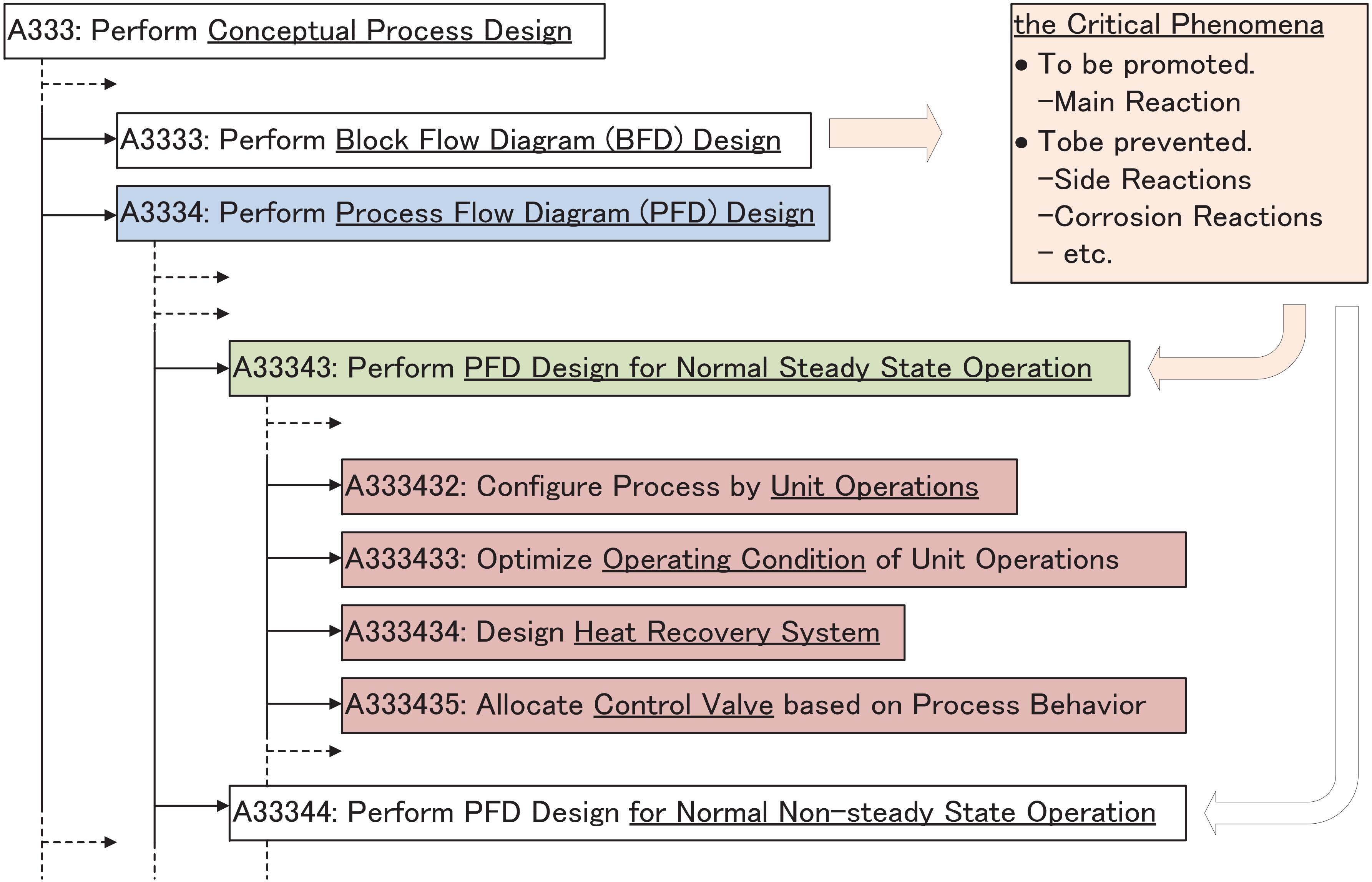
Relation between Process Development and Design



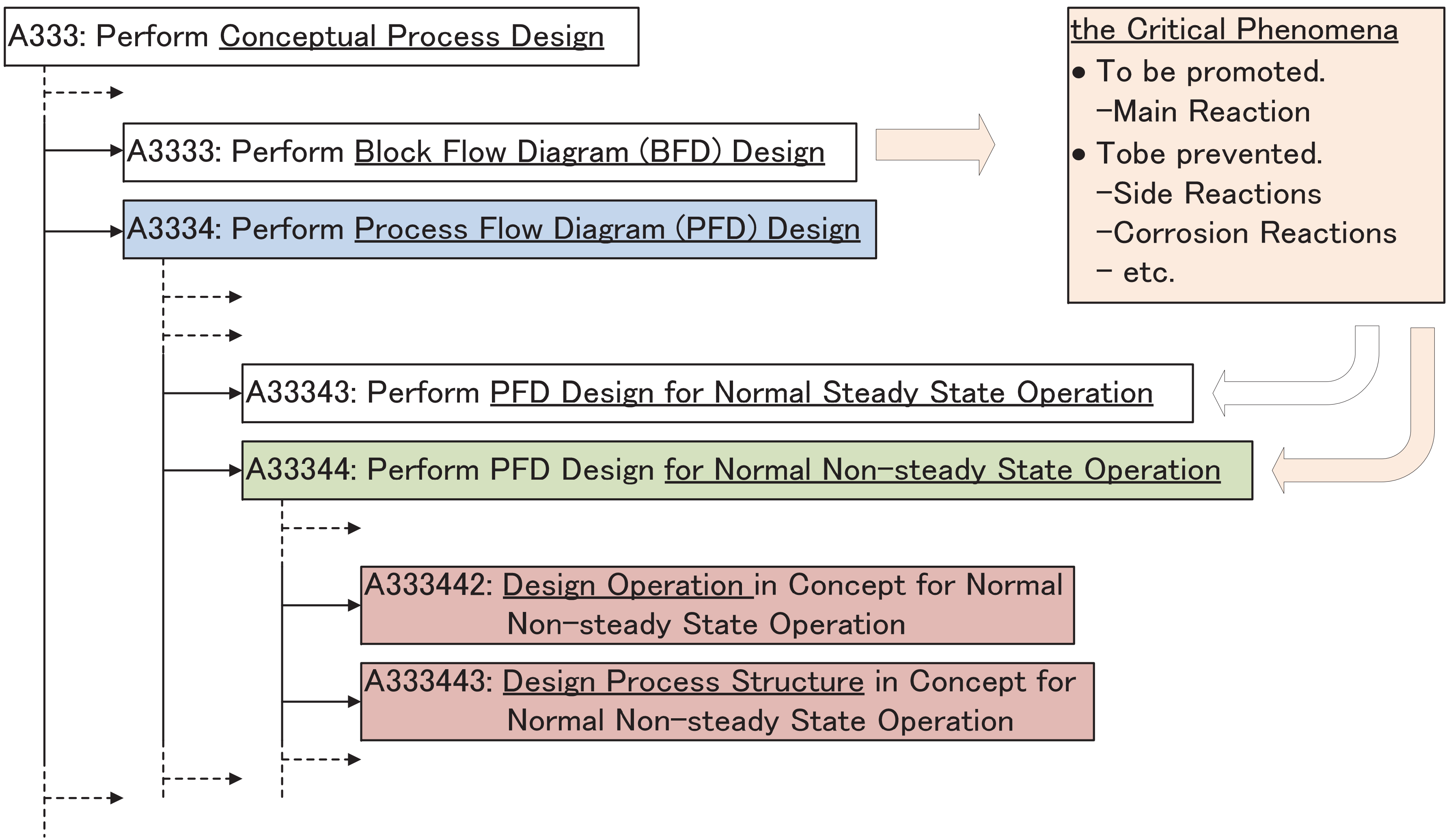
Business Process Model for BFD Design



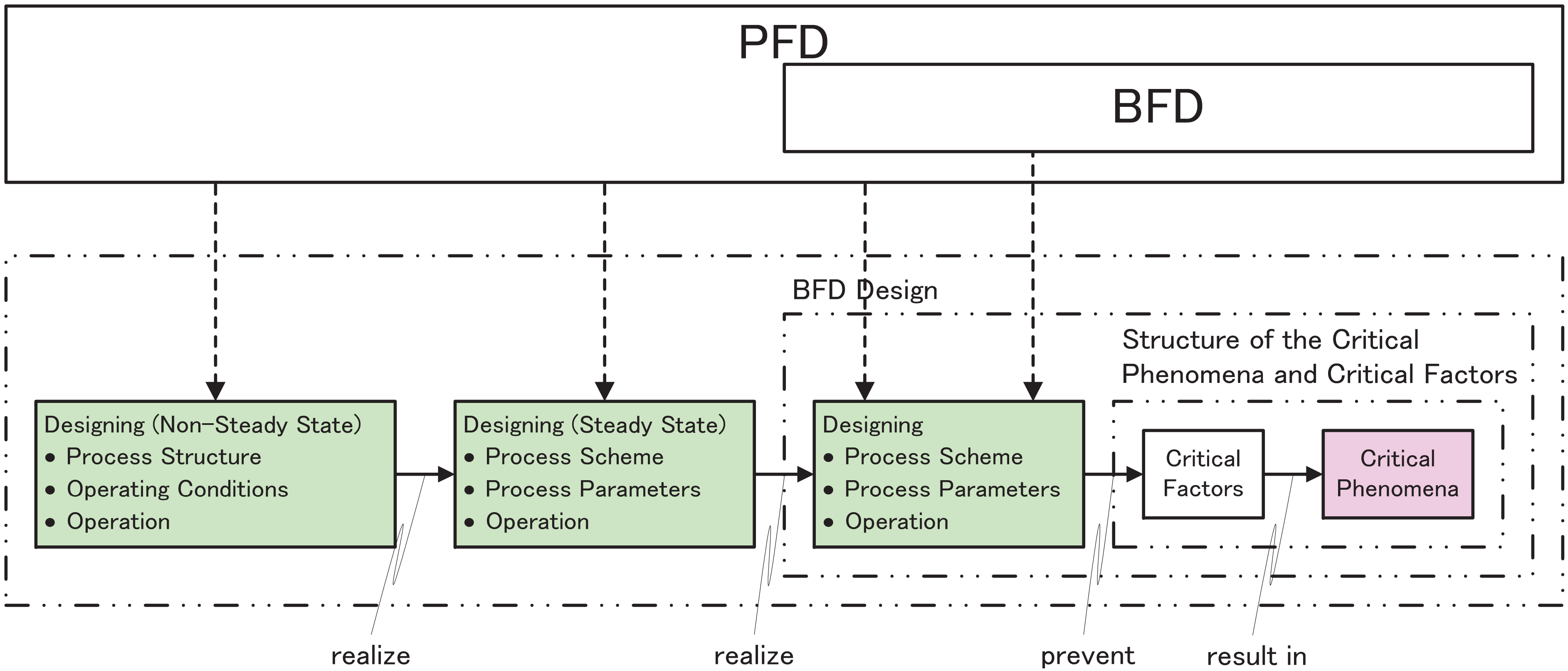
Business Process Model for PFD Design
- for Normal Steady State Operation -



Business Process Model for PFD Design
- for Normal Non-steady State Operation-



The Structure of Conceptual Process Design Process and The Representation of Design Rationale Information



Application for BFD Design of DME from Me-OH

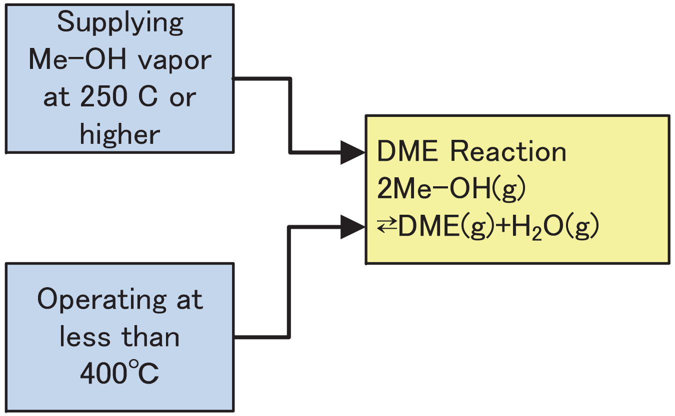
A Part of Design Requirement

Item	Specification
Feed Me-OH	75mol % Me-OH+25mol% Water
	30[C], 1.013[bar] Liquid(@BL)
	Impurity: containing a saturated amount of CO_2
Product	99.5 wt% DME (+Me-OH)
	46[C], 11.4[bar] Liquid (@BL)
Production rate	1500 (t/day)
Utilities	Heating Steam: 12[bar] saturated (=190[C])
	Cooling Water: 30[C] supply, 38[C] return
	LP high purity N_2 available
Waste Water	99wt% (less than 1wt% of Me-OH)

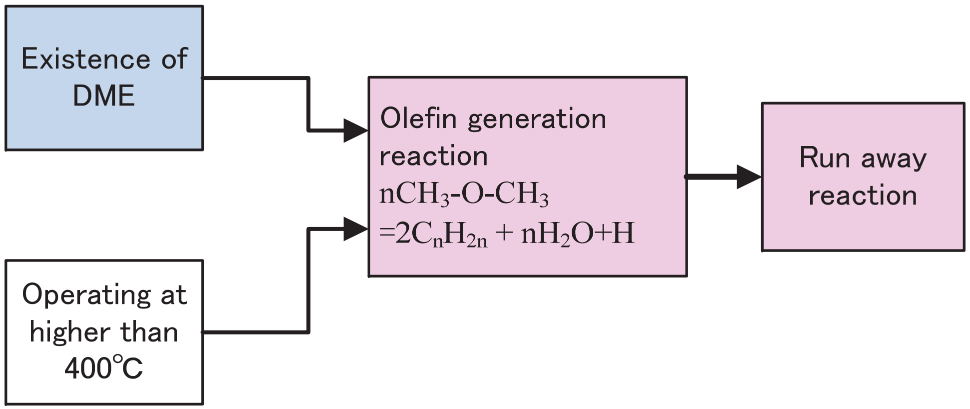
Technology Transfer Information

Category	Item	Transferred Information
Main Reaction	Thermochemical equation	$2CH_3\text{-}OH(g) \rightarrow CH_3\text{-}O\text{-}CH_3(g) + H_2O(g) + 11770$[kJ/kmol]
	Catalyst	Gamma Alumina
	Catalyst Deactivation	Condensed Water
	Normal Operating Region	250[C] to 400[C] without no side reaction
	Kinetic Model	$-r_M = k_0 \exp(-Ea/RT) p_{Me\text{-}OH} - k'_0 \exp(-E'_a/RT) p_W$ r_M [kmol/m^{3}cat-h], $P_{Me\text{-}OH}$[kPa], P_W[kPa], $k_0 = 1.21 \times 10^6$[kmol/m^{3}cat-h-kPa], $E_a = 80.48 \times 10^3$[kJ/kmol] $k'_0 = 5.07 \times 108$[kmol/m^{3}cat-h-kPa], $E'_a = 11.83 \times 10^4$[kJ/kmol] T[K], $R = 8.314$[kJ/K-kmol]
	Equilibrium Model	Refer to Ghavipour, M. and R,M.Behbahani, J of Ind. Eng. Chem., 20,1941-1951(2014)
Side Reactions	Me-Oh reaction	Me-OH ⇔ $2H_2$ + CO, Me-OH + H_2O ⇔$3H_2$+CO_2 (less than 250[C])
	Olefin reaction	nDME ⇔$2C_nH_{2n}$ + n H_2O (more than 400[C])
Corrosion	SUS	Carbonate acid pitting under deposits
	CS	Carbonate acid uniform corrosion under deposits
Physical properties estimating equation		PRSV

Structuring Critical Phenomena and their Critical Factors
(1) Normal Operating Region
(2) Olefin Reaction

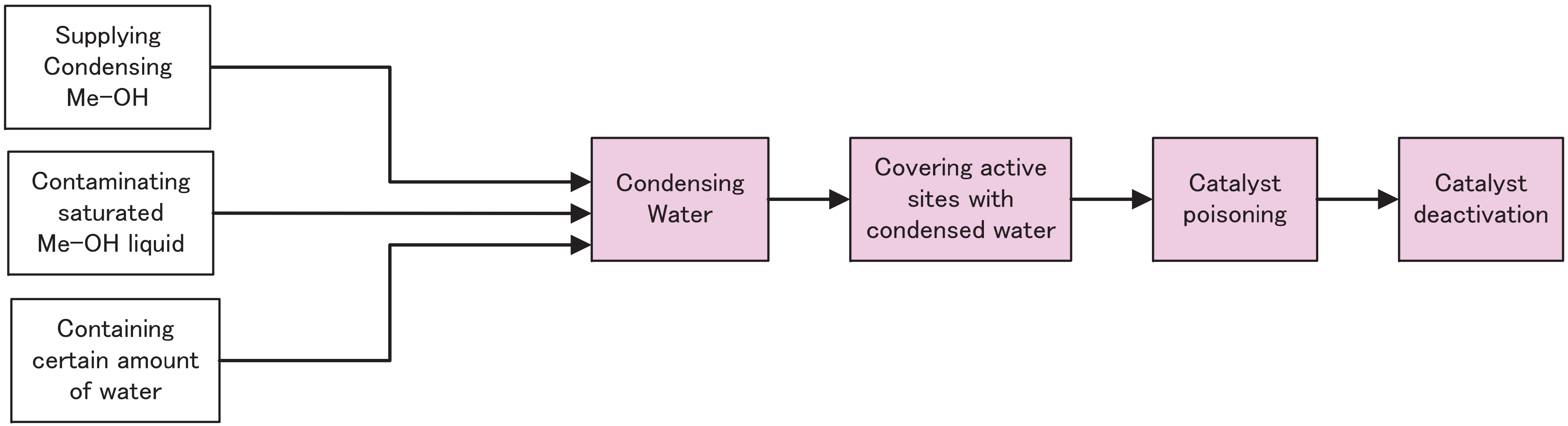


(1) Normal Operating Region

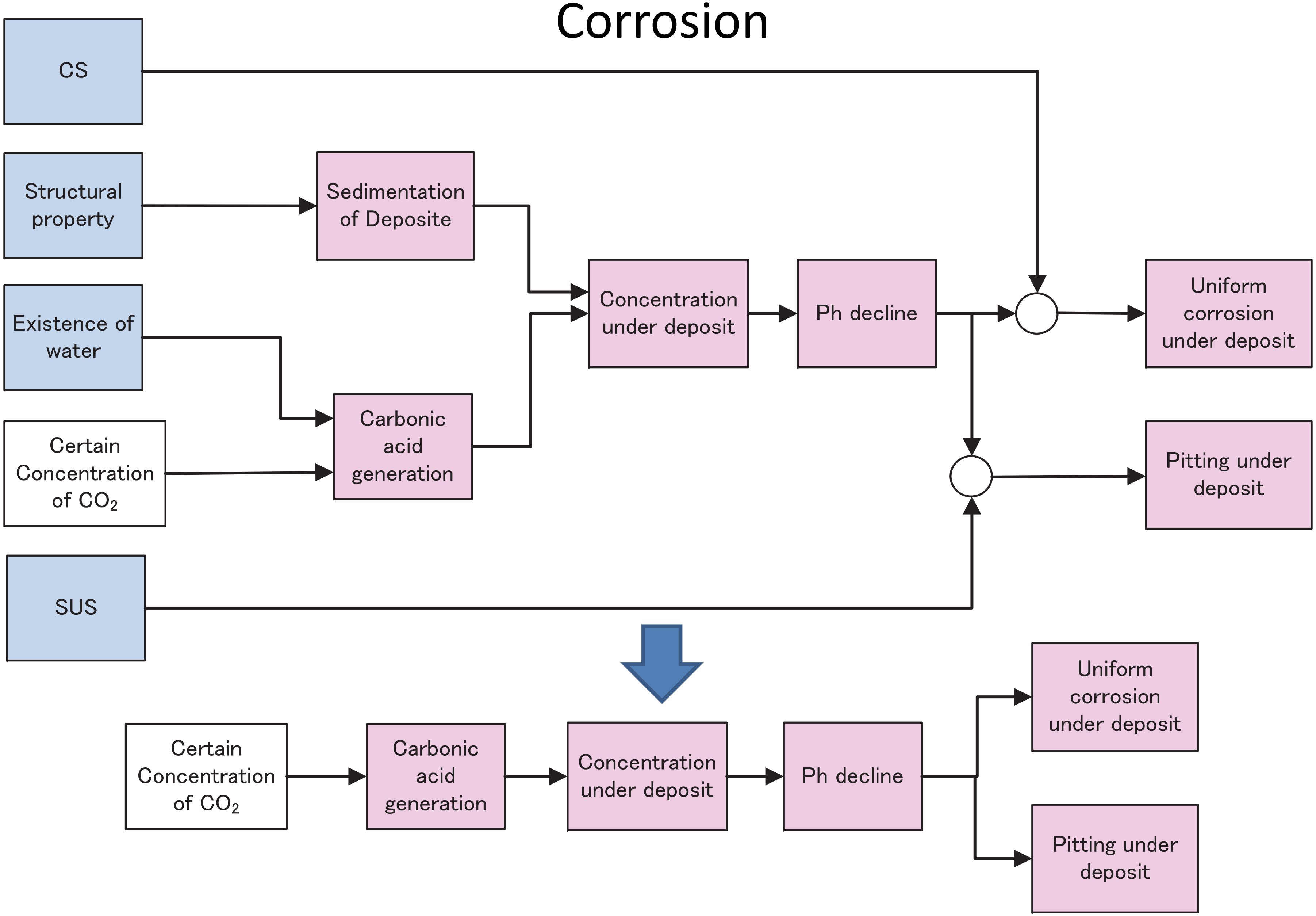


(2) Olefin Reaction

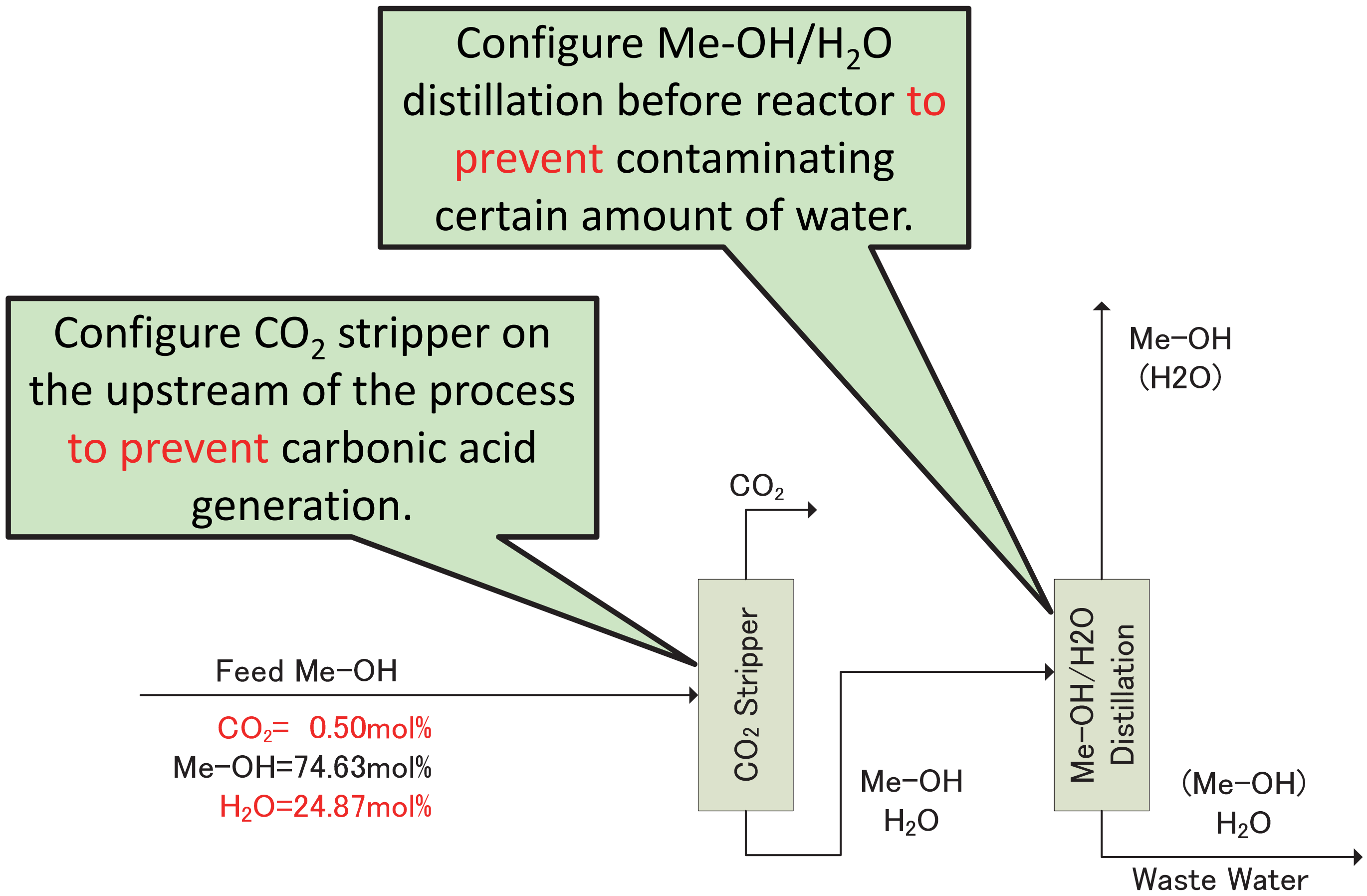
Structuring Critical Phenomena and their Critical Factors
Catalyst Deactivation



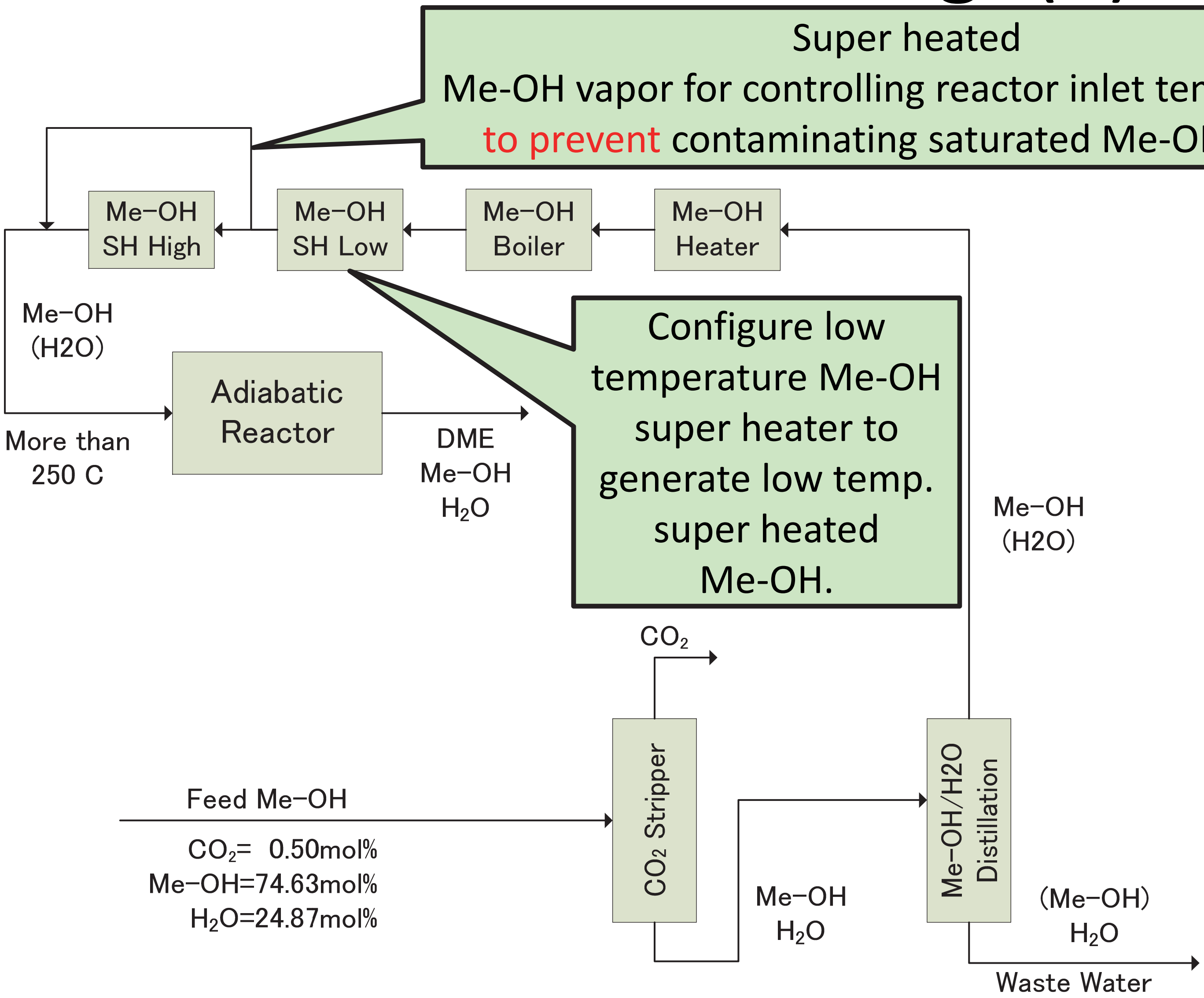
Structuring Critical Phenomena and their Critical Factors
Corrosion



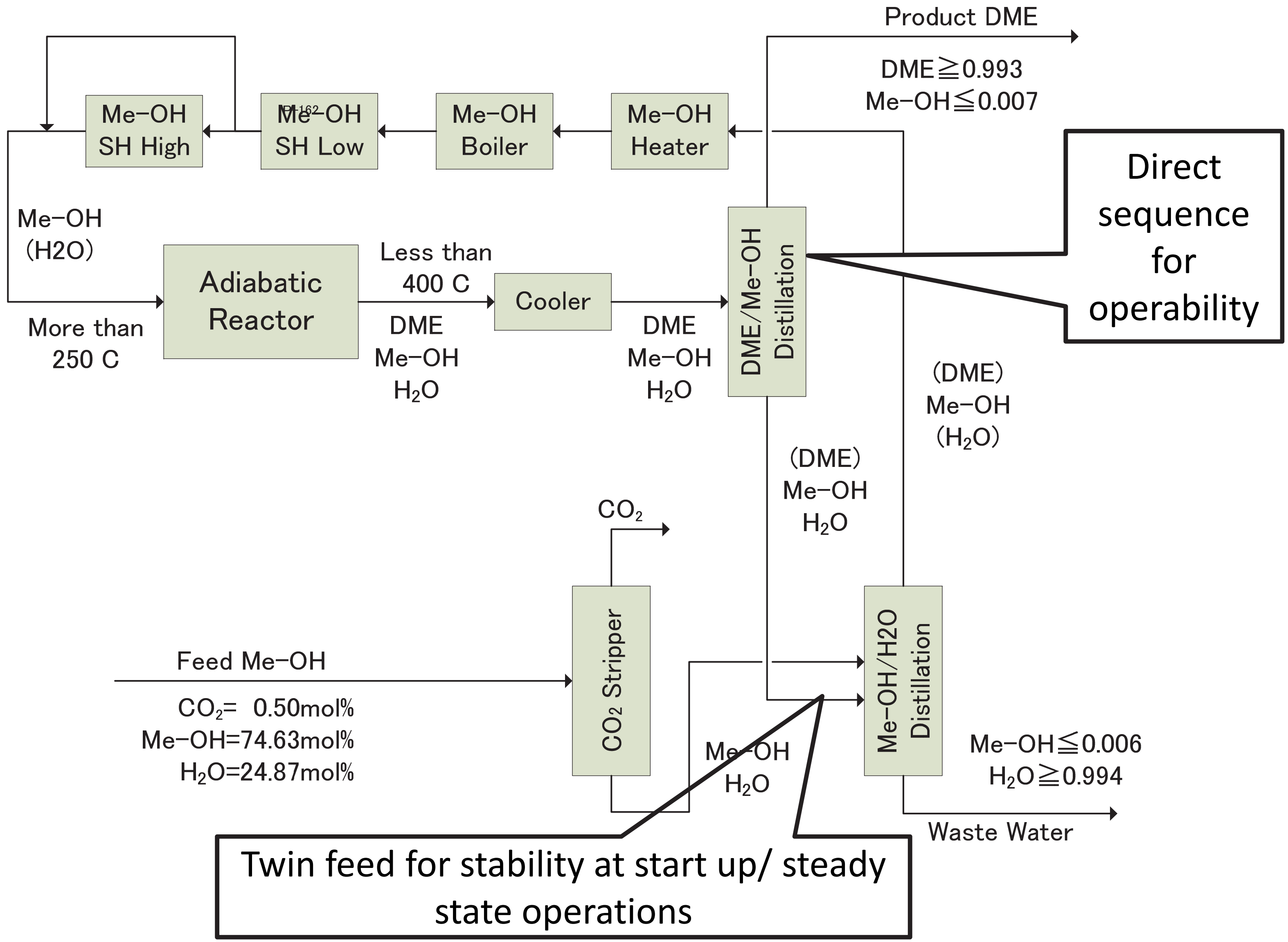
Process Schematic Design(1)



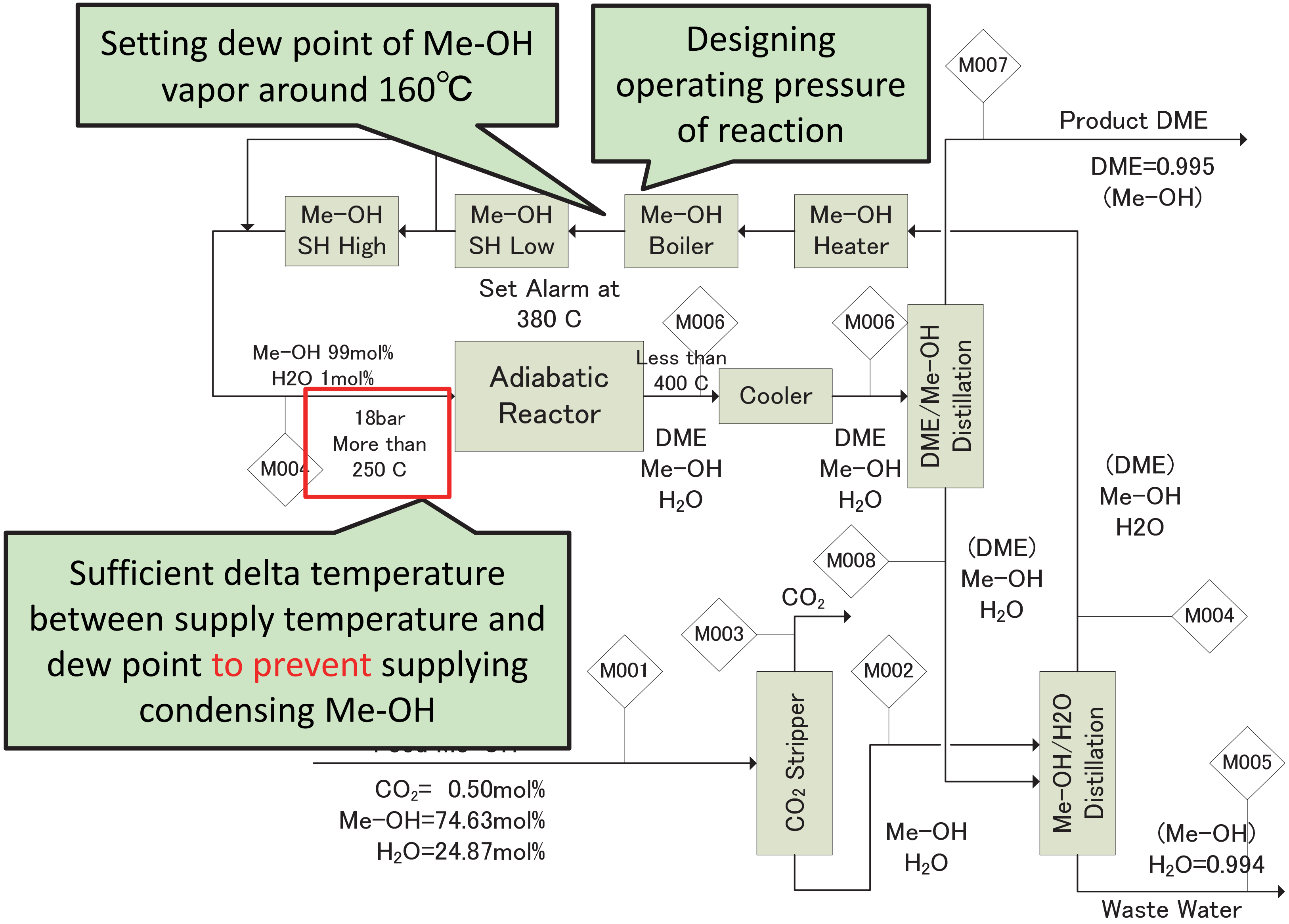
Process Schematic Design(2)



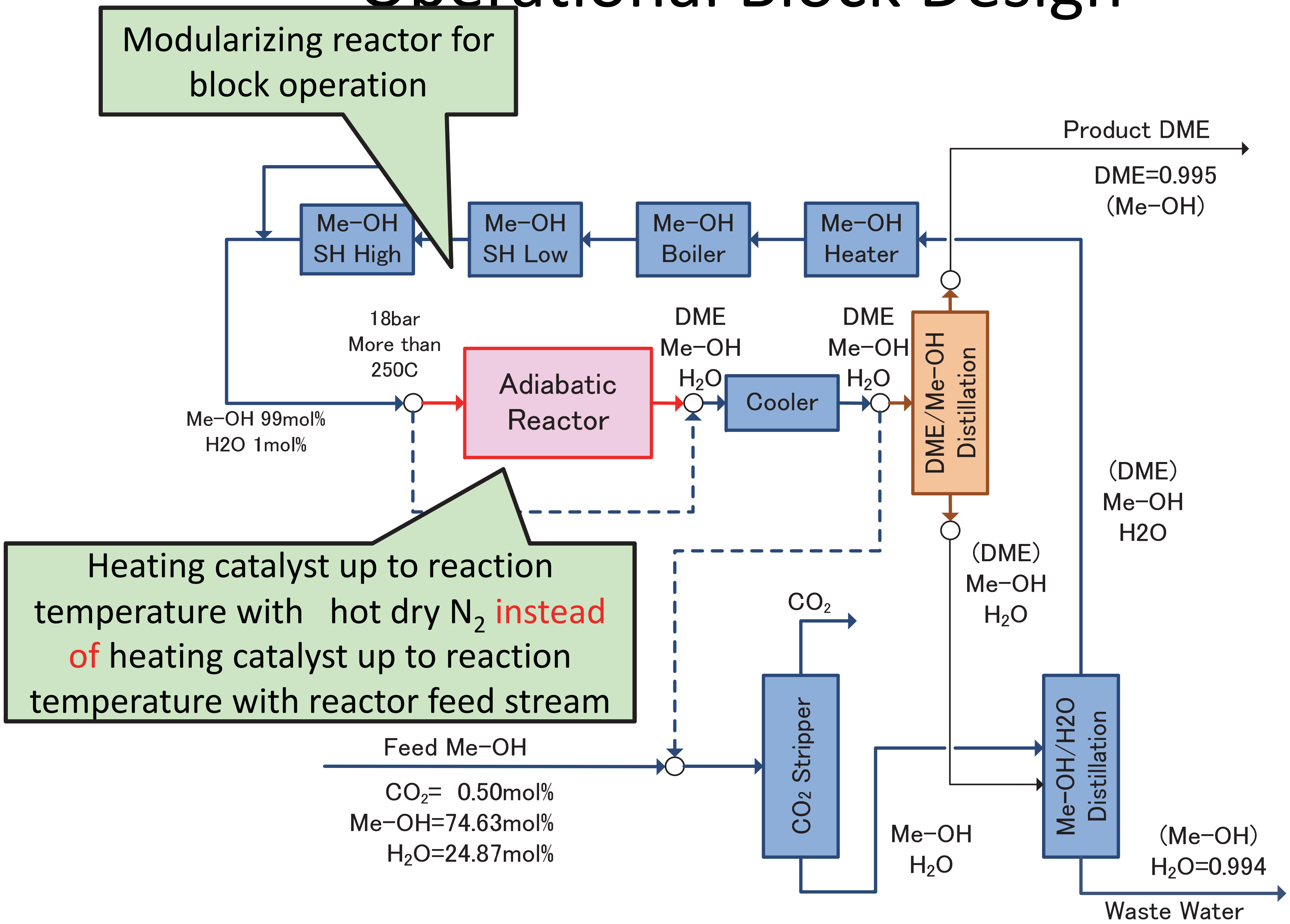
Process Schematic Design(3)



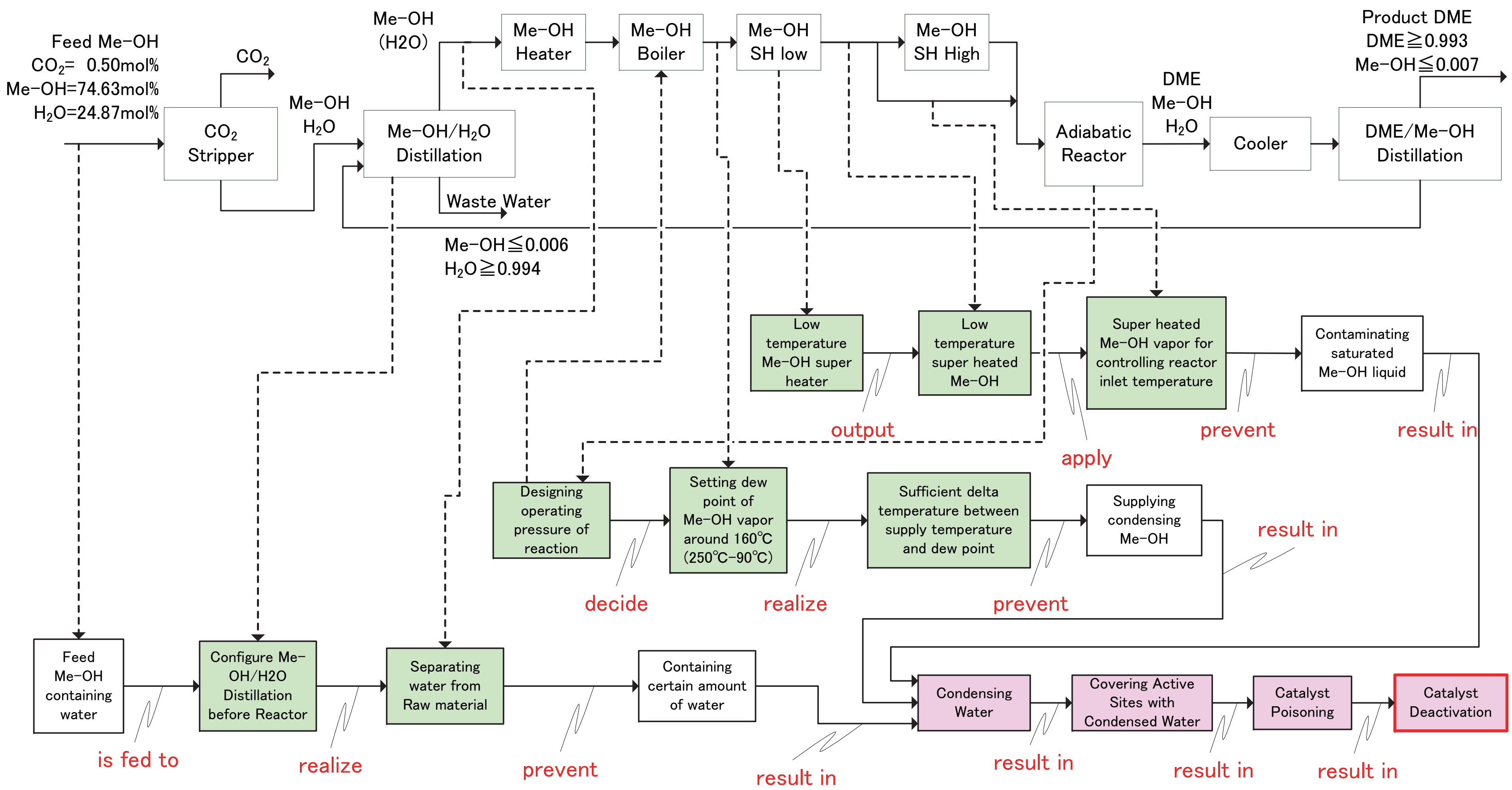
Parameter Design for BFD Level Design



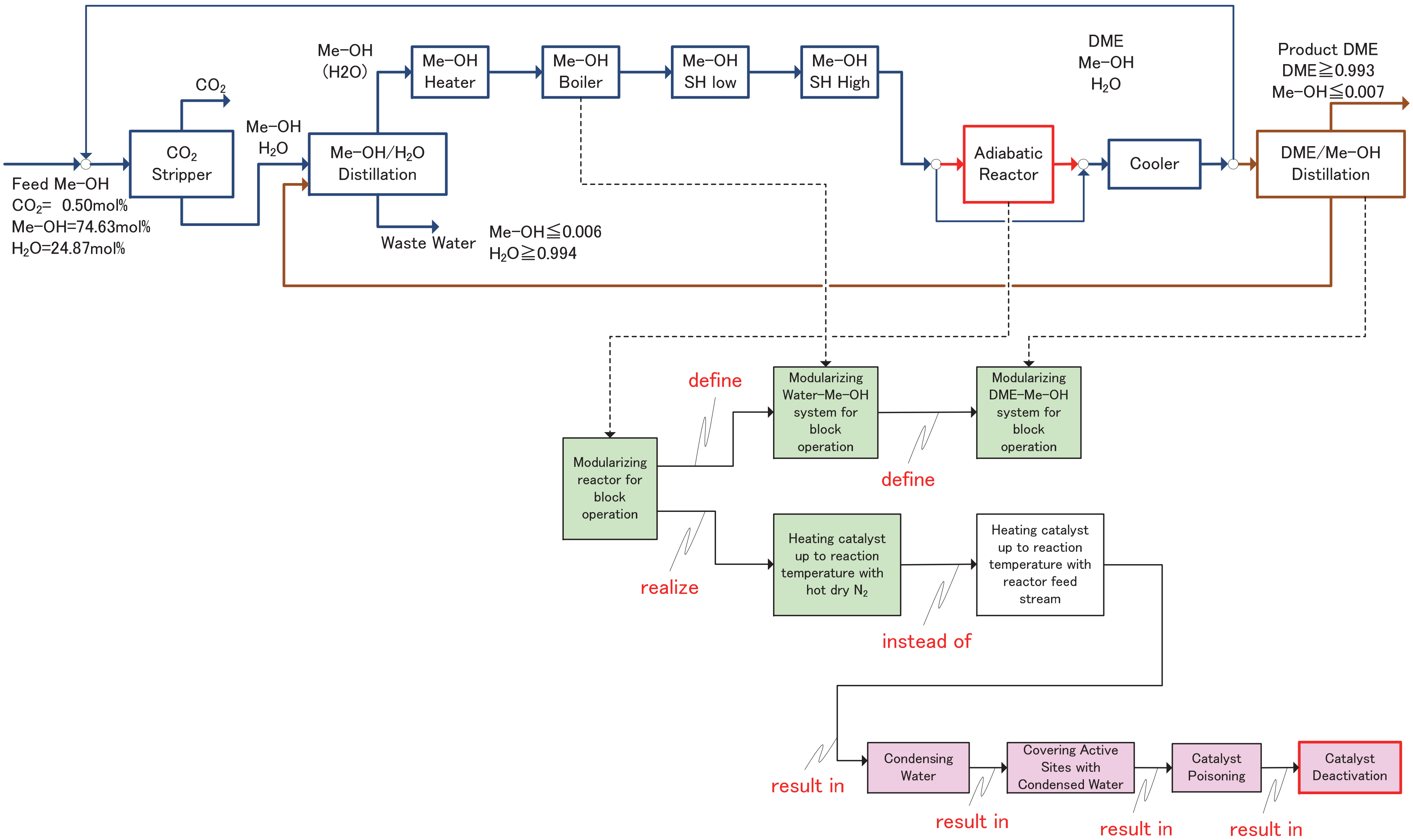
Operational Block Design



Representation of BFD Design Rationale to Avoid Catalyst Deactivation in Normal Steady State Operation



Representation of BFD Design Rationale to Avoid Catalyst Deactivation in Start-up Operation



Conclusion

- In this study, BFD and PFD designing processes to circumvent the critical phenomena and factors were considered as information objects, and were related to the BFD and/or PFD using associations.
- The process design rationale can be represented by such objects (entity) and relation model consistent with the process design process of chemical industry.
- The proposed method is still at the conceptual phase of development.
- The proposed method is based on applying the intelligent CAD environment.
- To implement the rationale based engineering support environment properly, the type of “relations” should be generalized, in the next step.

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