

INDIA

Technologies Customized List

&

Technologies One by One Sheets

2025 version Part 2: EAF (v.5.2)

*Recommended technologies for
energy-saving, environmental
protection and recycling in
Indian iron and steel industry*



Supported by
The Japan Iron and Steel Federation



Introduction

Overview

“Technologies Customized List” is a technology reference containing energy-saving, environmental-protection and recycling technologies, developed under a collaborative scheme of “The Public and Private Collaborative Meeting between Indian and Japanese Iron and Steel Industry”. The list is aimed at identifying appropriate technologies for the Indian steel industry in order to encourage energy saving and sustainable development of Indian steel industry.

The list reflects the knowledge acquired from public and private experiences of the Japanese steel industry, which achieves the highest energy efficiency in the world, and the technology needs of Indian steel industry. In this context, contents of the list are informative for public sectors for development of policies and measures, as well as for private sectors for the plan of the technology introduction and improvement of energy management activities in steel plants.

After the publication of the Technologies Customized List version 1 (2013), version 2 (2014), and version 3 (2017), the list was employed on many occasions such as Steel Plant Diagnosis and Public and Private Collaborative Meetings and Workshops. Based on the discussion at the 8th PPC meeting on the growing importance of small and medium size steel plants, it was proposed to update Technologies Customized List to include technologies for EAF plants. Thus, Technologies Customized List version 4 (2019) was compiled as two-part series: Part-1 for BF-BOF plants, and Part-2 for EAF plants.

The 2025 version of the Technologies Customized List is developed as part of ERIA (Economic Research Institute for ASEAN and East Asia)’s project, “Research on the Future Outlook for the Decarbonisation of the Steel Industry in Asia (Phase 1)” and incorporates the latest supplier information and factor changes such as energy costs and plant costs.

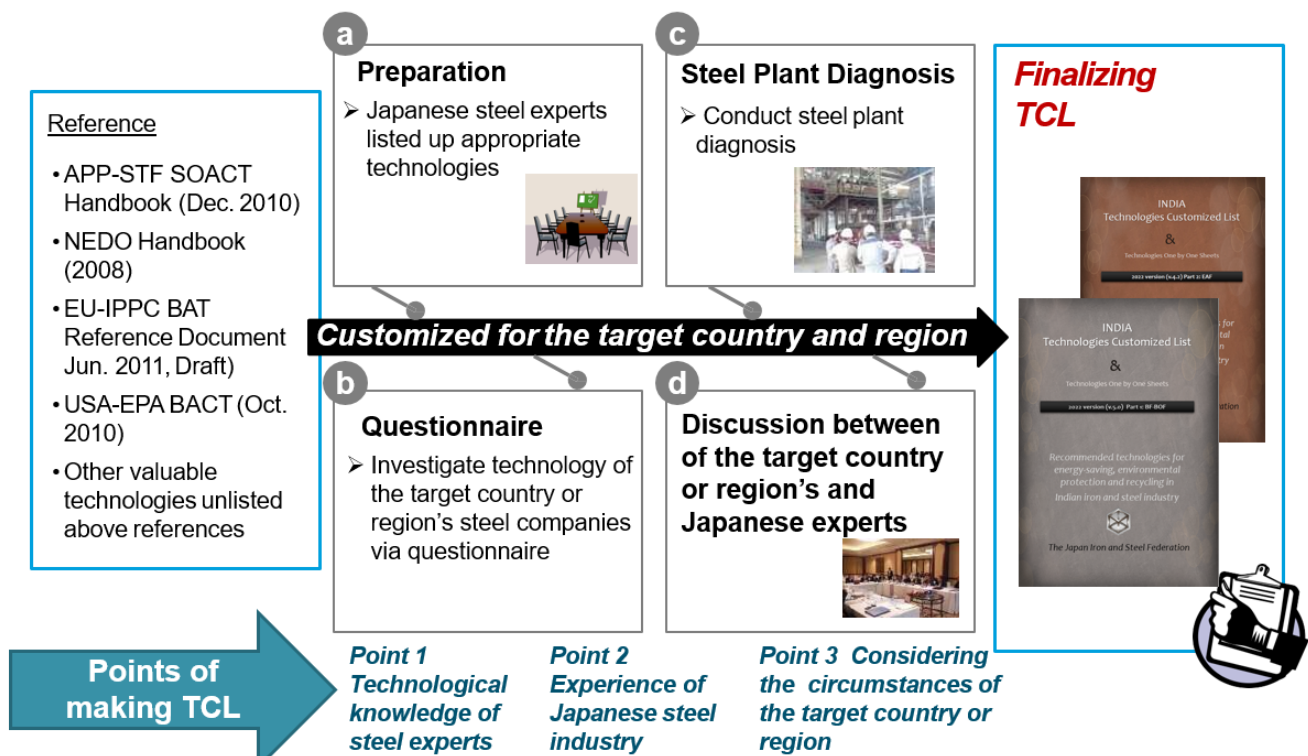


Development process of Technologies Customized List

Technologies on the Technologies Customized List are considered to contribute to energy saving and environmental protection in Indian steel industry. They were chosen from several technology references*1 in the world, based on the following criteria.

1. **Coverage:** Technologies Customized List contains the technologies for energy saving, environmental protection and recycling in the steel plants in India. Technologies for other purposes, such as quality improvement and production increase, are not covered in Technologies Customized List.
2. **Availability:** Target technologies should be commercially available. Technologies under development in Japan, which the supplier companies are not ready to diffuse in India, are not eligible for Technologies Customized List.
3. **Experience:** Steel experts in Japan have technological knowledge and experiences.

Development of Technologies Customized List



Technologies Customized List 2025 version
September, 2025

*1 Reference List

- The State-of-the-Art Clean Technologies (SOACT) for Steelmaking Handbook
- NEDO Handbook
- EU-IPCC BAT
- USA-EPA-BACT

Table of Contents

1. Technologies Customized List	4
2. Technologies One-by-One Sheet	7
Contact Points of Suppliers	43

1. Technologies Customized List

Pre-Conditions for Calculating Electricity and/or Thermal Energy Savings

Capacity and performance of the model steel plant to study costs and effects of energy saving project are assumed as below:

- 1) 100 % scrap use EAF plant to produce mild steel for construction use
- 2) Annual production is 500,000 ton/y with 80 ton EAF
- 3) Unit electricity consumption of EAF is 430 kWh/ton-billet
- 4) Unit thermal consumption of reheating furnace is 1,450 MJ/ton-billet
- 5) The plant possesses conventional facilities, without advanced technologies

Equipment List of Model Steel Plant

Annual Production		500,000 ton/year ¹⁾	
EAF		RHF	
Equipment Name	Value	Equipment Name	Value
Nominal capacity	80 ton ²⁾	Type	Walking beam
TTT	52 minutes	Nominal capacity	100 ton/h
Iron source	100 % scrap	Heated material	135 SQ billet
Scrap preheating	none	Heating temperature	1100 degC
Scrap charging	3 times	Fuel	Natural gas, LHV 44 MJ/m ³ N
Ladle furnace	used	Combustion air preheating	around 300 degC with low grade recuperator
NG burner	used only to facilitate melting	Air ratio for combustion	1.20 for all zones
O ₂ and C lances	installed only at slag-door side, water-cooled type	Computer control to set furnace temperature with heat transfer simulation	none
Process control by exhaust gas analysis and/or computer	none	Hot charge and/or direct rolling	none
Electricity consumption	430 kWh/ton	Insulation	firebrick
Oxygen consumption	30 m ³ N/ton	Heat consumption	1,330 MJ/ton-steel
Natural gas consumption	20 m ³ N/ton		
Coke consumption	15 kg/ton		
Product	Mild steel less than 0.2 % C		
Tapping temperature	1620 degC		
Atmosphere condition		25 degC with relative humidity 60 %	

- 1) The following technologies have different assumptions;
 - A-11 : 1,875,000 ton/year
 - A-14 : 576,000 ton/year
 - E-4 : 594,000 ton/year
- 2) The following technology have a different assumption;
 - A-11 : Two 150-ton EAF

Pre-Conditions for Calculating the profit, assumed investment cost, payback time and CO2 emission reductions

- 1) For calculating the profit, assumed investment cost and payback time for each technologies listed on the Technologies Customized List, the values shown on the table "Energy price, plant cost, and CO2 emission factor in India" were applied.
- 2) The assumed investment cost in India for each technology is calculated by multiplying "plant cost index" to the assumed investment cost in Japan.
- 3) CO2 emission reduction is calculated for each technology by using emission factor of electricity in India and the common value of CO2 emission rate from fuel.
- 4) Basically, LPG is assumed to calculate CO2 emission from fuel combustion as: 47.3 GJ/ton-LPG, 2,985 kg-CO2/ton-LPG ---> 63.1 kg-CO2/GJ. For D-2 and E-4, natural gas is assumed to calculate CO2 from emission from fuel combustion as: 35.9 GJ/ton-NG, 2,015kg-CO2/ton-NG ---> 56.1 kg-CO2/GJ.

Energy price, plant cost, and CO2 emission factor in India

Country	Electricity price for industry use ¹⁾ (US\$/kWh)	Fuel gas price for industry use ¹⁾ (US\$/GJ)	Plant cost location factor ²⁾ (Japan = 100.0)	CO2 emission factor ³⁾ (ton-CO2/MWh)
India	0.100	23.89	81.6	0.905
Japan (for reference)	0.143	19.11	100.0	0.436 ⁴⁾

- Source
- 1) JETRO website (2023)
 - 2) 2019PCI_LF_summary.pdf, Japan Machinery Center for Trade and Investment
 - 3) average of combined margin from CDM projects, IGES website (2024.2.29)
 - 4) The Electric Power Council for a Low Carbon Society, ELCS 2023

Technologies Customized List for Energy Saving, Environmental Protection, and Recycling for Indian Steel Industry 2025 version part 2: EAF (v.5.2)

No.	ID	Title of technology	Technical description	Expected effects of introduction					Assumed investment cost		
				Electricity saving	Thermal energy saving	CO2 reduction	Profit of Operation cost	Environmental benefits	Co-benefits	Assumed investment cost	Payback time
				(kWh/t of product)	(GJ/t of product)	(kg-CO2/t of product)	(US\$/t of product)			(million US\$)	(year)
A. Energy Saving for Electric Arc Furnace (EAF)											
1	A-1	High temperature continuous scrap preheating EAF	Combination of the technologies of - Air tight structure - High temperature scrap preheating (over 700 degC) - Continuous preheated scrap charging - Automatic process control by using data logging - Post-combustion of generated CO gas - Dioxin decomposition by secondary combustion	150.0	-	135.75	15	- Decomposition and reduction of dioxin, dispersing dust, & noise	- Low electrode consumption (0.8 - 1.0 kg/ton-product at AC)	31.01	4.1
2	A-2	Medium temperature batch scrap preheating EAF	- High melting efficiency batch charging type EAF with SPH. - Preheated scrap temperature is about 250 - 300 degC. - Fully enclosed automatic charging system to keep working floor clean. - Minimize scrap oxidation by temperature controlling - Material limitation free	40.0	-	36.20	4	- Reduction of dioxin emission, dispersing dust, & noise	-No limit of material for high quality products as like stainless steel.	8.16	4.1
3	A-3	High efficiency oxy-fuel burner/lancing for EAF	- Supersonic or coherent burner - Accelerate scrap melting during melting stage - Facilitate slag foaming during refining stage over the bath	14.3	-	12.94	1.43	-	- Reduction of nitrogen in steel for quality improvement	1.67	2.3
4	A-4	Eccentric bottom tapping (EBT) on existing furnace	- Slag free tapping - Reliable stopping and scraping mechanism	15.0	-	13.58	1.50	-	- Increase in Fe & alloy yield, productivity - Improve steel quality	3.26	4.4
5	A-5	Ultra high-power transformer for EAF	- Long arc by high voltage and low ampere operation - Water cooled wall-panel to protect refractories	15.0	-	13.58	1.50	-	- Procutivity increase	4.62	6.2
6	A-6	Optimizing slag foaming in EAF	- Proper chemical ingredients of slag - High efficient burner and/or lance - Controlled O2 & C injection into EAF proper position - Keeping slag thickness with air-tight operation	6.0	-	5.43	0.60	- Noise reduction & working floor cleaning	-	1.22	4.1
7	A-7	Optimized power control for EAF	- Data logging and visualization of melting process - Automatic judgement on meltdown and additional scrap charge - Automatic phase power independent control for well-balanced melting	15.0	-	13.58	1.50	-	- Productivity increase - Manpower saving	2.04	2.7
8	A-8	Operation support system with EAF meltdown judgment	Automatic Rapid Melting system - Data logging - Optimum electric power control - Alloy calculation - Automatic meltdown Judgment	6.0	-	5.43	0.60	-	- Productivity increase - Manpower saving - Operation standardization	0.53	1.8
9	A-9	Low NOx regenerative burner system for ladle preheating	- Regenerating burner use - High Energy Saving (about 40 %) - Automatic control - FDI Combustion	-	0.20	12.62	4.78	-NOx reduction	Contribute to better atmosphere around at workflow	0.33	0.1
10	A-10	Oxygen burner system for ladle preheating	- Rapid and high temperature ladle heating by oxygen burner - Automatic control - High Energy Saving (about 40 %)	-	0.20	12.62	4.78	-NOx reduction	Contribute to better atmosphere around at workflow	0.24	0.1
11	A-11	Waste heat recovery from EAF	- Waste heat boiler based on the OG boiler technology - Specified for splash and dust containing	132.0	-	119.46	13.20	-	-	48.96	7.4
12	A-12	Energy saving for dedusting system in EAF meltshop	- Damper openings and exhaust fan rotation are controlled in consonance - Combination of VVVF and proper damper opening	6.0	-	5.43	0.60	- Better working floor & atmosphere	-	0.65	2.2
13	A-13	Bottom stirring/stirring gas injection	- Inject inert gas (Ar or N2) into the bottom of EAF - Better heat transfer steel quality	18.0	-	16.29	1.80	-	- Fe yield increase 0.5 %	0.21	0.2
15	A-14	Induction type tundish heater	- Application of induction heating - Possible to uniformize temperature in 3 minutes after power supply	3.0 (compared to plasma heater)	-	2.72 (compared to plasma heater)	0.30	-	-	0.82	5.4
16	A-15	Scrap pretreatment with scrap shear	- Long size or low bulk-density scrap is shredded and packed. - Scrap pretreatment decreases the scrap-charging frequency, which will lead to energy saving.	20.0	-	18.10	2.00	-	Fe yield increase in 1.5 % (by Non-integrated steel producer's association)	3.10	3.1
17	A-16	Arc furnace with shell rotation drive	- By rotating furnace shell 50 degree back-and-force, cold spot will be decreased to realize smooth melting. - Assumed investment cost is the increase from the newly constructed conventional EAF.	32.0	-	28.96	3.20	-	- Decreasing power-on time, melting fuel, and refractory material	4.90	3.1

B. Environmental Protection for Electric Arc Furnace

18	B-1	Exhaust gas treatment through gas cooling, carbon injection, and bag filter dedusting for EAF	- Improved design configuration of the direct evacuation for treating hot unburned gas from much fuel use - Minimize dust and gas dispersion from EAF with enough capacity and suitable control	-	-	-	-	- Better workfloor & environment	-	-	-
19	B-2	Floating dust control in EAF meltshop	- Analyze air flow in EAF building	-	-	-	-	- Restrict dust loading on working floor to less than 5 mg/m ³	-	0.82	-
20	B-4	Dioxin adsorption by mixing EAF exhaust gas with building dedusting gas	- Cooling direct evacuation gas by mixing with building dedusting gas	-	-	-	-	- Dioxin will be lower than 5.0 ng TEQ/m ³ N	-	-	-
21	B-5	Dioxin absorption by 2 step bagfilter technology for EAF exhaust gas	- 2 step bag system can remove over 99% DXN's from EAF. - This system provide a clean working environment. - Effective evacuation decrease the consumption of electricity.	-	-	-	-	- Dioxin will be lower than 0.5 ng TEQ/m ³ N	-	-	-
22	B-6	PKS charcoal use for EAF	- Charcoal made from PKS can be used instead of injected coke into EAF.	-	-	-	-	- 39,000 ton-CO ₂ /y GHG reduction	-	-	-

C. Material Recycle for Electric Arc Furnace

23	C-1	EAF dust and slag recycling system by oxygen-fuel burner	- Zn recovery rate will be expected to be 95% - Remove heavy metals from dust and turn into harmless	-	-	-	-	-	- Zn material and heavy aggregate can be gained from EAF dust	-	-
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D. Energy Saving for Reheating Furnace

25	D-1	Process control for reheating furnace	- Setting furnace temperature by targeted billet temperature curve - Precise air ratio control and O ₂ analysis in exhaust gas	-	0.050	3.16	1.19	-	-	2.04	3.4
26	D-2	Low NOx regenerative burner total system for reheating furnace	- High efficient and durable burner system	-	0.189	10.60	4.52	- CO ₂ & NOx Reduction	-	6.53	2.9
27	D-3	High temperature recuperator for reheating furnace	- Heat transfer area is expanded - Special material tube is used instead of stainless	-	0.100	6.31	2.39	-	-	1.22	1.0
28	D-4	Fiber block for insulation of reheating furnace	- Low thermal conductivity - High temperature change response (low thermal-inertia)	-	0.039	2.46	0.93	- Reduction of Heat accumulation	-	1.22	2.6
29	D-6	Induction type billet heater for direct rolling	Compensate temperature drop of billets transferred from CC to rolling mill (from 950 degC to 1050 degC). Advantages : - Automatic control - Less exhaust gas (without reheating furnace)	-40.0	1.45	55.30	30.64	- Better working floor & atmosphere	-	0.82	0.1
30	D-7	Oxygen enrichment for combustion air	Thermal energy will be reduced with the decrease in the volume of exhaust gas. Assumed oxygen percentage in combustion air is 39 % in the study. Equipment of oxygen generator is not estimated, it is sometime rental use. Only electric power to generate oxygen is examined (0.5 kWh/m ³ N)	-23.6	0.26	-4.95	3.85	- Smaller exhaust gas volume from the stack	-	-	-

E. Common systems and General Energy Savings

31	E-1	Inverter (VFD; Variable Frequency Drive) drive for motors	Applying the Multi-Level Drive for motors enables to save energy cost from vane and valve control (constant speed motor). •Eco-Friendly •Power Source Friendly •Less Maintenance •Motor Friendly	13%	-	-	-	- CO ₂ Reduction	-	1.22	-
32	E-2	Energy monitoring and management systems	- Energy data are collected in process computer for evaluation	-	0.120	-	-	-	-	-	-
33	E-3	Management of compressed air delivery pressure optimization	- Energy saving in compressors requires consideration of the following points. * Selection of the appropriate capacity * Reduction in delivery pressure	285 MWh/y	-	-	-	-	-	-	-
34	E-4	Highly efficient combustion system for radiant tube burner	Silicon-carbide parts are inserted into the radiant tube to promote heat transfer from hot gas to the tube, which improve thermal efficiency of the furnace. Production of the target plant is assumed as 594,000 ton/y (CGL) with natural gas use.	-	0.0896	5.03	2.14	- CO ₂ Reduction	-	2.37	1.9

2. Technologies

One by One Sheets

A-1

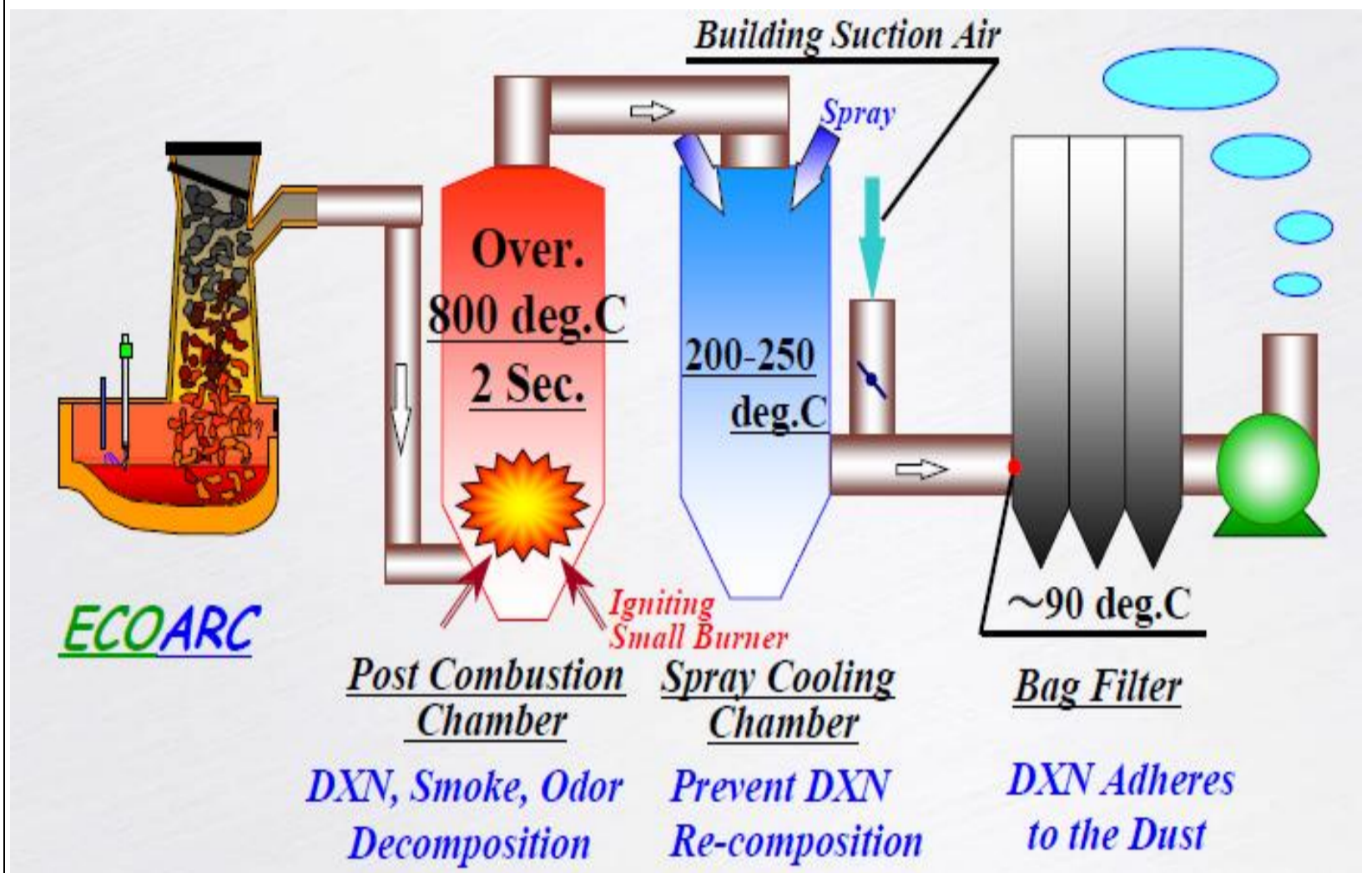
A. Energy Saving for Electric Arc Furnace (EAF)

High temperature continuous scrap preheating EAF

Item

Content

1. Process Flow or Diagram



2. Technology Definition/Specification

Preheating scraps with high-temperature exhaust gas is possible because the preheating shaft and melting chamber are directly and rigidly connected, so the scraps are continually present, from the steel to preheating areas. This enables high-temperature preheating of the scraps, resulting in a significant reduction of power consumption. The melting chamber is sealed off from outside air, to prevent the excess air inlet. It prevents over oxidation of scrap under high temperature preheating. As this equipment keeps always flat bath operation, electrode consumption is significantly improved. Furthermore, the electric facilities necessary to meet power quality regulation can be drastically reduced on it may not even unnecessary depending on required regulation. Dioxins are decomposed through an exhaust gas combustion chamber and rapid quench chamber in the exhaust gas duct system. Not only dioxins but also a volatile material that causes foul odors and white smoke will be decomposed and the dispersal of them are also prevented. The furnace prevents diluting of exhaust gasses. Therefore, the CO within the exhaust gas can be used as fuel, reducing the amount of fuel gas consumed. Flat bath operation dramatically reduces noise during operation. The reduction of power consumption also contributes to the reduction of emission of greenhouse gasses during power generation.

3. Expected Effect of Technology Introduction

• Electricity Saving	150 kWh/ton-product
• Thermal Energy Savings	-
• Environmental benefits	Decomposition of dioxin, reducing dispersing dust, & noise
• Co-benefits	Low electrode consumption (0.8 - 1.0 kg/ton-product at AC)

4. Japanese Main Supplier

JP Steel Plantech

5. Technologies Reference

SOACT 2nd Edition ("Ecological and Economical Arc Furnace"), Diagram from JP Steel Plantech

6. Comments

A-2

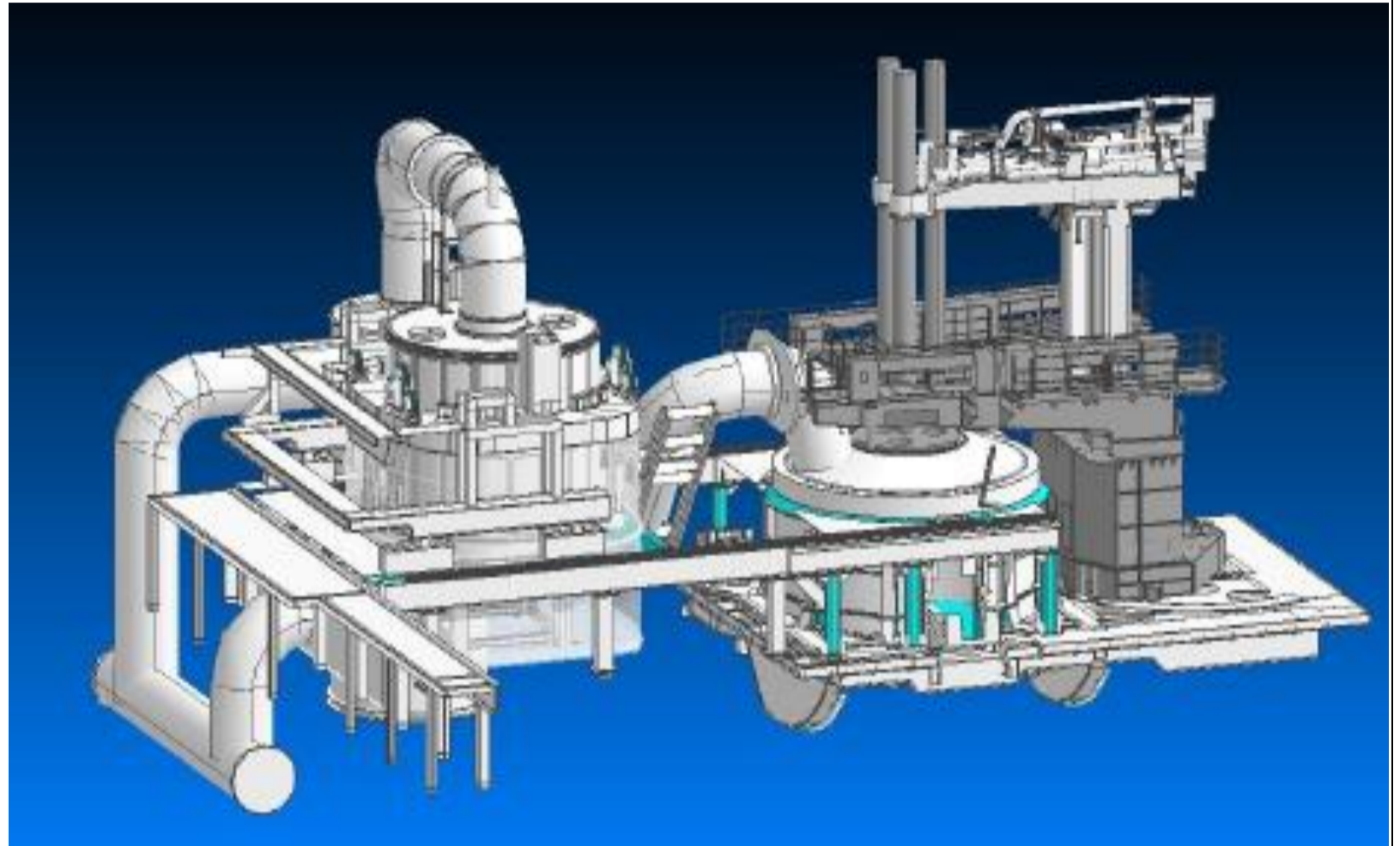
A. Energy Saving for Electric Arc Furnace (EAF)

Medium temperature batch scrap preheating EAF

Item

Content

1. Process Flow or Diagram



2. Technology Definition/Specification

- High melting efficiency batch charging type EAF with SPH.
- Preheated scrap temperature is about 250 - 300 degC.
- Fully enclosed automatic charging system to keep working floor clean.
- Minimize scrap oxidation by temperature controlling
- Material limitation free

3. Expected Effect of Technology Introduction

• Electricity Saving	40 kWh/ton-product
• Thermal Energy Savings	-
• Environmental benefits	Reduction of dioxin emission, dispersing dust & noise
• Co-benefits	No limit of material for high quality products as like stainless steel.

4. Japanese Main Supplier

Daido Steel

5. Technologies Reference

6. Comments

A-3

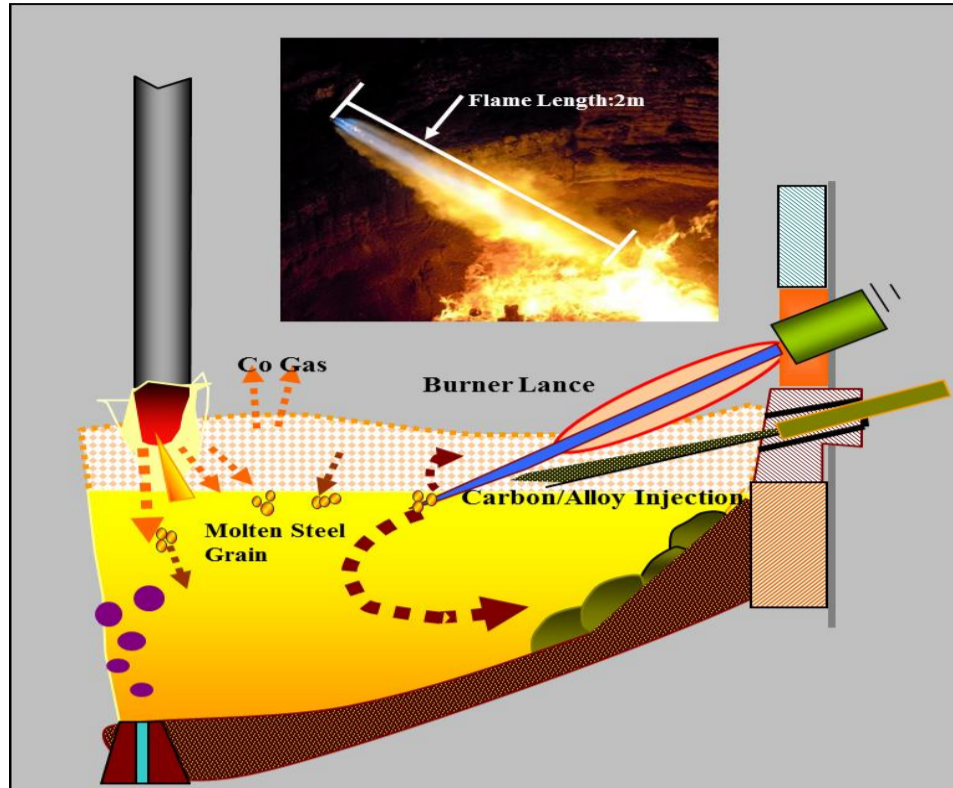
A. Energy Saving for Electric Arc Furnace (EAF)

High efficiency oxy-fuel burner/lancing for EAF

Item

Content

1. Process Flow or Diagram



New type of burner has been used to inject carbon and oxygen from side wall and closed slag door. The burner can realize evenly distributed slag-foaming and post-combustion without fully



Coherent burner can make long and sharp oxygen jet, which works instead of oxygen lance. Oxygen jet from the center hole is restricted to expand by the combustion around the jet, the combustion is generated by the fuel and oxygen from the peripheral

2. Technology Definition/Specification

- 'Conventional oxygen lances inserted through slag door causes;
- Local oxygen input near the slag door
- Uneven slag foaming through the bath
- Uneven post-combustion of generated CO
- Much hot gas escape caused by the cold air infiltration through the slag door

3. Expected Effect of Technology Introduction

• Electricity Saving	14.3 kWh/ton-product
• Thermal Energy Savings	-
• Environmental benefits	-
• Co-benefits	Reduction of nitrogen in steel, quality improvement

4. Japanese Main Supplier

Daido Steel, Nikko, JP Steel Plantech

5. Technologies Reference

SOACT 2nd edition (Add the word "High efficiency" to SOACT item for up-to-date oxygen use), Diagram from Nikko

6. Comments

<Source of "Electricity saving">
 $0.14 \text{ GJ/ton in SOACT} \rightarrow 0.14 \times 9.8/1000 = 14.3 \text{ kWh/ton}$

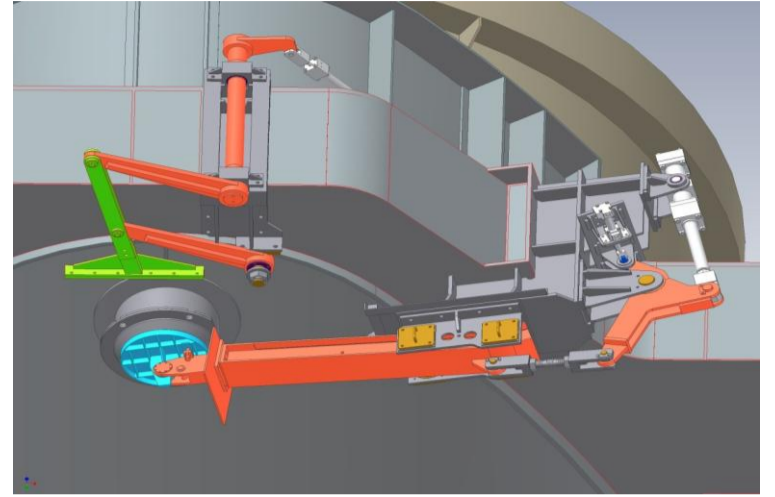
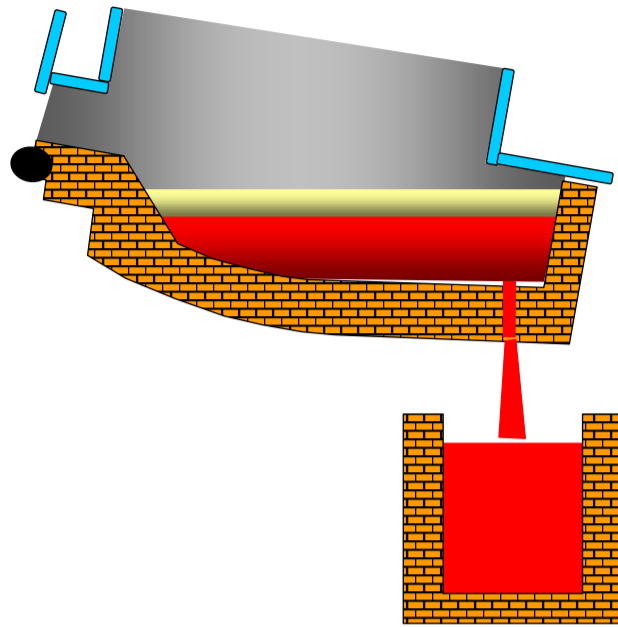
A-4

A. Energy Saving for Electric Arc Furnace (EAF)

Eccentric bottom tapping (EBT) on existing furnace

Item

Content



EBT concept and tapping

Effect of EBT

1. Process Flow or Diagram

Effect of EBT			Main factors
Category	Item	Effect	
Cost	1. Yield of Alloys	Si : 15 - 100%↑	Slag free tapping
	2. Yield of Fe	Fe : 1.1%↑	Slag free tapping, Hot heel
	3. Electric power consumption	7 - 25 kWh/t↓	Hot heel
	4. Electrode consumption	0.2 - 0.4 kg/t↓	Hot heel → Decrease of Electric power → High power factor
	5. Refractory consumption	Wall: 23 - 64%↓ Ladle: 9 - 54%↓	- Increase of water cooled area - Slag free tapping
	6. Lime consumption	15 - 25%↓	Hot heel
Productivity	1. Tap - to - On 2. On - to - Tap	1.0 - 3.0 min.↓ 1.0 - 7.2 min.↓	Shortened Hot repair, Shortened Tilting for Tapping, Decrease of Electrode con.
Quality	1. Dephosphorus 2. Inclusion	16 - 28%↑ Total [O] 1 - 3ppm↓	Hot heel Slag free tapping

2. Technology Definition/Specification

- Molten steel is tapped through the hole at the furnace bottom.
- ' - Tilting angle for tapping is smaller than conventional sput tapping, and quick tapping and returning are possible.
- ' - Tapping hole is plugged with silicon sand after tapping, which is held by stopping mechanism.
- ' - Slag free tapping is possible
- Reliable stopping and scraping mechanism to avoid leakage

3. Expected Effect of Technology Introduction

• Electricity Saving	15 kWh/ton-product
• Thermal Energy Savings	-
• Environmental benefits	-
• Co-benefits	Increase in Fe & alloy yield, and productivity Improve steel quality

4. Japanese Main Supplier

JP Steel Plantech, Daido Steel, Nikko

5. Technologies Reference

EPA-BACT (Sep. 2014), Diagram from JP Steel Plantech

6. Comments

- <Preconditions on calculating effects and investment costs>
- Values of "Electricity saving" are based on the EPA-BACT (Sep. 2014) & equipment supplier's rough estimation
 - "Profit" does not include such other advantages than electricity saving

A-5

A. Energy Saving for Electric Arc Furnace (EAF)

Ultra high-power transformer for EAF

Item

Content

1. Process Flow or Diagram



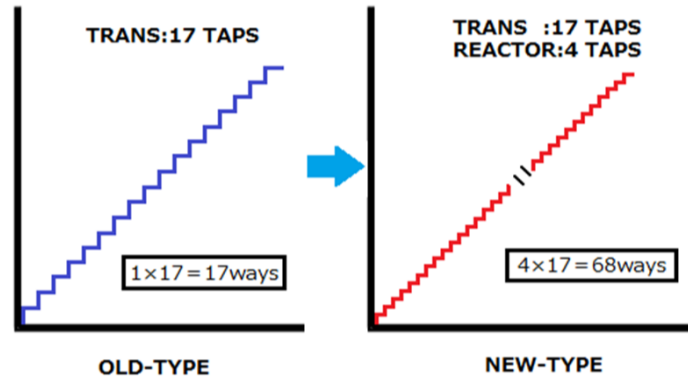
Forced-Oil Forced-Water Cooling type (OFWF) / 送油水冷式

Water-cooled oil cooler + oil pump
水冷クーラー+送油ポンプ

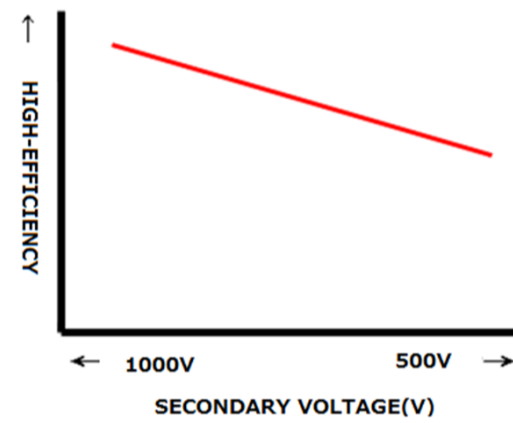
Single tube or double tube cooler
一重管 or 二重管クーラー



FINE-GRAINED VOLTAGE CONTROL



HIGH-EFFICIENCY FURNACE TRANSFORMER



2. Technology Definition/Specification

In the conventional system, series reactor was used for the early melting stage in order to stabilize arc and control of a flicker .
 Since High-Efficiency Furnace Transformer provides high impedance at early melting stage, series reactor is not required, though the same performance is achieved.
 - Reduce electric power consumption
 - Reduce electrode consumption
 - Shorten tap to tap time
 'In addition, it will conduct a fine-grained control by adding a reactor.

3. Expected Effect of Technology Introduction

• Electricity Saving	15 kWh/ton-product
• Thermal Energy Savings	-
• Environmental benefits	-
• Co-benefits	Increase productivity

4. Japanese Main Supplier

JP Steel Plantech, Daido, Nikko, Fuji Electric

5. Technologies Reference

EPA-BACT ("Transformer efficiency - ultra-high power transformers"), Diagram from Nikko

6. Comments

<Preconditions on calculating effects>
 - "Electricity saving" 15 kWh/ton-product comes from EPA-BACT, assuming that 44 MVA transformer for 80 ton EAF is revamped to 55 MVA.

A-6

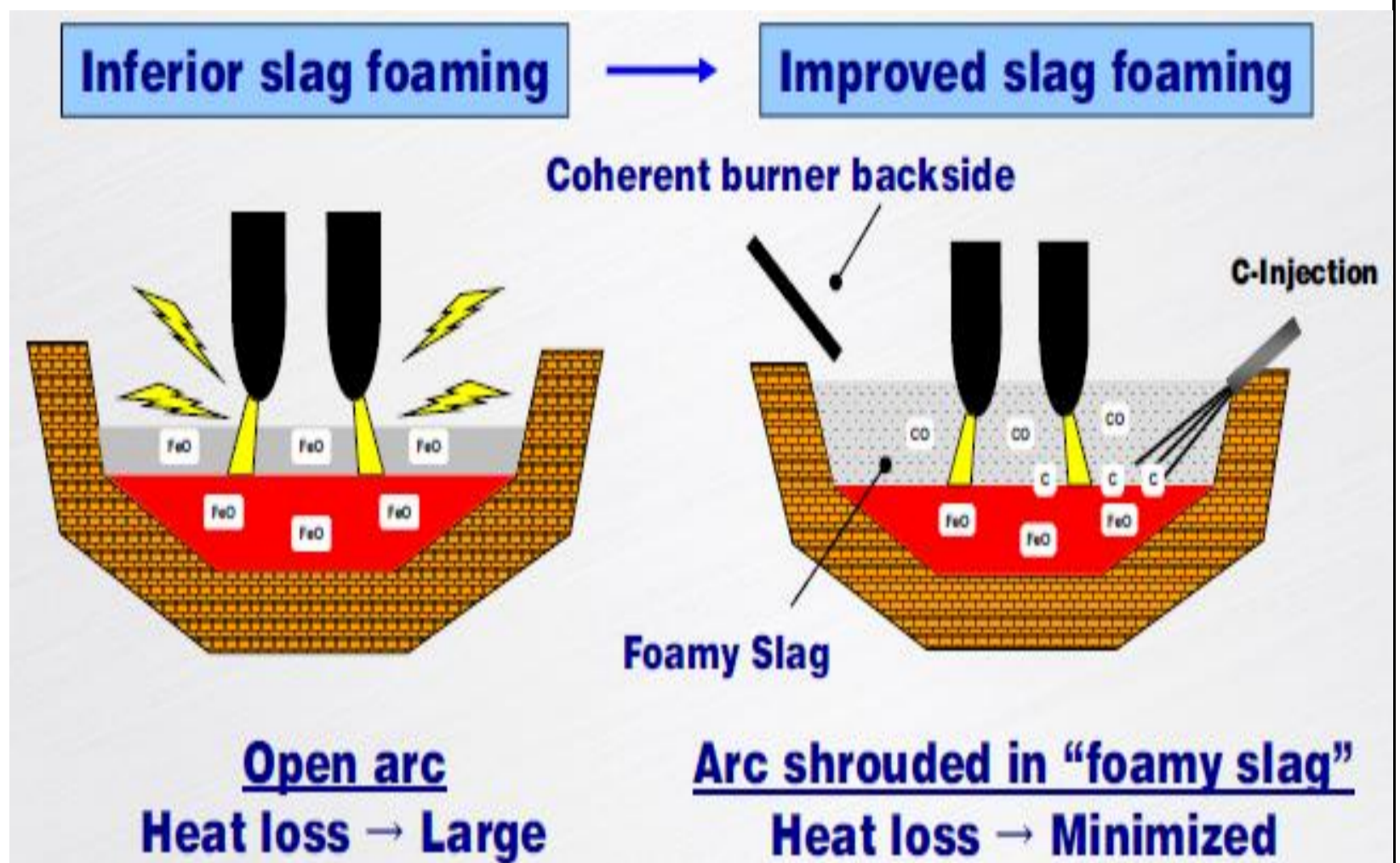
A. Energy Saving for Electric Arc Furnace (EAF)

Optimizing slag foaming in EAF

Item

Content

1. Process Flow or Diagram



2. Technology Definition/Specification

- Proper chemical ingredients of slag (Basicity 1.5 - 2.2, FeO 15 - 20 %)
- High efficient burner and/or lance
- Controlled O₂ & C injection into EAF proper position
- Keeping slag thickness with air-tight operation

3. Expected Effect of Technology Introduction

• Electricity Saving	6 kWh/ton-product
• Thermal Energy Savings	-
• Environmental benefits	Noise reduction & working floor cleaning
• Co-benefits	-

4. Japanese Main Supplier

JP Steel Plantech, Daido Steel, Nikko

5. Technologies Reference

SOACT 2nd Edition (Delete the word "Exchangeable Furnace and Injection Technology"), Diagram from JP Steel Plantech

6. Comments

<Source of "Electricity saving">
 (1) 2.5 - 3 % energy saving in SOACT ---> 430 kWh/ton x 0.03 = 12.9 kWh/ton
 (2) The phenomenum is explained by several factors, 6 kWh/ton is reasonable (Japanese experts).

A-7

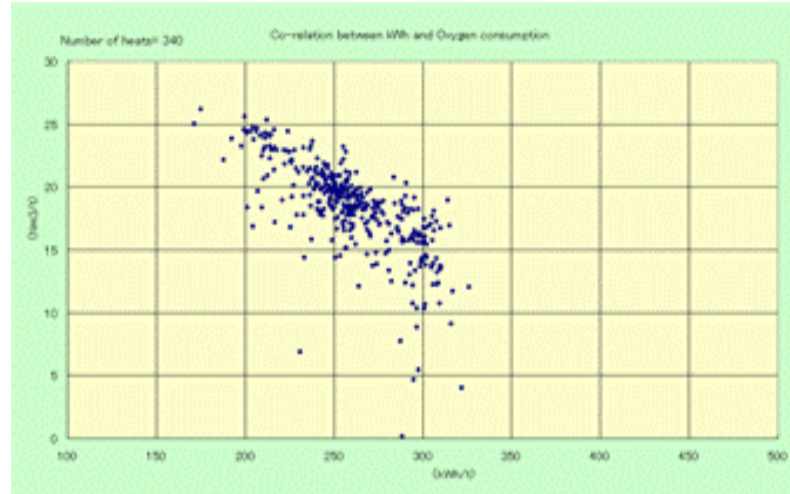
A. Energy Saving for Electric Arc Furnace (EAF)

Optimized power control for EAF

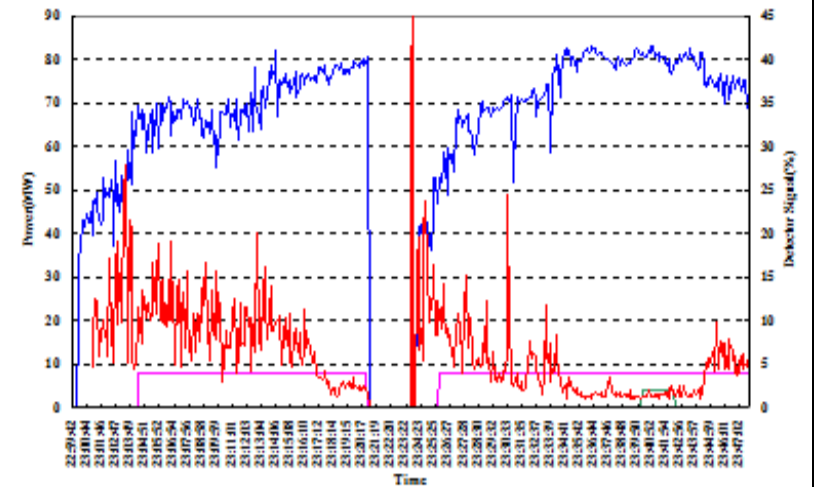
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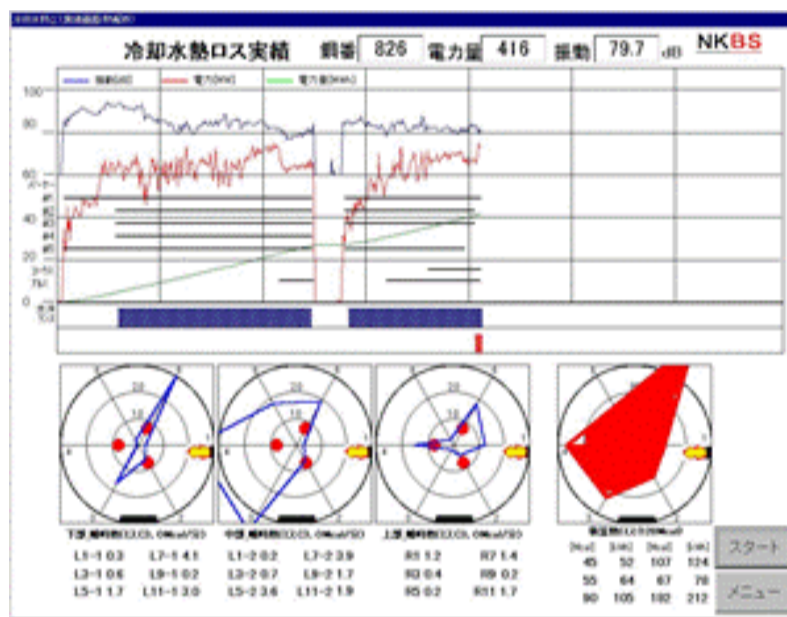
1. Process Flow or Diagram



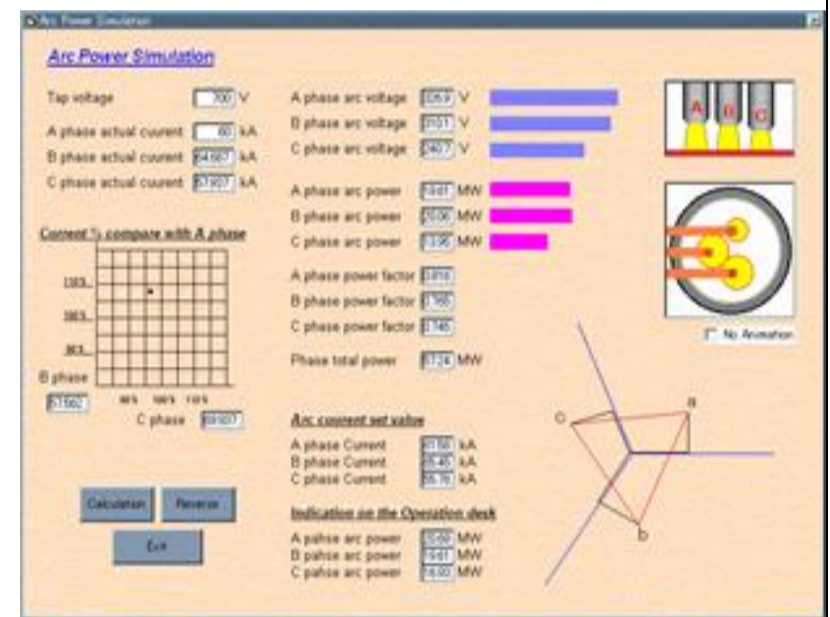
Statistical analysis



Slag foaming detection



Heat loss supervision



Power supply control for each phase

2. Technology Definition/Specification

- Data logging and visualization of melting process
- Automatic meltdown and additional scrap charging judgement
- Automatic phase power independent control for well-balance melting

3. Expected Effect of Technology Introduction

• Electricity Saving	15 kWh/ton-product
• Thermal Energy Savings	-
• Environmental benefits	Productivity increase Manpower saving
• Co-benefits	-

4. Japanese Main Supplier

JP Steel Plantech

5. Technologies Reference

SOACT 2nd Edition ("Improved Process Control (Neural Networks)"), Diagram from JP Steel Plantech

6. Comments

-

A-8

A. Energy Saving for Electric Arc Furnace (EAF)

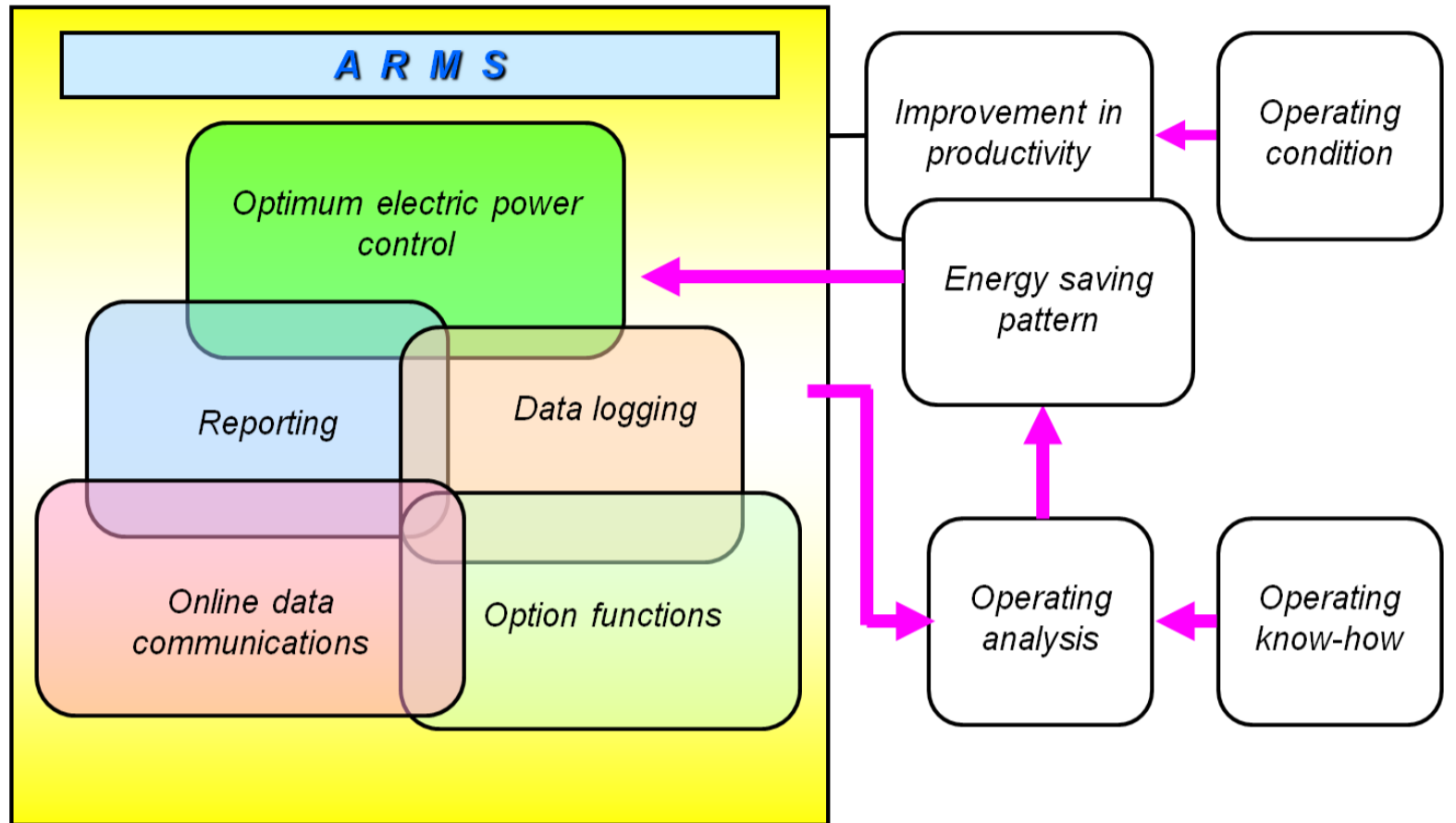
Operation support system with EAF meltdown judgment

Item

Content

1. Process Flow or Diagram

Consists of four basic functions and option functions.



2. Technology Definition/Specification

- Automatic rapid melting system for EAF
- Optimum electric power control
- Reporting, Data logging and online data communications
- Automatic meltdown Judgment
- Power supply and electrode position control for each phase

3. Expected Effect of Technology Introduction

- Electricity Saving 6 kWh/ton-product
- Thermal Energy Savings -
- Environmental benefits -
- Co-benefits Productivity increase
Manpower saving

4. Japanese Main Supplier

Daido Steel

5. Technologies Reference

Daido Steel

6. Comments

-

A-9

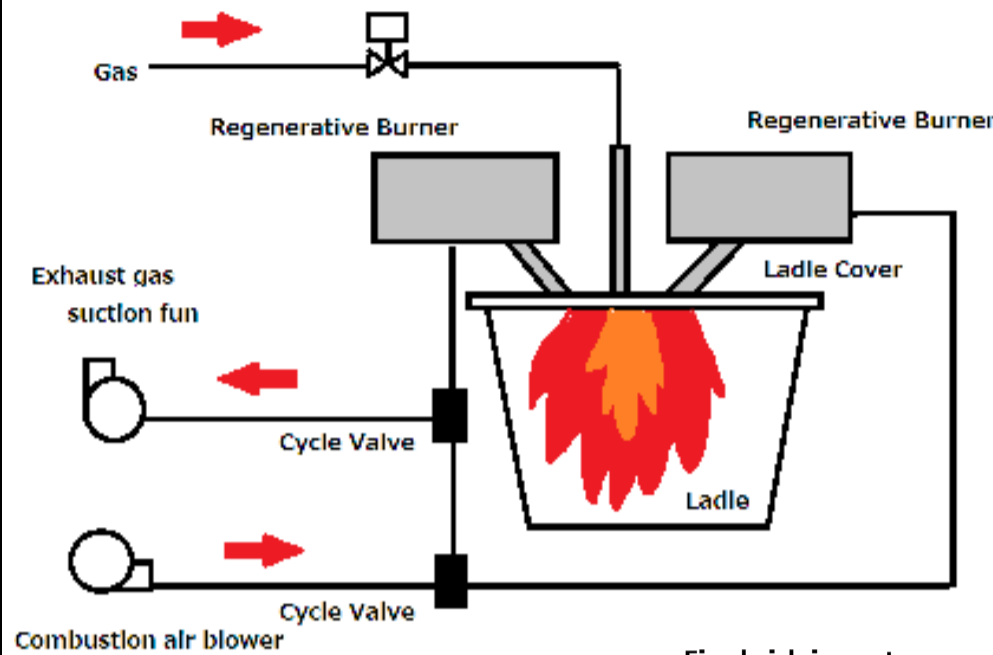
A. Energy Saving for Electric Arc Furnace (EAF)

Low NOx regenerative burner system for ladle preheating

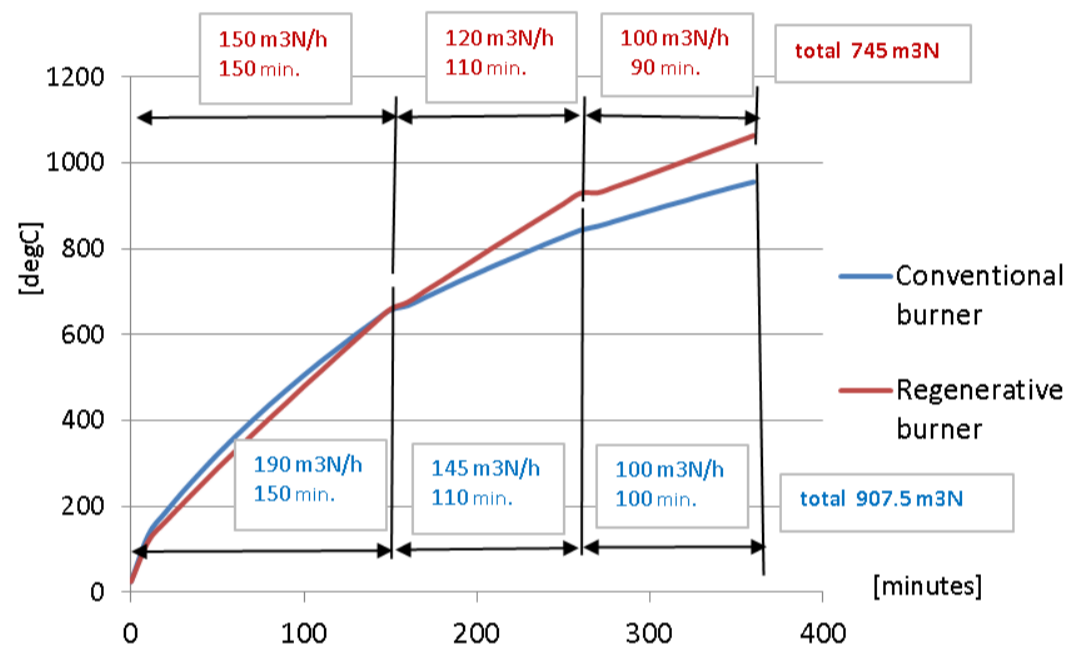
Item

Content

1. Process Flow or Diagram



Fire brick inner temperature with natural gas



2. Technology Definition/Specification

While one of the burners is burning, the other burner will work as an exhaust outlet. The exhaust gas is discharged from the system after the waste heat of the gas is recovered so that the temperature of the gas will be lowered to the extent that there will be no condensation in the regenerator. The combustion air receives heat from the regenerator. Therefore, the combustion air will be preheated to a super-high temperature (i.e., 90% of the temperature of the exhaust gas or over) before the combustion air is supplied to the burner. When the preset cycle time elapses, the burners exchange their roles of combustion and exhaustion.

3. Expected Effect of Technology Introduction

- Electricity Saving -
- Thermal Energy Savings 40 % fuel saving is expected comparing to existing preheater with conventional burner. 900 m3N natural gas in 6 hour burning for 80 ton ladle consumes about 40 GJ ---> 0.5 GJ/ton-steel x 40 % = 0.2 GJ/ton-steel save
- Environmental benefits Low NOx
- Co-benefits Higher brick temperature can allow lower tapping temperature for energy saving at EAF. Improving meltshop atmosphere by reducing hot gas which disturbs dirty gas suction at the canopy

4. Japanese Main Supplier Chugai-Ro, Nippon Furnace

5. Technologies Reference

6. Comments

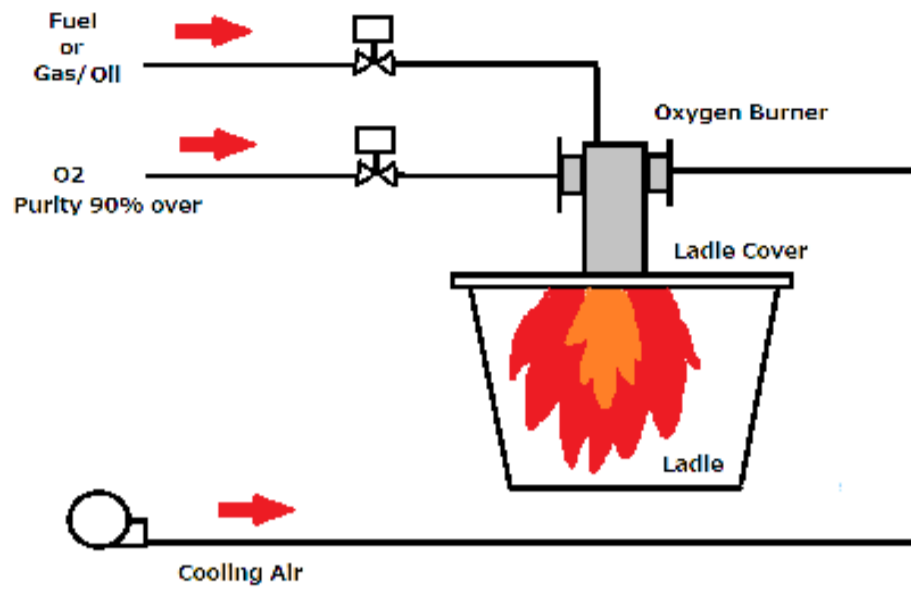
A-10

A. Energy Saving for Electric Arc Furnace (EAF)

Oxygen burner system for ladle preheating

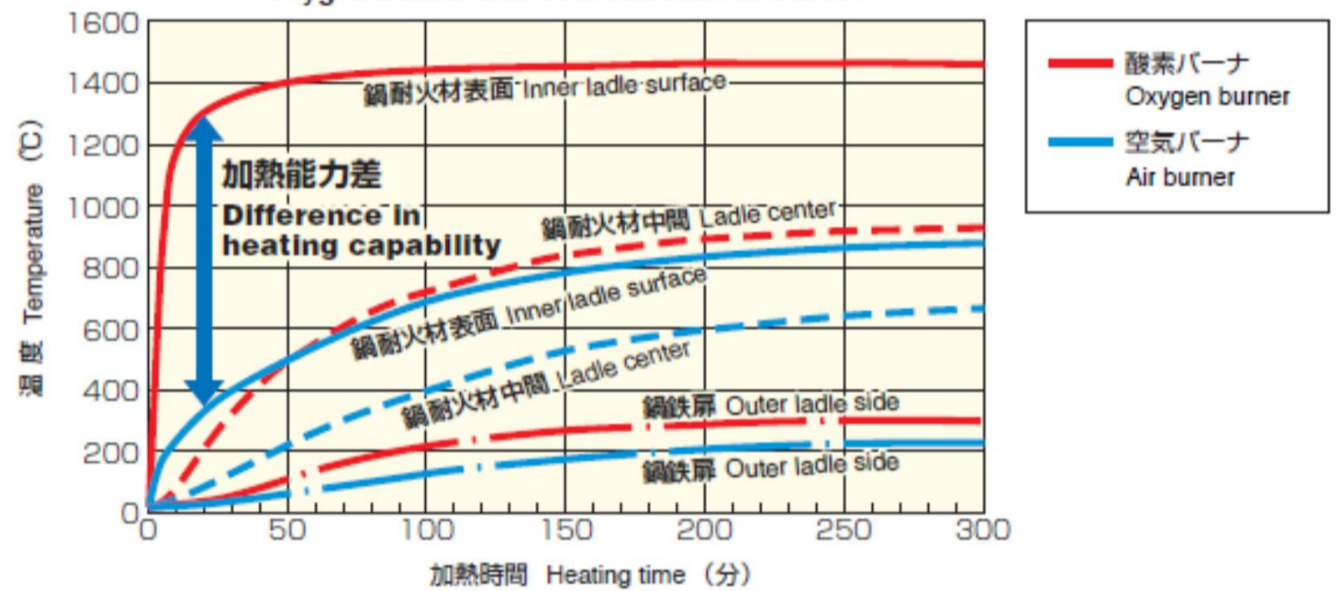
Item

Content



1. Process Flow or Diagram

酸素バーナと従来空気バーナとの加熱能力比較
Comparison in Heating Capability between Oxygen Burner and Conventional Air Burner



2. Technology Definition/Specification

Oxygen combustion achieve rapid heating by high flame temperature. High flame temperature achieve high wall temperature, therefore it can be possible low temperature feeding of melted metal in to the ladle.

3. Expected Effect of Technology Introduction

- Electricity Saving
- Thermal Energy Savings
- Environmental benefits
- Co-benefits

-
40 % fuel saving is expected comparing to existing preheater
Low NOx
Higher brick temperature can allow lower tapping temperature for energy saving at EAF.

4. Japanese Main Supplier

Chugai-Ro, Nippon Furnace

5. Technologies Reference

Diagram from Chugai Ro, May contact to suppliers

6. Comments

-

A-11

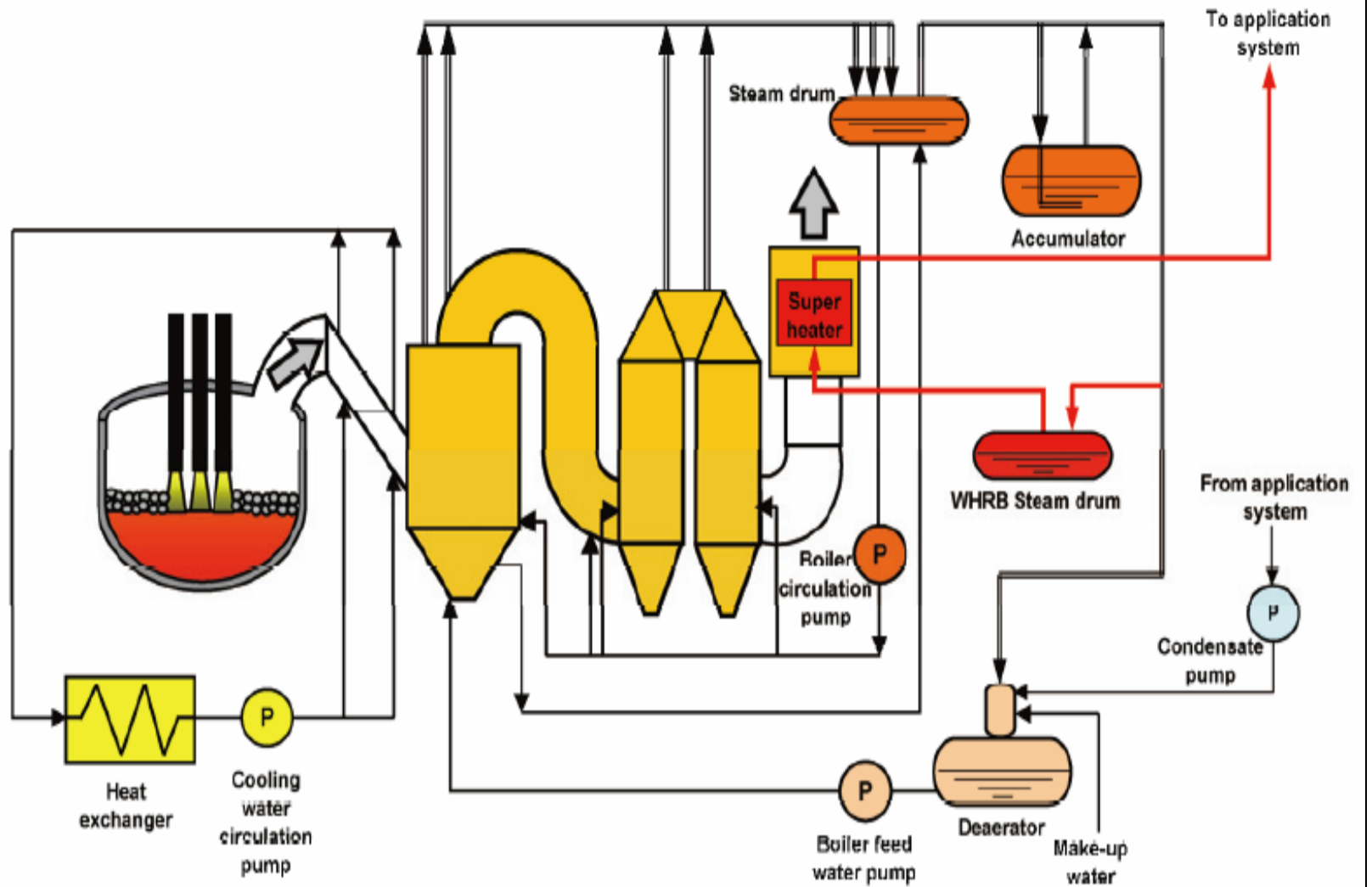
A. Energy Saving for Electric Arc Furnace (EAF)

Waste heat recovery from EAF

Item

Content

1. Process Flow or Diagram



2. Technology Definition/Specification

- Waste heat boiler based on the OG boiler technology
- Specified for splash and dust containing
- Main boiler is radiative type, and convective type super heater is located at the downstream of boiler to avoid clogging.

3. Expected Effect of Technology Introduction

• Electricity Saving	132 kWh/ton-product
• Thermal Energy Savings	-
• Environmental benefits	-
• Co-benefits	-

4. Japanese Main Supplier

JP Steel Plantech (yoshidah@steelplantech.co.jp, tel +81-45-471-3917 fax +81-45-471-4002)

5. Technologies Reference

Diagram from JP Steel Plantech, May contact to JP Steel Plantech

6. Comments

- <Preconditions on calculating effects>
- Power generation is 248,000 MWh/year with two 150 ton EAFs for DRI
 - Assumed annual production by two 150 ton EAF
 $= 500,000 / 80 \times 150 \times 2 = 1,875,000 \text{ ton/y}$
 - Unit power generation = $248,000 \times 1,000 / 1,875,000 = 132 \text{ kWh/ton-product}$
 - Suited to DRI continuous charging EAF, not scrap EAF

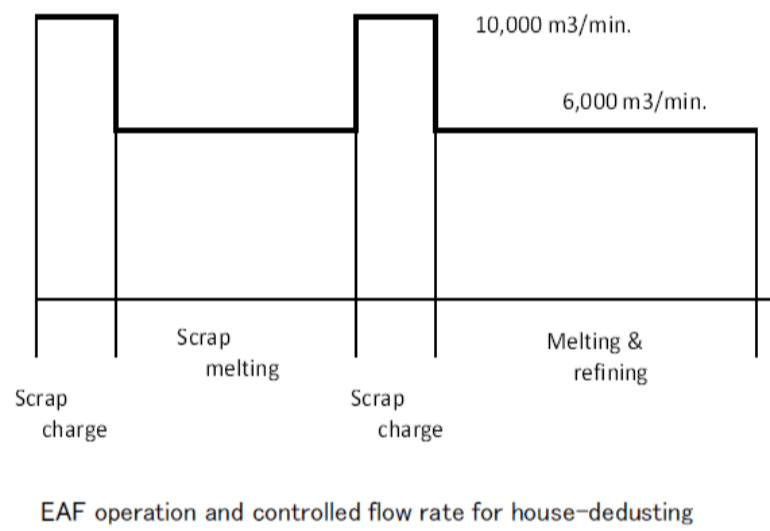
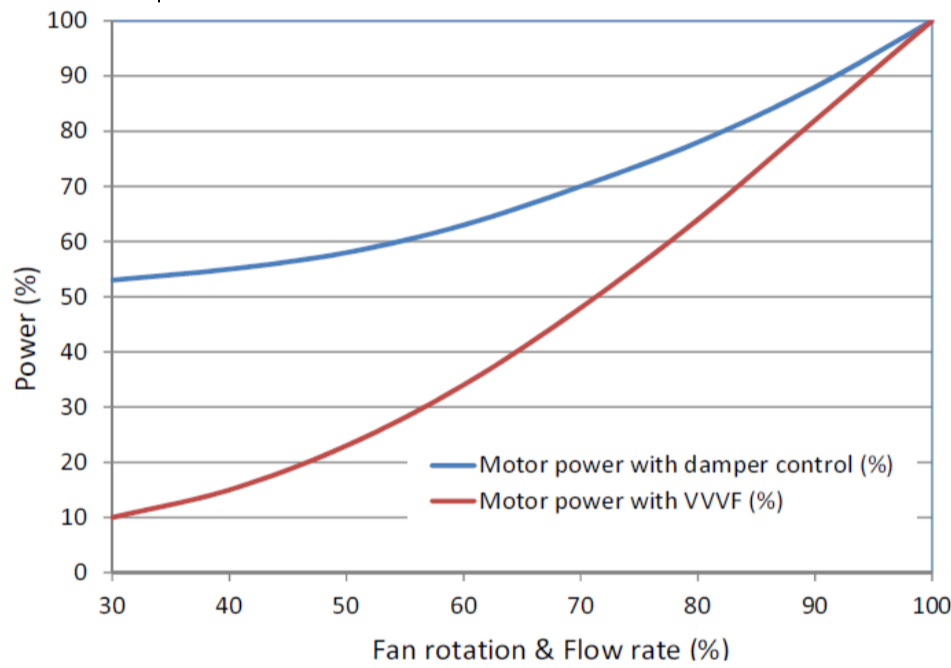
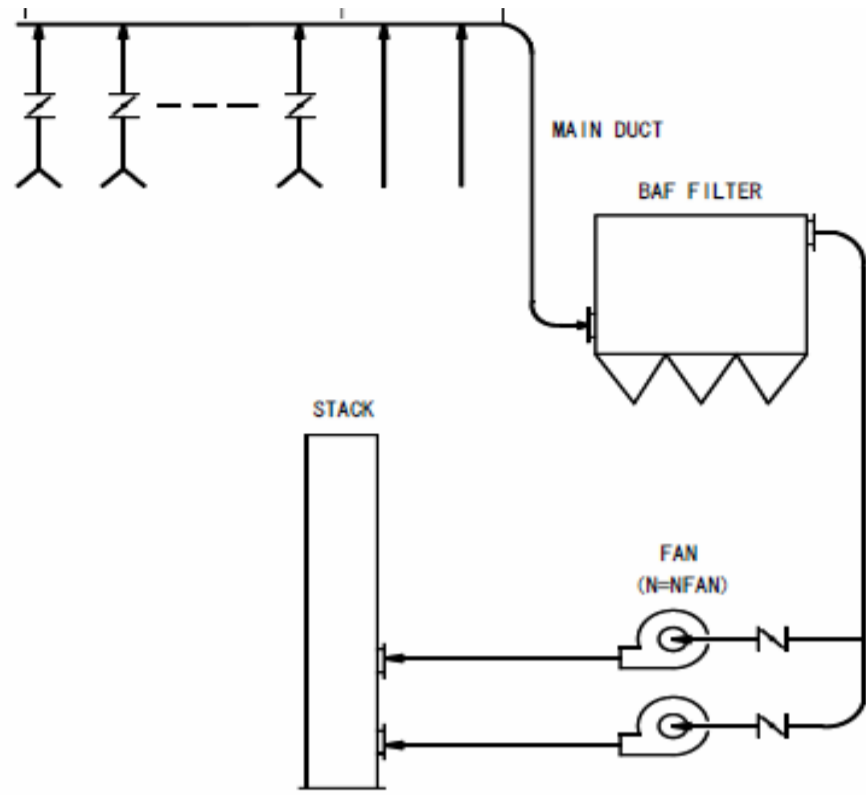
A-12

A. Energy Saving for Electric Arc Furnace (EAF)

Energy saving for dedusting system in EAF meltshop

Item	Content
------	---------

1. Process Flow or Diagram



2. Technology Definition/Specification	<ul style="list-style-type: none"> - Damper openings and exhaust fan rotation are controlled in consonance with the furnace operation pattern - Reducing fan rotation with VVVF system enables to save motor power, comparing to the simple damper control system.
3. Expected Effect of Technology Introduction	<ul style="list-style-type: none"> • Electricity Saving: 6 kWh/ton-product (25 % of assumed unit power consumption) • Thermal Energy Savings: - • Environmental benefits: Better working floor and atmosphere • Co-benefits: -
4. Japanese Main Supplier	JP Steel Plantech, Daido, Nikko, Fuji Electric
5. Technologies Reference	Diagram from JP Steel Plantech
6. Comments	<p><Preconditions on calculating effects> Assumed electricity consumption for building dedusting is 24 kWh/ton-product, and 25 % power saving is expected.</p>

A-13

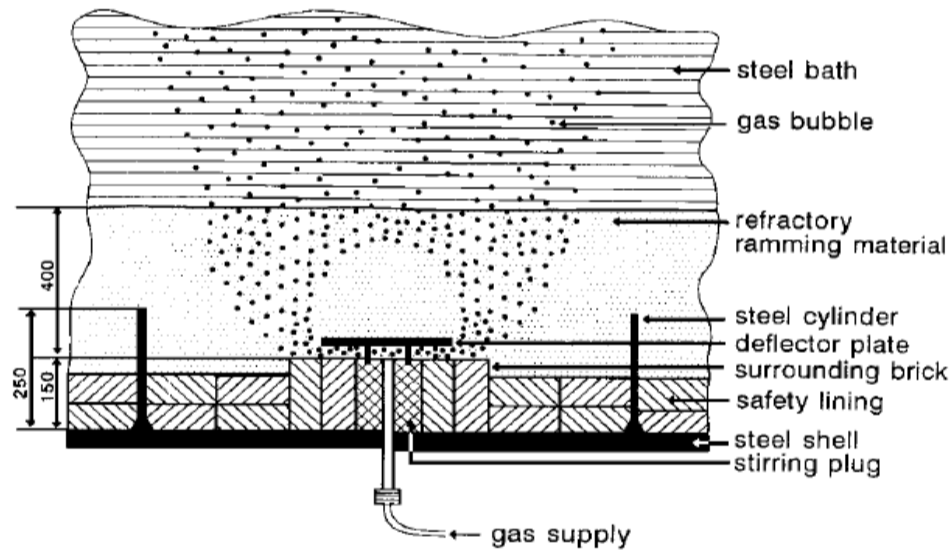
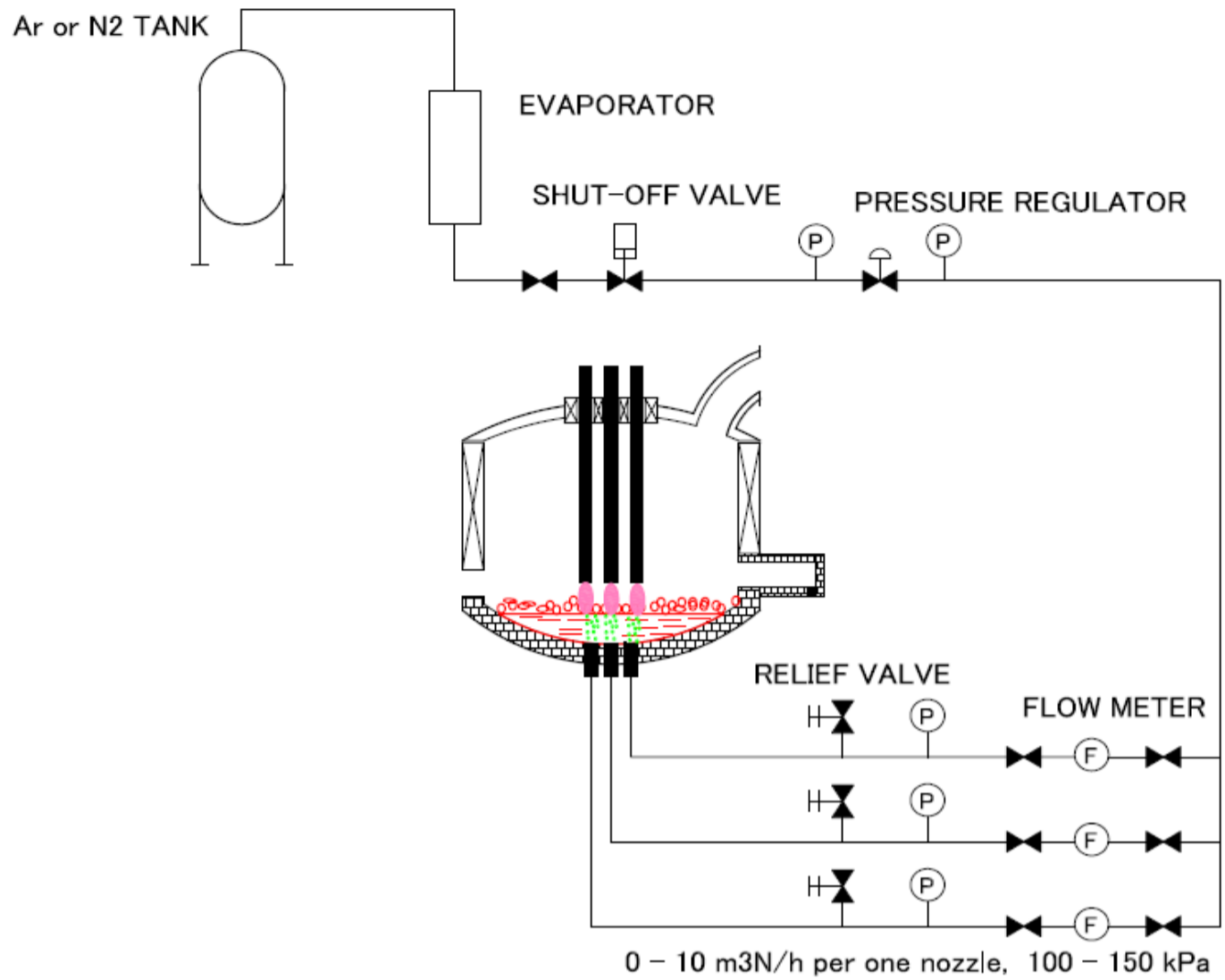
A. Energy Saving for Electric Arc Furnace (EAF)

Bottom stirring/stirring gas injection

Item

Content

1. Process Flow or Diagram



Schematic sketch of gas injection nozzle

2. Technology Definition/Specification

Inject inert gas (Ar or N₂) into the bottom of EAF to agitate steel bath
 Expected effects : 2)
 - homogenize chemical composition and temperature in steel bath
 - accelerate chemical reaction between steel and slag
 - shorten tap-tap-time
 - save electrical energy
 - increase yields of iron and alloys

3. Expected Effect of Technology Introduction

•Electricity Saving	18 kWh/ton-product 1)
•Thermal Energy Savings	-
•Environmental benefits	-
•Co-benefits	Fe yield increase 0.5 % 1)

4. Japanese Main Supplier

Nikko, Daido Steel

5. Technologies Reference

1) EPA-BACT
 2) Bottom-stirring in an electric-arc furnace:Performance results at ISCOR Vereeniging Works (The Journal of The South African Institute of Mining and Metallurgy, January 1994)

6. Comments

A-14

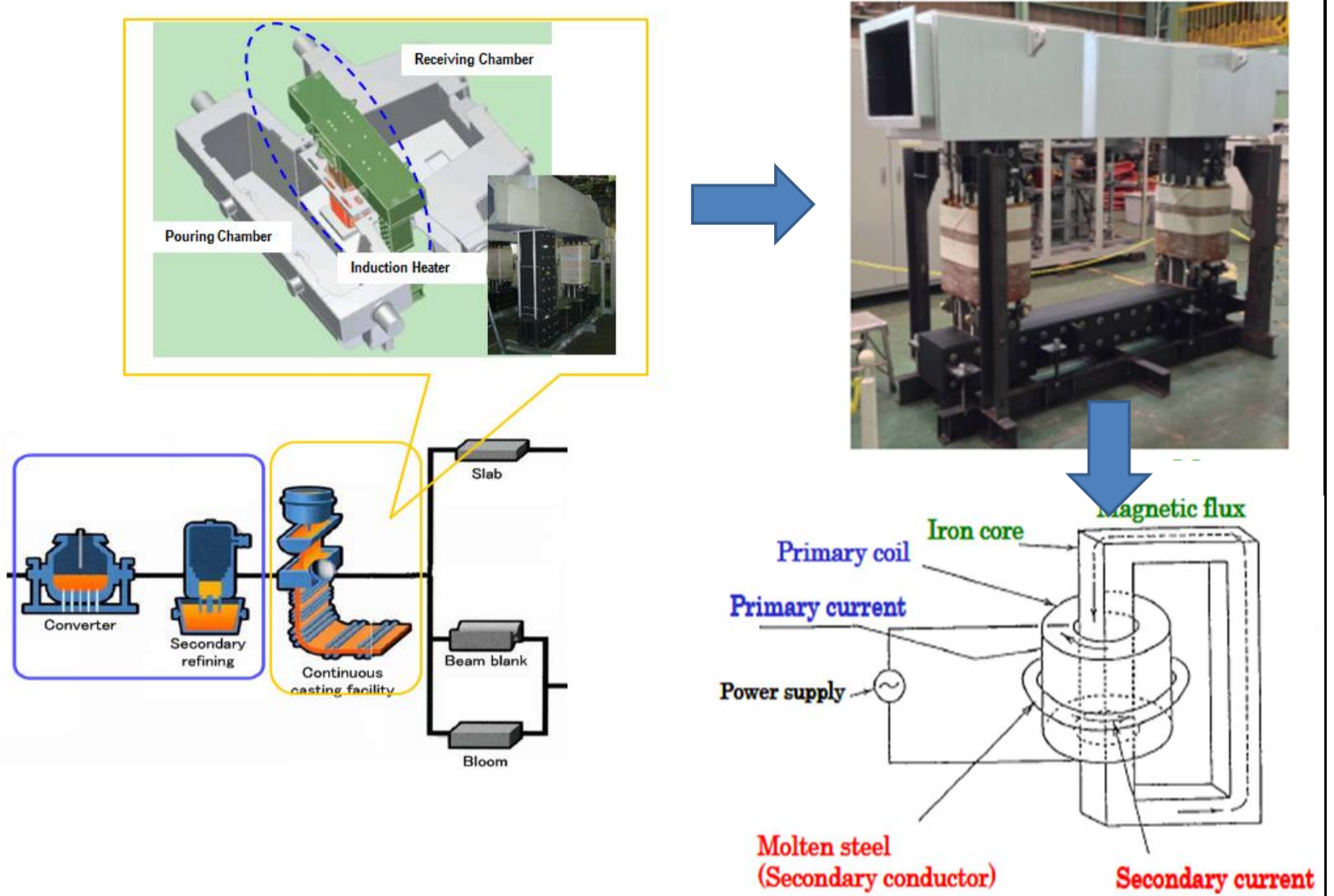
A. Energy Saving for Electric Arc Furnace (EAF)

Induction type tundish heater

Item

Content

1. Process Flow or Diagram



2. Technology Definition/Specification

- < Features for Induction Tundish heater >
- 1.Uniformity of Element of Molten Steel:Agitation effect by electromagnetic force.
 - 2.High Precision Temperature Control:Target Temp.±2.5degree.
 - 3.High Heating Efficiency : More than 90% by channel type inductor.
 - 4.Ease of maintenannce:Water cooled feeder with quick connector.Self-cooled type Induction coil and so on.

3. Expected Effect of Technology Introduction

• Electricity Saving	3 kWh / ton-product (Effect is calculated comparing to electricity consumption of plasma type heater)
• Thermal Energy Savings	-
• Environmental benefits	-
• Co-benefits	1.Productivity increase 2.Quality improvement

4. Japanese Main Supplier

Fuji Electric

5. Technologies Reference

Fuji Electric

6. Comments

- <Preconditions on calculating effects>
- Assumed plasma type tundish heater is installed
 - Ladle capacity: 200 ton
 - Operated days: 30 days/month
 - Electricity intensity of heater: 13.7 kWh/ton
 - Heat efficiency: 70%
 - Pouring amount: 2.5 ton/min
 - Dissolution time: 80 min/charge
 - Rised temperature: 40 degeree C
 - Number of charges: 8 charges/day
 - Monthly production: 48,000 ton
 - Annual production: 576, 000 ton

A-15

A. Energy Saving for Electric Arc Furnace (EAF)

Scrap pretreatment with scrap shear

Item

Content

1. Process Flow or Diagram



Before scrap pretreatment (0.3 ton/m3)

After scrap pretreatment (0.6)

2. Technology Definition/Specification

- Long size or low bulk-density scrap is shredded and packed.
- For example, bulk density of 0.3 m3/ton can be decreased to 0.6 with 1250 ton shear x 2 for 80 ton EAF.
- Scrap pretreatment decreases the scrap-charging frequency, which will lead to energy saving.

3. Expected Effect of Technology Introduction

- Electricity Saving
- Thermal Energy Savings
- Environmental benefits
- Co-benefits

20 kWh/ton-product (reported by Non-integrated steel producer's association of Japan)

-

-

- Fe yield increase in 1.5 %, TTT shortening

4. Japanese Main Supplier

Fuji Car Manufacturing

5. Technologies Reference

6. Comments

A-16

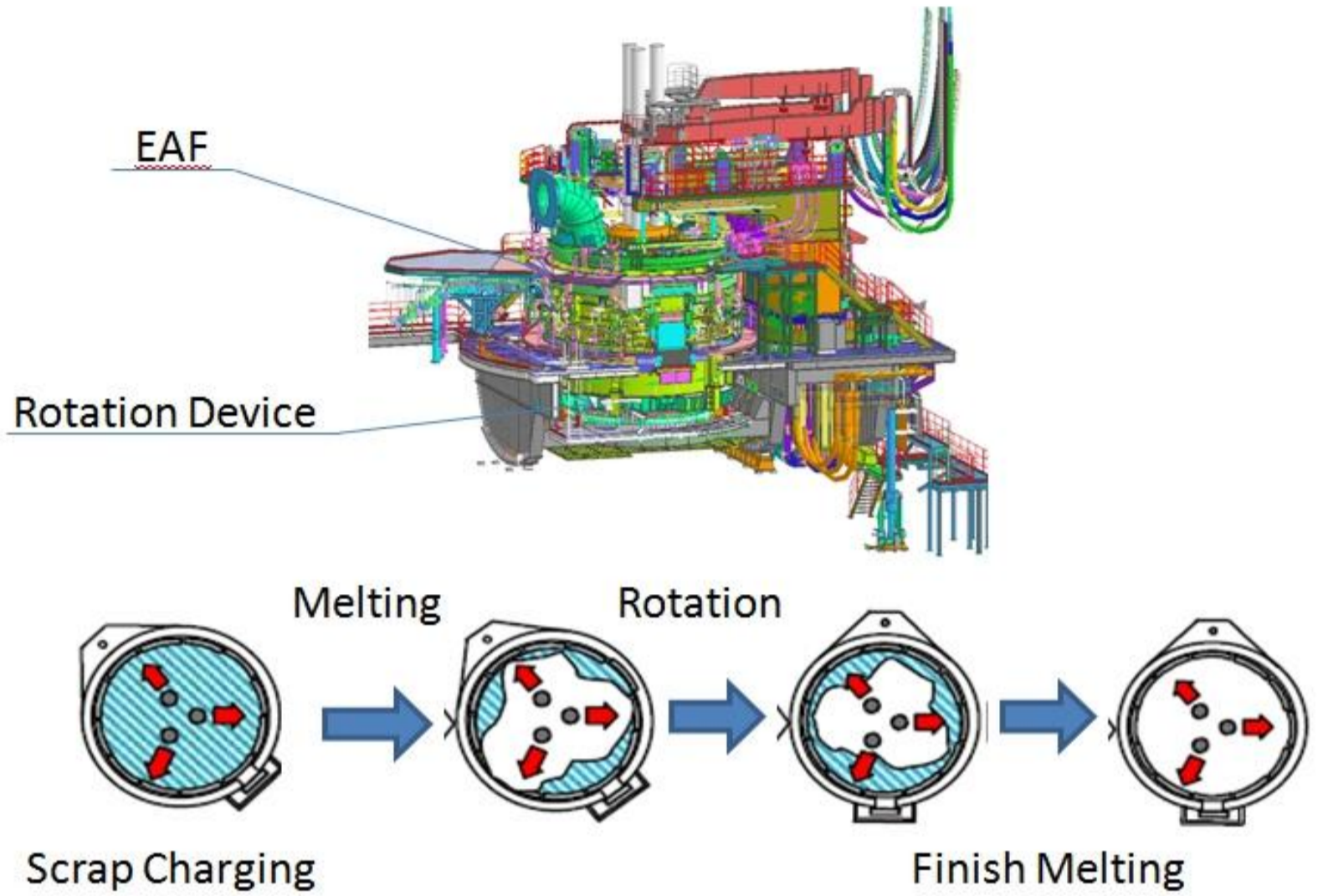
A. Energy Saving for Electric Arc Furnace (EAF)

Arc furnace with shell rotation drive

Item

Content

1. Process Flow or Diagram



2. Technology Definition/Specification

Furnace shell is rotated 50 degree back-and-forth
 Uniform scrap melting with furnace shell rotation

- Shortening power-on time
- Reduction in cooling water energy loss
- Reduction in scrap cutting oxygen
- Reduction in refractory repairing materials

3. Expected Effect of Technology Introduction

• Electricity Saving	32 kWh/ton-product
• Thermal Energy Savings	-
• Environmental benefits	-
• Co-benefits	- No limit of material for high quality products - Reduction of refractory consumption

4. Japanese Main Supplier

Daido Steel

5. Technologies Reference

6. Comments

B-1

B. Environmental Protection for Electric Arc Furnace

Exhaust gas treatment through gas cooling, carbon injection, and bag filter dedusting for EAF

Item

Content

1. Process Flow or Diagram



2. Technology Definition/Specification

- Improved design configuration of the direct evacuation for treating hot unburned gas from much fuel use
- Minimize dust and gas dispersion from EAF with enough capacity and suitable control
- Much fossil fuel use becomes possible to save electricity.

3. Expected Effect of Technology Introduction

• Electricity Saving

- When capacity increase is applied to the standard size EAF (30 m³N-O₂/ton-steel, 20 m³N-natural gas/ton-steel, and 15 kg-carbon/ton-steel), expected electrical energy saving becomes as:
4 - 5 kWh/m³N-O₂
8 - 9 kWh/m³N-natural gas
8 - 9 kWh/kg-carbon
- Decrease in yield is assumed as 1 - 2 % per 10 m³N-O₂/ton-steel.

• Thermal Energy Savings

-

• Environmental benefits

Better workflow environment

• Co-benefits

-

4. Japanese Main Supplier

JP Steel Plantech, Daido Steel, Nikko

5. Technologies Reference

SOACT 2nd Edition
Recent Progress of Steelmaking Technology in Electric Arc Furnace (1993, JISF)

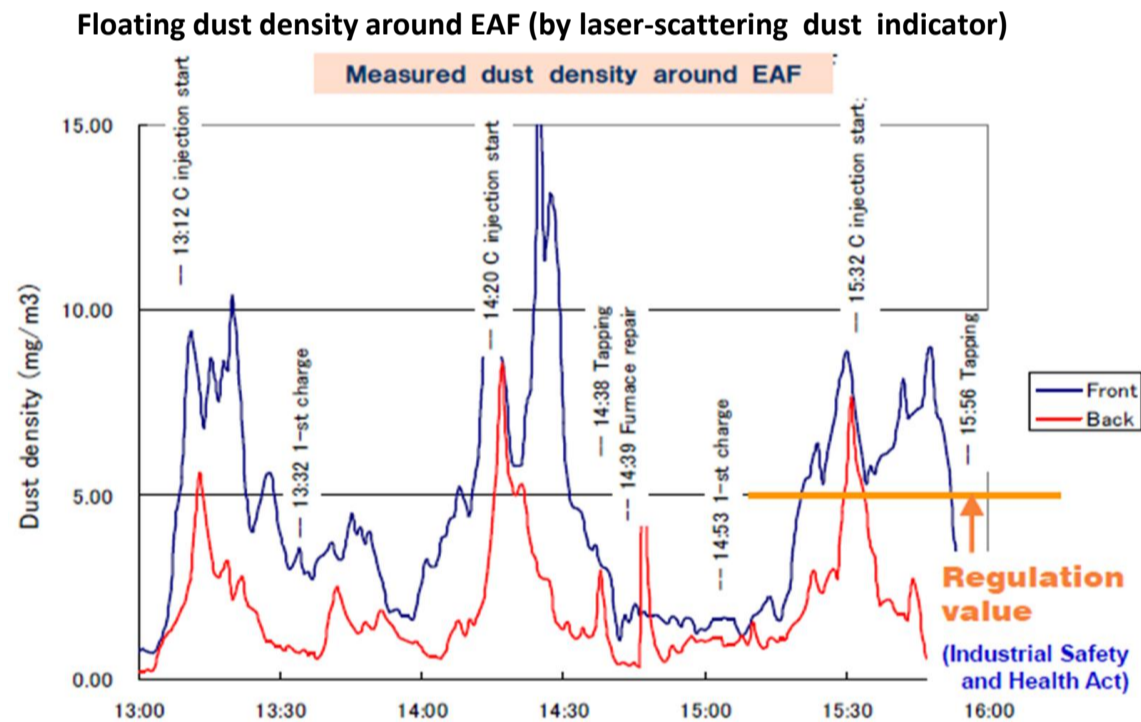
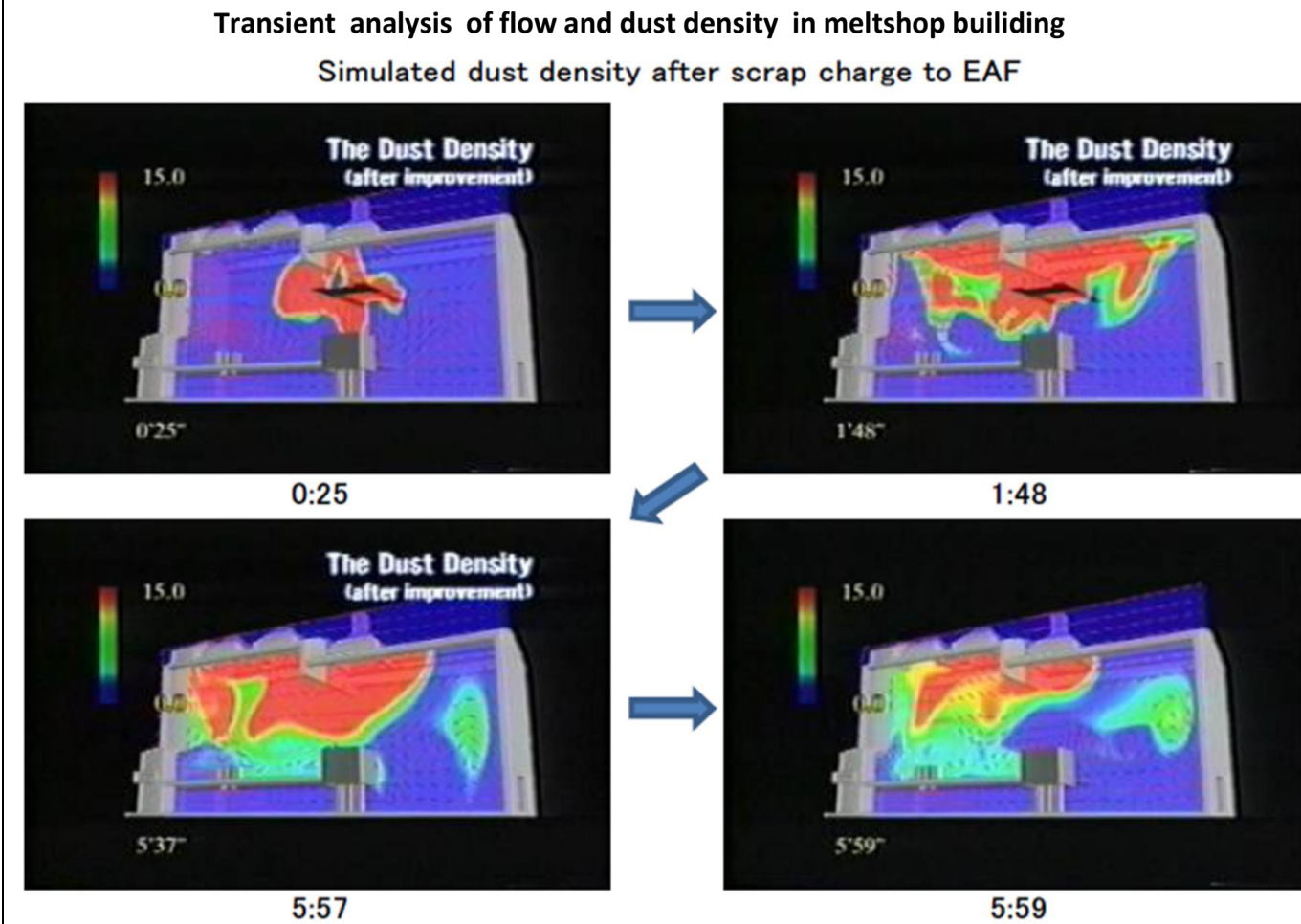
6. Comments

B-2

B. Environmental Protection for Electric Arc Furnace

Floating dust control in EAF meltshop

1. Process Flow or Diagram



2. Technology Definition/Specification

- In modern EAF meltshop, fully enclosed building is required to avoid dust dispersion to the outside, but enclosed building raises workflow pollution which affects workers health.
- Proper design and operation of dedusting system based on the flow analysis and real dust data are essential.
- Building and suction system revamping shall be executed based on the flow analysis.
- Target value of dust loading on working floor should be less than 5 mg/me, for example, specified in Industrial Safety and Health Act. in Japan

3. Expected Effect of Technology Introduction

- Electricity Saving -
- Thermal Energy Savings -
- Environmental benefits Restrict dust loading on working floor to less than 5 mg/m3
- Co-benefits -

4. Japanese Main Supplier

JP Steel Plantech, Daido Steel

5. Technologies Reference

Diagram from JP Steel Plantech, May contact to suppliers

6. Comments

B-4

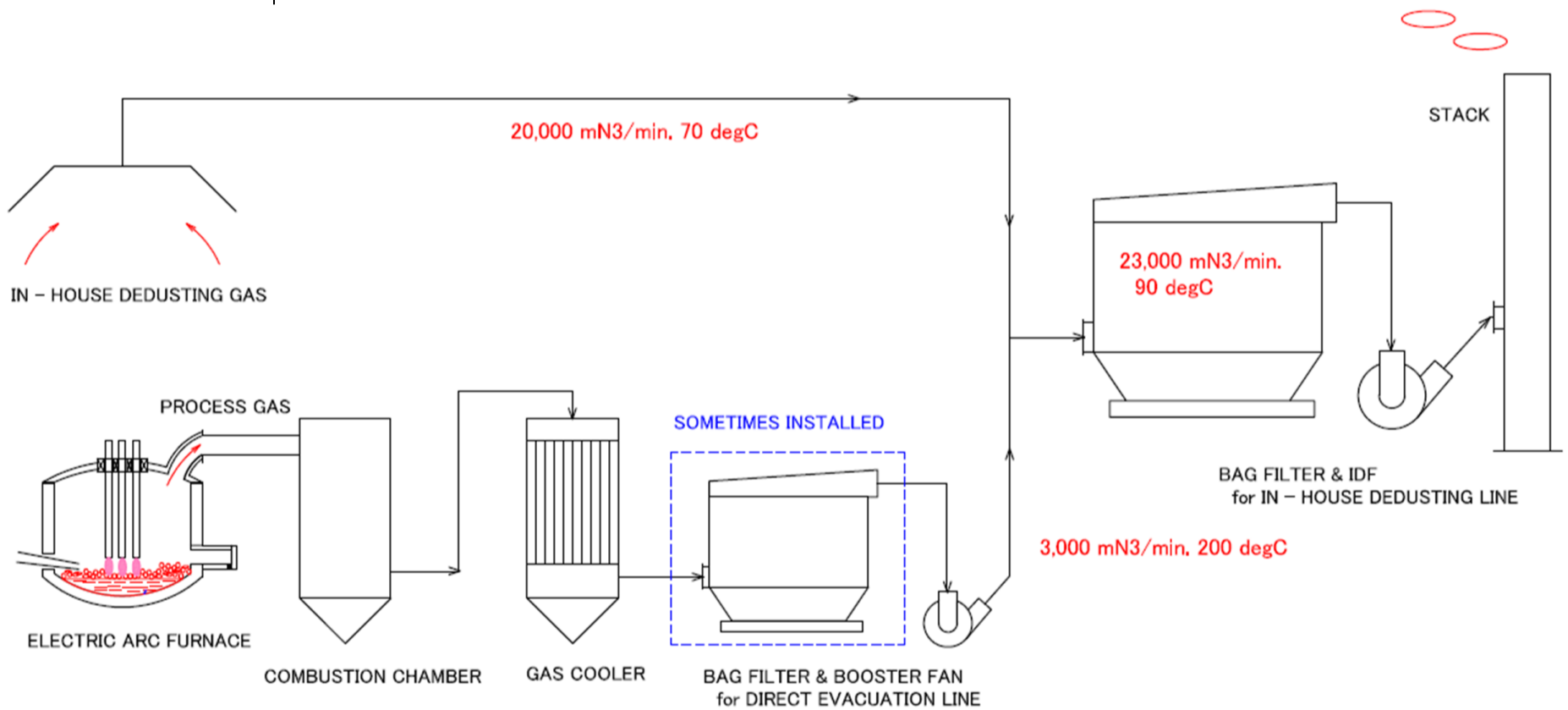
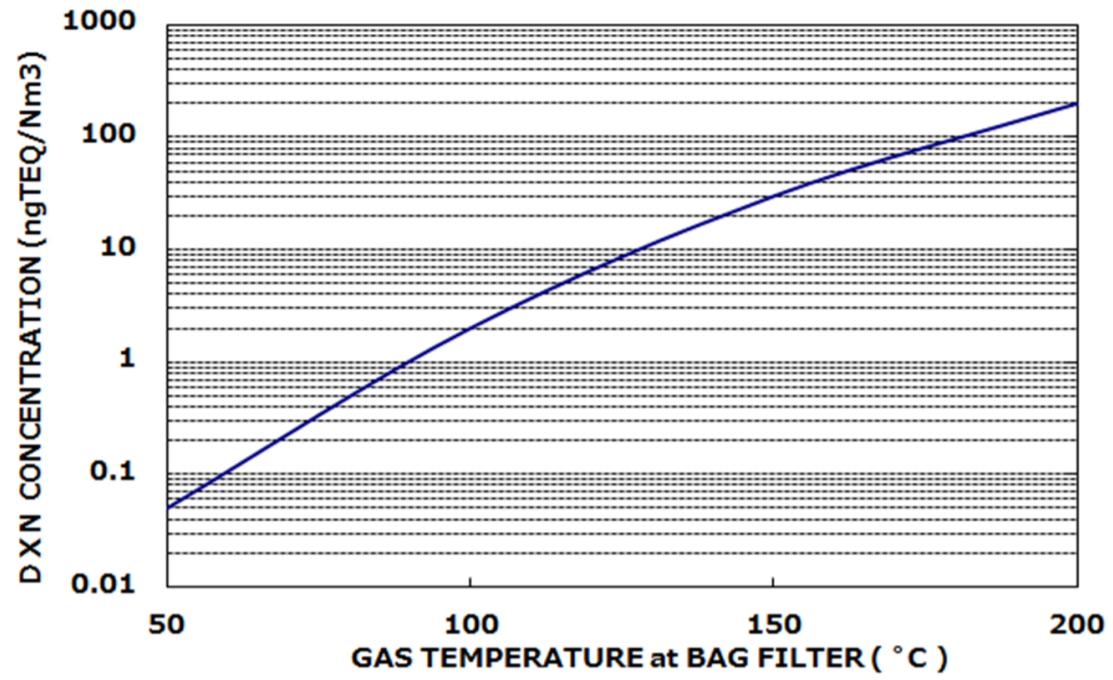
B. Environmental Protection for Electric Arc Furnace

Dioxin adsorption by mixing EAF exhaust gas with building dedusting gas

Item

Content

1. Process Flow or Diagram



2. Technology Definition/Specification

- Dioxin concentration in the EAF exhaust gas at the exit of bag filter is strongly susceptible to the gas temperature.
- In order to comply with the regulated value of 5.0 ngTEQ/m3N (applied to the existing EAF in JAPN), common technology is to mix the hot process gas with the in-house dedusting gas to cool down the gas through the bag filter.
- Dioxin seems to be captured by the oily dust which is accumulated on the surface of filter.
- When gas temperature at the inlet of bag filter ascends up to about 110 degC, where oil is vaporised, dioxin concentration rapidly increases after bag filter even in a short time.
- Collected duct at bag filter should be carefully treated, as it contains much dioxin.
- This phenomenon is different from the case of incinerators, where the dust does not contain oily substances.

3. Expected Effect of Technology Introduction	•Electricity Saving	-
	•Thermal Energy Savings	-
	•Environmental benefits	Dioxin will be lower than 5.0 ng TEQ/m3N
	•Co-benefits	-

4. Japanese Main Supplier: JP Steel Plantech, Daido Steel, Nikko

5. Technologies Reference

6. Comments

B-5

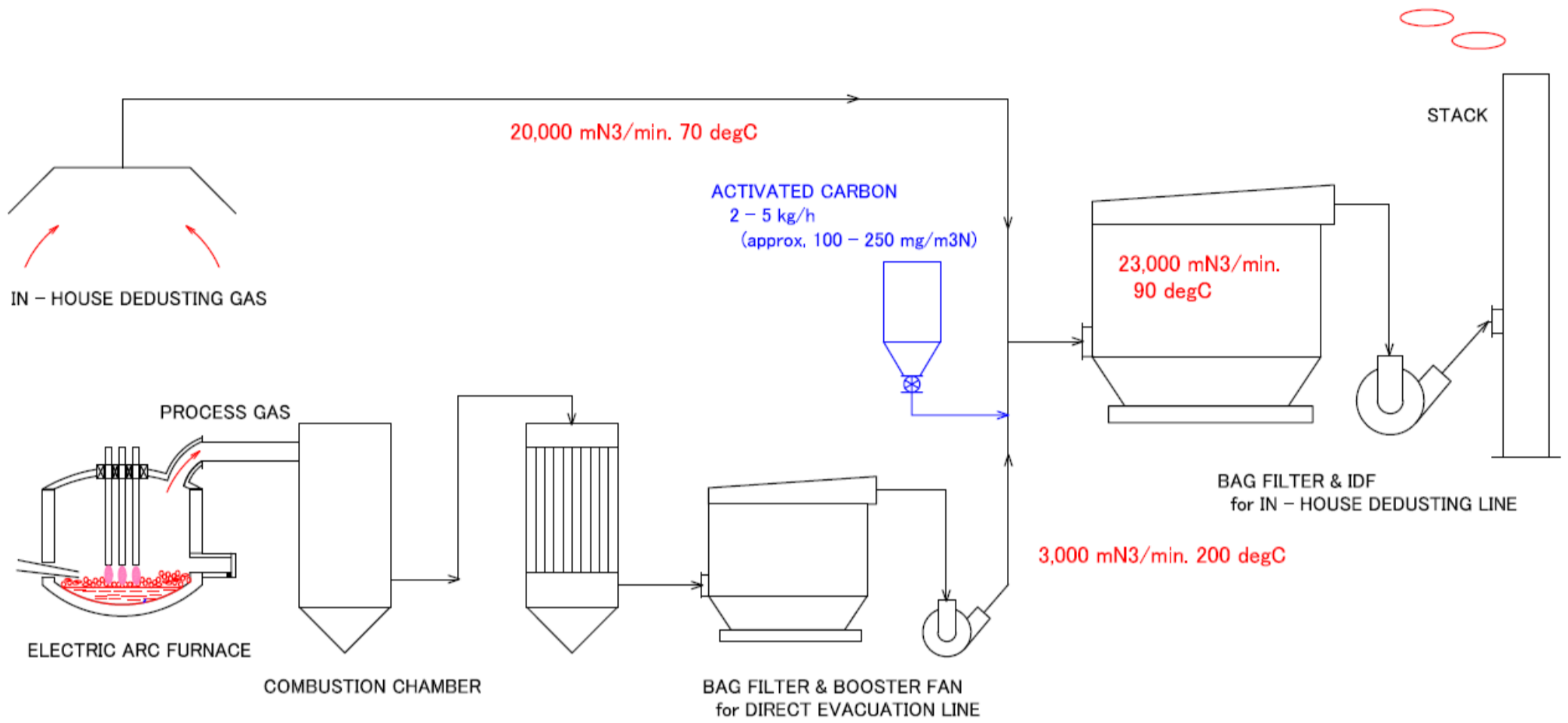
B. Environmental Protection for Electric Arc Furnace

Dioxin adsorption by 2 step bagfilter technology for EAF exhaust gas

Item

Content

1. Process Flow or Diagram



2. Technology Definition/Specification

- In order to comply with the more stringent regulation of 0.5 ngTEQ/m3N (applied to the new EAF in JAPN), two-step bag filter system is applied with the careful temperature control.
- When 0.1 ngTEQ/m3N is requested from the authorities, for the cases of installation at dense-population area or industrial wastes treatment, activated carbon injection into the exhaust gas line is effective.
- Dust loading in the process gas is much higher than that of in-house dedusting gas, therefore, activated carbon is injected into the gas which is dedusted with the primary bag filter. This activated carbon powder is accumulated on the filters of secondary bag filter and adsorbs dioxin.

3. Expected Effect of Technology Introduction

- Electricity Saving -
- Thermal Energy Savings -
- Environmental benefits Dioxin will be lower than 0.5 ng TEQ/m3N
- Co-benefits -

4. Japanese Main Supplier

JP Steel Plantech, Daido Steel, Nikko

5. Technologies Reference

Diagram from JP Steel Plantech

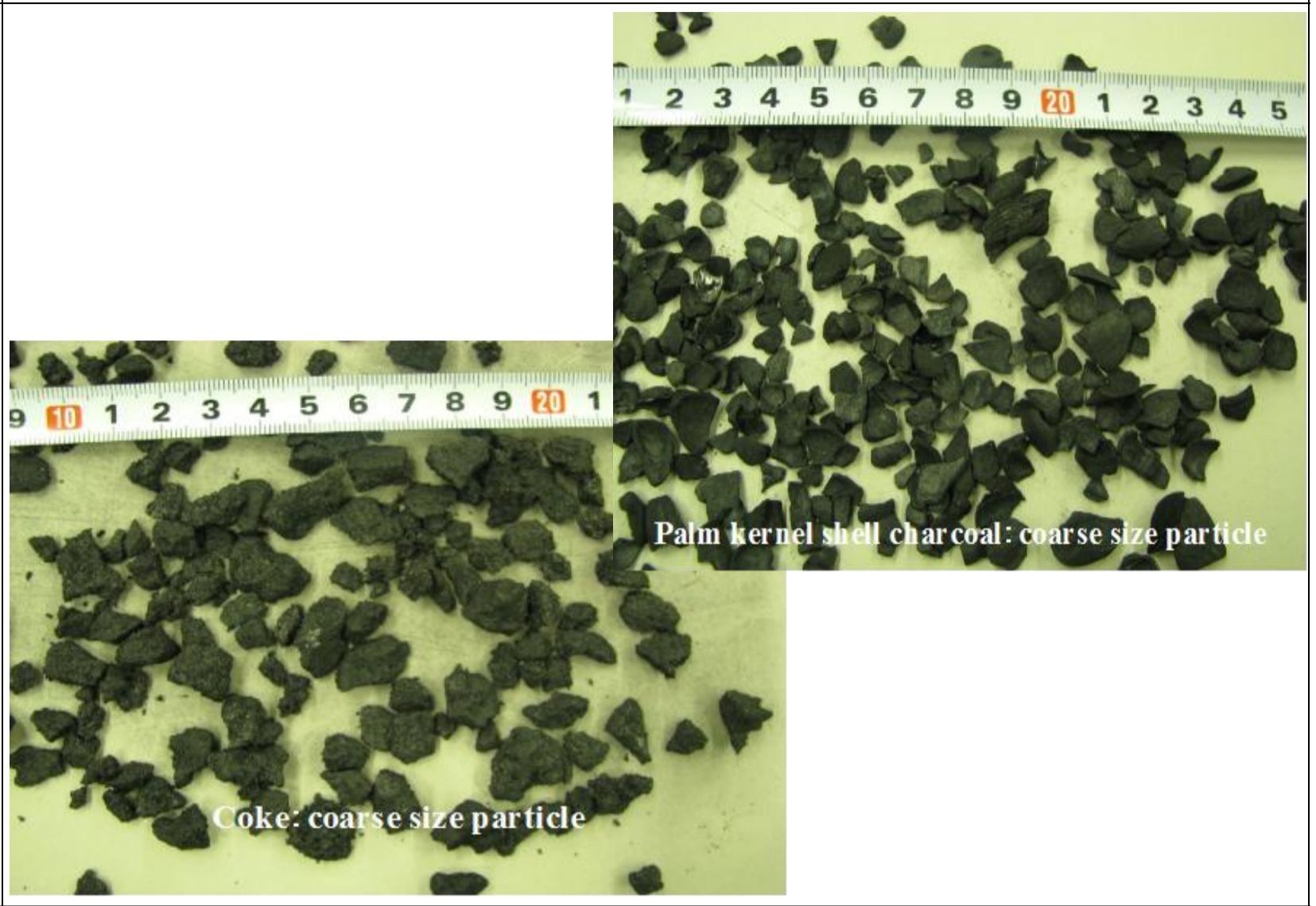
6. Comments

-

B-6

B. Environmental Protection for Electric Arc Furnace

PKS charcoal use for EAF

Item	Content								
1. Process Flow or Diagram									
2. Technology Definition/Specification	<ul style="list-style-type: none"> - Charcoal made from PKS (Palm Kernel Shell) has similar quality with coke commonly used for carbon injection into EAF - Higher heating value, lower sulfur content than fossil fuel coke - CO₂ generated from charcoal is not counted as GHG (Green House Gas) - PKS charcoal is produced for the production of activated carbon in a small scale - Equipmet is very simple and can be constructed by local technology - Japanese supplier will provide with know-how 								
3. Expected Effect of Technology Introduction	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 15%;">•Electricity Saving</td> <td style="width: 10%;">-</td> </tr> <tr> <td>•Thermal Energy Savings</td> <td>-</td> </tr> <tr> <td>•Environmental benefits</td> <td>39,000 ton-CO₂/y GHG reduction from 500,000 ton/y EAF plant</td> </tr> <tr> <td>•Co-benefits</td> <td>-</td> </tr> </table>	•Electricity Saving	-	•Thermal Energy Savings	-	•Environmental benefits	39,000 ton-CO ₂ /y GHG reduction from 500,000 ton/y EAF plant	•Co-benefits	-
•Electricity Saving	-								
•Thermal Energy Savings	-								
•Environmental benefits	39,000 ton-CO ₂ /y GHG reduction from 500,000 ton/y EAF plant								
•Co-benefits	-								
4. Japanese Main Supplier	JP Steel Plantech								
5. Technologies Reference									
6. Comments	<p><Preconditions on calculating effects> Replaced coke at EAF : 25 kg/ton-steel C content in coke : 85 % CO₂ generation from coke = 0.85 x 44 / 12 = 3.12 ton-CO₂/ton-coke GHG reduction = 500,000 ton-steel/y x 0.025 x 3.12 = 39,000 ton-CO₂/y</p>								

C-1

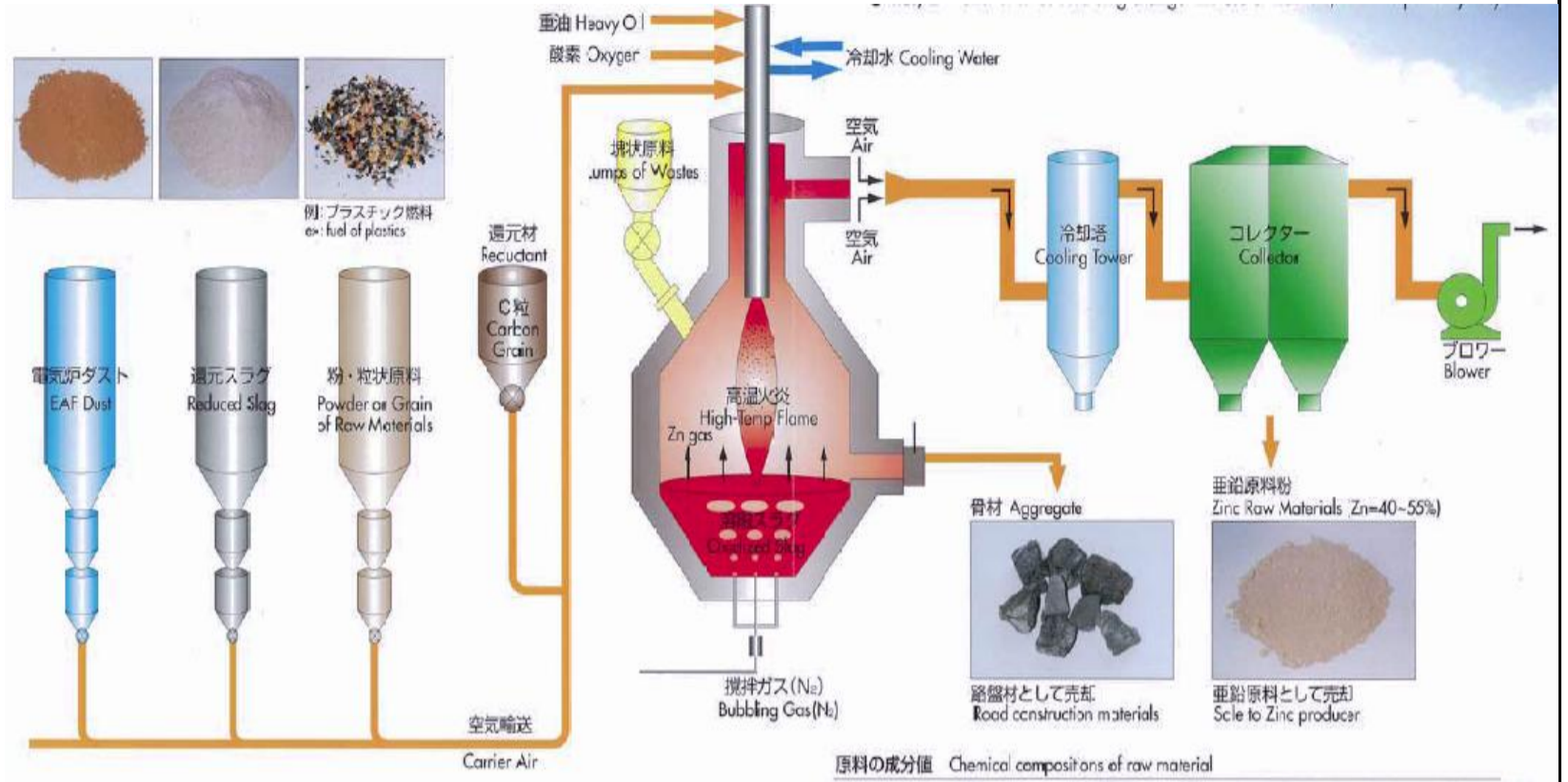
C. Material Recycle for Electric Arc Furnace

EAF dust and slag recycling system by oxygen-fuel burner

Item

Content

1. Process Flow or Diagram



2. Technology Definition/Specification

As dust and slag are melted down completely at high temperature, it is very effective against dioxin. Produced valuable substances are completely harmless and can meet all environmental standards. More than 99% of dioxin can be removed by high temperature treatment in the furnace and strong rapid cooling mechanism. Besides electrical furnace dust and reduced slag, it is expected that this system will be applied to other waste treatments. The equipment is simple and compact because of unnecessary pretreatment such as dust granulation and so forth. Through simple design, excels in operability and suitable for on-site processing. Also this system can recover expected 95% Zn from EAF dust as Zn raw material.

3. Expected Effect of Technology Introduction

- Electricity Saving
- Thermal Energy Savings
- Environmental benefits
- Co-benefits

Example of the Leaching test result of Aggregate (Notice 46 by ME, Japan)							
mg/l	Pb	Cd	Cr ⁺⁶	As	Hg	Se	
Aggregate	<0.006	<0.001	<0.005	<0.005	<0.0005	<0.004	
Regulation	0.01	0.01	0.05	0.01	0.0005	0.01	

Zn material can be gained from EAF dust
Heavy aggregate can be gained from EAF dust

4. Japanese Main Supplier

Daido Steel

5. Technologies Reference

Diagram from Daido Steel, May contact to Daido Steel

6. Comments

Example of the chemical composition of raw material							
(wt%)	T-Fe	CaO	SiO ₂	Zn	Pb	Cl	F
Zn raw material	6.5	2.5	0.9	52.3	8.5	7.7	1.4
Aggregate	40.1	17.8	10.2	2.1	<0.01	0.4	0.3

Expected consumption per EAF dust	
Heavy Oil	160.0 L/t-EAF Dust
Oxygen	390.0 m ³ N/t-EAF Dust
Waste Plastic	96.0 kg/t-EAF Dust

D-1

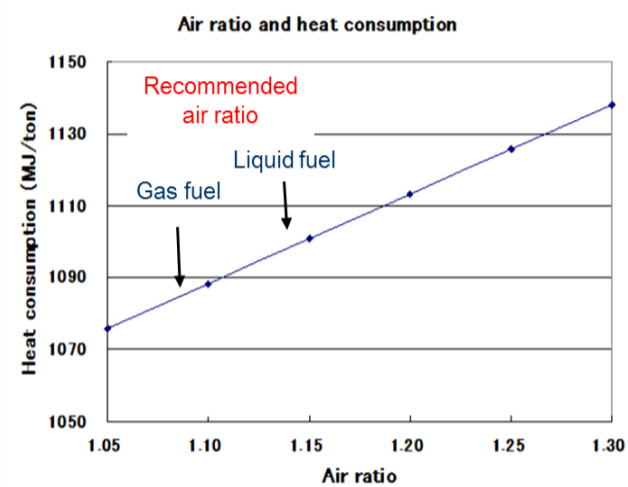
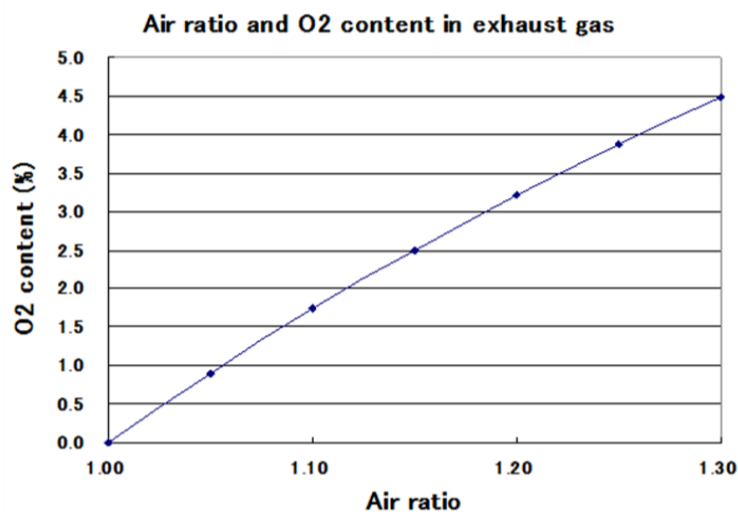
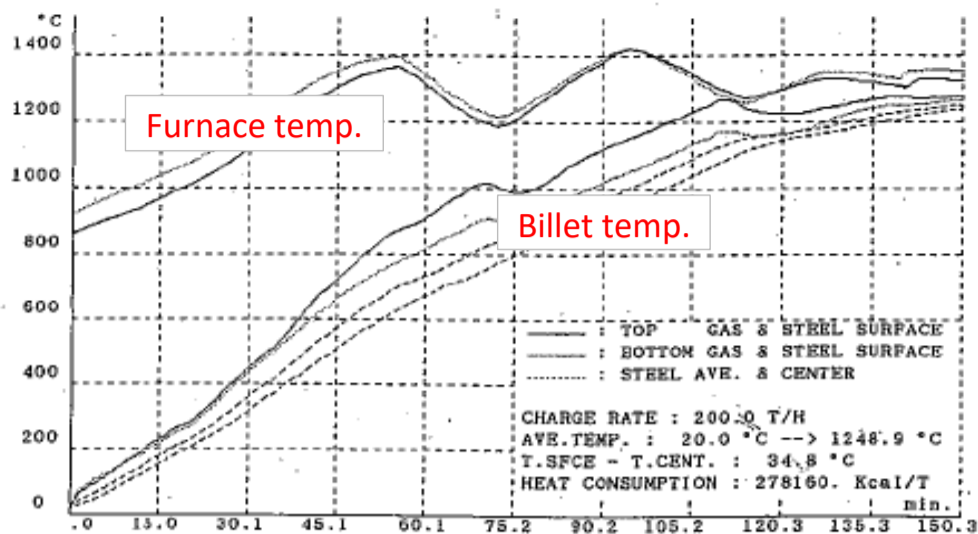
D. Energy Saving for Reheating Furnace

Process control for reheating furnace

Item

Content

1. Process Flow or Diagram



2. Technology Definition/Specification

- Setting furnace temperature by targeted billet temperature curve
- Precise air ratio control and O2 analysis in exhaust gas

3. Expected Effect of Technology Introduction

- Electricity Saving
- Thermal Energy Savings
- Environmental benefits
- Co-benefits

0.05 GJ/ton-product (3.5 % fuel saving from the base line of 1,450 MJ/ton)

4. Japanese Main Supplier

Chugai-Ro, Rozai Kogyo

5. Technologies Reference

May contact to Chugai-Ro

6. Comments

-

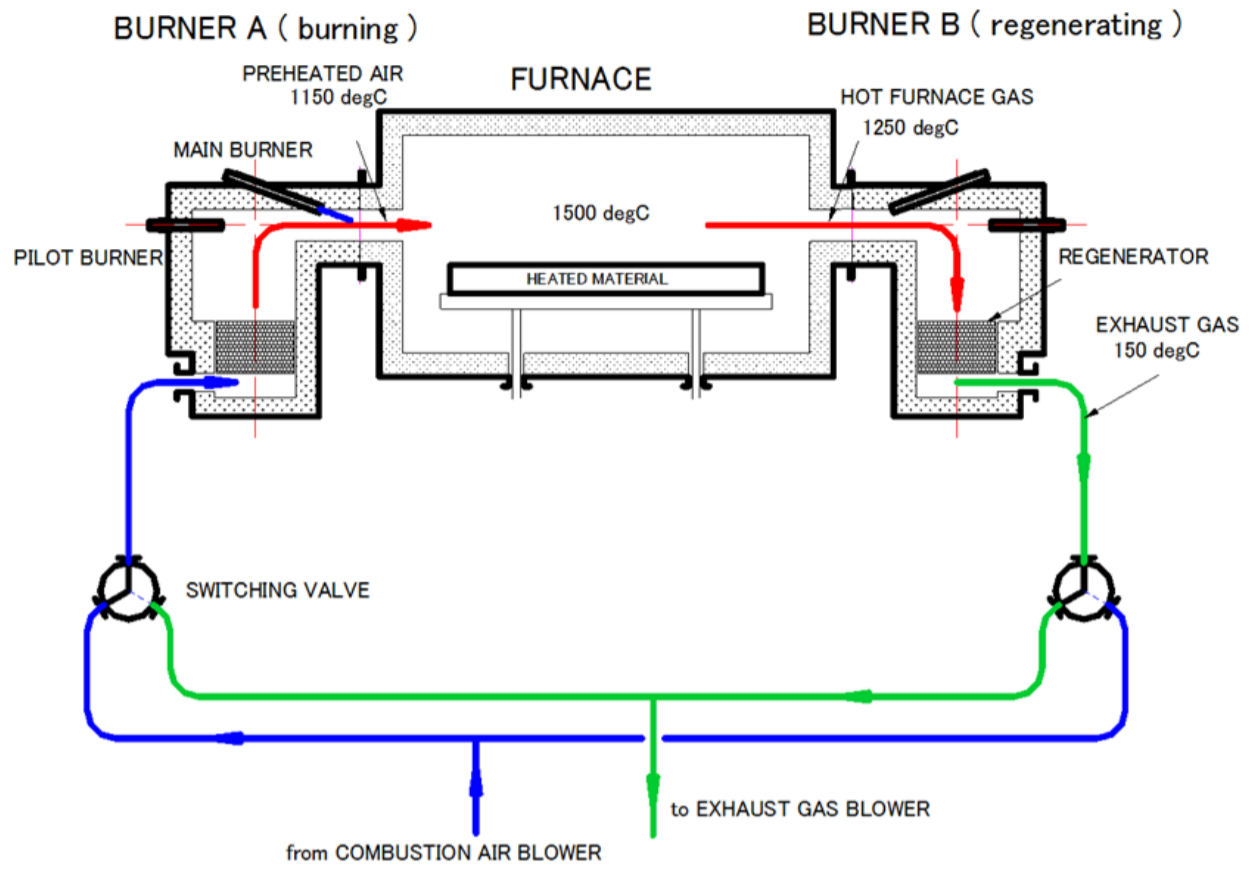
D-2

D. Energy Saving for Reheating Furnace

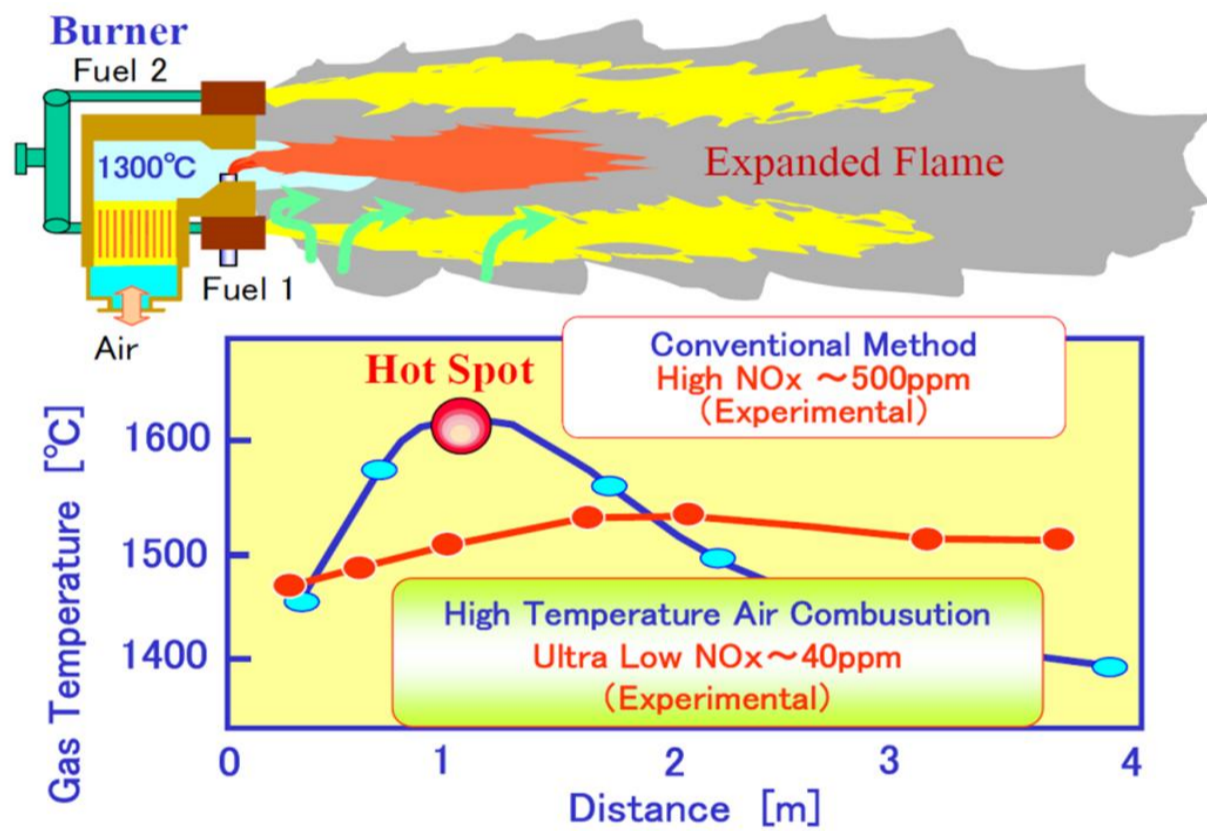
Low NOx regenerative burner total system for reheating furnace

Item

Content



1. Process Flow or Diagram



2. Technology Definition/Specification

While one of the burners is burning, the other burner will work as an exhaust outlet. The exhaust gas is discharged from the system after the waste heat of the gas is recovered so that the temperature of the gas will be lowered to the extent that there will be no condensation in the regenerator. The combustion air receives heat from the regenerator. Therefore, the combustion air will be preheated to a superhigh temperature (i.e., 90% of the temperature of the exhaust gas or over) before the combustion air is supplied the burner. When the preset cycle time elapses, the burners exchange their roles of combustion and exhaustion.

3. Expected Effect of Technology Introduction

- Electricity Saving
- Thermal Energy Savings
- Environmental benefits
- Co-benefits

-
0.189 GJ/t (about -13%)
CO₂ & NO_x Reduction
-

4. Japanese Main Supplier

Chugai-Ro, Nippon Furnace, Rozai Kogyo

5. Technologies Reference

Diagram from Chugai Ro, May contact to suppliers

6. Comments

-

D-3

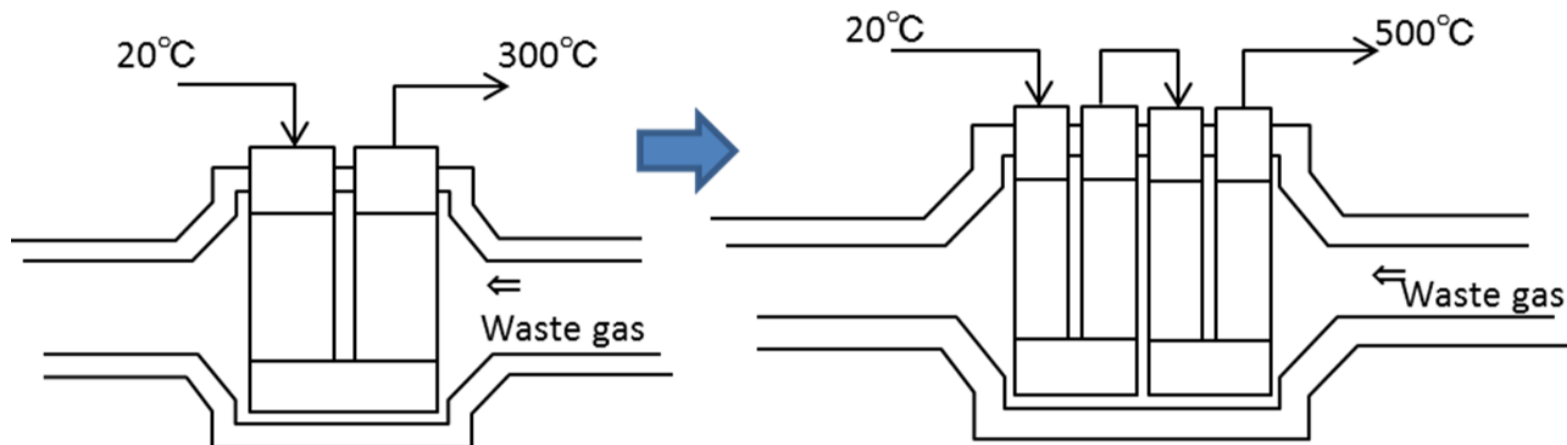
D. Energy Saving for Reheating Furnace

High temperature recuperator for reheating furnace

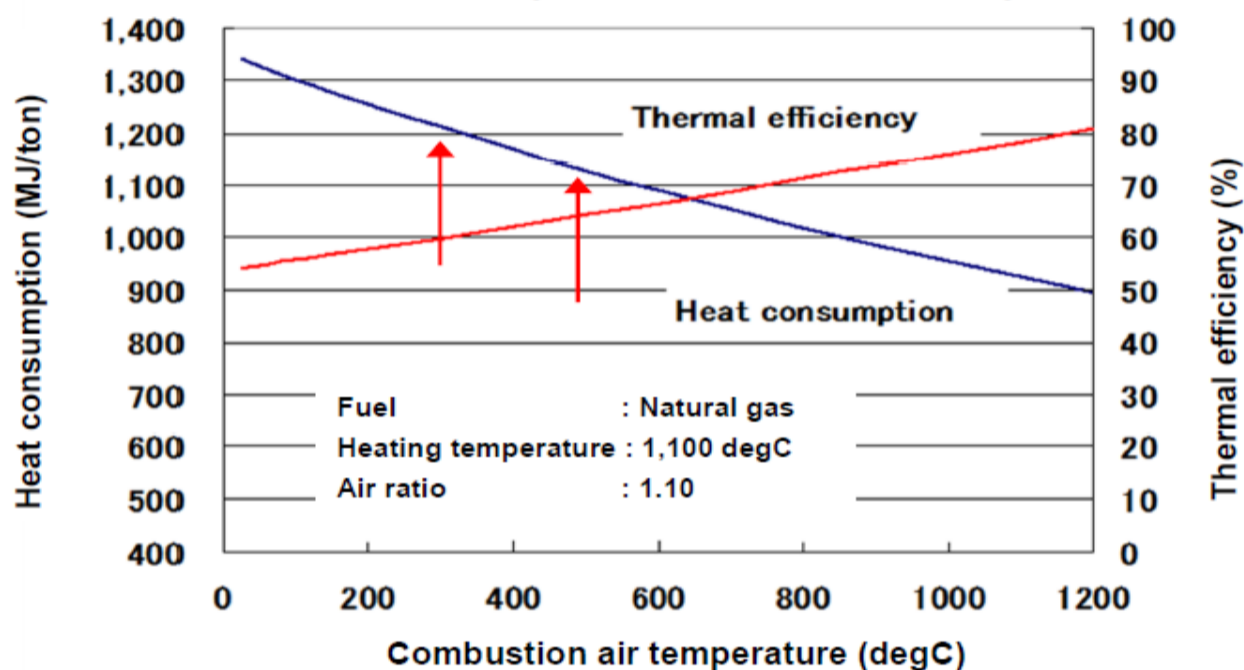
Item

Content

1. Process Flow or Diagram



Preheated air temperature and heat consumption



2. Technology Definition/Specification

Heat transfer area of the existing recuperator shall be increased (for example, by changing two-pass to four-pass) in order to raise the preheated combustion air temperature.

For this purpose, the followings may or may not be needed.

- Modification of Recuperator room
- Change of air duct
- Increase in discharge pressure of blower
- High grade recuperator material

3. Expected Effect of Technology Introduction

• Electricity Saving

-

• Thermal Energy Savings

0.100 GJ/t (about -7%)

• Environmental benefits

CO2 Reduction

• Co-benefits

-

4. Japanese Main Supplier

Chugai-Ro, Rozai Kogyo

5. Technologies Reference

Diagram from Chugai Ro

6. Comments

<Preconditions on calculating effects>

When 300 degC air temperature is raised to 500 degC, 7 % enrgy saving is expected.

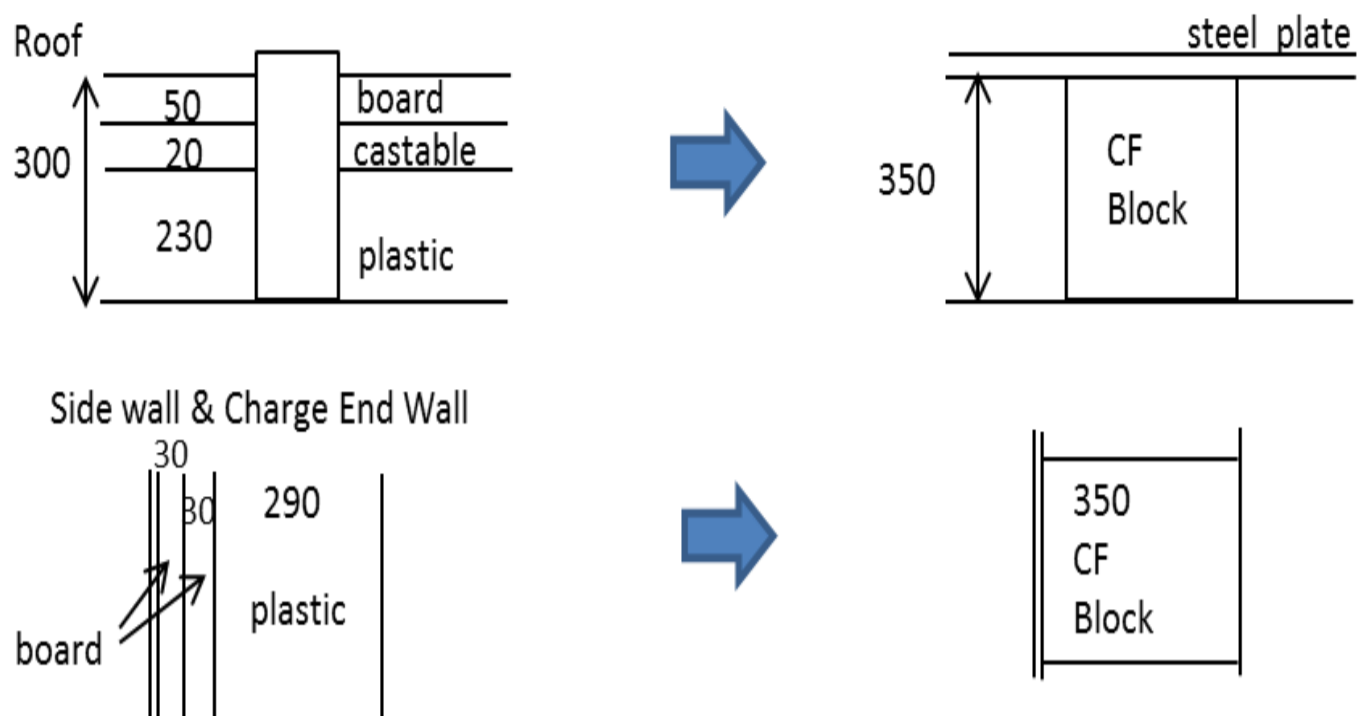
D-4

D. Energy Saving for Reheating Furnace

Fiber block for insulation of reheating furnace

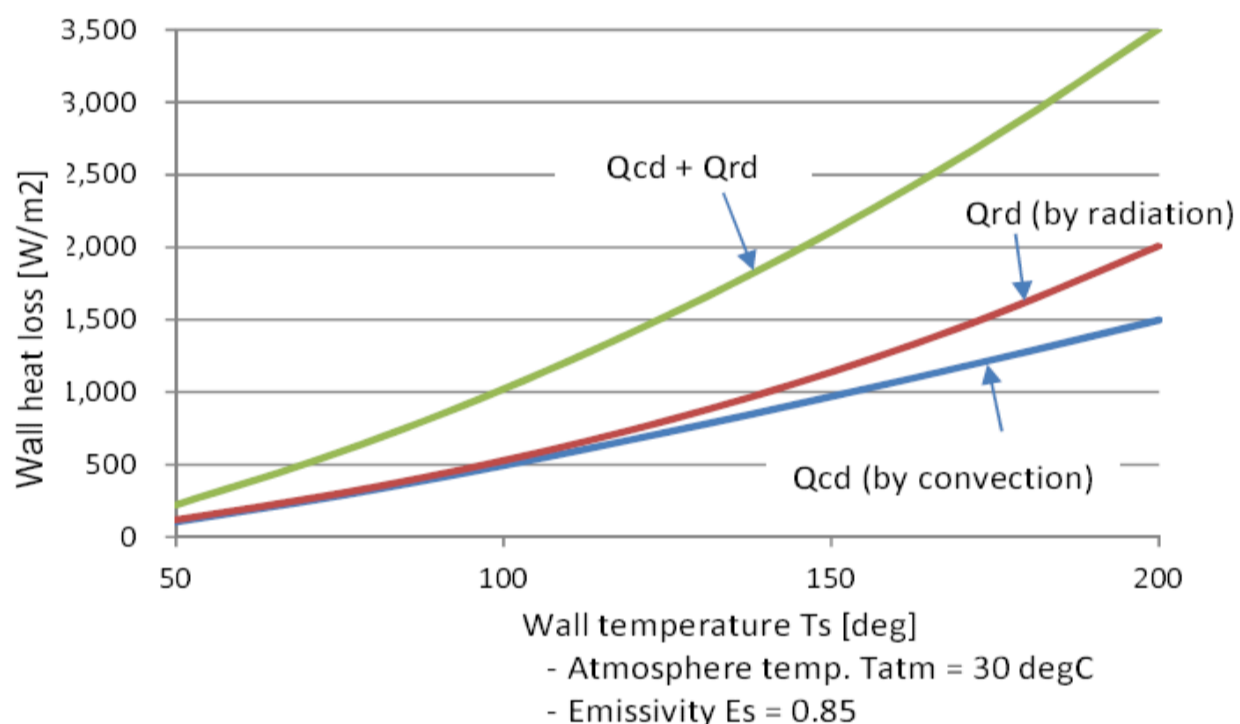
Item

Content



1. Process Flow or Diagram

Heat loss from furnace outer shell



$$Q_s = 2.44 \times (T_s - T_{atm})^{1.25} + 5.674 / 10^8 \times \epsilon_s \times ((T_s + 273.15)^4 - (T_{atm} + 273.15)^4) \quad [\text{W/m}^2]$$

(1 [kcal/h·m²] = 0.86 x 1 [W/m²])

2. Technology Definition/Specification

Ceramic fiber is lighter in weight and has the lower thermal conductivity than conventional brick or castable. Ceramic fiber can be used for the insulation of furnace roof and side wall.

3. Expected Effect of Technology Introduction

- Electricity Saving
- Thermal Energy Savings
- Environmental benefits
- Co-benefits

-

0.039 GJ/t (about 2.7 %)

Reduction of Heat accumulation

Quick heat-up and cool-down of the furnace temperature for smooth and energy-saving operation.

4. Japanese Main Supplier

Chugai-Ro, Rozai Kogyo

5. Technologies Reference

Diagram from Chugai Ro and JP Steel Plantech

6. Comments

<Preconditions on calculating effects>
 assumed surface area of 100 ton/h furnace : 1350 m²
 atmosphere temperature : 30 degC
 surface temp. and heat loss of brick lining case : 130 degC, 7.96 GJ/h
 surface temp. and heat loss of brick lining case : 90 degC, 4.08 GJ/h
 (7.96 - 4.08) / 100 (ton/h) = 0.0388 GJ/ton ---> 0.039 GJ/ton saving
 <Notice>
 High-sulphur fuel may cause problem due to the corrosion of fixing pins.

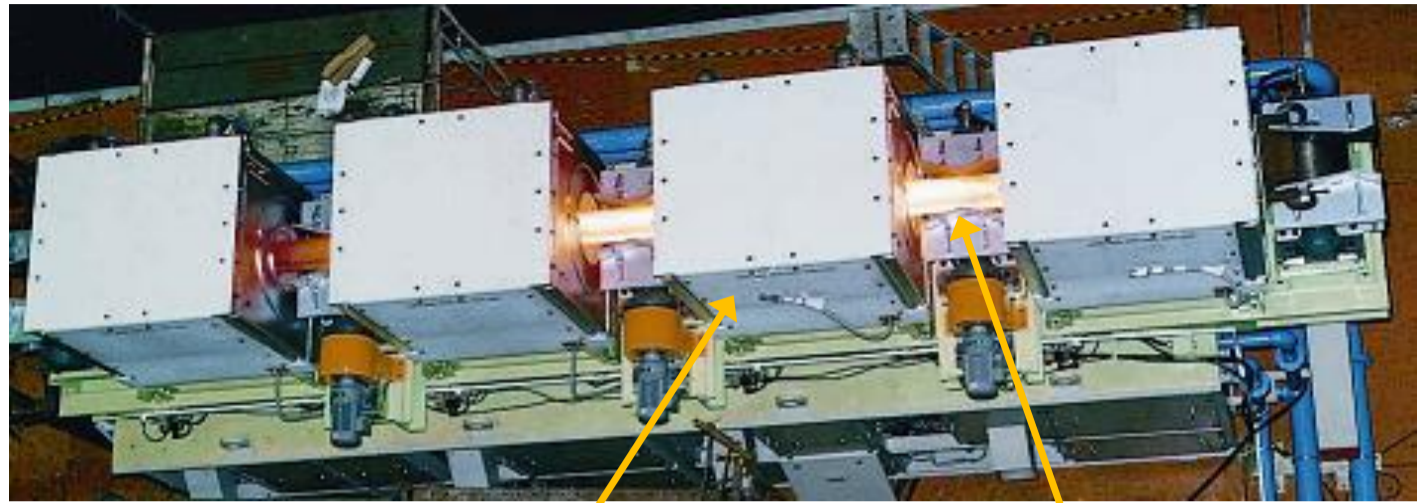
D-6

D. Energy Saving for Reheating Furnace

Induction type billet heater for direct rolling

Item

Content

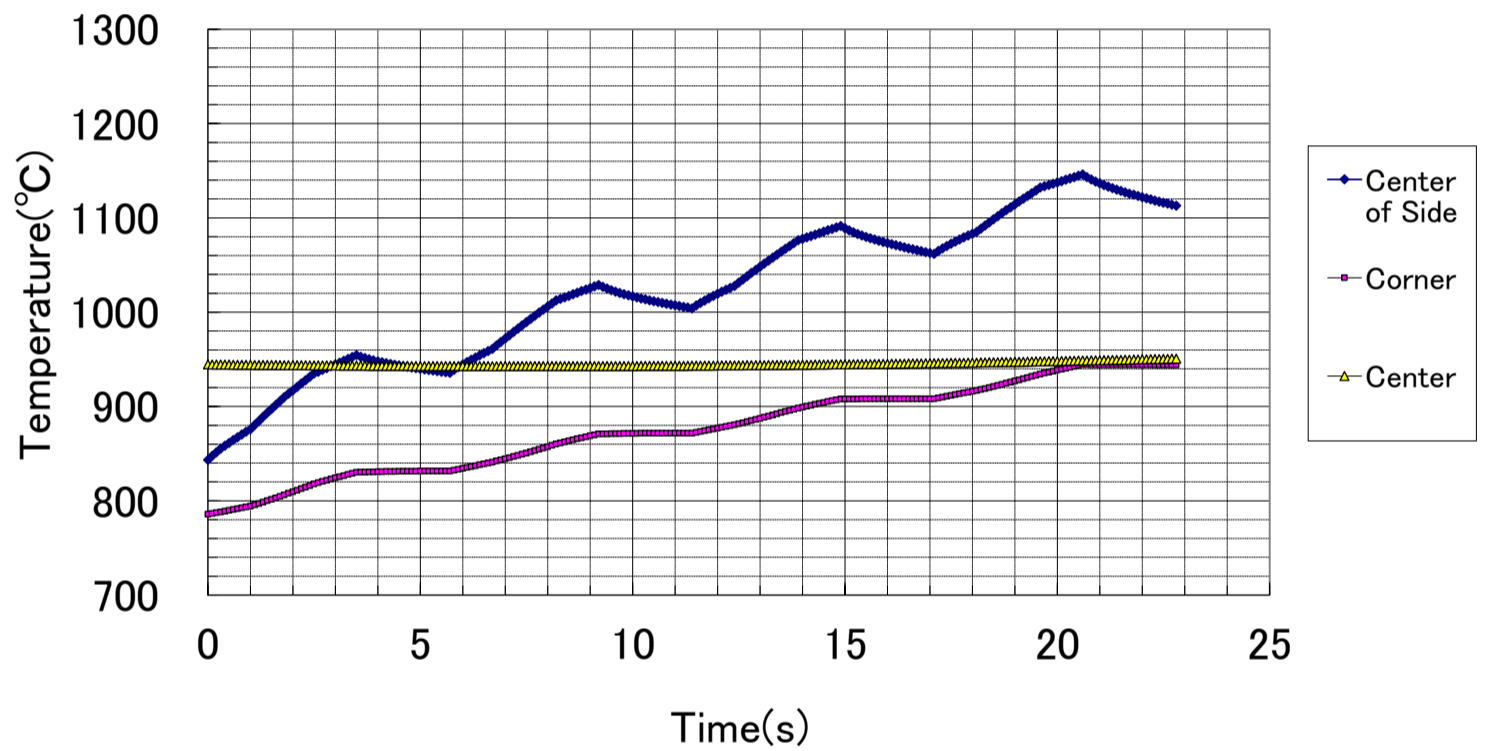


Induction coil

Hot billet

Heating Curve

1. Process Flow or Diagram



2. Technology Definition/Specification

Compensate temperature drop of billets transferred from CC to rolling mill (from 950 degC to 1050 degC).
 Advantages :
 - Automatic control
 - Less exhaust gas (without reheating furnace)

3. Expected Effect of Technology Introduction

- Electricity Saving: 40 kWh/ton-product increase (electrical energy for billet heating)
- Thermal Energy Savings: 1.45 GJ/ton-product (Cold charge to reheating furnace is replaced.)
- Environmental benefits: Better working floor and atmosphere
- Co-benefits: -

4. Japanese Main Supplier

Mitsui E&S Power Systems Inc.

5. Technologies Reference

-

6. Comments

D-7

D. Energy Saving for Reheating Furnace

Oxygen enrichment for combustion air

Item

Content

1. Process Flow or Diagram

When oxygen is mixed into combustion air to increase the O₂ percentage, thermal energy will be reduced with the decrease in the volume of exhaust gas. In many EAF plants, oxygen is generated by PSA or VPSA process, therefore, new equipment for oxygen generation is not considered in this sheet. Only the electric power to generate oxygen is studied to estimate its economical effect.

2. Technology Definition/Specification

Effects of oxygen enrichment are studied for the model RHF of 100 ton/h 1,100 degC billet heating (500,000 ton/y). The upper list shows the required fuel (thermal energy) and volume of oxygen. When oxygen percentage is raised to 42 %, exhaust gas volume from the furnace reduces to 45 % with 19.5 % fuel saving. The list also shows the required oxygen volume. The oxygen is assumed to be generated by VPSA process, with the purity of 93 %. The bottom list shows the economical effect of oxygen enrichment. Required electric power is assumed as 0.5 kWh/m³N-O₂ of 0.1 MPa pressure. Energy price is based on the latest Japanese values of 17.11 US\$/GJ and 0.123 US\$/kWh.

O ₂ in com. air	Unit heat cons.	Rate	Fuel gas flow rate	Oxygen flow rate	Ex. gas flow rate from furnace	Power to produce O ₂
21 %	1,330 MJ/ton	100.0 %	3,930 m ³ N/h	0 m ³ N/h	48,890 m ³ N/h	0 kWh/ton
24 %	1,230 MJ/ton	92.5 %	3,638 m ³ N/h	1,613 m ³ N/h	39,720 m ³ N/h	8.1 kWh/ton
27 %	1,182 MJ/ton	88.9 %	3,483 m ³ N/h	2,585 m ³ N/h	34,440 m ³ N/h	12.9 kWh/ton
30 %	1,140 MJ/ton	85.7 %	3,363 m ³ N/h	3,300 m ³ N/h	30,480 m ³ N/h	16.5 kWh/ton
33 %	1,120 MJ/ton	84.2 %	3,298 m ³ N/h	3,883 m ³ N/h	27,660 m ³ N/h	19.4 kWh/ton
36 %	1,100 MJ/ton	82.7 %	3,236 m ³ N/h	4,338 m ³ N/h	25,320 m ³ N/h	21.7 kWh/ton
39 %	1,080 MJ/ton	81.2 %	3,190 m ³ N/h	4,715 m ³ N/h	23,430 m ³ N/h	23.6 kWh/ton
42 %	1,070 MJ/ton	80.5 %	3,150 m ³ N/h	5,029 m ³ N/h	21,850 m ³ N/h	25.1 kWh/ton

O ₂ in com. air	Required thermal energy	Fuel cost	Power to produce O ₂	Electricity cost produce O ₂	Sum of energy cost	Rate of cost
21 %	665,000 GJ/y	11.38 mill. US\$/y	0 MWh/y	0 mill. US\$/y	11.38 mill. US\$/y	100.0 %
24 %	615,000 GJ/y	10.52 mill. US\$/y	4,050 MWh/y	0.50 mill. US\$/y	11.02 mill. US\$/y	96.8 %
27 %	591,000 GJ/y	10.11 mill. US\$/y	6,465 MWh/y	0.79 mill. US\$/y	10.90 mill. US\$/y	95.8 %
30 %	570,000 GJ/y	9.75 mill. US\$/y	8,250 MWh/y	1.01 mill. US\$/y	10.76 mill. US\$/y	94.6 %
33 %	560,000 GJ/y	9.58 mill. US\$/y	9,710 MWh/y	1.19 mill. US\$/y	10.77 mill. US\$/y	94.6 %
36 %	550,000 GJ/y	9.41 mill. US\$/y	10,845 MWh/y	1.33 mill. US\$/y	10.74 mill. US\$/y	94.3 %
39 %	540,000 GJ/y	9.24 mill. US\$/y	11,800 MWh/y	1.45 mill. US\$/y	10.69 mill. US\$/y	93.9 %
42 %	535,000 GJ/y	9.15 mill. US\$/y	12,550 MWh/y	1.54 mill. US\$/y	10.69 mill. US\$/y	93.9 %

3. Expected Effect of Technology Introduction

- Electricity Saving
- Thermal Energy Savings
- Environmental benefits
- Co-benefits

When oxygen percentage is raised to 39 %, 23.6 kWh/ton of electricity is needed.

When oxygen percentage is raised to 39 %, 0.26 GJ/ton of thermal energy is saved.

4. Japanese Main Supplier

Chugai-Ro, Nippon furnace

5. Technologies Reference

6. Comments

Furnace manufactureres can arrange the oxygen control system and piping revamping.

E-1

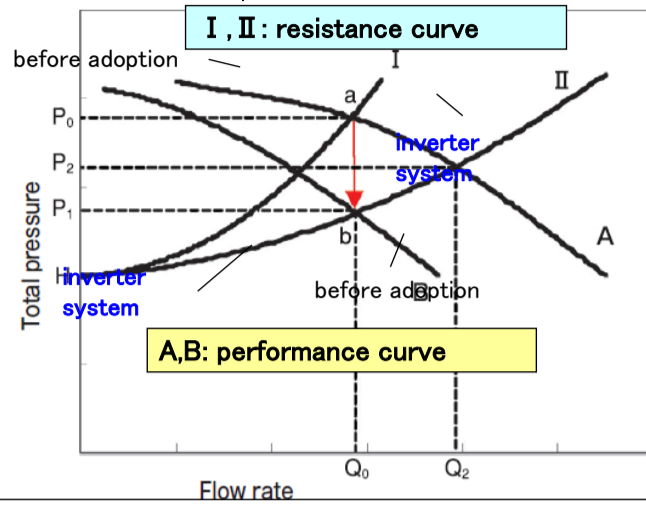
E. Common systems and General Energy Savings

Inverter (VVVF; Variable Voltage Valuable Frequency) Drive for Motors

Item

Content

1. Process Flow or Diagram



- Pumps are running at point “a” in the current situation, and will be running at point “b” after adoption of an inverter system.
- Power for pumps is proportional to “flow rate × total pressure”, and motor input ratio before and after installation is the ratio of $Q_0 \times P_1$ and $Q_0 \times P_0$.

Fig.1 Relationship between flow rate and total pressure before/after adoption of an inverter system. *1

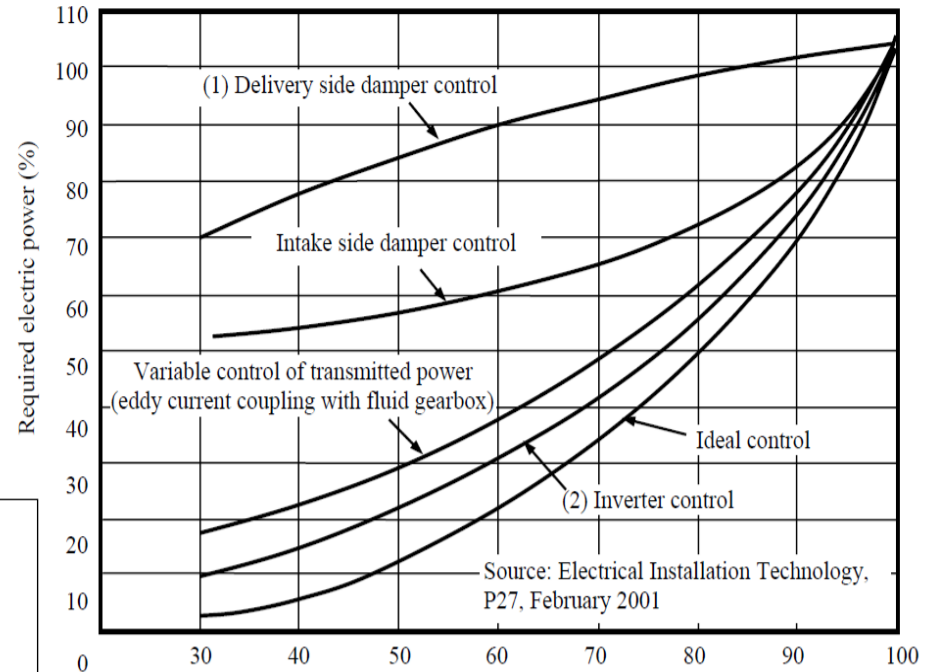


Fig.2 Relationship between airflow and required electric power relating to the type of control *2

2. Technology Definition/Specification

* Problems with the current situation: Generally, flow rate of centrifugal pumps and fans is controlled by valves because of uncontrollable motor rotation speed, resulting in great power loss (see Fig.1 I and A).

* Improvement measures: An inverter system will be adopted in pumps and fans, in order to control the rotation speed according to the load (flow rate) with valves fully open. This results in electricity savings (see Fig.1 I and A). *1

An inverter is a variable speed device controlling frequency and voltage to allow precise control of rotation. Energy saving effect : Conversion of six 55kW electric motors with eddy current coupling, and reduction in power consumption. *2

Calculation conditions/NEDO :

- * Overall efficiency of conventional electric motors with eddy current coupling : 0.65
- * Overall efficiency of electric motors converted to inverter control : 0.80
- * Reduction in power consumption by lowering motor speed : 15% (assumed)

3. Investment Cost & Operating Life

¥2,000,000/unit(assumed) [NEDO]

4. Effect of Technology Introduction

- Reduction of CO2 Emission
- Electricity Savings

Not announced

125,000 kWh/y [=55kW/unit x 0.7(assumed average motor power) x 6units x 3600h/y x 0.15]

5. Direct Effect (Annual Operating Cost)

- Economic Effect (payback time)
- Productivity Improvement
- Maintenance Cost Reduction

1.5 years [NEDO]

Not announced

Not announced

6. Indirect Effect (Co-benefits)

- Product Quality Improvement

Not announced

7. Diffusion Rate of Technology in Japan

No data

8. Japanese Main Supplier

Major electric equipment suppliers

9. Technologies Reference:

- *1 Guidebook on Energy Conservation for Factories (2010/2011), ed. by The Energy Conservation Center, Japan
- *2 Energy savings Diagnosis Examples-Common Equipment Volume', Energy conservation Center, Japan

10. Preconditions

- * Payback time is defined as (Investment cost / Economical merit) in this project.
- * annual operation : 3,600 h/y,
- * unit cost of power : ¥15/kWh

E-2

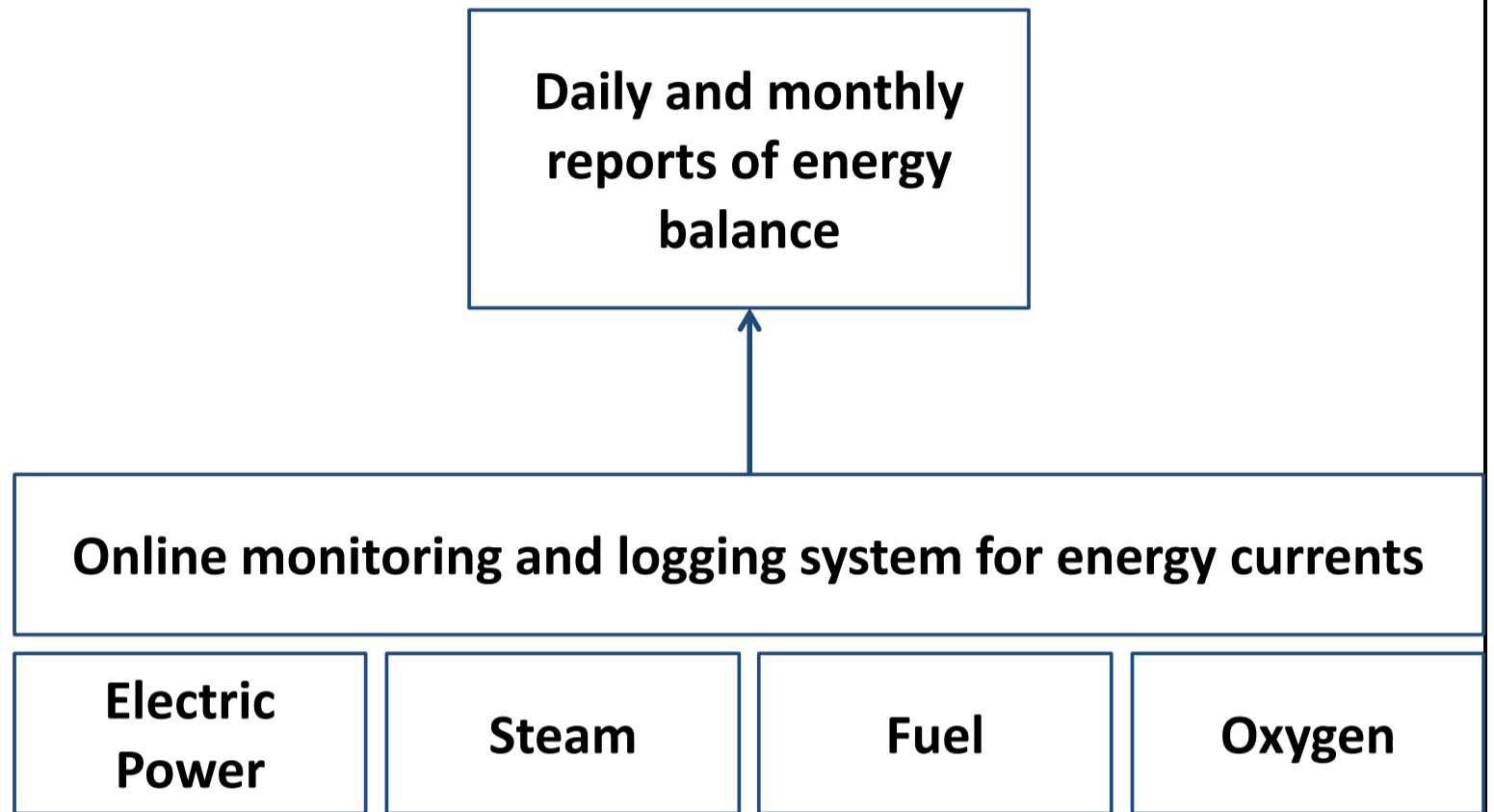
E. Common systems and General Energy Savings

Energy monitoring and management systems

Item

Content

1. Process Flow or Diagram



2. Technology Definition/Specification

This measure includes site energy management systems for optimal energy consumption in the plant.

- Online monitoring: This is often used for the most important energy flows at the site. The data are stored for a long time so that typical situations may be analyzed. It is very important to monitor for all energy sources on online. It is the main technique used to avoid energy losses.
- Continuous monitoring systems: Since all energy-related process parameters are used to optimize process control and to enable instant maintenance, uninterrupted production process could be achieved.
- Reporting and analyzing tools: Reporting tools are often used to check the average energy consumption of each process. In connection with cost controlling, controlling energy is the basis for optimizing energy consumption and cost savings. An energy controlling system enables to compare actual data with historical data (e.g. charts)

3. Expected Effect of Technology Introduction

- Electricity Saving
- Thermal Energy Savings
- Environmental Benefits
- Co-benefits

-

Energy saving effect depends on the local conditions, therefore, quantitative estimation is difficult.

-

-

4. Japanese Main Supplier

Fuji Electric Co., Ltd.

5. Technologies Reference

6. Comments

E-3

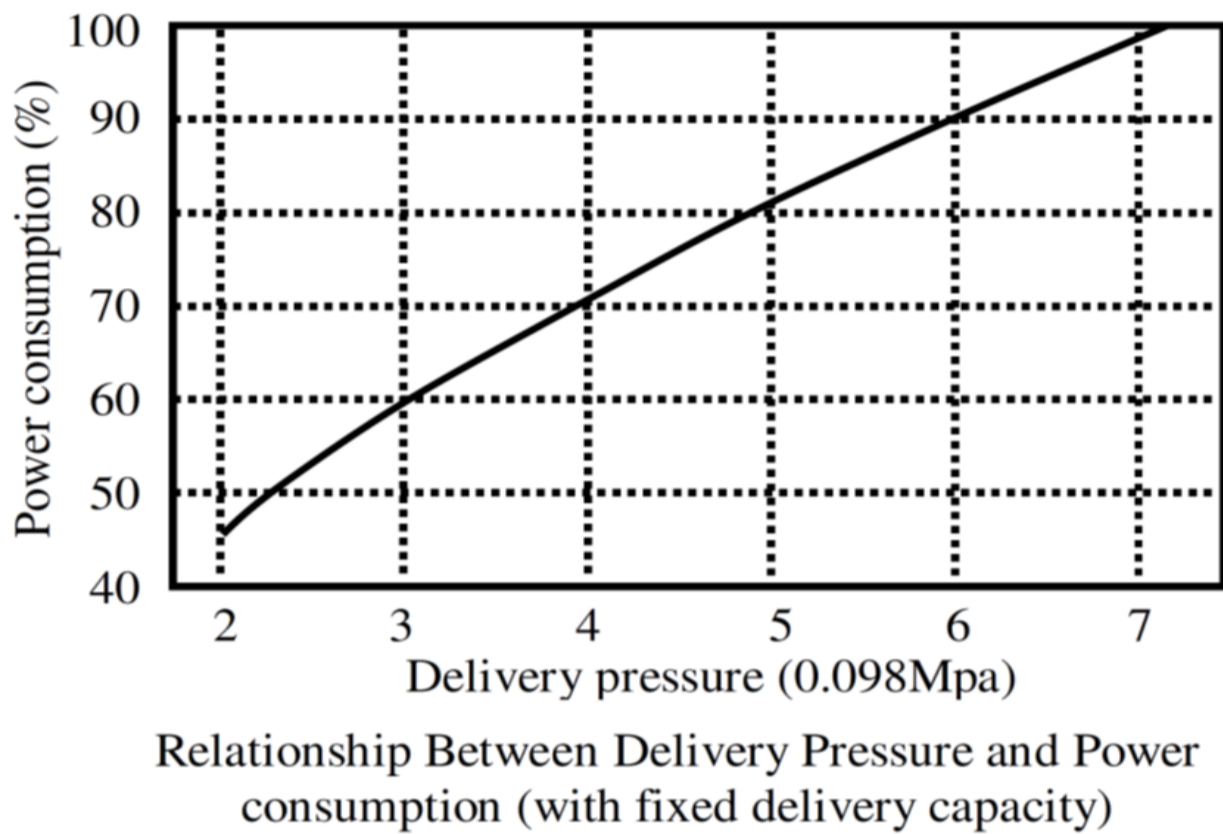
E. Common systems and General Energy Savings

Management of compressed air delivery pressure optimization

Item

Content

1. Process Flow or Diagram



2. Technology Definition/Specification

Energy saving in compressors requires consideration of the following points.

- * Selection of the appropriate capacity
- * Reduction in delivery pressure by keeping the required working power

Since the required motive power increases with increased delivery pressure, appropriate delivery pressure should be selected in consideration of the items below.

- * Prevention of leakage
- * Reduction in temperature of the compressed air
- * Reduction in intake air resistance

Intake air resistance increases with intake filters, silencers, and valves in piping etc, and will increase the required motive power if excessive. Care is required to reduce pressure losses in the intake air system through periodic cleaning of filters to eliminate clogging.

- * Reduction in piping resistance

From the figure above, when delivery pressure is reduced to 0.098MPa, load on the electric motor can be reduced by approximately 10%. When low pressure air is sufficient, low pressure unit should be additionally adopted instead of pressure reducing valves.

3. Expected Effect of Technology Introduction	•Electricity Saving	285 MWh/y (=823 kW x 60 % x 10 % x 24 h/d x 241 days/y)
	•Thermal Energy Savings	-
	•Environmental benefits	-
	•Co-benefits	-

4. Japanese Main Supplier Major electric equipment suppliers

5. Technologies Reference Japanese Technologies for Energy Savings/GHG Emissions Reduction 《2008 Revised Edition》, edited by NEDO

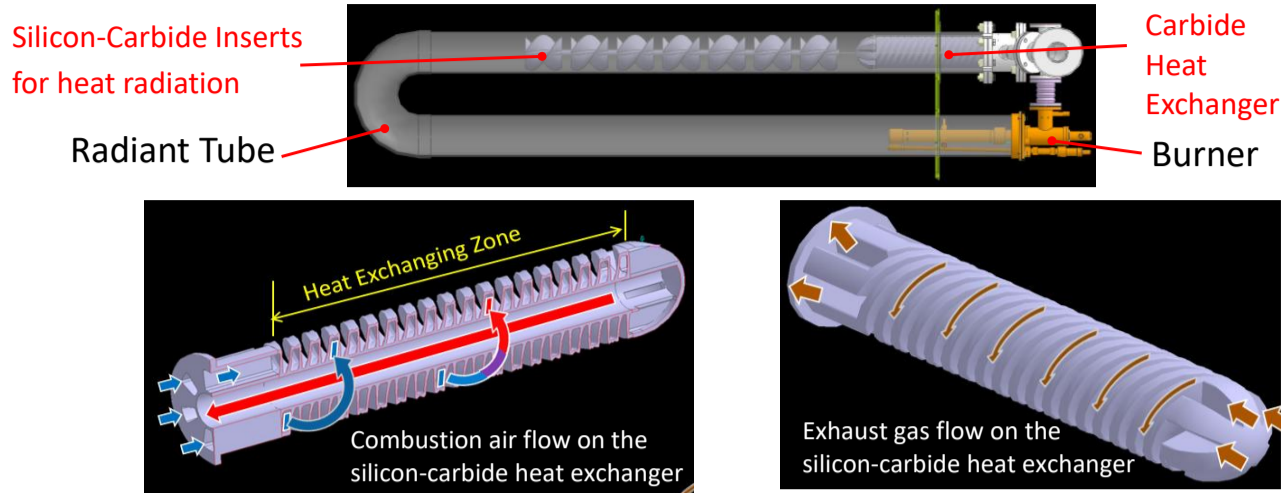
6. Comments Preconditions for trail calculating above>

- Number of compressors; Total of 17, *Delivery pressure; 0.8 MPa,
- Equipment capacity; 823 kW, *On-load operation load; 60 %,
- Daily operation; 24 h/d, *Annual operation; 241 days'

E-4

E. Common systems and General Energy Savings

Highly efficient combustion system for radiant tube burner

Item	Content
1. Process Flow	
2. Technology Definition/Specification	<p>Radiant tube burner which consists of 1) Radiant tube (U shape or W shape), 2) Gas Burner, 3) 3-D formed silicon-carbide Inserts for heat radiation, and 4) Heat exchanger made of 3-D formed silicon carbide.</p> <p>These 3-D formed silicon carbide elements have high thermal conductivity and wide surface area, which allow approx. 10% improvement in heat recovery compared to conventional radiant tube burners with heat exchanger made of steel.</p> <p>Any industrial furnace with radiant tube burner will potentially be applicable and typical applicable furnace will be CGL, Continuous Galvalizing Line or CAL, Continuous Annealing Line, with approx. 100-200 radiant tube burners of 210-420MJ/hour of rated combustion volume.</p> <p>*Radiant tube burner is often used for the industrial furnaces such as heat treatment furnace which requires indirect heating.</p>
3. Investment Cost & Operating Life	<p>The cost of adding this system into existing furnace will be approximately 1.6 million JPY for one burner which have 420MJ/hour of combustion rate. This includes the cost for installation work and combustion adjustments.</p> <p>Operating life for silicon carbide elements is considered to be semipermanently.</p>
4. Effect of Technology Introduction	<ul style="list-style-type: none"> • Reduction of CO2 Emission <p>2,654t-CO2/year under assumptions below.</p> <ol style="list-style-type: none"> 1) 10% of Fuel substitution will be achieved by replacing conventional recuperator into DINCS (Daido Innovative Neo Combustion System) to the CGL with 200 radiant tube burners. 2) Each burners have 420MJ/h of rated combustion volume, and combusted at 80% rate on average. 3) Furnace operation is 330days/year, 24 hours/day. Production capacity is assumed as 594,000 ton/y (75 ton/h x 24h x 330 day/y) 4) The effect is calculated as comparison with steel heat exchanger system 5) Natural gas is used as for combustion. $53222(GJ/year) \times 0.0136(tC/GJ) \times \frac{44}{12} = 2,654(tCO2/year)$ • Fuel Savings <p>53,222GJ/year under assumptions same as above 0.0896 GJ/ton saving (= 53,222 GJ/y / 594,000 ton-product/y)</p> • Electricity Savings <p>N/A</p>
5. Direct Effect (Annual Operating Cost)	<ul style="list-style-type: none"> • Economic Effect (payback time) <p>Approx. 4.9 years under assumptions same as above. Cost for installation work and combustion adjustment are included (1,600,000JPY) and the price of thermal energy is assumed to be 19.11 US\$/GJ (2,100 JPY/GJ). Annual profit = 53,222 GJ/y x 19.11 US\$/GJ / 594,000 ton/y = 1.71 US\$/ton-product</p> <p><Calculation> Payback time = (1,600,000 JPY x 200 units) / (53,222 GJ/y x 2,100 JPY/GJ) = 2.86 year</p> • Productivity Improvement <p>Since this system transfers the heat effectively into the furnace or into product, line speed of the furnace can be increased which results in productivity improvement, if there is no restrictions for the equipment other than the combustion system.</p> • Maintenance Cost Reduction <p>Conventional heat exchanger made of steel usually requires replacement every 3-4 years, but silicon carbide elements will not deteriorate over time and last semipermanently.</p>
6. Indirect Effect (Co-benefits)	<ul style="list-style-type: none"> • Product Quality Improvement <p>N/A</p> • SOx, Dust Decrease <p>N/A</p> • Water-saving <p>N/A</p>
7. Proficiency Level of Technology in Japan	<p>Applied to more than 30 heat treatment furnaces.</p>
8. Japanese Main Supplier	<p>Daido Steel Co., Ltd.</p>
9. Technologies Reference:	<p>Japanese patent No.6587411 (Radiant tube type heating device) Japanese patent No.6790554 (Radiant tube type heating device)</p>
10. Preconditions	<p>Investment cost and benefit vary depending on furnace specification, operation condition, fuel cost, etc of each customer.</p>

Contact Points of Suppliers

Company	Contact Points	Technologies
JP Steel Plantech Co.	Kaneko 2nd Building 4-9F 2-6-23 Shin-yokohama, Kohoku-ku, Yokohama 222-0033 JAPAN Phone: +81-45-471-3911 Fax: +81-45-471-4002 https://steelplantech.com/en/	A-1: High temperature continuous scrap preheating EAF A-3: High efficiency oxy-fuel burner/lancing for EAF A-4: Eccentric bottom tapping (EBT) on existing furnace A-5: Ultra high-power transformer for EAF A-6: Optimizing slag foaming in EAF A-7: Optimized power control for EAF A-11: Waste heat recovery from EAF A-12: Energy saving for dedusting system in EAF meltshop B-1: Exhaust gas treatment through gas cooling, carbon injection, and bag filter dedusting for EAF B-2: Floating dust control in EAF meltshop B-4: Dioxin adsorption by mixing EAF exhaust gas with building dedusting gas B-5: Dioxin adsorption by 2 step bagfilter technology for EAF exhaust gas B-6: PKS charcoal use for EAF
Daido Steel Co., Ltd.	1-10, Higashisakura 1-chome, Higashi-ku, Nagoya, Aichi, 461-8581, Japan TEL:+81-52-963-7501 FAX: +81-52-963-4386 https://www.daido.co.jp/	A-2: Medium temperature batch scrap preheating EAF A-3: High efficiency oxy-fuel burner/lancing for EAF A-4: Eccentric bottom tapping (EBT) on existing furnace A-5: Ultra high-power transformer for EAF A-6: Optimizing slag foaming in EAF A-8: Operation support system with EAF meltdown judgment A-12: Energy saving for dedusting system in EAF meltshop A-13: Bottom stirring/stirring gas injection A-16: Arc furnace with shell rotation drive B-1: Exhaust gas treatment through gas cooling, carbon injection, and bag filter dedusting for EAF B-2: Floating dust control in EAF meltshop B-4: Dioxin adsorption by mixing EAF exhaust gas with building dedusting gas B-5: Dioxin adsorption by 2 step bagfilter technology for EAF exhaust gas C-1: EAF dust and slag recycling system by oxygen-fuel burner E-4: Highly efficient combustion system for radiant tube burner
Nikko Industry Co., Ltd.	2-4-10, Nunobiki-cho, Chuo-ku, Kobe-city, Hyogo 651-0097. Japan TEL: +81-78-222-1688 FAX: +81-78-222-2916 https://www.nikko-japan.co.jp/home_en/ E-mail: nikko@nikko-japan.co.jp	A-3: High efficiency oxy-fuel burner/lancing for EAF A-4: Eccentric bottom tapping (EBT) on existing furnace A-5: Ultra high-power transformer for EAF A-6: Optimizing slag foaming in EAF A-13: Bottom stirring/stirring gas injection B-1: Exhaust gas treatment through gas cooling, carbon injection, and bag filter dedusting for EAF B-4: Dioxin adsorption by mixing EAF exhaust gas with building dedusting gas B-5: Dioxin adsorption by 2 step bagfilter technology for EAF exhaust gas
Chugai Ro Co., Ltd.	2-4 Chikko-shinmachi, Nishi-ku, Sakai 592-8331, Japan TEL:+81-72-247-2108 FAX:+81-72-247-2174 https://chugai.co.jp/en/	A-9: Low NOx regenerative burner system for ladle preheating A-10: Oxygen burner system for ladle preheating D-1: Process control for reheating furnace D-2: Low NOx regenerative burner total system for reheating furnace D-3: High temperature recuperator for reheating furnace D-4: Fiber block for insulation of reheating furnace D-7: Oxygen enrichment for RHF combustion air
Nippon Furnace Co., Ltd.	2-1-53, Shitte, Tsurumi-ku, Yokohama City, Kanagawa Prefecture, 230-8666 Japan TEL.+81-45-575-8111 FAX.+81-45-575-8046 http://www.furnace.co.jp/en.html E-mail: webmaster@furnace.co.jp	A-9: Low NOx regenerative burner system for ladle preheating A-10: Oxygen burner system for ladle preheating D-2: Low NOx regenerative burner total system for reheating furnace D-7: Oxygen enrichment for RHF combustion air

Fuji Electric Co., Ltd.	Gate City Ohsaki, East Tower, 11-2, Osaki 1-chome, Shinagawa-ku, Tokyo 141-0032, Japan https://www.fujielectric.com/contact/?ui_medium=gl_gl_nav	A-5: Ultra high-power transformer for EAF A-12: Energy saving for dedusting system in EAF meltshop A-14: Induction type tundish heater E-2: Energy monitoring and management systems
Fuji Car Manufacturing Co., Ltd.	13-1 Chishiro-cho, Moriyama-city, Shiga, JAPAN 524-0034 TEL +81-77-583-1235 / FAX +81-77-582-8805 http://www.fujicar.com/ENG_fujicar/	A-15: Scrap pretreatment with scrap shear
Rozai Kogyo Kaisha Ltd.	2-14, Minamihorie 1-chome, Nishi-ku, Osaka, Japan 550-0015 Phone: +81 6-6534-3609 / Fax: +81 6-6534-3602 http://www.rozai.co.jp/en/company/index.html	D-1: Process control for reheating furnace D-2: Low NOx regenerative burner total system for reheating furnace D-3: High temperature recuperator for reheating furnace D-4: Fiber block for insulation of reheating furnace
Mitsui E&S Power Systems Inc.	MESPS Nihonbashi Office: TEL:+81-3-6665-6435 FAX:+81-3-6665-6436 sales@mesps.mes.co.jp	D-6: Induction type billet heater RHF for direct rolling

