IPEEC-Energy Management Action NetworK
6th Workshop (At New Delhi)
Waste heat recovery policy and practices in Japan

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Today's topics

1. Waste heat recovery and utilization in EC Act in Japan
2. Technologies and examples for waste heat recovery

1. Waste heat recovery and utilization in “EC Act” in Japan

Points of EC Act in waste heat recovery

1) Standard of Judgment (standard values)

--- exhaust gas temperature and recuperation ratio etc. are stipulated

2) Standard of Judgment (EC Guide line)

--- Enterprises are required to comply with the EC Guide line

3) EM manual

--- According to the EC Guide line, enterprises are required to make EM manual

1) Standard of Judgment (standard values)

a. Waste gas temperatures for boilers

b. Rates of waste heat recovery for industrial furnaces

c. Furnace wall outer surface temperatures

There are two kinds of criteria: standard and target

a. Waste gas temperatures for boilers

Type & Size of the Boiler	Exhaust Gas Temperature [° C]			
	Liquid Fuel		Gas Fuel	
	Standard Temp.	Target Temp.	Standard Temp.	Target Temp.
For Electric Utility	145	135	110	110
Evaporation over 30 t/h	200	160	170	140
Evaporation 10–30 t/h	200	160	170	140
Evaporation 5–10 t/h	220	180	200	160
Evaporation under 5 t/h	250	200	220	180
Small Once-Through Boiler	250	200	220	180

b. Rates of waste heat recovery for industrial furnaces

Exhaust gas temperature (℃)	Rates of waste heat recovery (%)					
	standard			target		
	A	B	C	A	B	C
600＞	25	25		35	35	
600－700	35	30	25	40	35	30
700－800	35	30	25	40	35	30
800－900	40	30	25	45	40	35
900－1000	45	35	30	55	45	40
1000≦	45	35	30	55	45	40

A : equal or more than 84,000MJ/h(Capacity of the furnace)

B : 21,000－84,000MJ/h

C : 840－21,000MJ/h

c. Furnace wall outer surface temperatures

Inside temperature of the furnace (℃)	Furnace wall outer surface temperatures (℃)					
	Standard			Target		
	Ceiling	Side wall	Base*	Ceiling	Side wall	Base*
1,300≦	140	120	180	120	110	160
1100－1,300	125	110	145	110	100	135
900－1,100	110	95	120	100	90	110
900＞	90	80	100	80	70	90

* In case bottom is in contact with open air

2) EC guide line and EM manual

In the EC guide line, “Recovery and utilization of waste heat” is stipulated.

That part is composed of

a. Management

b. Measurement/recording

c. Maintenance/inspection

d. Measures in installing new waste heat recovery facilities

a. Management

i) waste gas temperature or Rate of waste heat recovery

ii) i) shall be managed referencing to standard value

iii) Temperature, volume, and property of steam drain

iv) Range of recovery of heated solid or liquid

v) Waste heat shall be utilized in an appropriate manner

Regarding i),iii),iv), to make “EM manual” is required

b. Measurement/recording

i) Temperature, heat quantity, components of heat media etc. shall be measured and recorded

ii) To make EM manual regarding "i)" is also required

c. Maintenance/inspection

i) Waste heat recovery facilities shall be inspected and maintained including cleaning of the heat transfer surface, etc. and prevention of heat media leakage

ii) To make EM manual regarding "i)" is also required

d. Measures in installing new waste heat recovery facilities

i) When ducts for exhaust gas are newly installed, measures shall be taken which raise exhaust gas temperature (prevent leakage, insulation etc.)

ii) When recuperation equipment for waste heat is newly installed, measures shall be taken which raise heat recuperation ratio (improvement of properties and configurations for heat transfer surface, increase in heat transfer area etc.)

Steam boiler management manual (Example)

Energy management manual	"Steam boiler" (Example)	Reference No.: B-2	
		Revised:	Page: 1/1

1. Purpose

This energy management manual is for rationalization of the use of energy based on Article 4 of the Energy Conservation Act and the public notice "Energy Conservation Guideline".

2. Scope of Application

To be applied to steam boilers (1.5 t/h x 3 units, A heavy oil)

Item	Description	EC Guideline No.	Management Manual	Reference manual
Operation management	**1. Management of fuel combustion --- Omit**			Operation management manual
	2. Heating equipment --- Omit			
	3. Waste heat recovery (1) Waste gas temperature or waste heat recovery ratio is set. (2) Those which fall under the category of (A) (1) of the appendix 2 shall comply with the standard values listed in the appendix. (3) The recovery scope of the temperature, quantity and nature of steam drain is set.	II-3(1)A II-3(1)B II-3(1)C	- Waste gas temperature, 180 ºC or lower - Standard exhaust gas temperature, 220 ºC or lower - Water quality: Within JIS's scope	
	4. Electric power application --- Omit			

Measurement and record	1. Management of fuel combustion --- Omit			Record book
	2. Heating equipment --- Omit			
	3. Waste heat recovery (1) Matters necessary for knowing waste heat such as waste gas temperature	II-3(2)	- Once a day	
	4. Electric power application --- Omit			
Maintenance and inspection	1. Management of fuel combustion --- Omit			Maintenance and inspection manual Record book
	2. Heating equipment --- Omit			
	3. Waste heat recovery (1) Inspection and cleaning of economizer's heat transfer surface	II-3(3)	- Once a year	
	4. Thermal insulation, heat-retention --- Omit			
	5. Electric power application --- Omit			
alla tion	New installation is judged based on technologies and investment effect then prevailing.			

Revision history	Revision date	Revision contents	Creation	Approval

Approval		Exami-nation		Creation		Date of imple-mentation	
						Date of establishment	

Summary of EC Act in waste heat recovery

1) Standard value (Standard of Judgment)

exhaust gas temperature, recuperation ratio and furnace wall temperature

2) EC Guide line (Standard of Judgment)

Enterprises shall comply with EC Guide line

3) EM manual

According to EC Guide line, enterprises are required to make EM manual

2. Technologies and examples for waste heat recovery

Contents of this chapter

(1) Overview of waste heat recovery

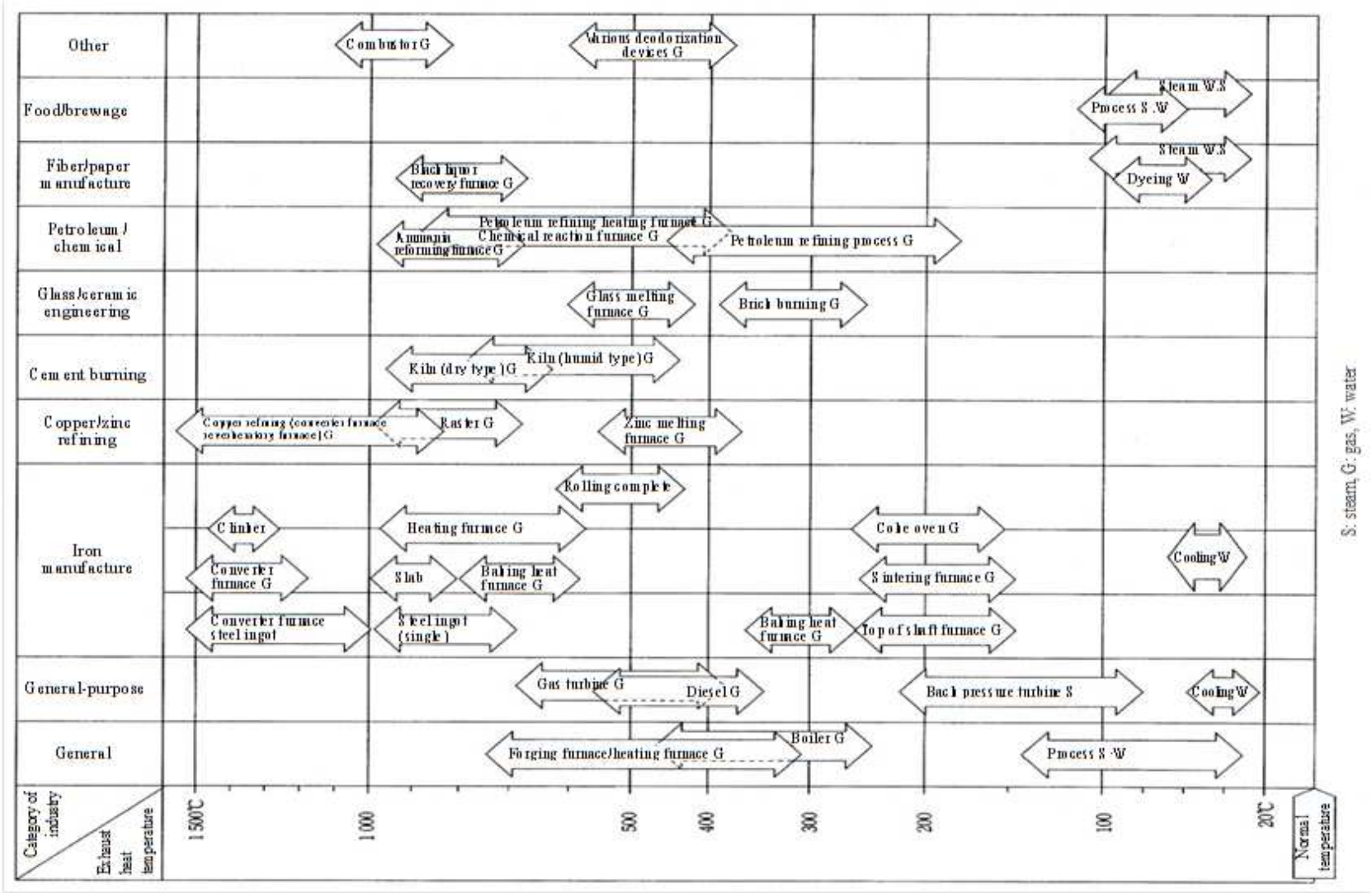
(2) Types of heat exchangers and selections

(3) Case studies

(1) Overview of waste heat recovery
1) Waste Heat Source and its Utilization

Facility	Heat Source	Utilization
Furnace, boiler, dryer	Exhaust gas	Pre-heating of combustion air or water
Gas turbine	Exhaust gas	Generation of steam or hot water
High temperature furnace	Furnace cooling water	Generation of hot water or steam
Frozen food thawing	Cold heat of frozen stuff	Pre-cooling of water before chiller facility
Washer, sterilizer, cooker (textile, food factory)	Hot waste water	Pre-heating of process water
Burning process (ceramic, cement, paint baking)	Burning gas	Pre-heating of raw material, or heat source of dryer

2) Exhaust heat sources and temperature conditions



(2) Types of heat exchangers and selections
1) heat exchangers(1/4)

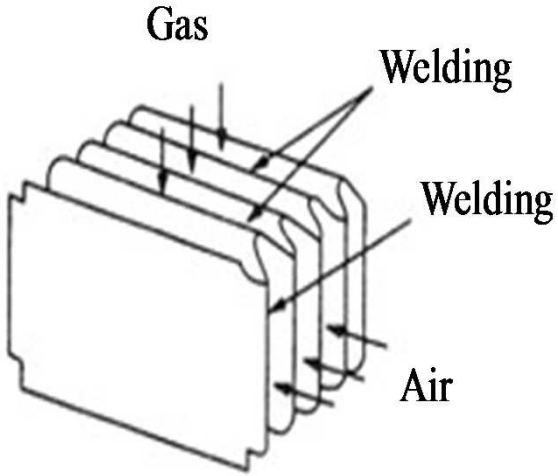
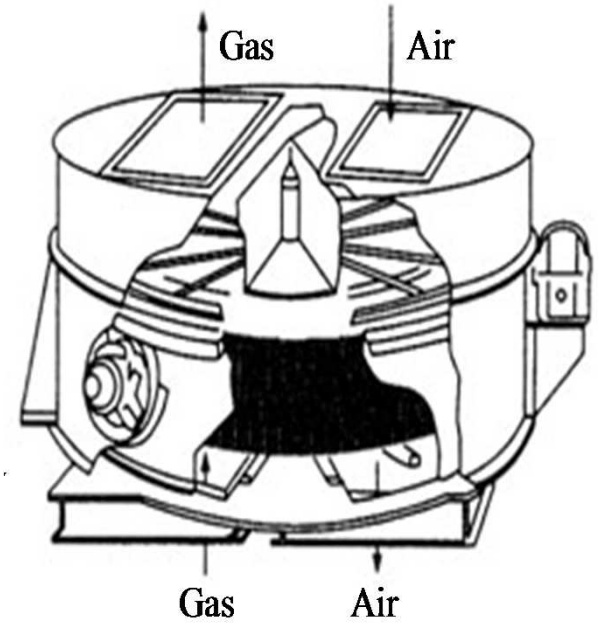
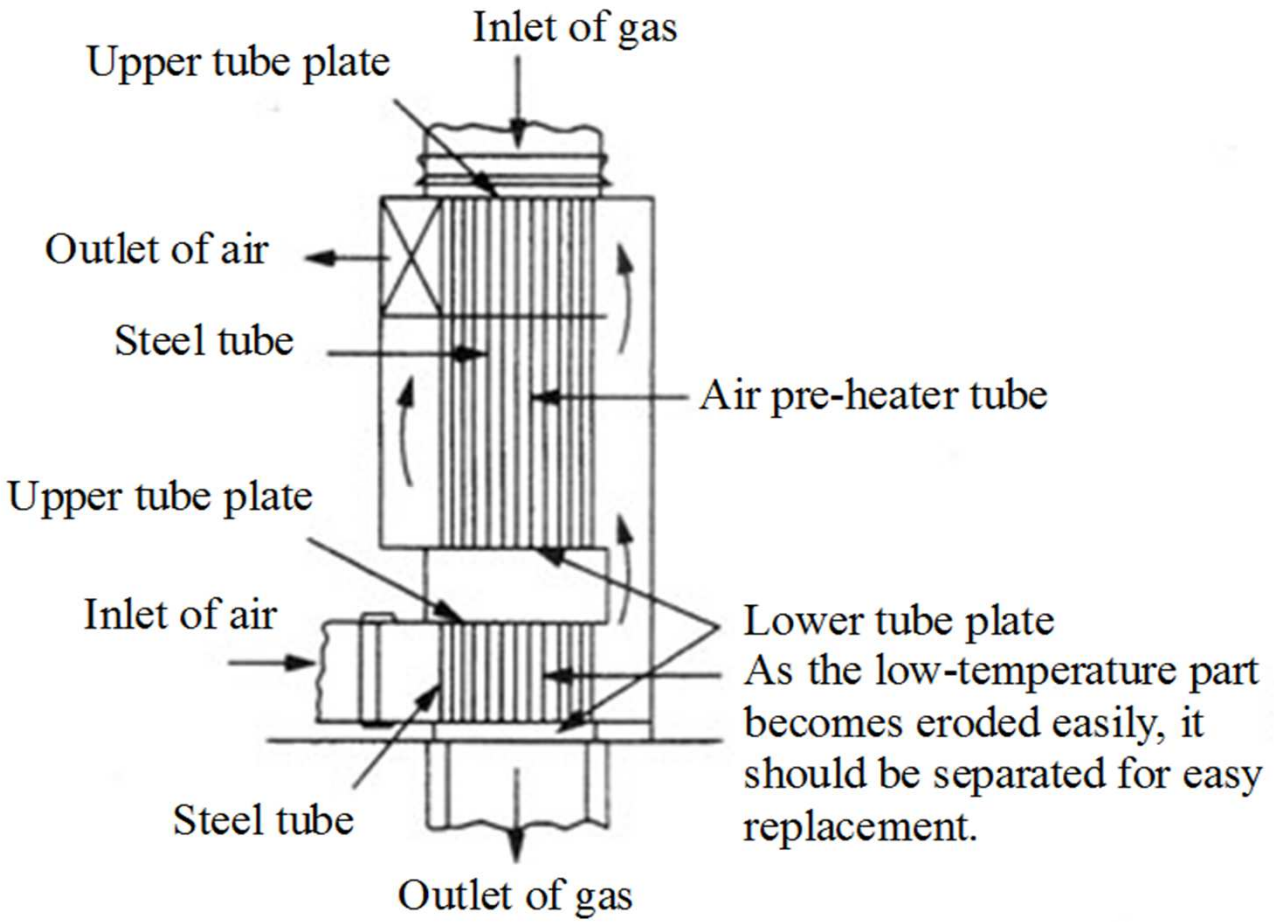


Plate-type air pre-heater



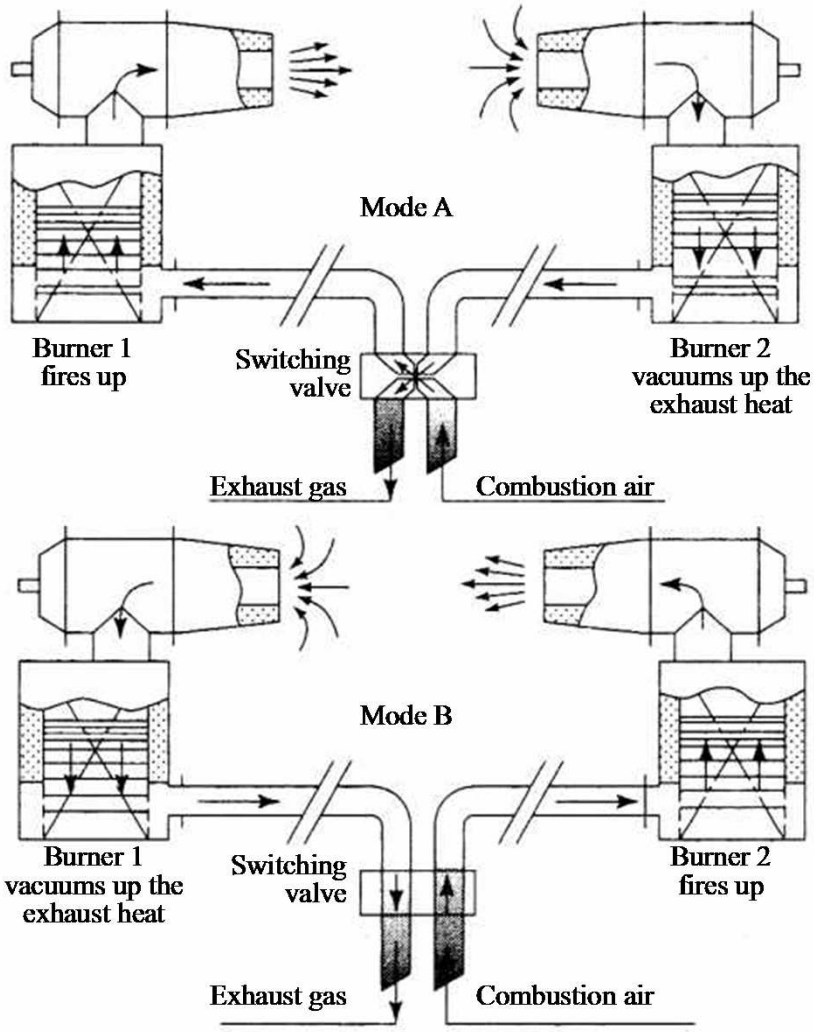
Rotating regenerative air pre-heater

heat exchangers(2/4)



Multi-tubular air pre-heater

heat exchangers(3/4)
Operating principle of a regenerative burner

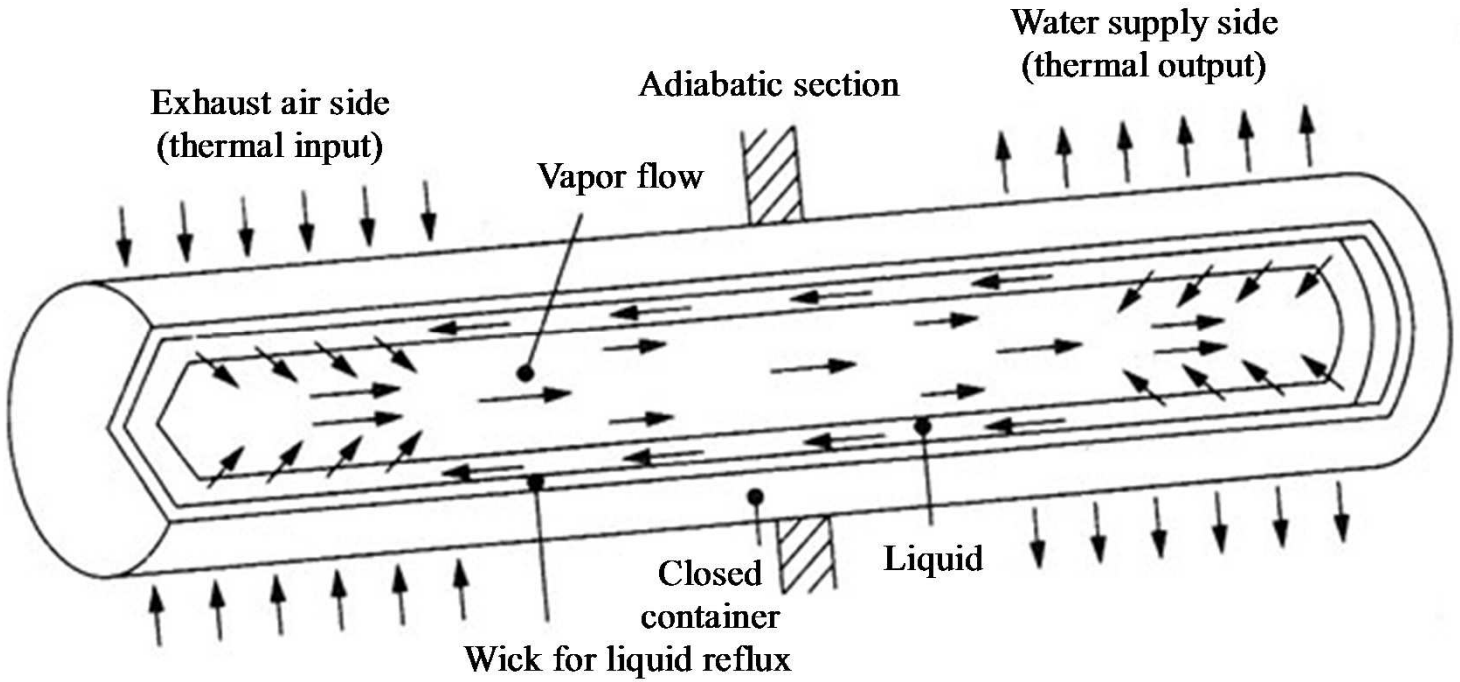


ceramic heat storage bodies are equipped

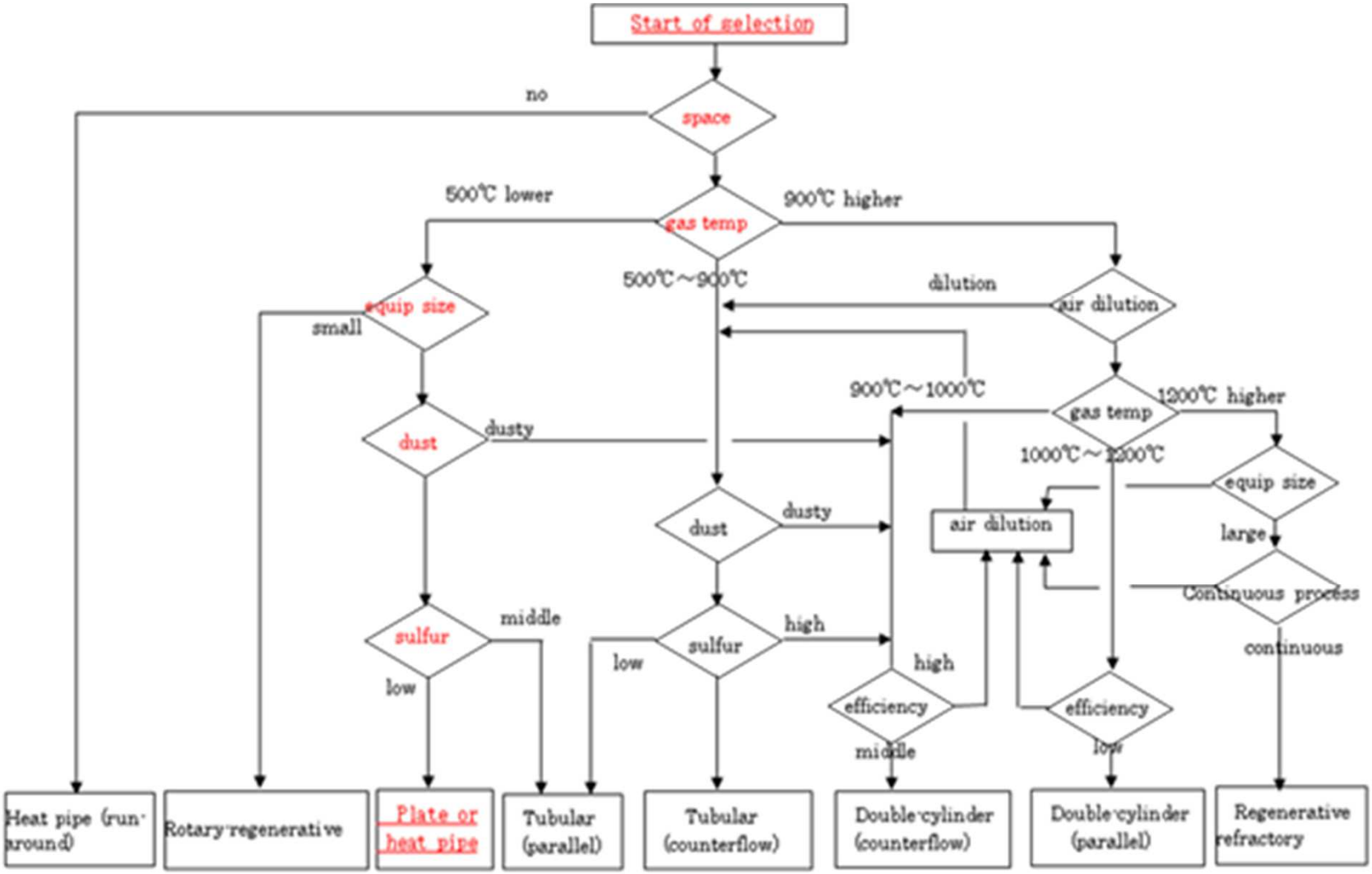
switching valve operates for 30–90sec

the exhaust gas temperature is lowered to 300° C or less regardless of the temperature conditions in the furnace

heat exchangers(4/4)
Working principle of heat pipe



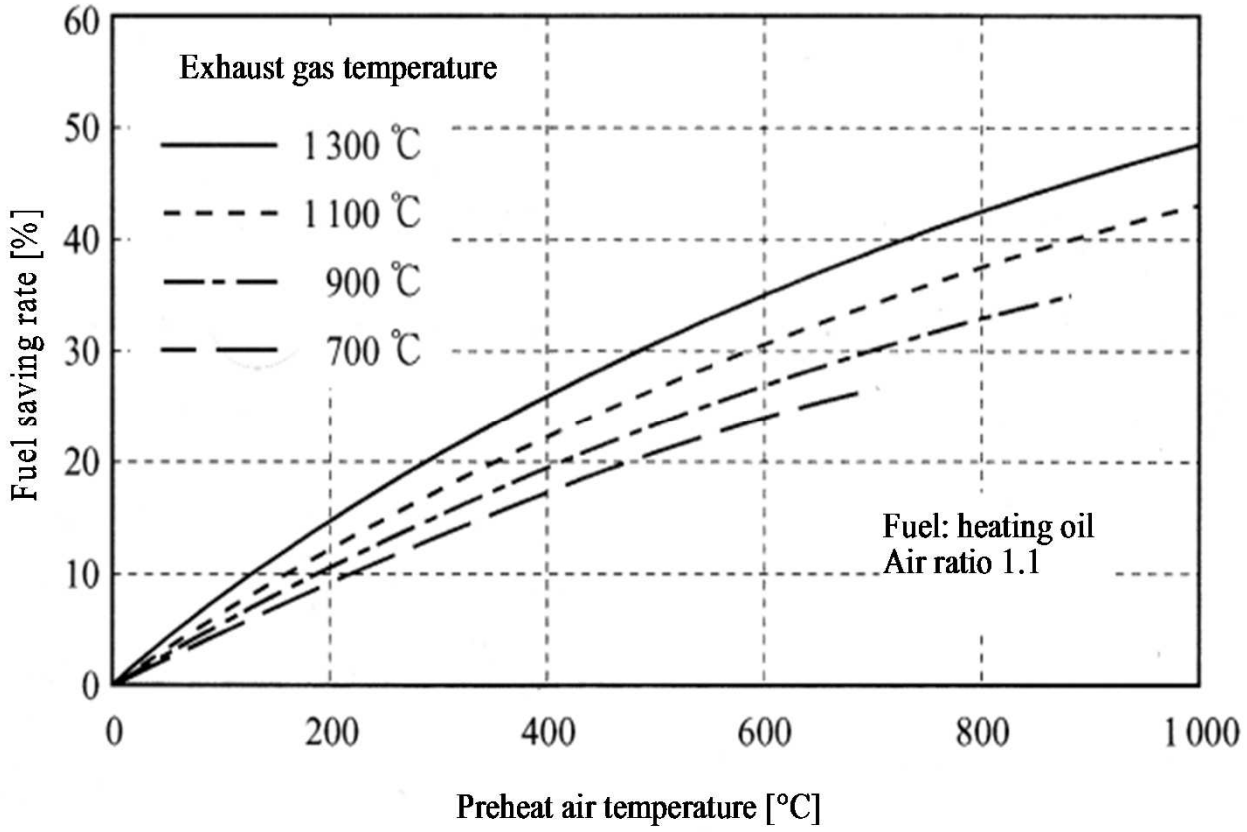
2) Selection tree for heat Exchangers



(3) Case studies

1) Preheating of the combustion air
2) Renewal to regenerative burners
3) Steam drain-off recovery
4) Heat retention of steam valves
5) Air and gas preheating systems for a boiler plant
6) Process flow involving the use of a heat-pipe-type air pre-heater
7) Heat recovery of tunnel dryer exhaust gas
8) Waste heat recovery in tunnel kiln

1) Preheating of the combustion air



Preheating of the combustion air by a pre-heater (recuperator, heat exchanger) is most widely used

2) Renewal to regenerative burners

■Preconditions of estimation

Fuel	13A gas (natural gas)
Gas consumption	250,000m3/y
Present air preheating temperature	200℃
Present exhaust gas temperature	850℃
Efficiency of regenerative burner	80%
Air preheating temperature after renewal	684℃
Air ratio	1.2
Fuel price	¥102/m3

■Effect estimation

Gas reduction	62,500m3/y (25%)
(Oil equivalent	73kL/y)
Sum of saving	¥6,370,000/y

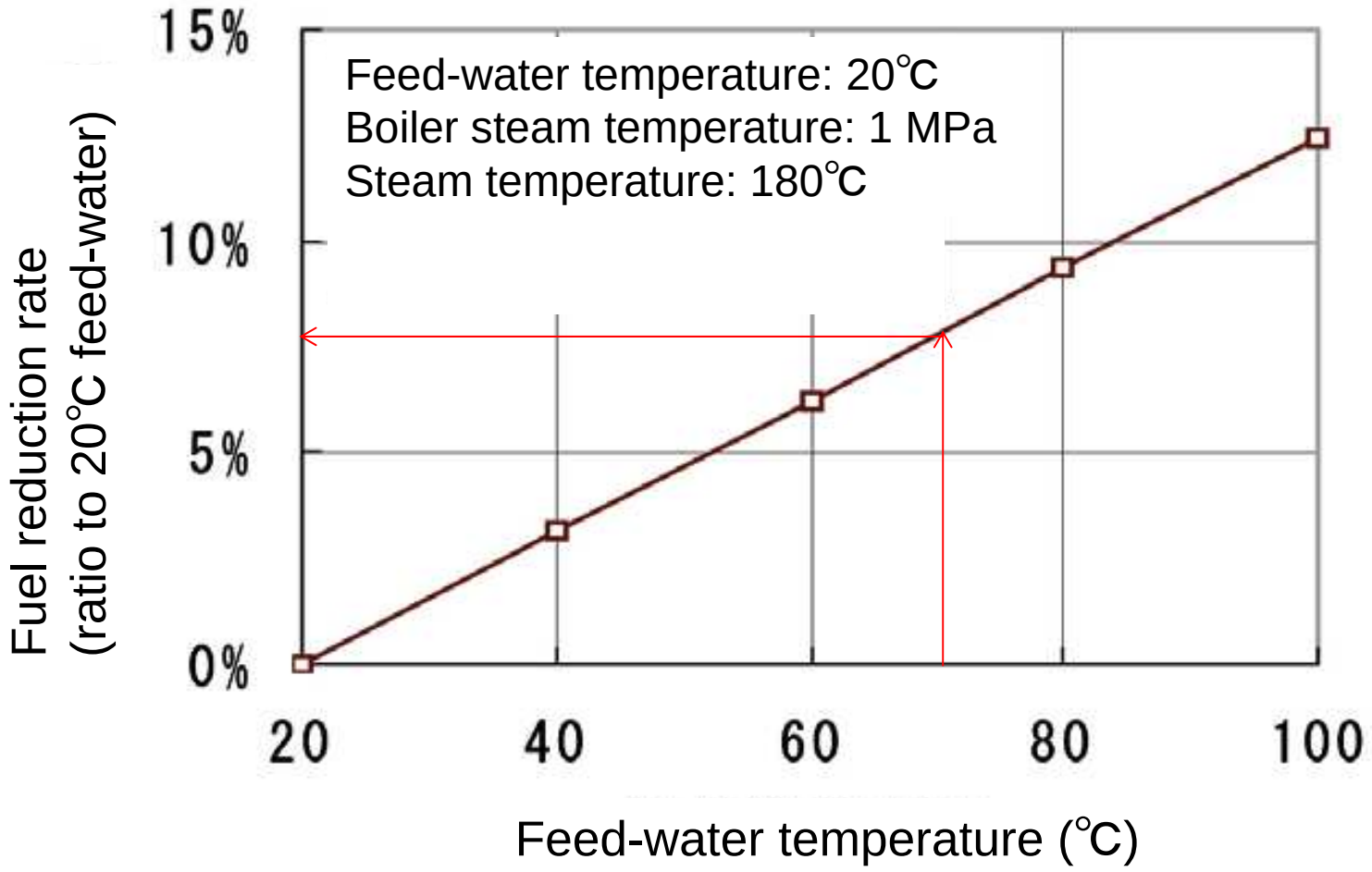
3) Steam drain-off recovery

● Problems with the current situation

Drain-off discharged from mold steam heaters is supposed to be recovered by a tank through pipes, but actually, drain-off is not recovered because impurities flowing out from heaters cause iron rust inside the tank.

● Improvement measures

For prevention of iron rust, the inside of the drain-off tank and the mold will be cleaned up, and antirust paint applied to the inside of the tank. After that, drain-off will be recovered in boilers.



Feed-water temperature and fuel reduction rate

● Effect estimation

■Calculation formula

Feed-water temperature after drain-off recovery (℃) = former feed-water temperature (℃) + ηd × (drain-off temperature - former feed-water temperature) ℃

Ratio of drain-off recovery against feed-water volume ηd = drain-off recovery amount (t) ÷ boiler feed-water volume (t)

Fuel reduction rate after drain-off recovery: obtained from the above chart

Fuel reduction = fuel consumption in the current situation (kL/year) × fuel reduction rate after drain-off recovery

■Preconditions of estimation

Boiler fuel consumption: Type-A heavy oil 340 kL/year; Boiler efficiency: 80% ; Evaporation factor: 10.9 kg/L; Blow rate: 8%

Amount of evaporation: 340 kL/year × 10.9 kL/L = 3,706 t/year

Amount of feed-water: 3,706 t/year × 1.08 = 4,002 t/year

Drain-off recovery rate: 80% ; Drain-off recovery temperature: 90℃ ; Former feed-water temperature: 20℃

Recovered amount: 3,706 t/year × 0.8 = 2,965 t/year

Drain-off recovery rate against feed-water volume ηd = 2,965 t/year ÷ 4,002 t/year = 0.741

Type-A heavy oil unit price: 60 yen/L

Waterworks unit price (including sewerage charge): 780 yen/t = 0.78 yen/kg

■Effect estimation

Feed-water temperature after drain-off recovery = 20℃ + 0.741 × (90℃ - 20℃) = 72℃

Fuel reduction rate: 7.5% based on the above chart

Fuel consumption reduction: 340 kL/year × 0.075 = 25.5 kL/year

4) Heat retention of steam valves

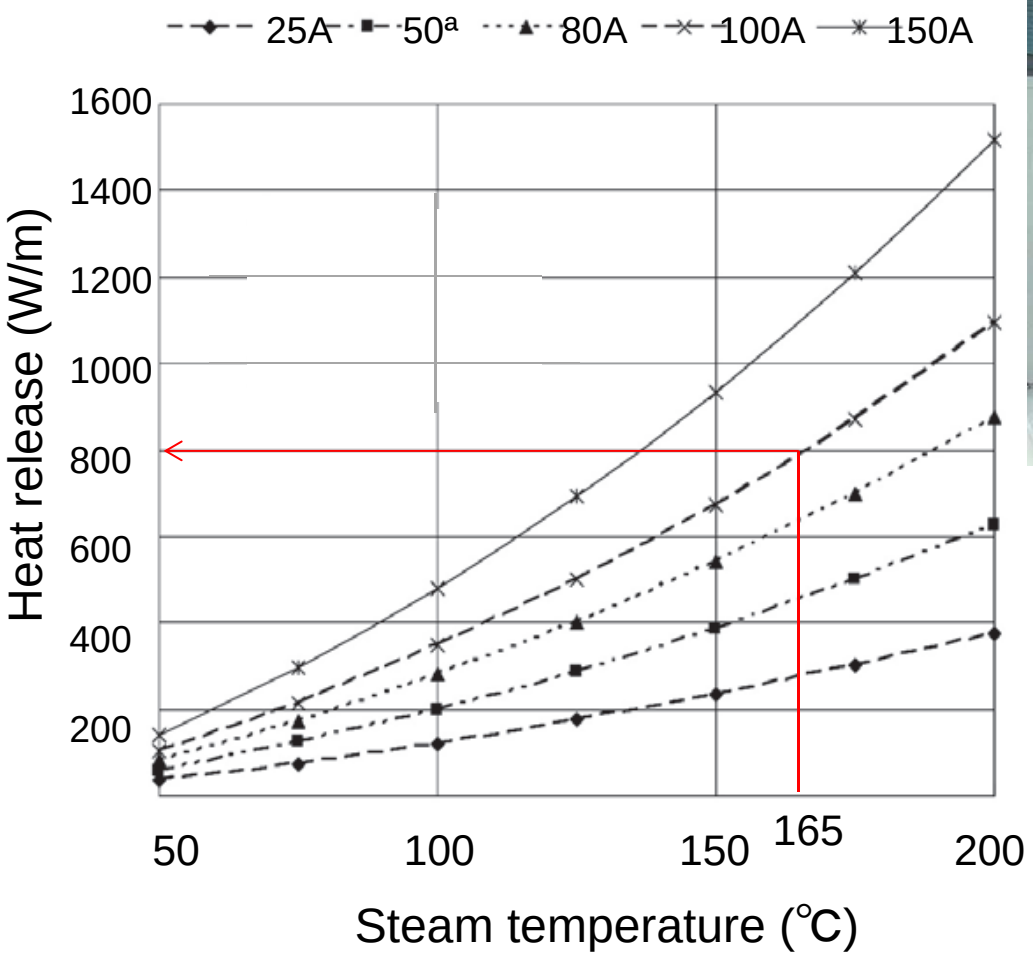
● Problems with the current situation

In a large hospital (total floor area: 60,000 m2), steam piping valves, which do not have heat retention covers, release heat from the surface.

● Improvement measures

Heat loss is prevented by putting heat retention covers with a hook and loop fastener on steam valves. They can be quickly attached to and removed from intricately-shaped valves.

Heat release from bare steam pipes



Heat retention of valves at the steam header

[Calculation conditions]
Horizontal pipes, natural convection
Ambient air temperature = 20℃
Emissivity ε = 0.7

● Effect estimation

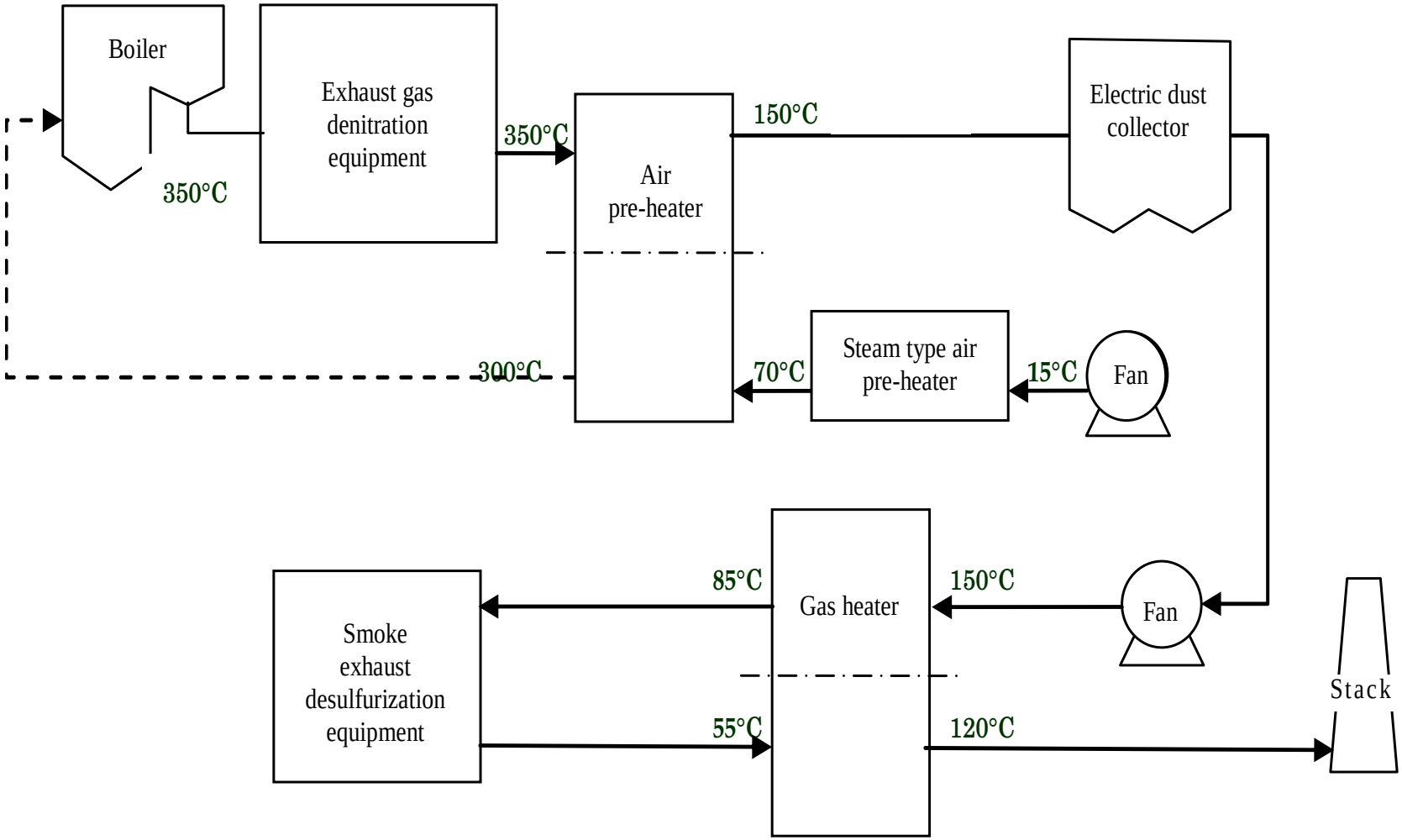
■ Preconditions of estimation

Steam pressure/temperature (saturated): 0.7 MPa･165℃
Specifications and number of steam valves: 100A flanged type spherical valve, 100 units
Straight pipe length equivalent of 100A flanged type spherical valve: 1.27 m/unit
Bare valve heat loss: 100A bare steam pipe heat loss (see the Chart 2) x straight pipe length equivalent to the
valve surface area = 800 W/m x 1.27 m/unit = 1.0 kW/unit
Heat retention efficiency (= heat loss reduction after heat retention ÷ bare pipe heat loss): 85%
Boiler efficiency: 70% (including operation efficiency)
Operating hours: 12 h/day x 365 day/year = 4,380 h/year
Calorific value (low calorific value) (13A): 40.7MJ/m3
Average gas unit price: 70 yen/m3

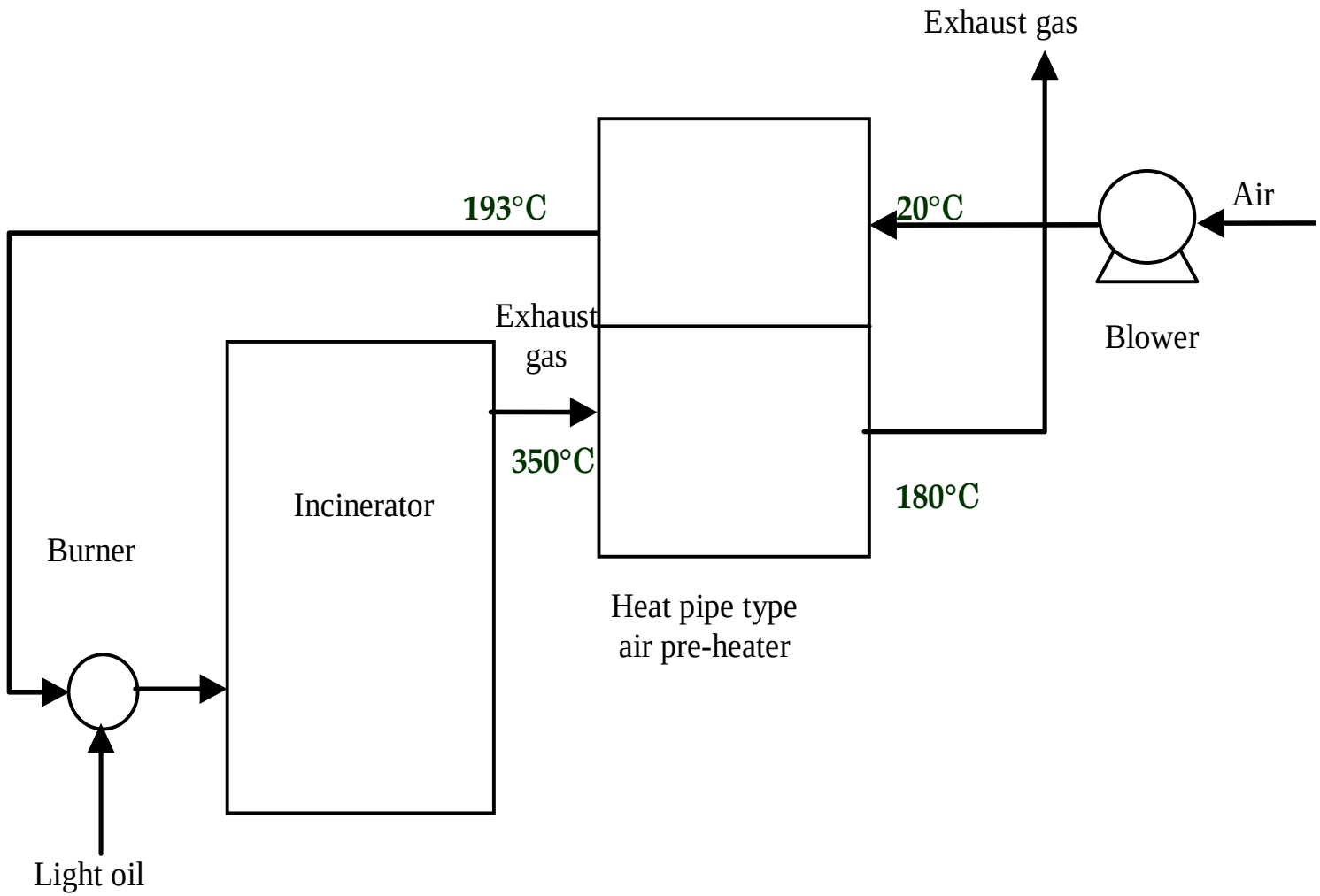
■ Effect estimation

Heat loss reduction = 1.0 kW/unit x 100 units x 0.85 x 4,380 h/year x 3.6 MJ/kWh = 1,340,280 MJ/year
Gas reduction = 1,340,280 MJ/year ÷ (40.7 MJ/m3 x 0.7) = 47,044 m3/year

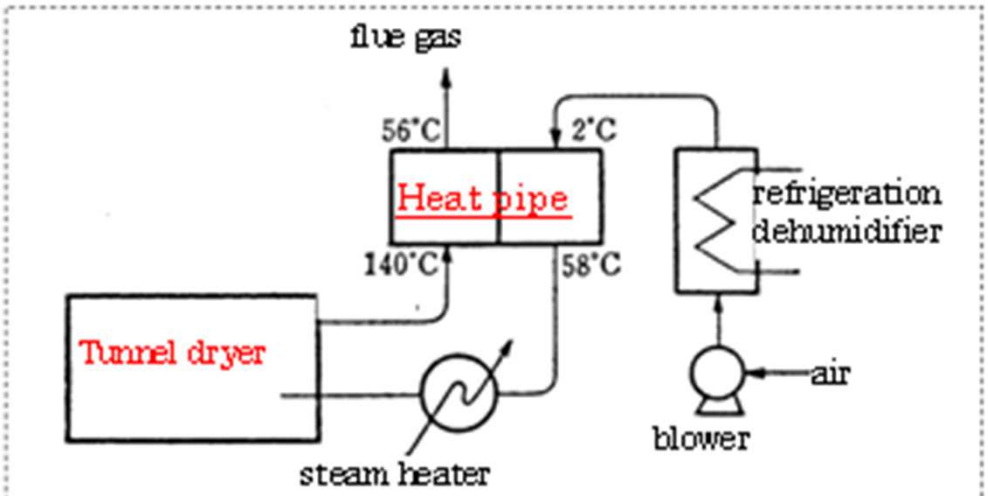
5) Air and gas preheating systems for a boiler plant



6) Process flow involving the use of a heat-pipe-type air pre-heater



7) Heat recovery of tunnel dryer exhaust gas

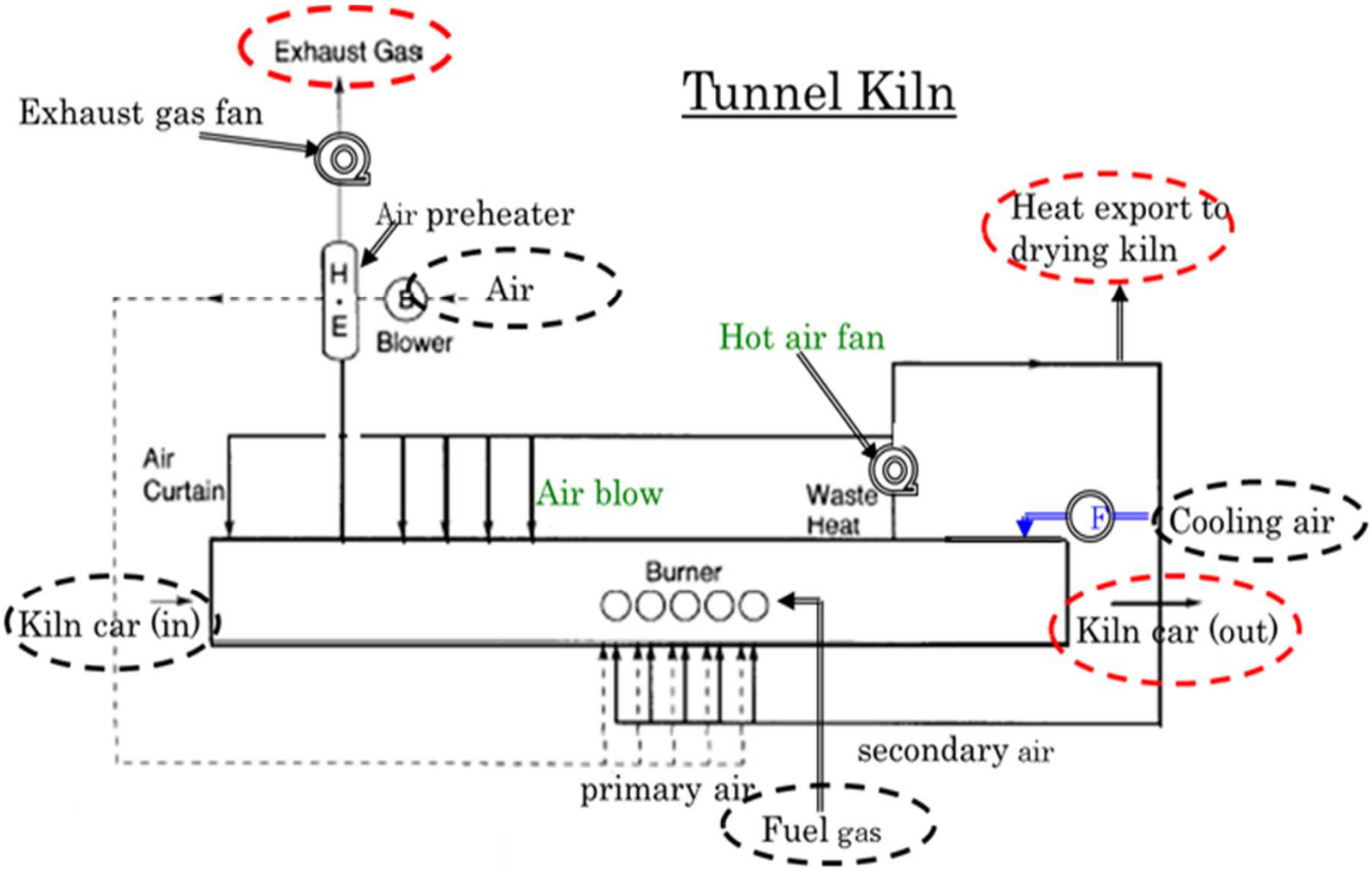


Recover waste heat of tunnel dryer flue gas to reheat cold dehumidified air (heat pipe)

Size(cm)	55h * 160l * 36w
Recovery rate	65700 kcal/h
Saving	3.5 * 10⁵ ¥/yr

Heat Pipe (heat source of drying)		
	Hot side	Cold side
fluid	Flue gas	Air
Rate(Nm³/h)	2520	3780
Inlet, ℃	140	2
outlet	56	58
Temp efficiency, %	61	41
ΔP, mm Aq	14	9

8) Waste heat recovery in tunnel kiln (Ceramic factory)



Thank You

Very Much

For More Information
The Energy Conservation Center, Japan
http://www.eccj.or.jp

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