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Simulation Analysis of NH_3 Mixed Combustion in Clinker Manufacturing Process

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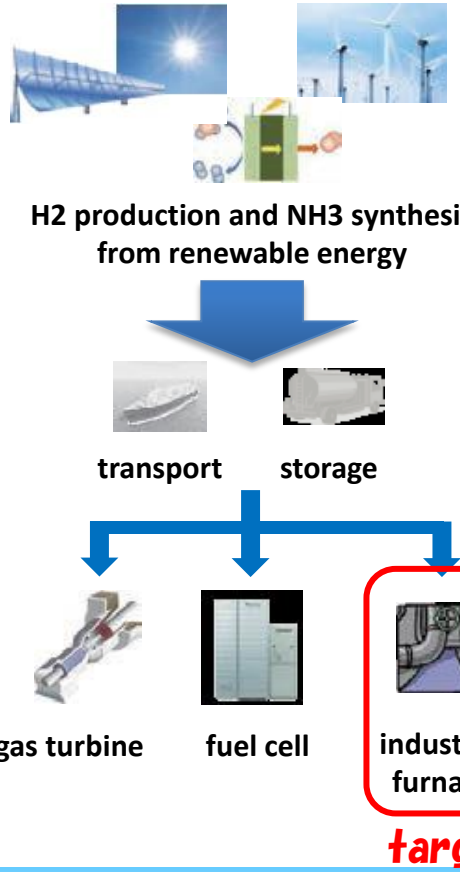
Introduction

- ✓ In order to realize a low-carbon society, it is necessary to diffuse large-scale use of renewable energy and hydrogen energy.
- ✓ Consistent technology from NH_3 production, transportation to storage is already developed. Therefore, it is expected that NH_3 is utilized as a CO_2-free energy source by directly using as a hydrogen energy carrier.

We participated in the project (SIP※) and conducted technical development and empirical research to thermally utilize NH_3 in the industrial furnace.

- ➢ Estimation of CO_2 reduction effect by applying NH_3
- ➢ Mixed combustion basic experiment in small industrial furnace
- ➢ Experiment of clinker firing in small industrial furnace
- ➢ Simulation study ←today's topic

※Strategic Innovation Promotion Program (2014/04-2019/03)



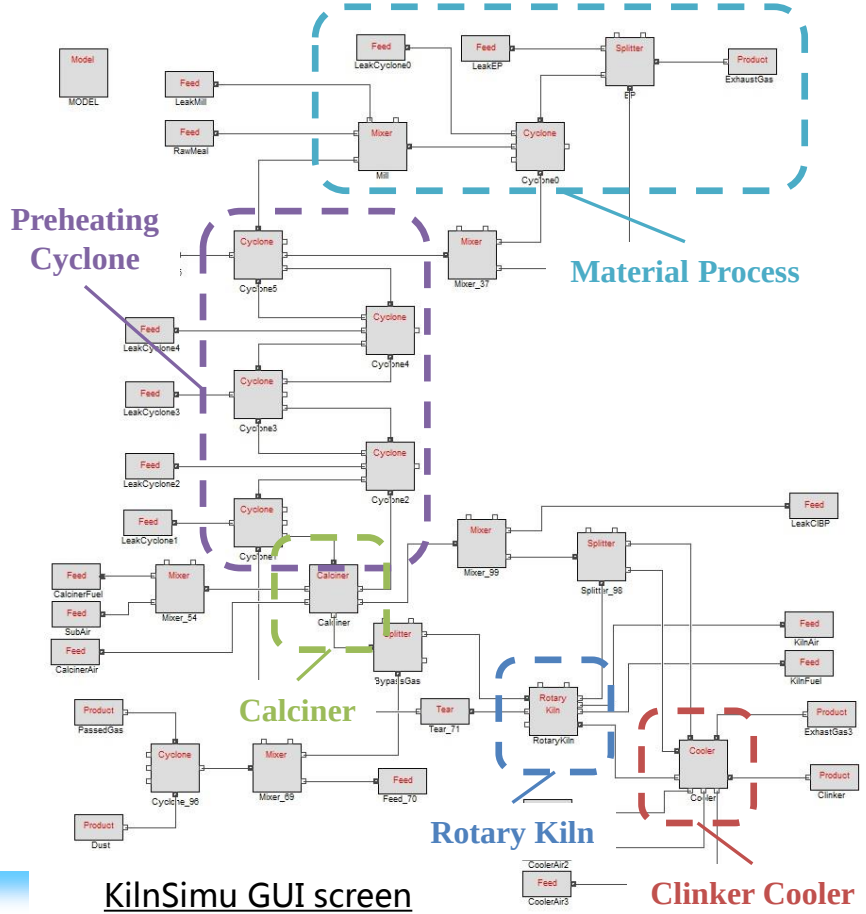
Process Simulation

Simulator (KilnSimu)

- It has several functions specialized in kiln operation analysis.
  (residence time in kiln, etc.)
- It is based on thermodynamic equilibrium theory.

Model

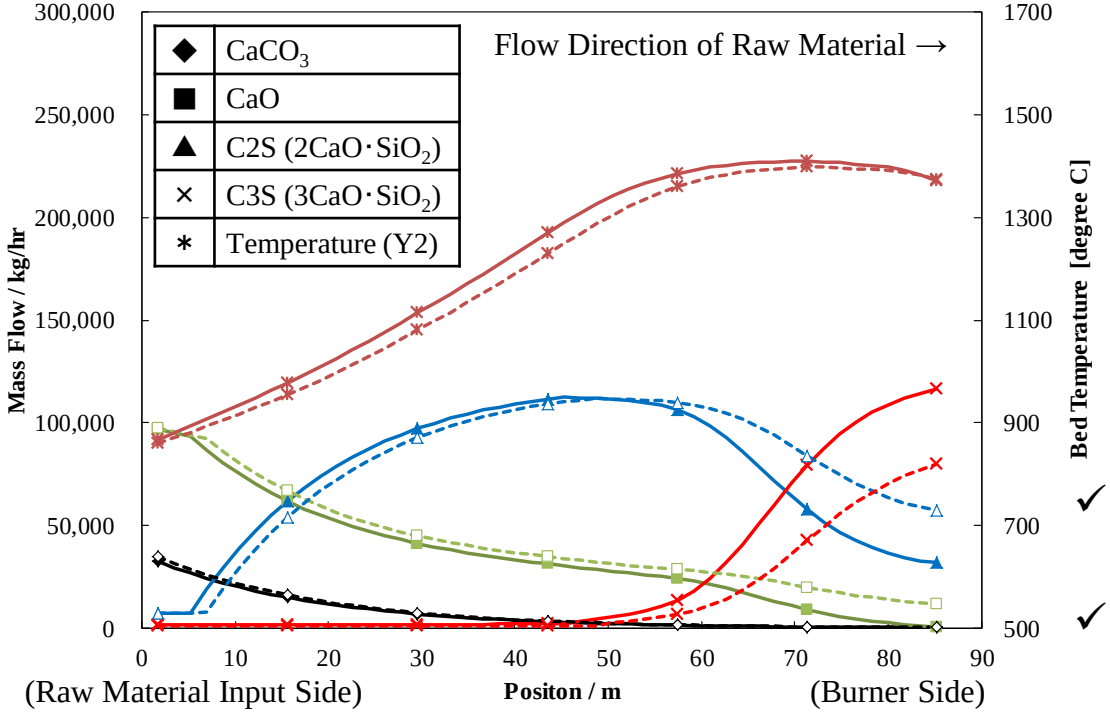
- We selected our own kiln as an analysis target.
  length : 87m
  outer diameter : 4.8m
  production volume : 200t/h
- The analysis target is limited to the kiln in order to check the influence of NH_3 mixed combustion in the kiln.



KilnSimu GUI screen

Results and Discussion (1)

Solid Lines : Coal Only Condition
Dotted Lines : NH_3 mixed Condition



temperature and materials transitions in the kiln

clinker composition at products exit

	Coal Only	NH_3 mixed
C3S (wt%)	59.43	44.18
C2S (wt%)	16.50	27.42
C3A (Aluminate, wt%)	8.88	8.77
C4AF (Ferrite, wt%)	9.21	9.17
f-CaO (wt%)	0.32	4.68

↑ less than 1% is desirable.

- ✓ It cannot be satisfied with the 30% NH_3 condition examined this time.
- ✓ For this reason, it is thought that radiation heat transfer decreased due to a change in gas composition in the kiln and sufficient thermal energy was not supplied to the raw material.

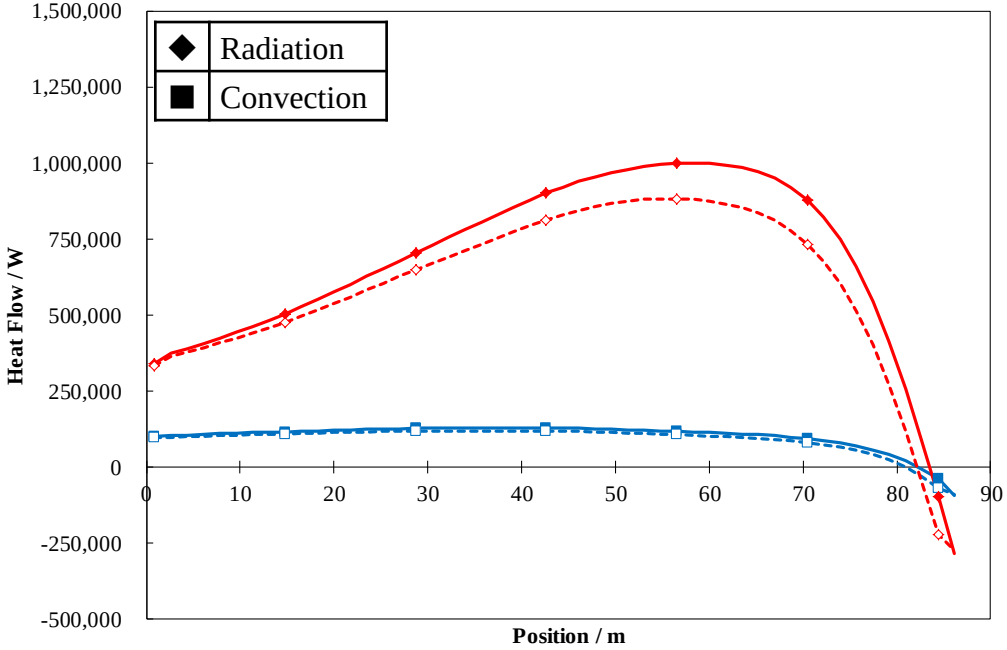
Results and Discussion (2)

ε : emissivity (-)
C : correction factor of emissivity (-)
C_{SO} : spectral-overlap correction factor (-)

The emissivity of the mixed gas in KilnSimu is given by

$$\varepsilon_g = (\varepsilon_{CO2} C_{CO2} + \varepsilon_{H2O} C_{H2O})(1 - C_{SO})$$

→ Coal only : ε_g = 0.293, NH_3 mixed : ε_g = 0.268



heat flow rates from the combustion gas

Solid Lines : Coal Only Condition
Dotted Lines : NH_3 mixed Condition

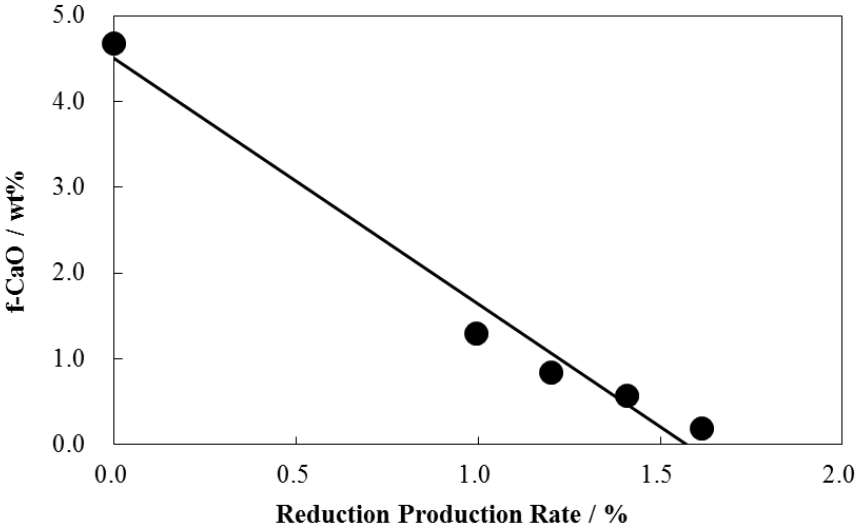
✓ The heat flow rate of radiation of NH_3 mixed condition is greatly reduced.

Operational Condition for NH_3 Mixed Operation

To satisfy cement clinker quality indicators under NH_3 mixed condition, we studied thermal efficiency improvement plans.

(i) reduced production

(ii) oxygen enrichment operation



relation between the reduced production rate and f-CaO

- ✓ If we set the target value of f-CaO to be <1.0%, we found that it is necessary to reduce production by about 1.3%.
- ✓ About oxygen enrichment operation, when the O_2 concentration is 23.5%, the value of f-CaO is 0.27%. It is about the same level as in the case of coal only combustion condition.

Thank you for your attention !

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