

Study for energy-saving operation of electric furnace steel manufacturing

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Agenda

- Introduction
 - Electric Furnace Steel Manufacturing

- The Study of Energy-saving Operation in Melting Process
 - Relationship of Total Energy Cost and the Balance of Heat Resources Amount
 - Operation with Pre-heating by Combustion

- Summary

- Future work

UBE Business Overview

Chemicals

43% of net sales



- Nylon raw materials and resin
- Synthetic rubber
- Industrial chemicals
- Specialty products
- Battery materials
- Fine chemicals

Pharmaceuticals

1% of net sales



- Drug discovery and co-development
- Contract manufacturing

Cement & Construction Materials

35% of net sales



- Cement, ready-mixed concrete
- Building materials
- Calcia, magnesia

Machinery & Metal Products

12% of net sales



- Molding machines (Injection molding machines, die-casting machines)
- Industrial machinery
- Bridge

Energy & Environment

10% of net sales



- Coal storage/sales
- IPP/Power business

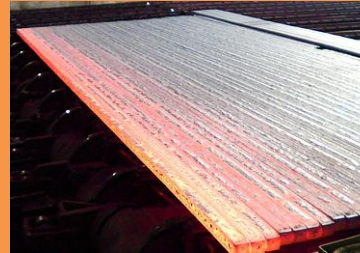
Industrial Application in UBE-Group

UBE / UBE INDUSTRIES.LTD.



Cement(C3S, C2S, etc.)
Behavior analysis of the circulation materials in rotary kiln

UBE / UBE STEEL CO..LTD.



steel(billets, casting)
the study of energy saving operation in electric furnace





KilnSimu



magnesia(MgO)
analysis for kiln burning process (removing impurities)

Comparison of two steelmaking process

electric furnace	process	blast furnace
	image	
steel scrap	main raw material	Iron ore, coal(koks)
batch	operation	continuous
electricity	main heat resources	fuel and oxygen
fewer CO ₂ emission, suitable for many kinds	merit	mass production

About UBE Steel CO.,LTD

Outline

UBE STEEL CO.,LTD

Business Lines : Manufacture and sales of steel billets and casting
Production Capacity : (Billets) 30,000ton/month, (Casting) 1,200ton/month
Employees : about 240
Electric Furnace : 3 (60T(60,000kVA), 30T, 10T)

Billet

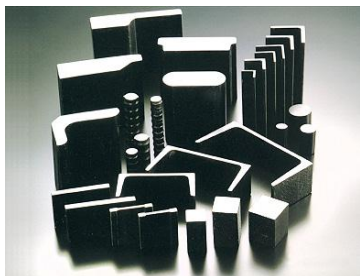
steel type : JIS(SD, SS, SM, SN, etc.), SAE, ASTM etc.

size : custom cross section, length

Casting

material : normal, low alloy, for welding etc.

usage : major industries, car, ship, power plant, public demand etc.



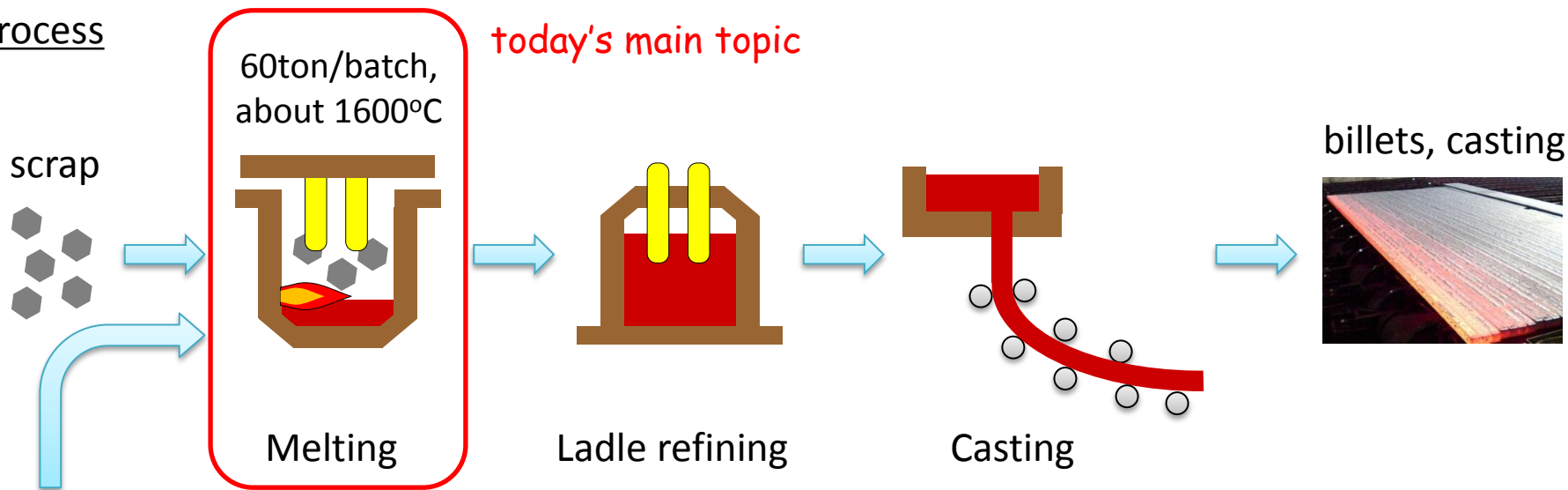
テーブル



フレーム

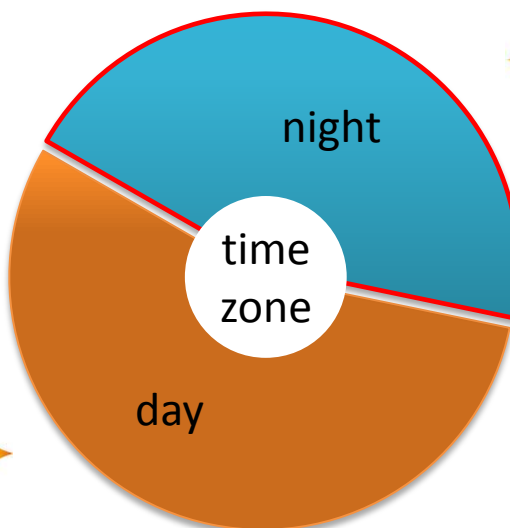
Process Flow of Electric Furnace Steel Manufacturing

Process



- waste plastics
- dust from process
- medical waste etc.

Action to industrial waste recycling

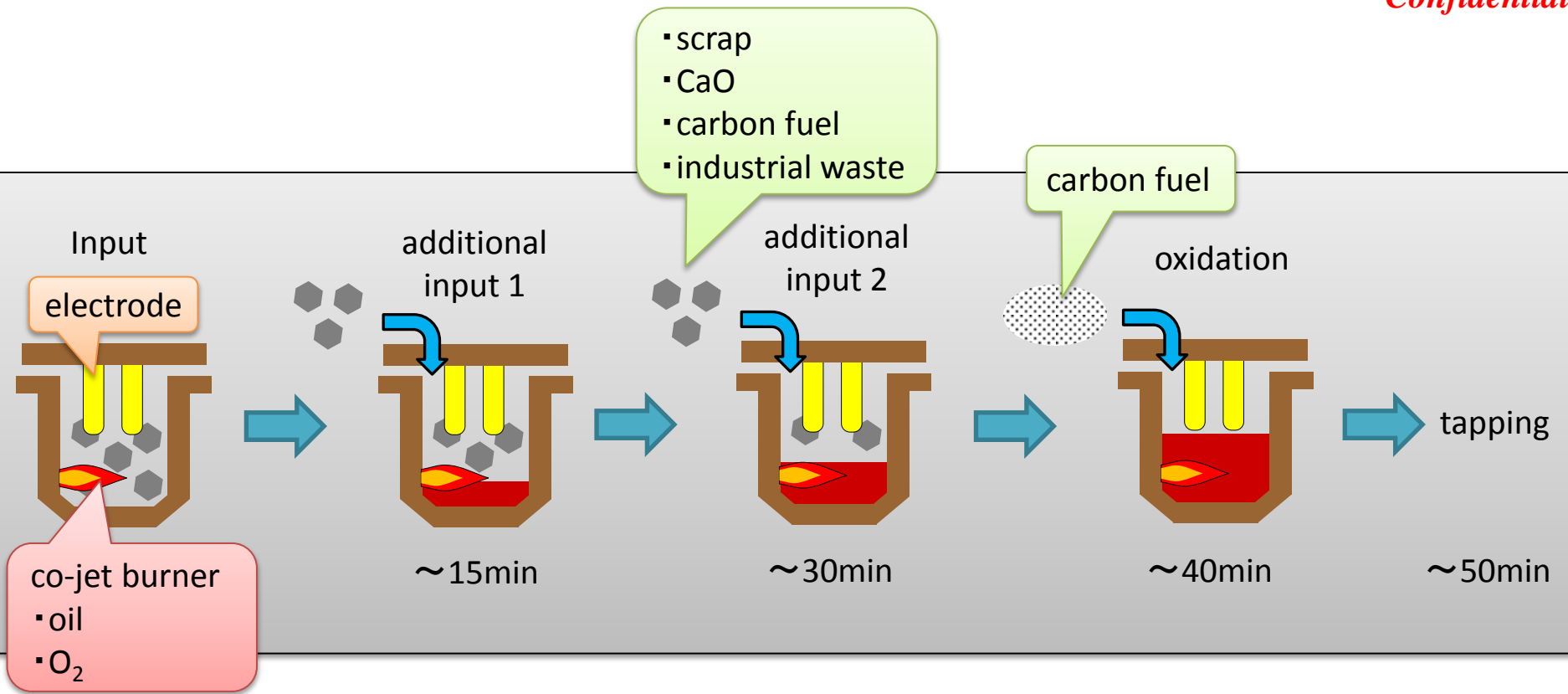


electric power cost

daytime > **nighttime**

⇒ operation is done in nighttime.

Outline of the Operation of Scrap Melting Process



Heat resources

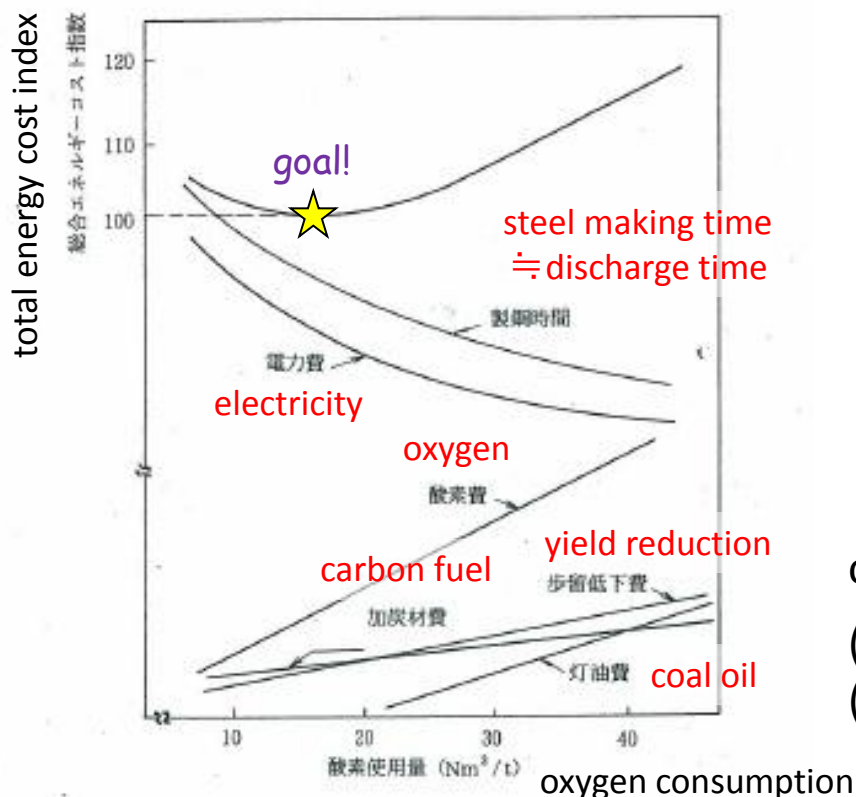
- arc discharge (**main operation cost**)
- burner combustion

} studying the balance from the viewpoint of...

- **total energy cost**
- **the quality** (phase composition, purity ...)

Study of Total Energy Cost

Relationship of “Oxygen Consumption” and “Total Energy Cost Index”



oxygen consumption vs total energy cost

(merit) electricity ↓, steel making time ↓

(demerit) yield ↓, carbon fuel ↑, coal oil ↑, oxygen ↑

図 2.2.15 酸素使用量と製鋼時間及び総合エネルギーコスト指数

Searching the oxygen amount when total energy cost is minimized

Electric Furnace Analysis using FactSage

Containing very many oxides and solution database

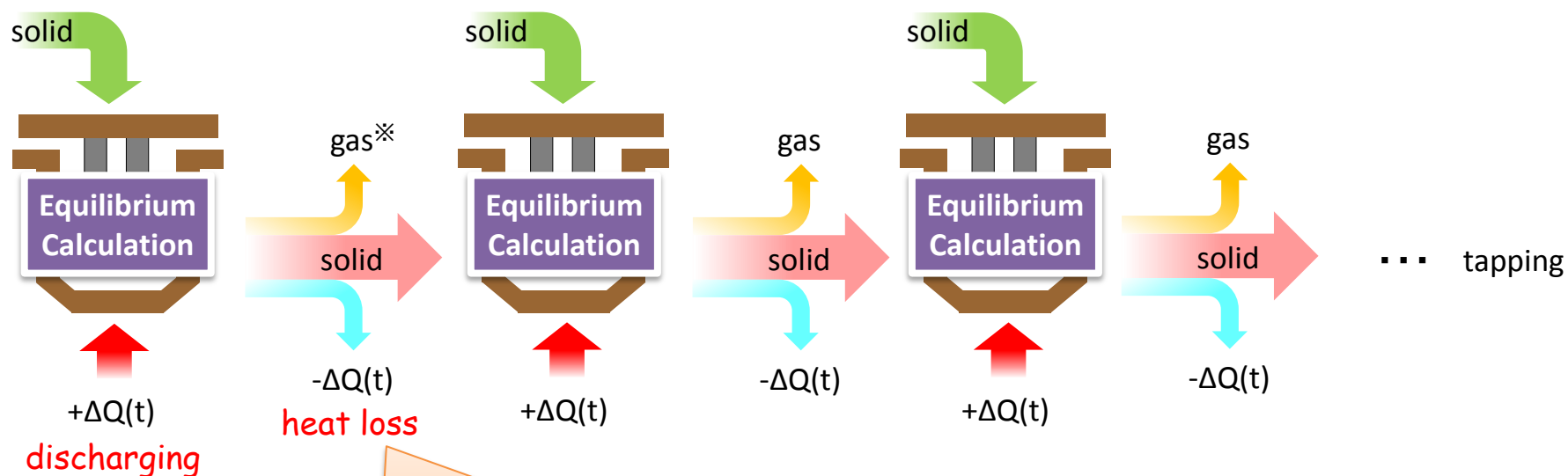
molten steel (Fe-liq.)
Fe, Cu, Mn, Cr, S, Ca, ...etc.



liquid slag
CaO, Al₂O₃, SiO₂, Fe₂O₃, ...etc.



(flow of calculation) ※atmosphere open type

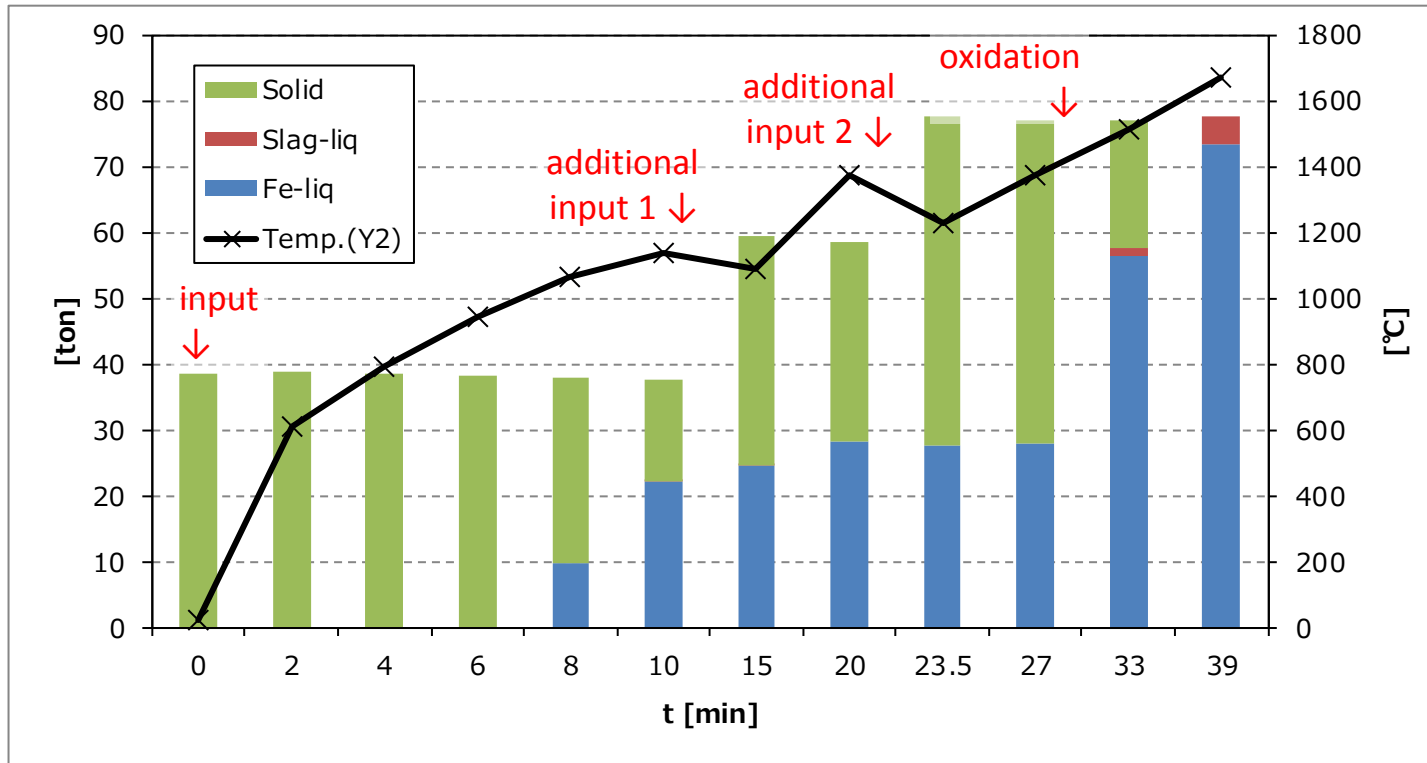


Stefan-Boltzmann law

$$Q = \sigma \epsilon A (T_s^4 - T_0^4)$$

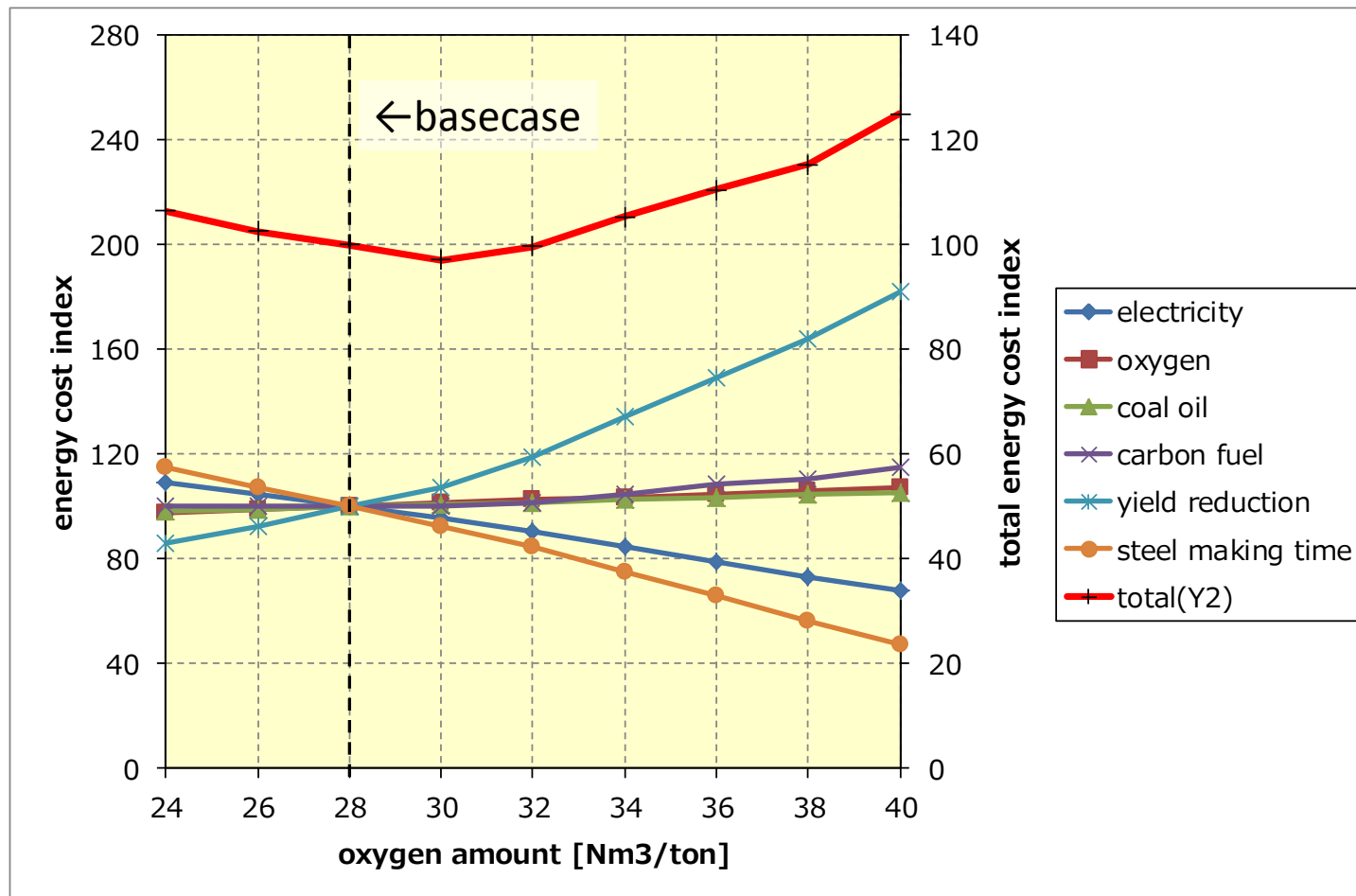
*multi-phase(semi-batch)
calculation*

An Example of Calculated Solutions Profile



- Time interval of just after first input makes short.
- We can see all phases and temperature profile.
- By adding input, temperature is down temporarily.
- By adding oxidation, molten steel phase and slag-liquid phase increase.

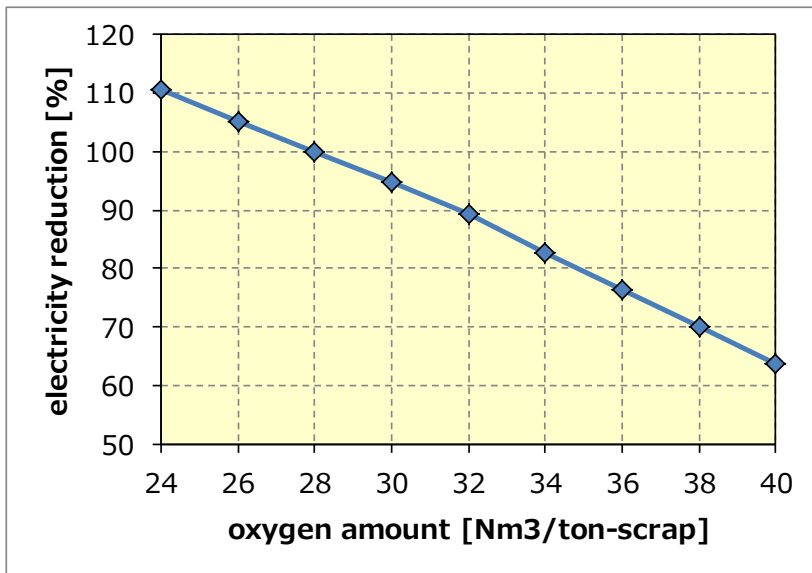
Oxygen Amount vs Total Energy Cost



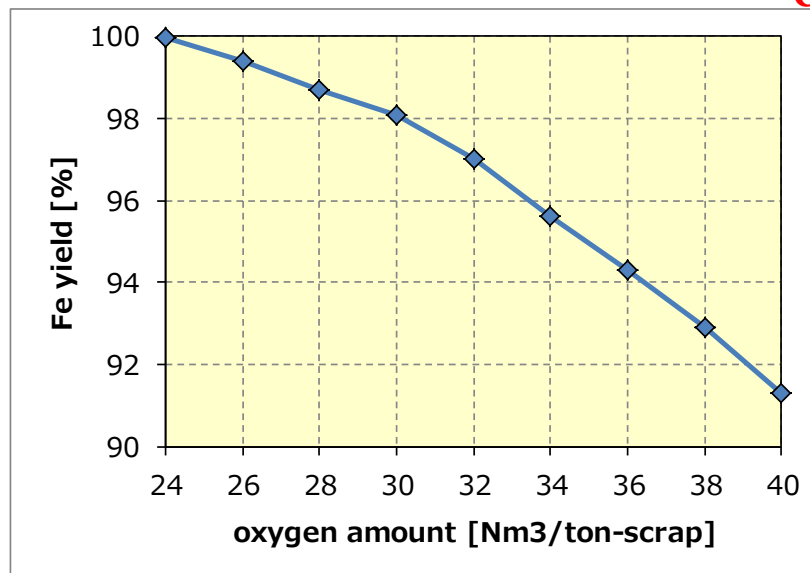
(base case) O₂ = 28Nm³/ton-scrap

- Most influential factor is “yield reduction”
- Total energy cost is minimum when oxygen amounts are 30Nm³/ton-scrap

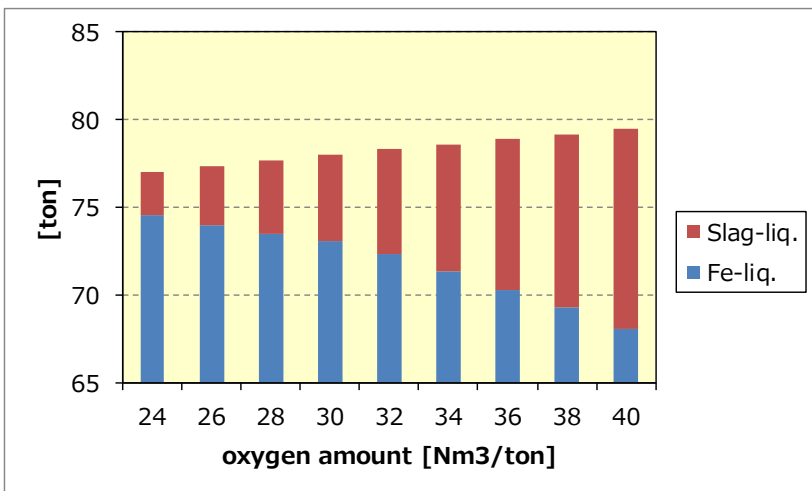
Influence on Each Factor and Quality



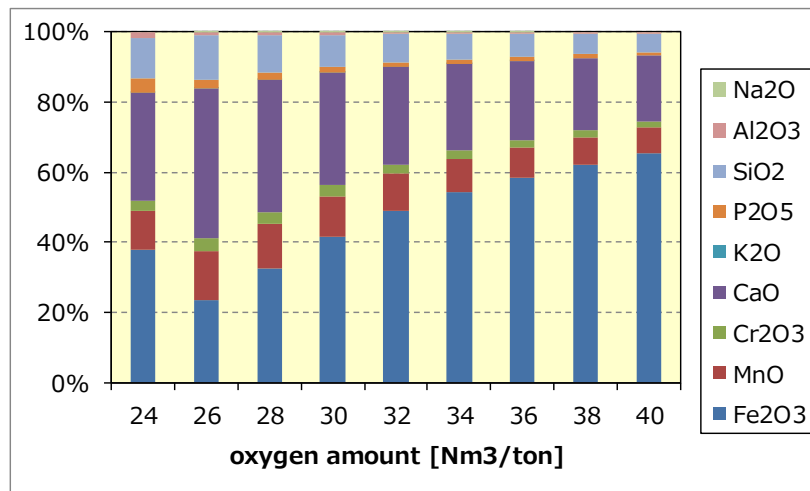
electricity reduction rate



Fe yield





phase (Fe-liquid and Slag-liquid)



components of Slag-liquid

Study for Energy-Saving Operation Method

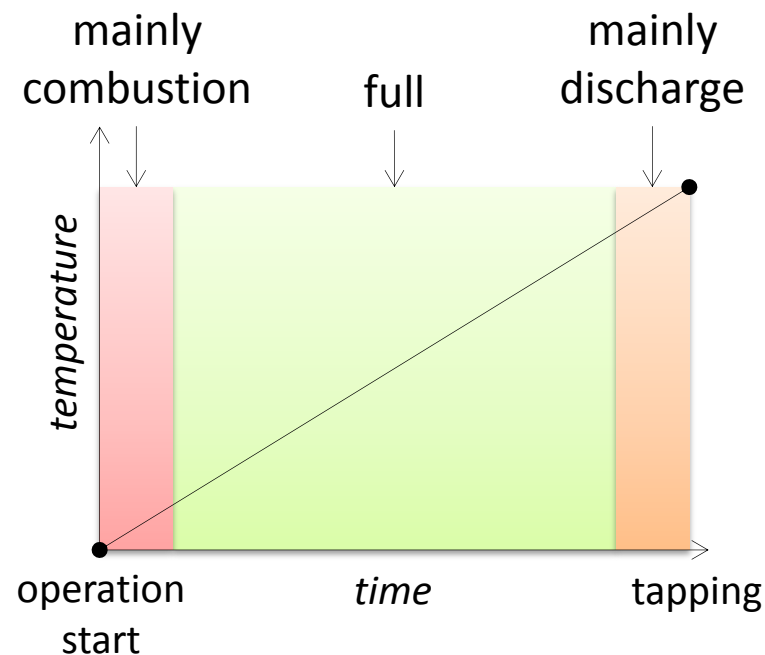
Features of heat resources

arc discharge		burner combustion
		
high	temperature area (effective)	low
high	cost(relative)	low

To reduce the energy cost,
using properly two heat resources
in appropriate temperature area.

~ Operation with Pre-heating

operation image



Concept of Energy-saving Operation

normal operation

raw materials

carbon fuel

input

combustion

discharge

additional
input 1

additional
input 2

oxidation

tapping

How long ?

~?min

~15min

~30min

~40min

~50min

~50+?min

Operation with pre-heating

input

discharge
start

combustion

discharge

additional
input 1

additional
input 2

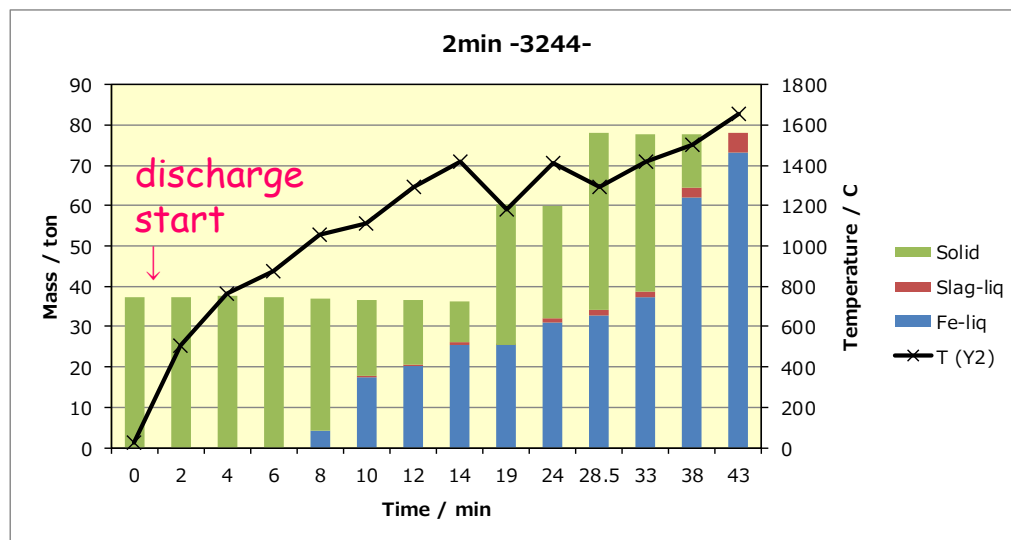
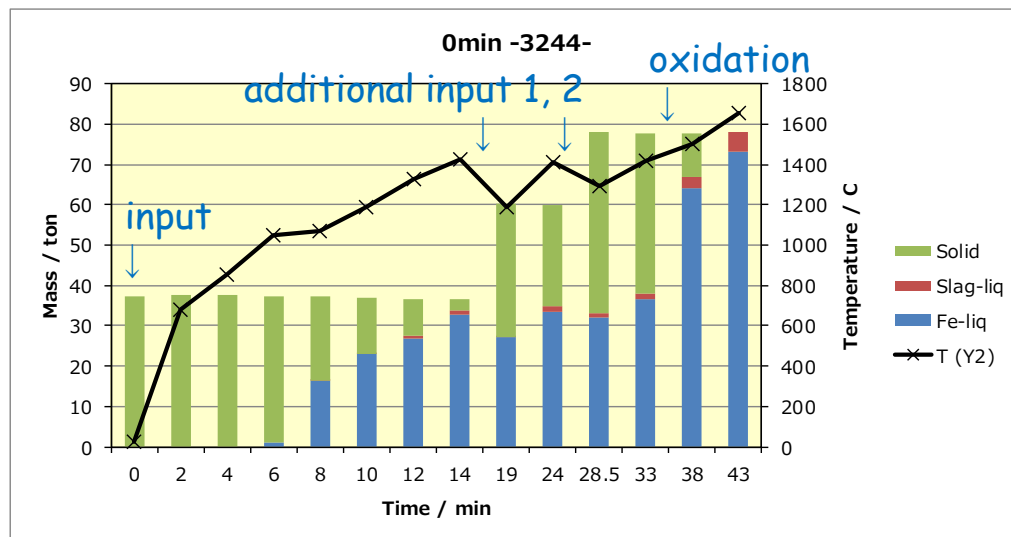
oxidation

tapping

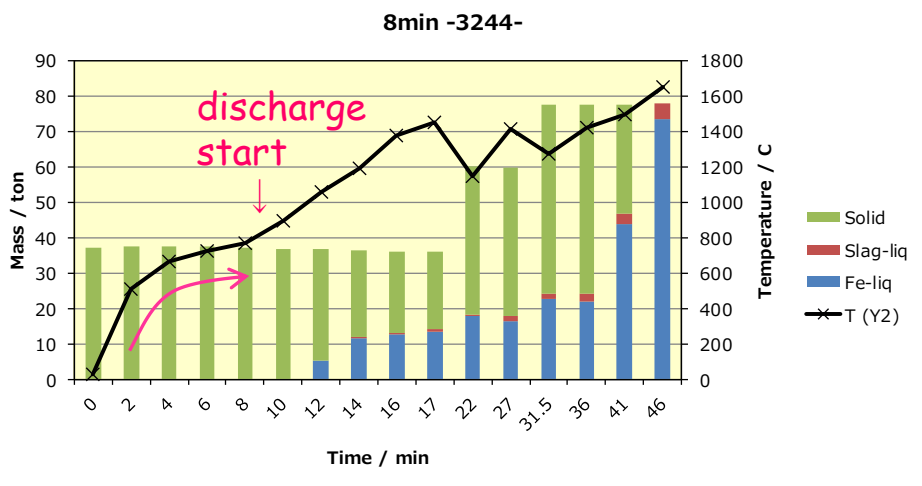
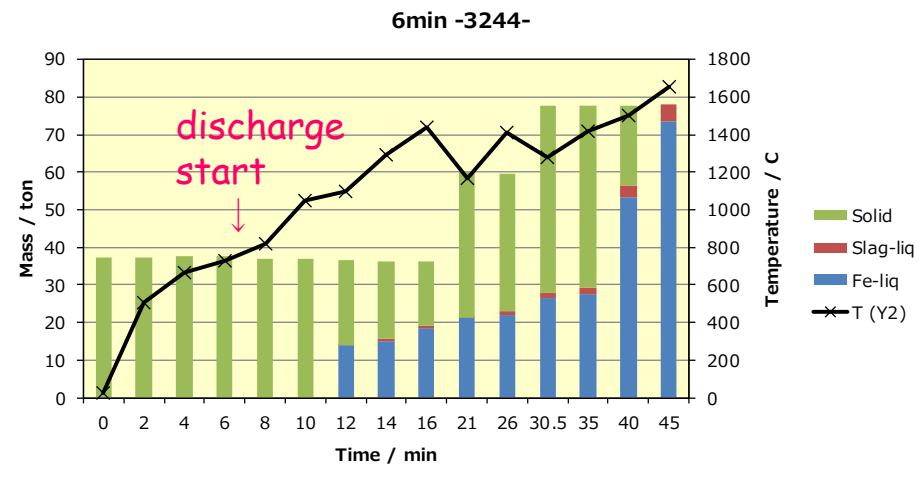
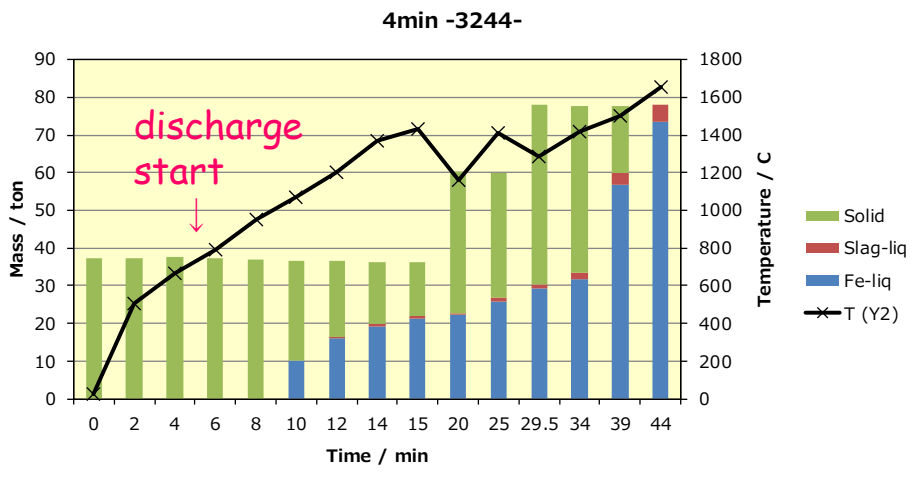
Conditions Setting and Results

- Steel type : normal (for General structure use)
- Tap Temperature : 1650°C
- Pre-heating time : 0, 2, 4, 6, 8 min

- Additional input time is decided by Temperature in furnace.
- In first 2 minutes, (normal operation) 680°C
(energy-saving operation) 520°C



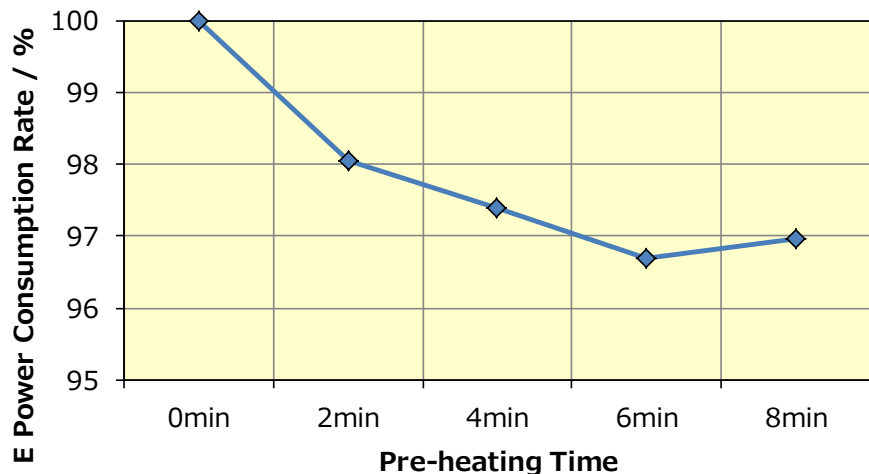
Results(2)



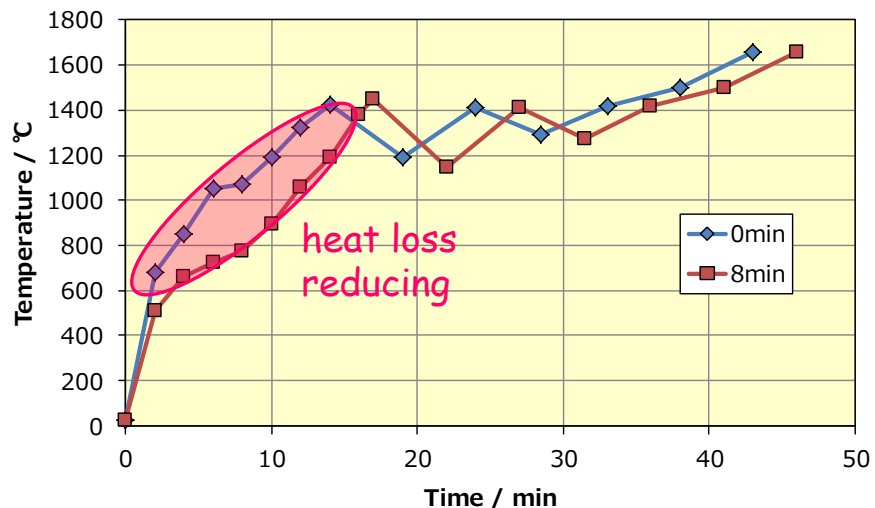
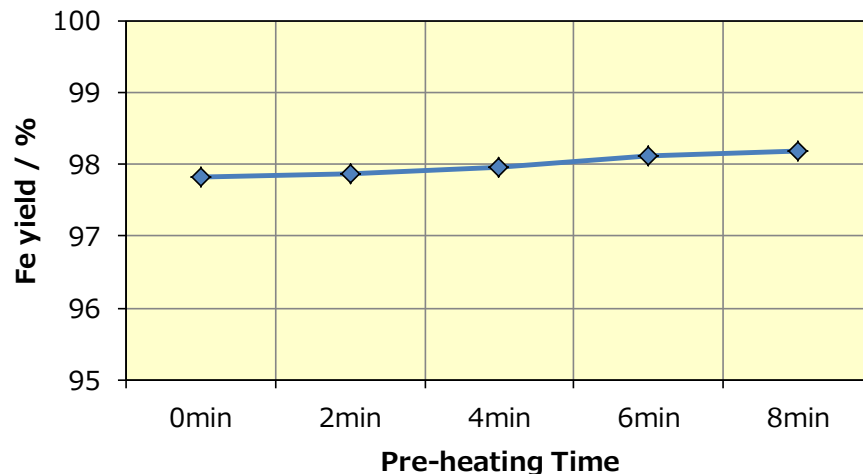
- By pre-heating, temperature in furnace reaches to about 800°C.
- When pre-heating time is too long, rise of temperature is few because of heat radiation.

Results(3)

Electric Power Consumption Rate



Fe yield



- Pre-heating is effective for saving electric power consumption rate.
- By applying operation with pre-heating, we can reduce the heat loss.
- Little influence on Fe yield.

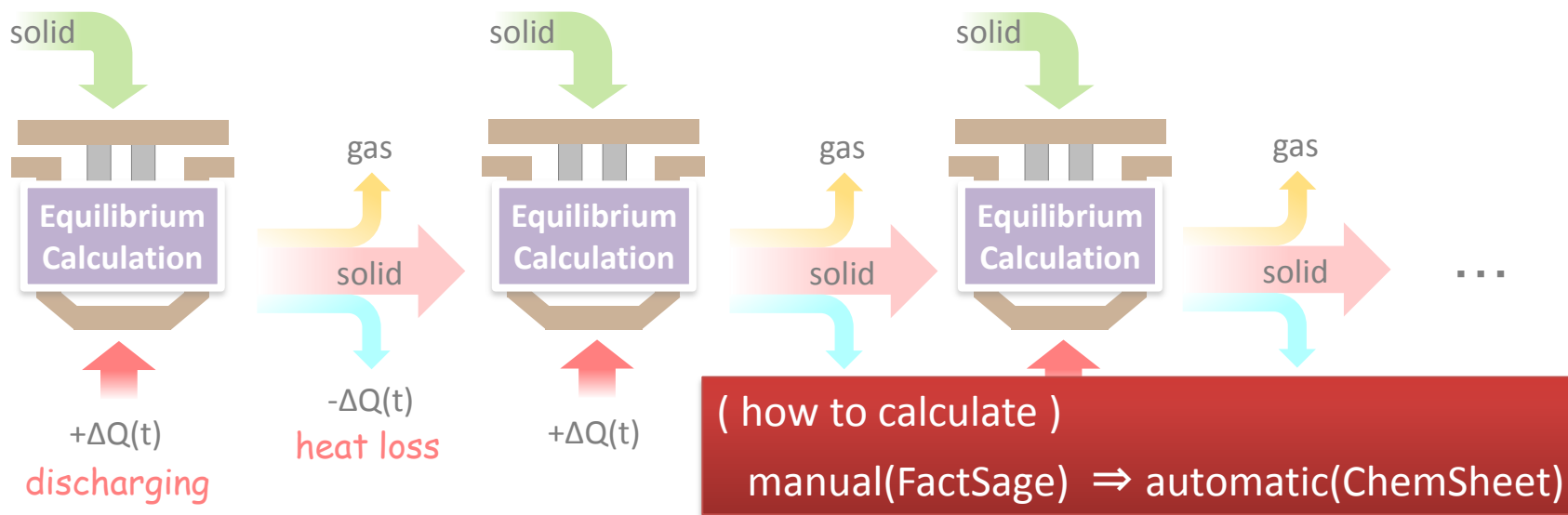
Summary

We applied FactSage to the analysis of electric furnace steel manufacturing process.

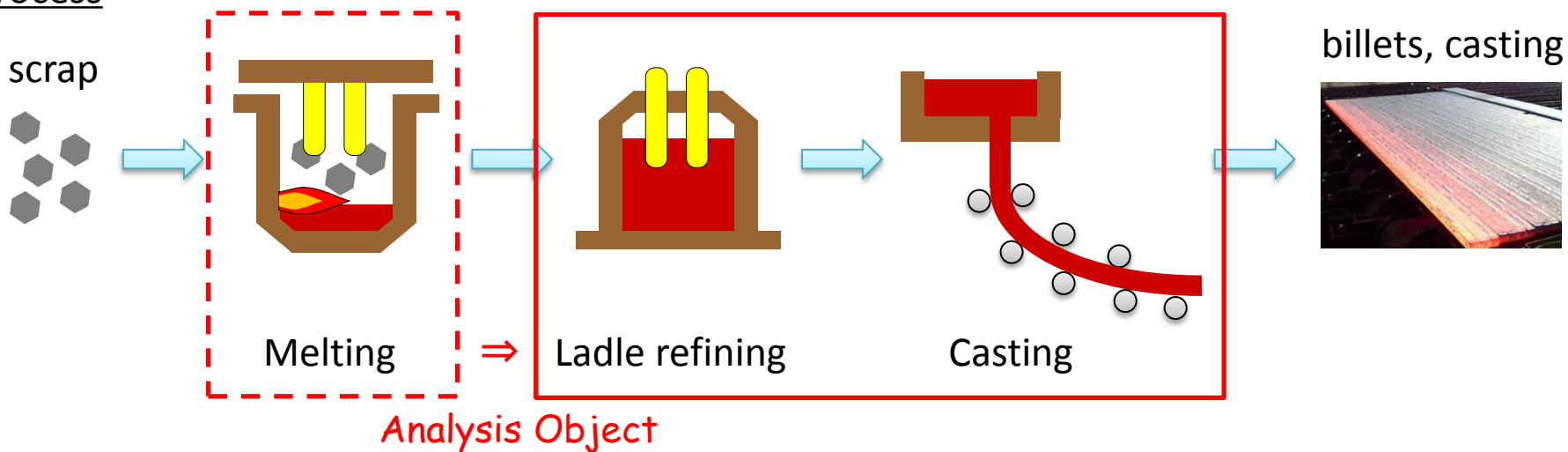
- ❑ We calculated all phases and temperature profiles through the melting process.
- ❑ By changing oxygen amounts using in melting process, we found the relationship of total energy cost and the balance of heat resources amount.
- ❑ Operation with pre-heating by combustion is effective for energy-saving. But when pre-heating time is too long, the effect decreases because of heat radiation.

In the Future...

flow of calculation



Process





Thank you for your attention !