IGRC Seoul 2011
International Gas Union Research Conference

Applications of High Efficiency Gas Burners to Contribute to Energy Saving in Industrial Field

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JAPAN

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Contents

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Contents

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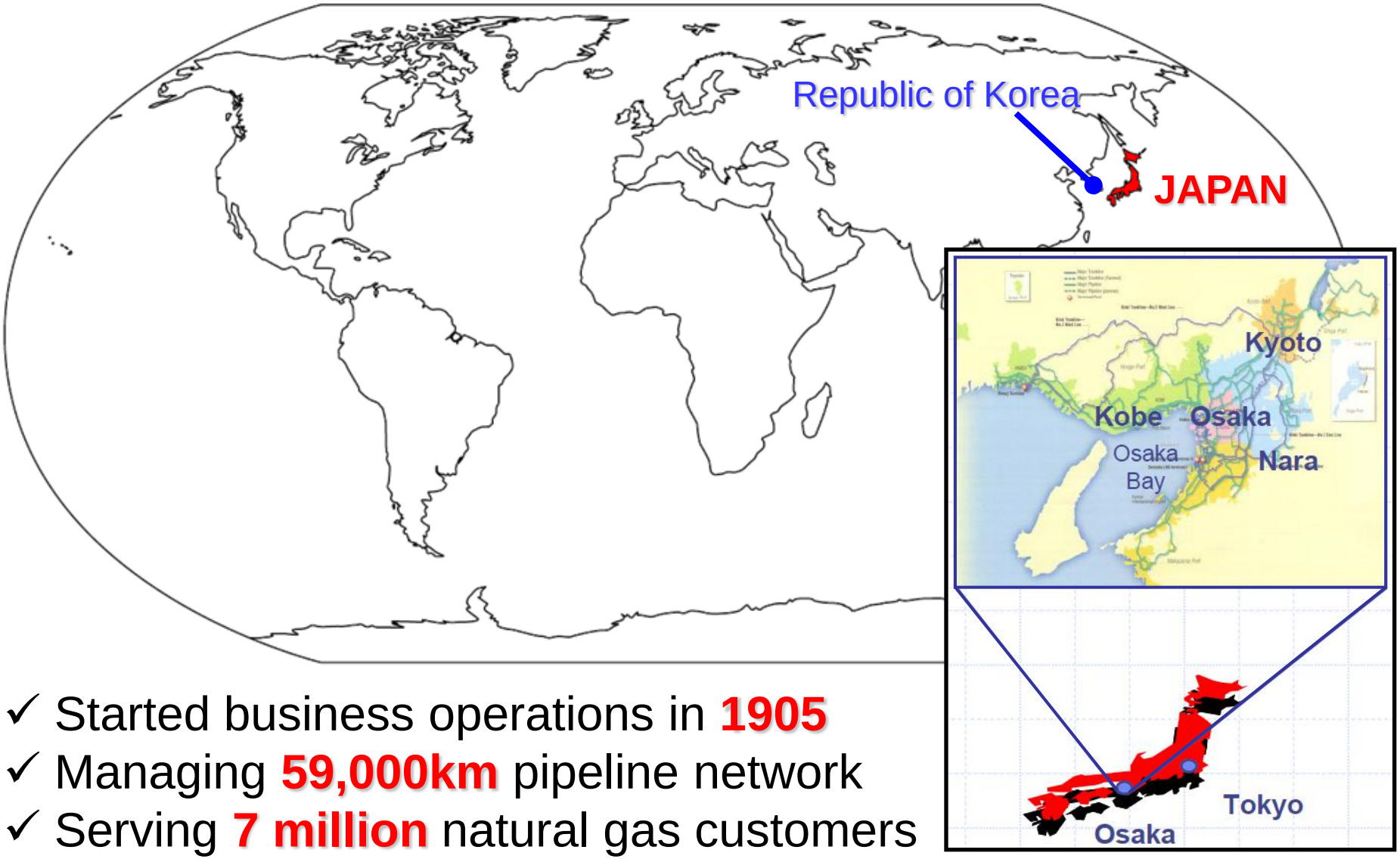
Key Features of Osaka Gas



- ✓ Started business operations in **1905**
- ✓ Managing **59,000km** pipeline network
- ✓ Serving **7 million** natural gas customers (**25%** of all gas sold in Japan)

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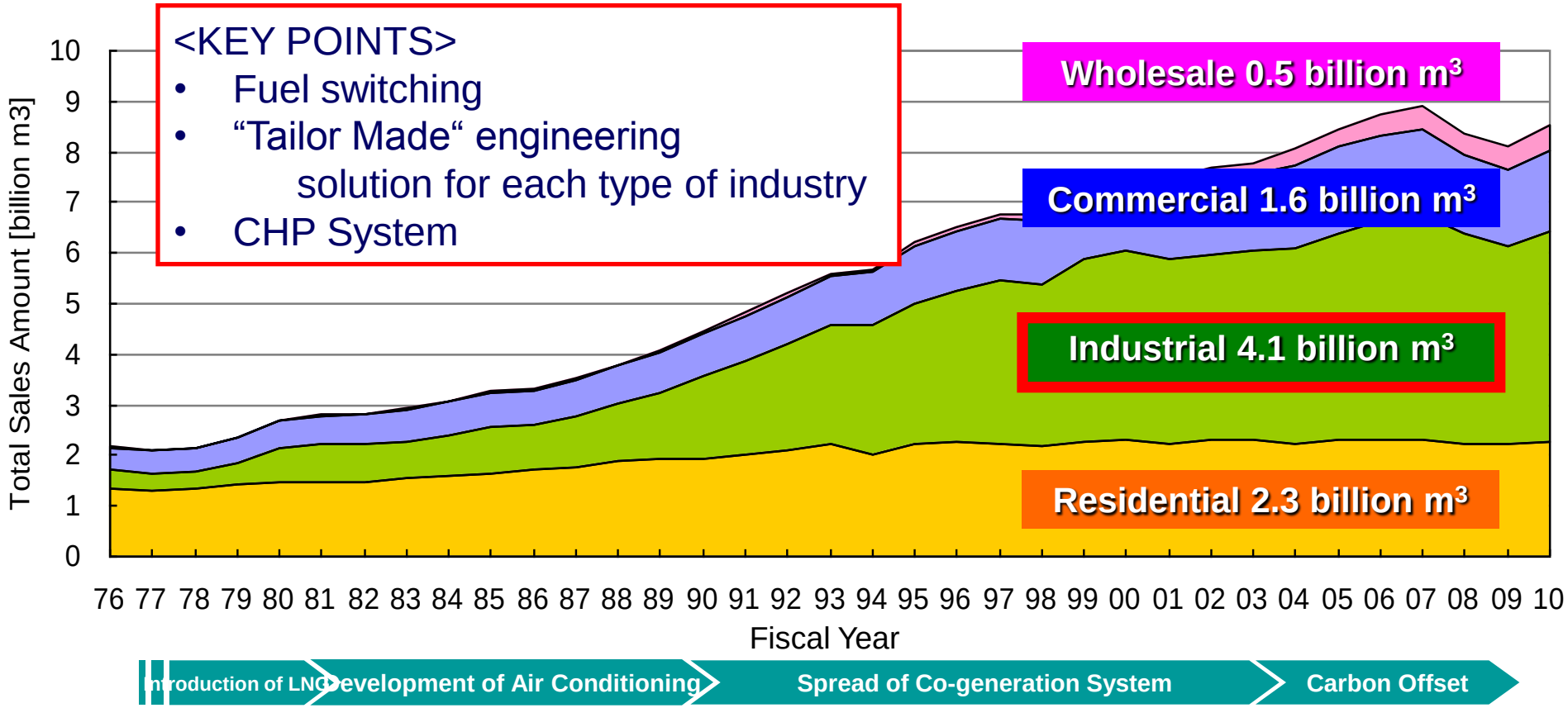
Key Features of Osaka Gas Marketing

Osaka Gas Total Sales Amount

- ✓ Reaching **8.5 billion m³** by the end of 2010 fiscal year
- ✓ **70%** of sales : **Commercial** and **Industrial** Uses



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Key Features of Osaka Gas Marketing

- ***We differentiate ourselves from others in the following ways***

✓ **Providing energy solutions**

- Engineering services for energy efficient systems

✓ **Promoting R&D**

- Development of gas alliances, eg; CHP, GHP, gas absorption chillers, cookers, burners

✓ **Offering maintenance services**

- Building strong relationship with customers and feed-back their needs to R&D

✓ **Others**

- Sales and installation of gas equipment
- Finance services
- Strategic gas price menus

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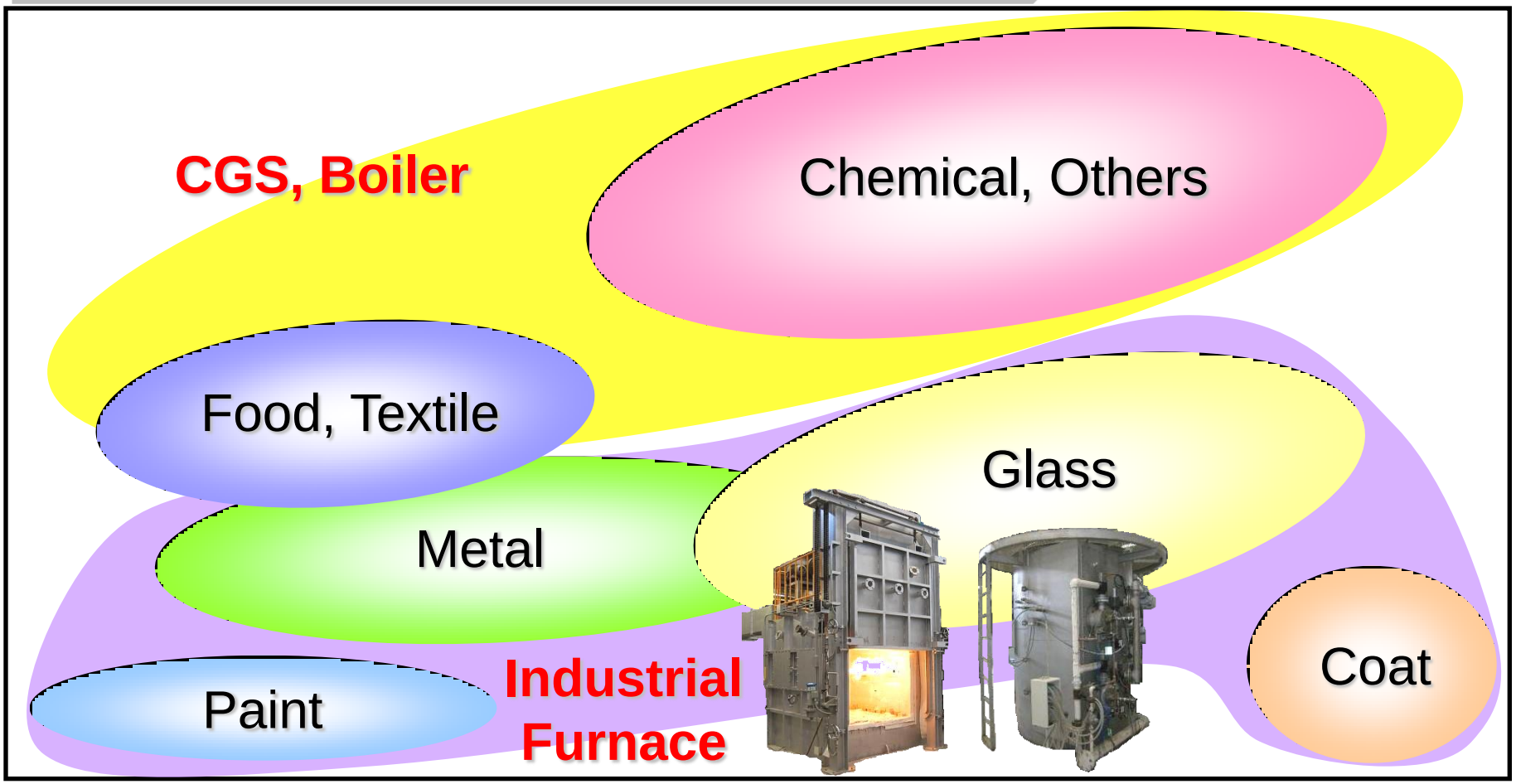
Commitment to Gas Services

- **Development of Osaka Gas Unique Technology**
  - ✓ Reaction against liberalization of energy market



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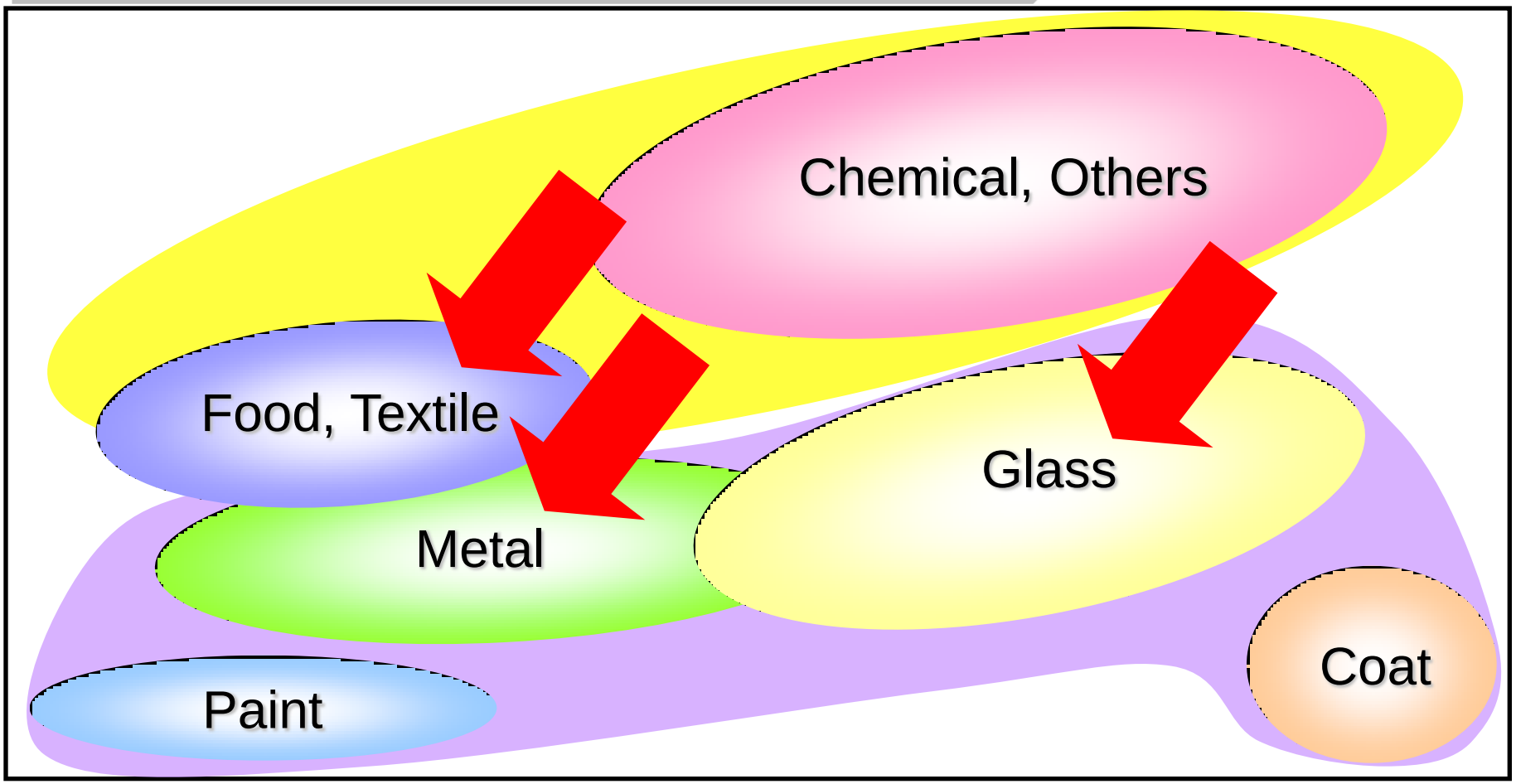
Commitment to Gas Services

- **Development of Osaka Gas Unique Technology**
  - ✓ Reaction against liberalization of energy market



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Contents

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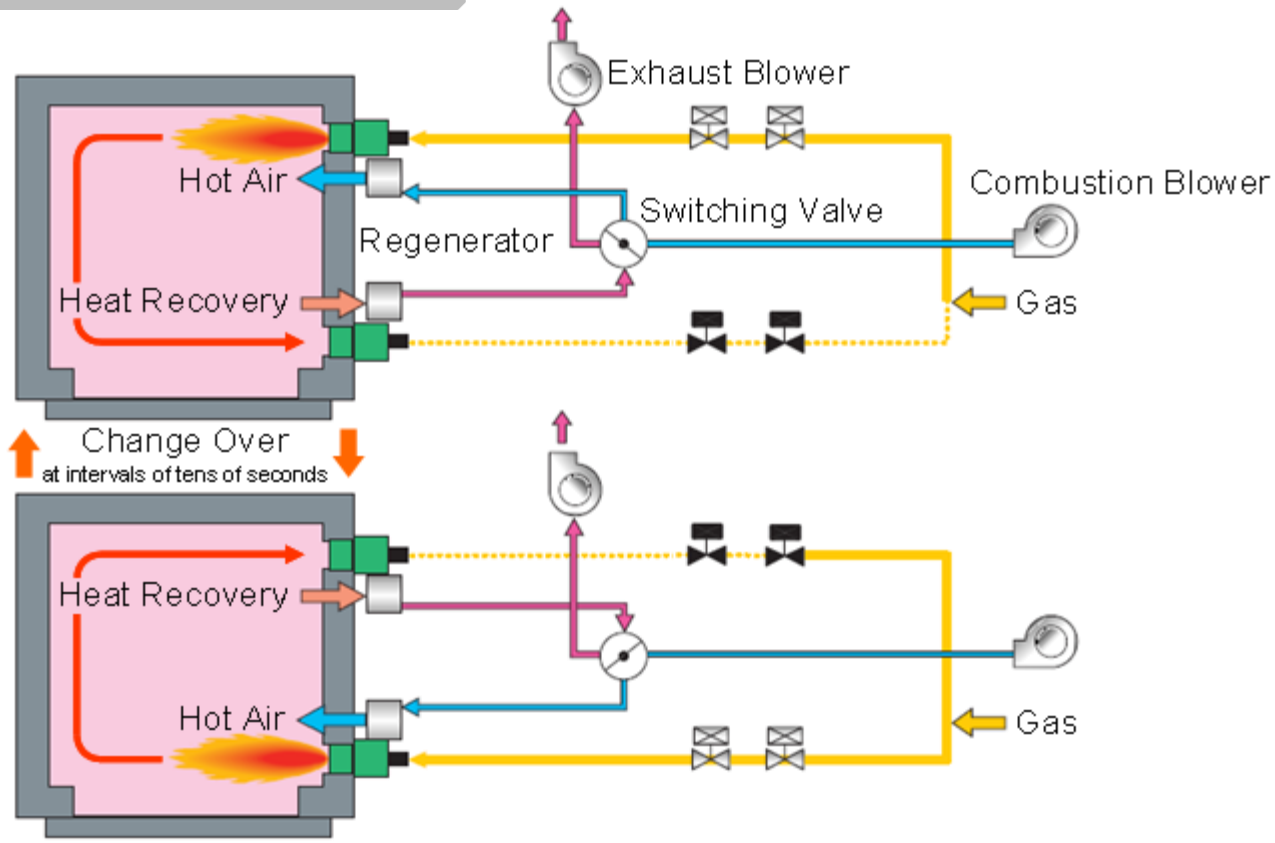
2. Regenerative Gas Burners for Heat Treating Furnaces

Characteristics of Osaka Gas Regenerative Burners

- ***R&D on burners***
  - ✓ Development in anticipation of the market of the whole industry
  - ✓ Regenerative burners for **small and compact sized furnaces**
  - ✓ 4 types of compact regenerative burners
  - ✓ Development of switching valve makes simplification of piping; **compact combustion system and low cost** are achieved
  - ✓ Slow combustion technique makes low NO_X
- ***Experience in fuel switching***
  - ✓ Installations of **257 pairs** regenerative burners (**150 furnaces**)
  - ✓ **1000 furnaces** with regenerative burners in Japan
  - ✓ Achieving energy saving of **50%** compared to furnaces without heat exchanger

2. Regenerative Gas Burners for Heat Treating Furnaces

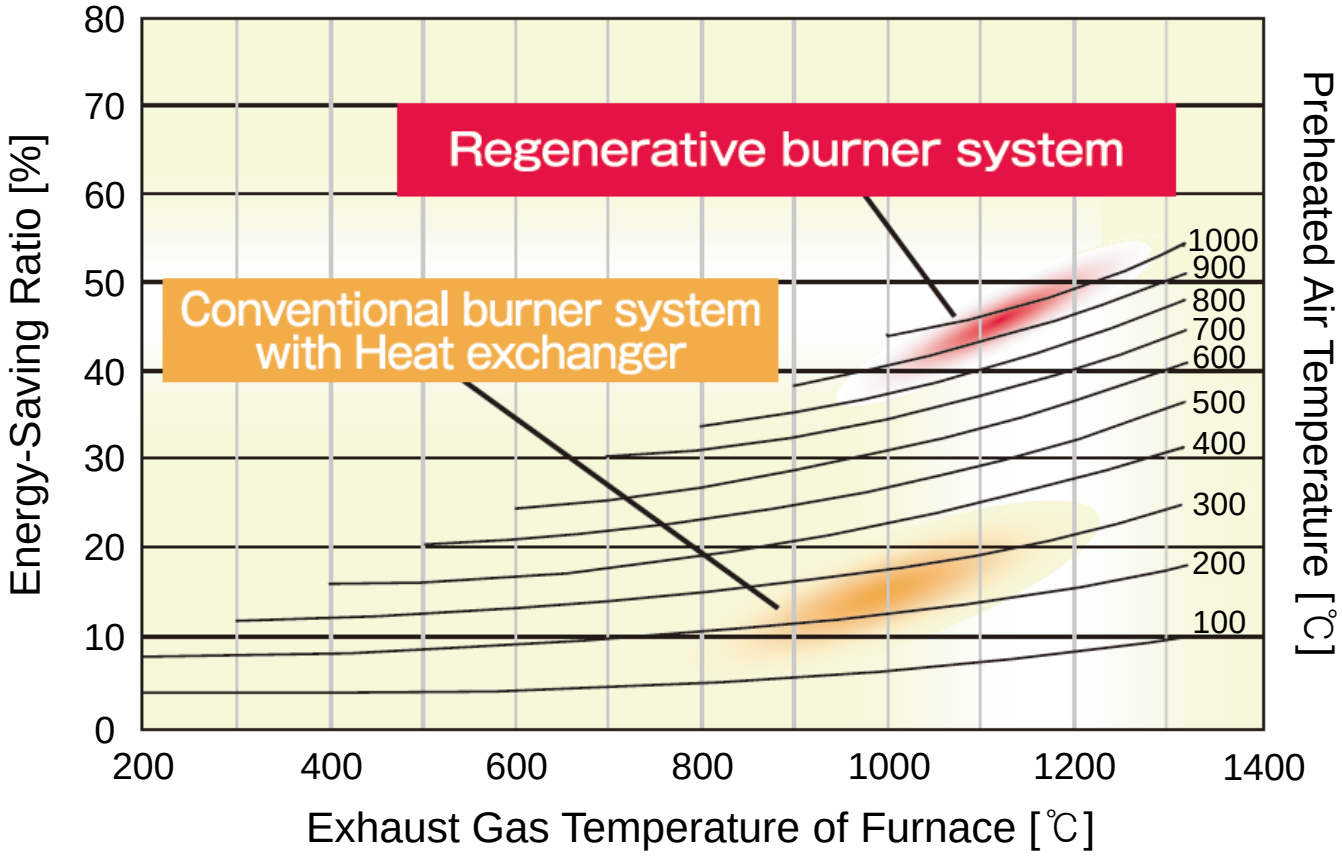
Regenerative Burner System



- ✓ Two burners make combustion alternately at **intervals of several tens of seconds**.
- ✓ **Preheated air with high temperature** is produced by regenerative heat exchange.

2. Regenerative Gas Burners for Heat Treating Furnaces

Relation between preheated air temperature and energy-saving ratio
(natural gas, air ratio=1.1)

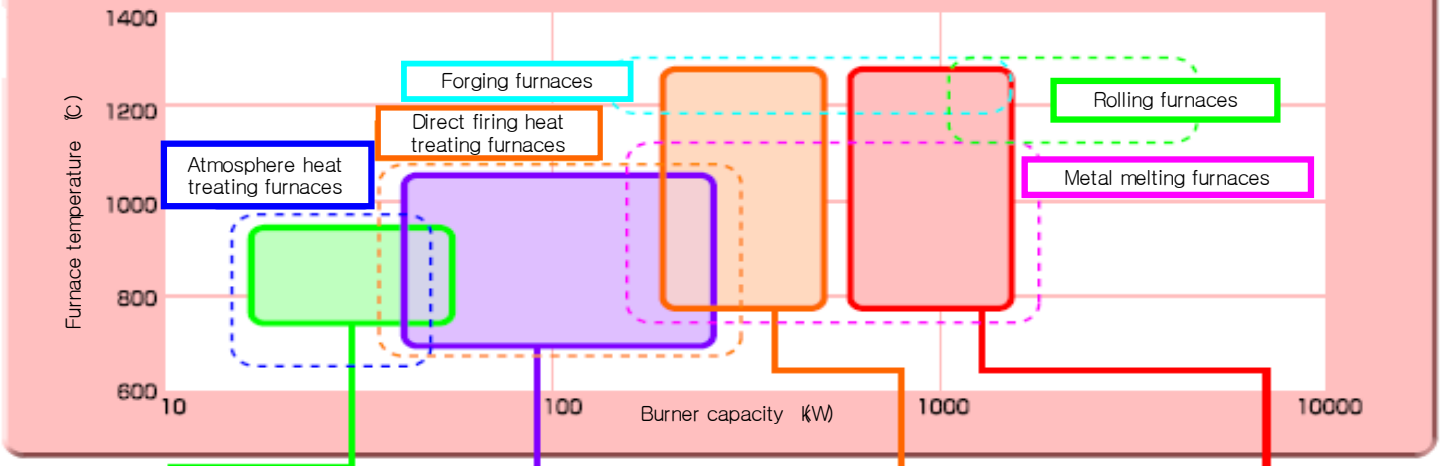


✓ Regenerator made of ceramic can store much more heat than that made of metal.

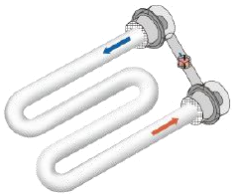
2. Regenerative Gas Burners for Heat Treating Furnaces

Line-up of Osaka Gas Regenerative Burners

The industry's largest lineup from low to high temperature; from small to large capacity

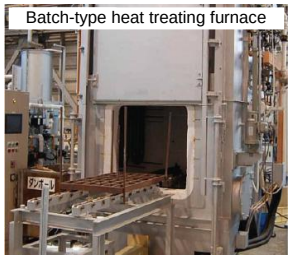


Radiant Tube Regenerative burner



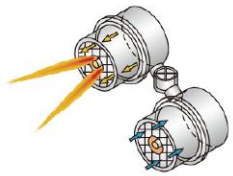
<Actual Case>

Batch-type heat treating furnace



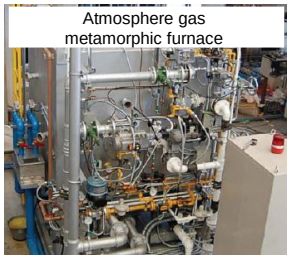
RTR

Insert-type Regenerative burner



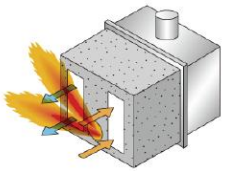
<Actual Case>

Atmosphere gas metamorphic furnace



IREG

Self Regenerative burner

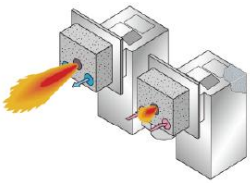


<Actual Case>

Aluminum melting and Holding furnace

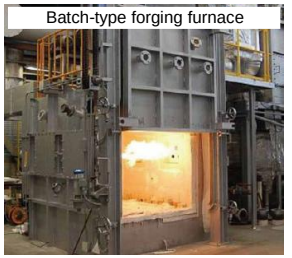
SREG

Twin Regenerative burner



<Actual Case>

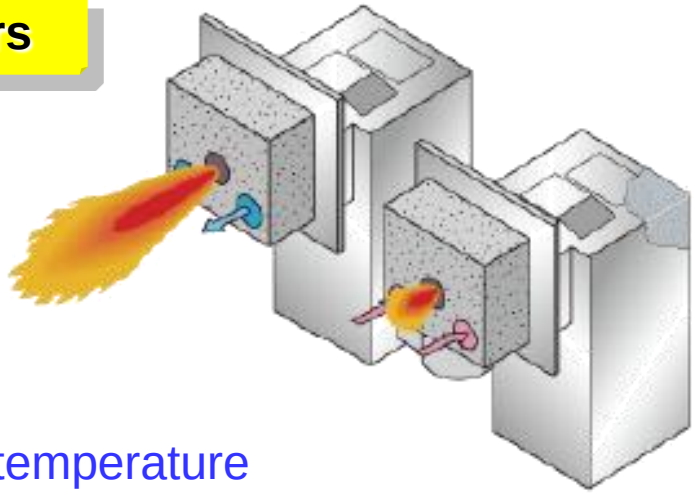
Batch-type forging furnace



TREG

2. Regenerative Gas Burners for Heat Treating Furnaces

Specification of Twin-type Regenerative Burners



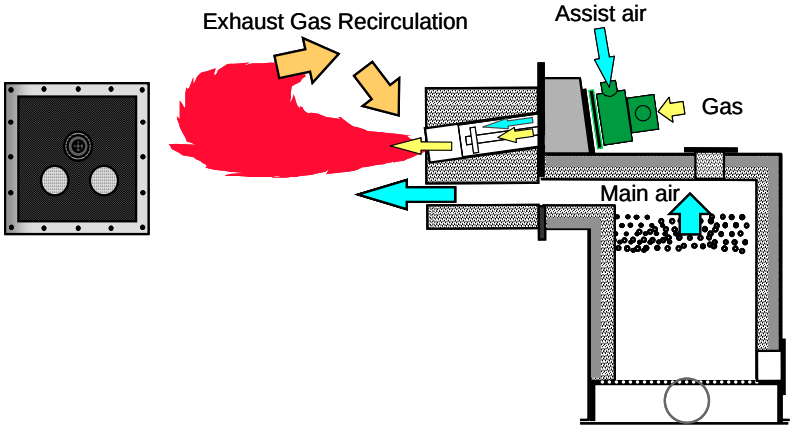
- ✓ For **directly-fired high temperature heat treating furnace**
- ✓ Extremely high efficiency
- ✓ Compact and low cost with simplified structure
- ✓ High durability by gas gun not to be set in high temperature
- ✓ Alternate combustion makes uniform temperature distribution

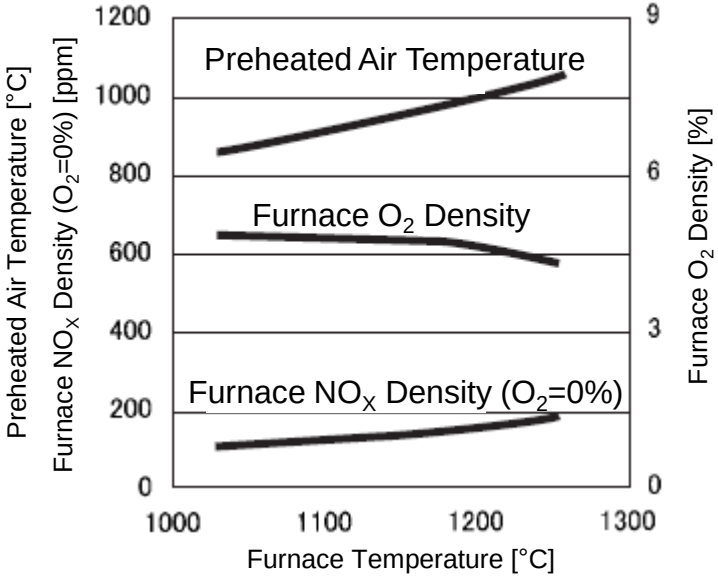
Model TREG-___K	250	400	800	1400	1700	Remarks
Fuel	Natural gas					
Firing Rate [kW]	250	400	850	1400	1700	including pilot burner
Pilot Burner Firing Rate [kW]	12	23	29	41	46	
Main Gas Fuel Pressure [kPa]	1.5	1.1	3.6	2.0	2.0	Air/Fuel Ratio = 1.2
Main Air Pressure [kPa]	2.4	3.0	1.9	2.1	1.8	at 1250°C
Max. Furnace Temp. [°C]	1300					
Temperature Control	Time Proportional On/Off Control					
Change-over Time [sec]	30					

2. Regenerative Gas Burners for Heat Treating Furnaces

Structure of Twin-type Regenerative Burners

Application example
Batch type forging furnace

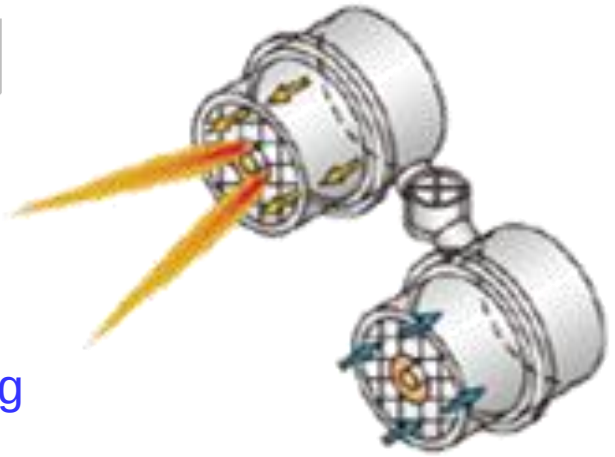




TREG test data
Combustion rate: 870kW

2. Regenerative Gas Burners for Heat Treating Furnaces

Specification of Insert-type Regenerative Burners



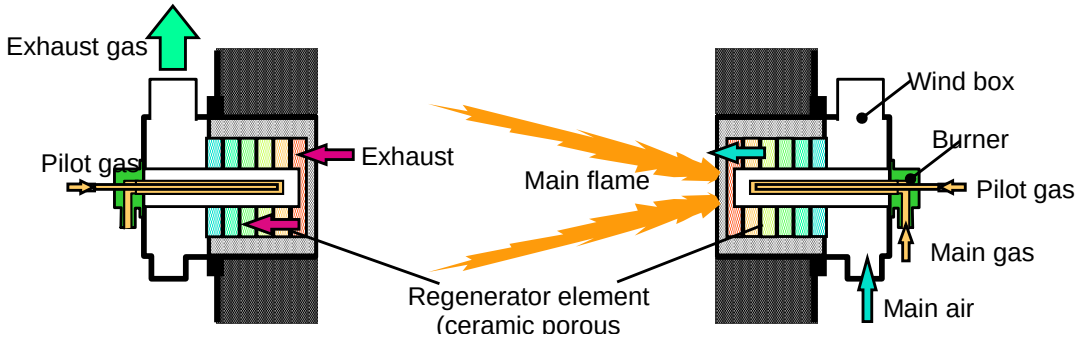
- ✓ For **directly-fired heat treating furnace**
- ✓ Inserting regenerator in a furnace wall portion
- ✓ Switching valves are specially developed for a simplification of piping
- ✓ Low NOx is achieved by dividing flame
- ✓ Energy saving rate is about 35% compared with the normal case

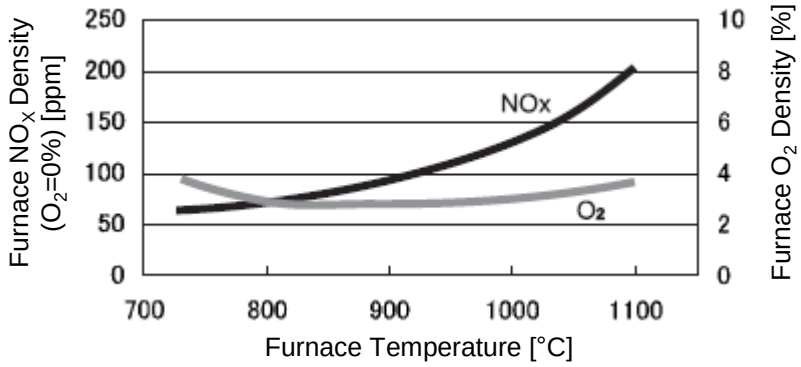
Model IREG-___K	50	100	Remarks
Fuel	Natural gas		
Firing Rate [kW]	58	116	
Pilot Burner Firing Rate [kW]	2	4	Pre-mixed / Continuously
Main Gas Fuel Pressure [kPa]	3.4	3.2	Air/Fuel Ratio = 1.2
Main Air Pressure [kPa]	0.37	0.54	at 1050°C
Max. Furnace Temp. [°C]	1100		
Temperature Control	Time Proportional On/Off Control		
Change-over Time [sec]	30		

2. Regenerative Gas Burners for Heat Treating Furnaces

Structure of Insert-type Regenerative Burners

Application example
Atmosphere gas metamorphic furnace

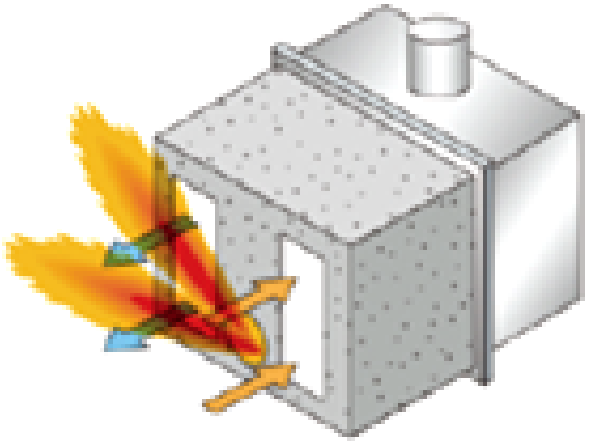




IREG Test Data
Combustion Rate: 116kW

2. Regenerative Gas Burners for Heat Treating Furnaces

Specification of Self Regenerative Burners



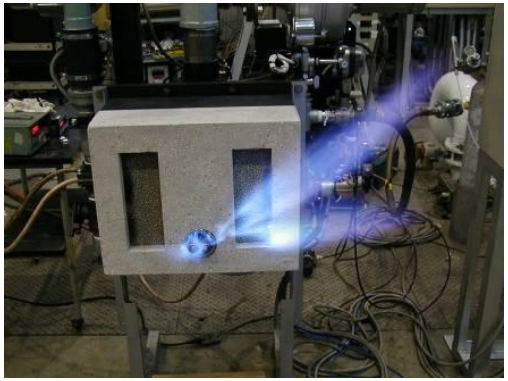
- ✓ For **cast-iron pot type non-ferrous metal melting furnace**
- ✓ Two burners are integrated into one unit
- ✓ Heat reservoirs are arranged in furnace wall portion
- ✓ The package-type furnace “EcoMelter” is developed
- ✓ Energy saving rate is about 35%

Model	SREG-100K-i	Remarks
Fuel	Natural gas	
Firing Rate [kW]	112	
Pilot Burner Firing Rate [kW]	11	Continuously
Main Gas Fuel Pressure [kPa]	1.6	Air/Fuel Ratio = 1.2
Main Air Pressure [kPa]	0.6	at 1000°C
Max. Furnace Temp. [°C]	1100	
Temperature Control	Time Proportional On/Off Control	
Change-over Time [sec]	30	
Auxiliary Air Pressure [MPa]	0.3	

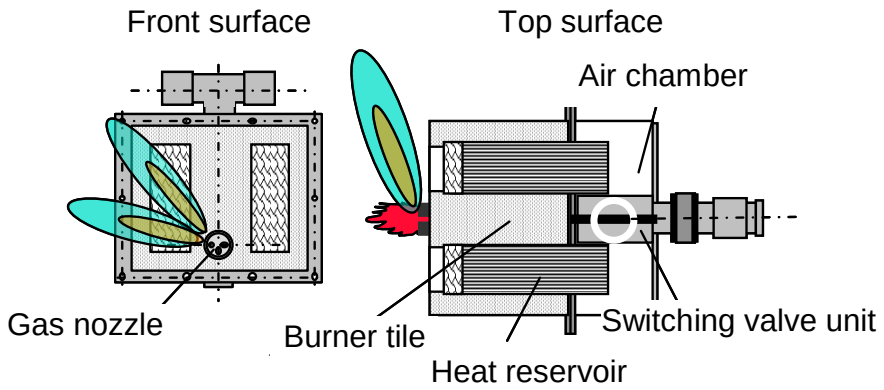
2. Regenerative Gas Burners for Heat Treating Furnaces

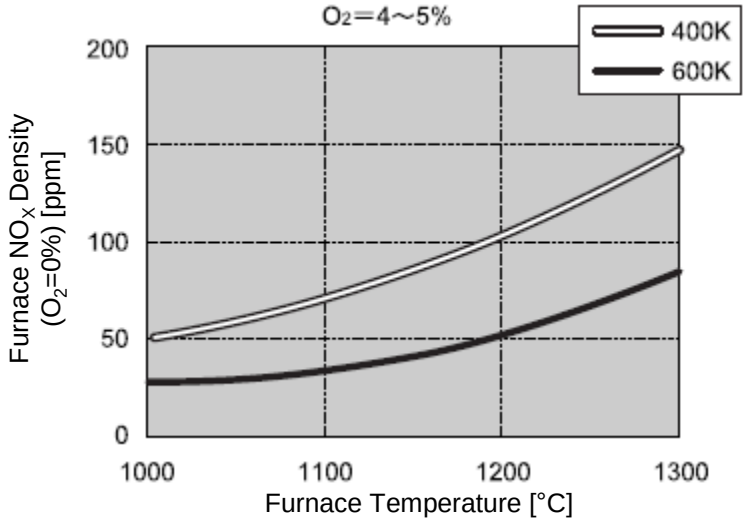
Structure of Self Regenerative Burners

Cast-iron pot type non-ferrous metal melting furnace



Flame shape of SREG





SREG Test Data
Combustion Rate: 400kW/600kW

2. Regenerative Gas Burners for Heat Treating Furnaces

Specification of Radiant Tube Regenerative Burners

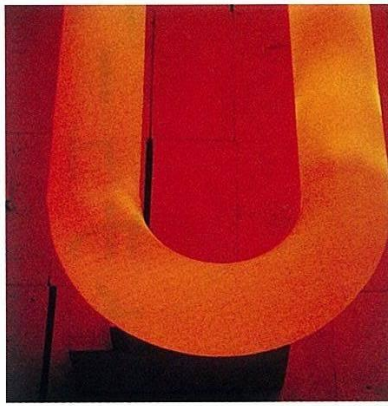
- ✓ For **indirectly-fired heat treating furnace**
- ✓ Uniform temperature distribution on radiant tube surface
- ✓ Exhaust gas recirculation technique makes low NO_X
- ✓ Energy saving rate is about 35%

Model RTR-___A	80	100	125	Remarks
Tube size [inch]	3	4	5	
Fuel	Natural gas			
Firing Rate [kW]	35	52	75	
Main Gas Fuel Pressure [kPa]	2.5	2.5	2.5	Air/Fuel Ratio = 1.2
Main Air Pressure [kPa]	2.0	2.5	2.5	Furnace Temp. = 950°C
Recommended tube length [m]	3.0	4.5	5.0	
Max. Furnace Temp. [°C]	950			
Temperature Control	Time Proportional On/Off Control			
Change-over Time [sec]	30			

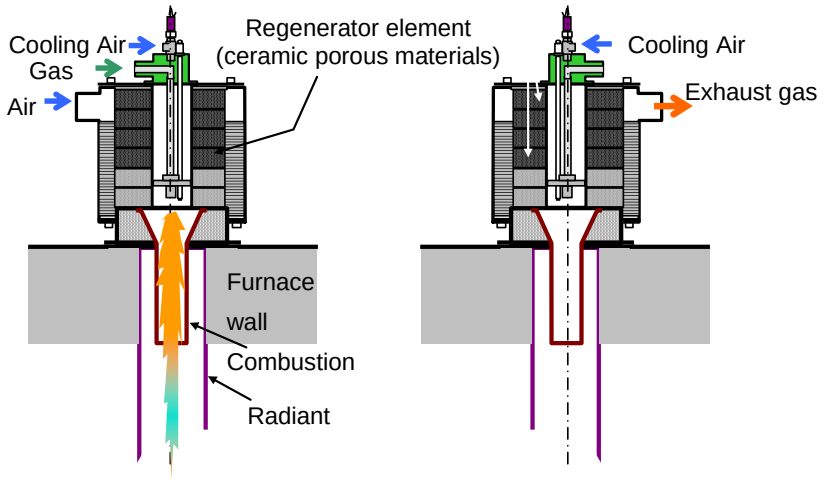
2. Regenerative Gas Burners for Heat Treating Furnaces

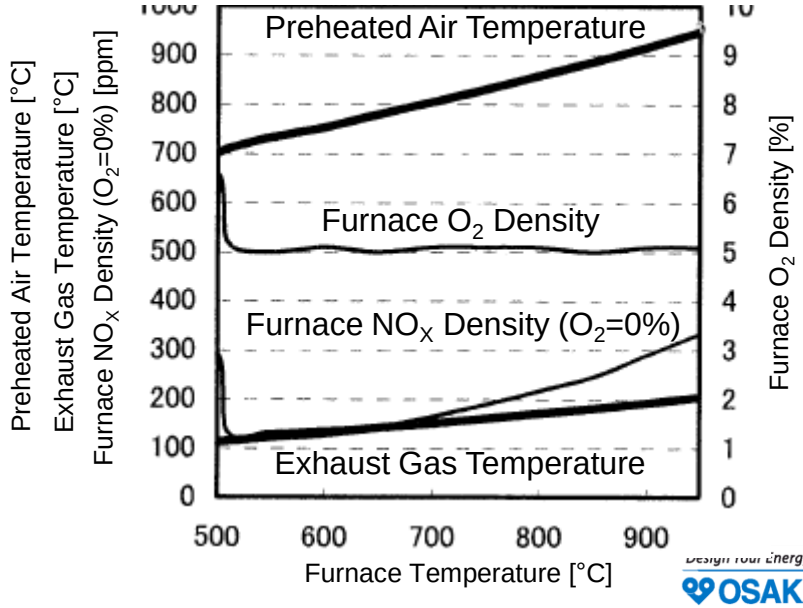
Structure of Radiant Tube Regenerative Burners

Application example
Batch type in-direct heat treating furnace



Radient tube

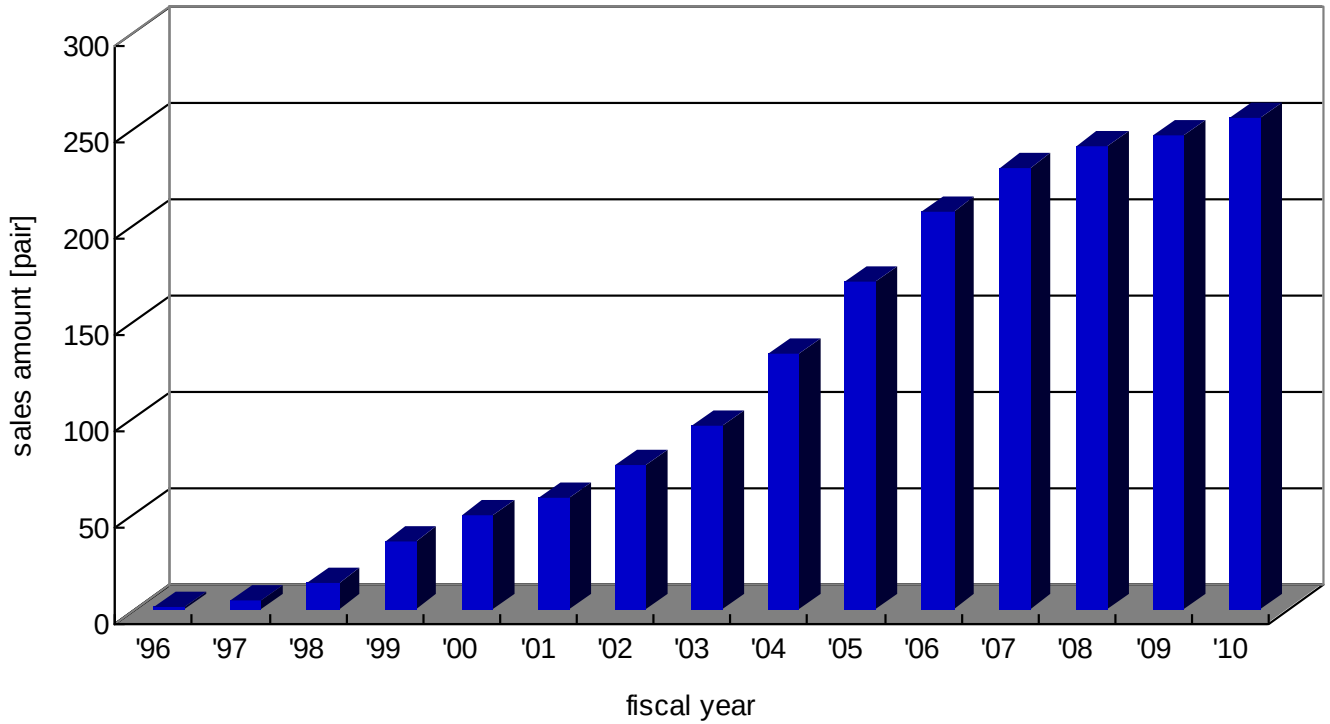




2. Regenerative Gas Burners for Heat Treating Furnaces

Achievement and Forecast

- ✓ 83 pairs of TREG burners have been installed to 56 furnaces
- ✓ 57 pairs of IREG burners have been installed to 32 furnaces
- ✓ 34 pairs of SREG-i burners equipped with “EcoMelter” have been installed
- ✓ 29 pairs of SREG burners have been installed to 25 furnaces
- ✓ 54 pairs of RTR burners have been installed to 17 furnaces
- ✓ Total rated combustion capacity : **74,720 kW** by the end of fiscal 2010 year



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Contents

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3. Gas Burners for Glass Melting Furnaces

Characteristics of Osaka Gas Burners

- ***R&D on burners***
  - ✓ Much energy consumption with technical problems when gas combustion
  - ✓ All burners developed and made-to-order
  - ✓ Optimum burners selected from 3 original gas burners (**50 patents**) and integrated into actual furnace
  - ✓ Activities for glass tank furnaces by having **largest-scale test furnace in Japan**

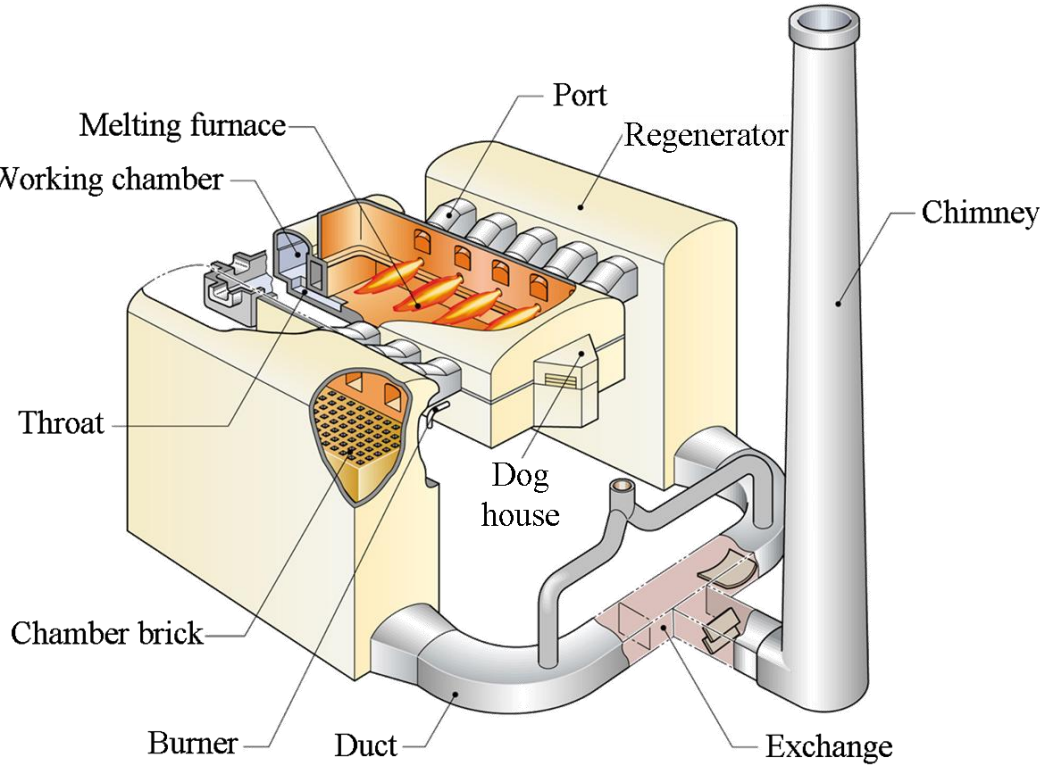
- ***Experience in fuel switching***
  - ✓ Achieving both **energy saving** and **low NO_X** combustion; clearing Japan's Air Pollution Control Law (**NO_X<450ppm** @O_2=15%)

3. Gas Burners for Glass Melting Furnaces

What is Glass Tank Furnace?

- Operating
  24 hours / 365 days
- Operating life
  5 to 10 years

- Products
  bottle, sheet glass, plate
- Gas Consumption Amount
  10 to 30 million m^3/year



In Japan,

Heavy oil is mainly used

Furnace conditions differ by customers

3. Gas Burners for Glass Melting Furnaces

Difficulties of Fuel Switching

Comparison of flame

<Oil combustion>

<Gas combustion>

Matter

I. Shortage of luminance

II. Increase of flame temperature

Phenomenon

I. Decrease of radiation heat transfer

II. Increase of NO_X

Lower the radiation heat transferring,
Lower the heating efficiency

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3. Gas Burners for Glass Melting Furnaces

Difficulties of Fuel Switching

Anticipated impacts by fuel switching to gas;

- ✓ Higher energy consumption, typically 3 to 7 %
- ✓ Higher regenerator temperature by 10 to 50 °C
- ✓ Lower temperature at firing side,
  thus lower temperature at reverse side
- ✓ Uniform temperature profile along flame
- ✓ Altered oxidation and reduction
- ✓ Lower heat transfer could limit the melting amount
  (especially in cross firing furnace)

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3. Gas Burners for Glass Melting Furnaces

Difficulties of Fuel Switching

Improvement technique of heat efficiency by gas burner

Concept of development

Q. How is the radiation heat transferring Q_g improved?

A. Increase of **flame luminosity** and **flame surface area** while controlling flame temperature rising

$$Q_g = 4.88 \times \varepsilon_g \times A_g \times (T_g / 100)^4$$

- ε_g 2. Flame luminosity
- A_g 1. Flame surface area
- T_g Flame temperature

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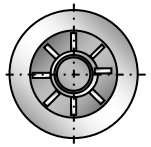
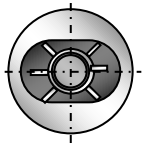
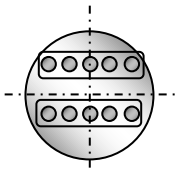
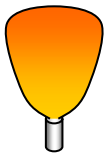
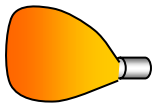
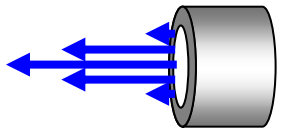
3. Gas Burners for Glass Melting Furnaces

Line-up of Burners

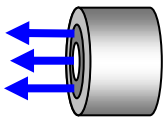
Burner Type	Burner Shape	Flame Shape from above	Flame Shape from side	Characteristic
Round Hole Double Jet (DJ)	 Patented			**Long and narrow** Ordinary oil burner
Elliptical Hole Double Jet (DJ)	 Patented			**Rather short and broad** in horizontal direction
Flat Flame	 Applied for patent			**Short and broad** in horizontal and vertical directions

- Conventional gas burner



Flow rate is high at center

- Osaka Gas DJ burner

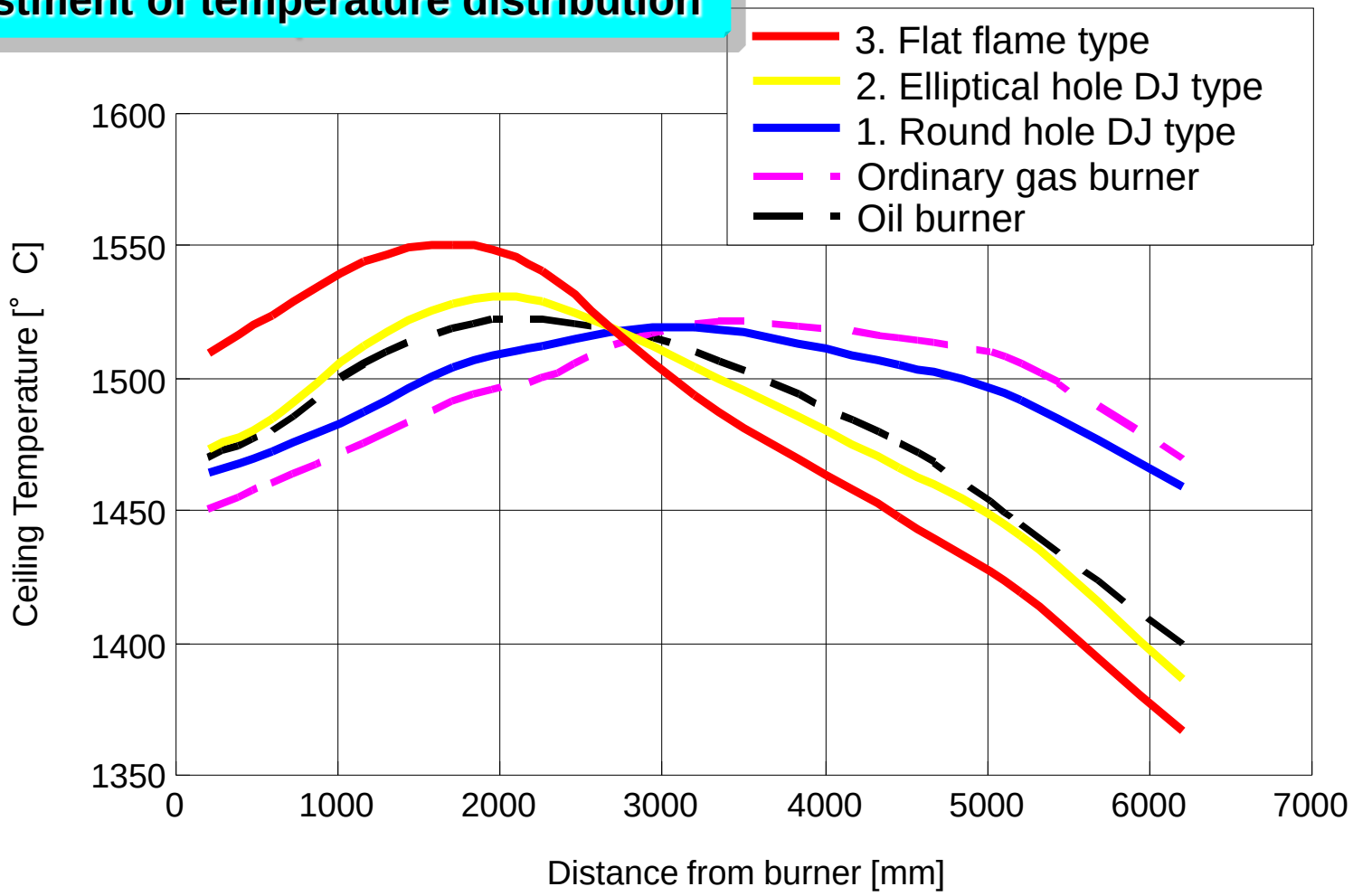


Uniform flow rate

- ✓ Development of 3 types burners with adjustment of flame shape for various furnace shapes
- ✓ High luminosity and low NO_X is achieved by uniform and slow flow rate that generate soot

3. Gas Burners for Glass Melting Furnaces

Adjustment of temperature distribution



Various temperature profiles are possible

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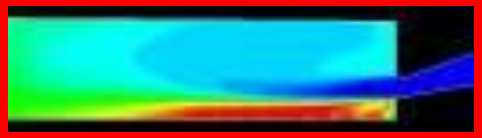
3. Gas Burners for Glass Melting Furnaces

Development of Gas Burners for Glass Melting Furnaces

Improvement of furnace temperature distribution
(Evaluation by Software)

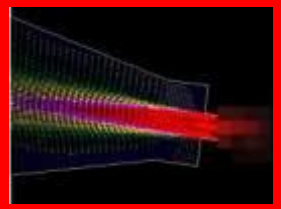
- ✓ Flame shape optimization
- ✓ Furnace shape simulation



- ✓ Oxygen combustion simulation

Port shape optimization design
(Evaluation by Software)

- ✓ Port shape optimization simulation
- ✓ Burner placement and tile optimization

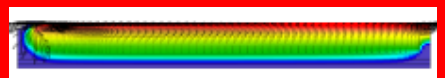


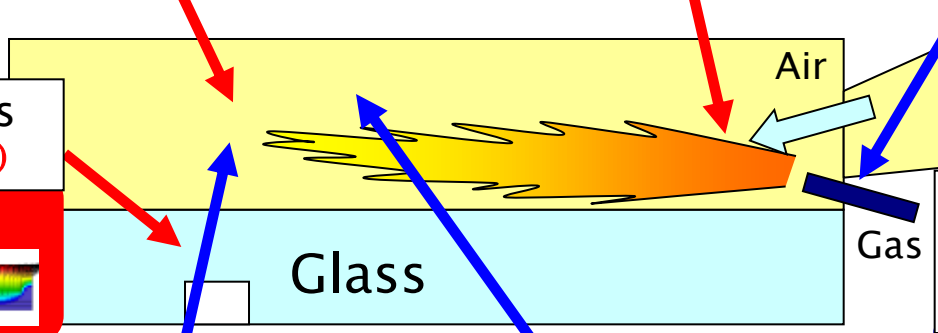
Burner engineering development
(Evaluation by Hardware)

- ✓ Nozzle structure
- ✓ Energy saving
- ✓ Port shape

Glass flow analysis
(Evaluation by Software)

- ✓ Flow simulation





Environment improvement technology
(Evaluation by Hardware)

- ✓ Improvement in combustion (low NO_X combustion)
- ✓ Reburning

Furnace diagnosis
(Evaluation by Hardware)

- ✓ Energy saving of furnace

Furnace shape optimization design
(Evaluation by Hardware)

- ✓ Optimization of combustion space

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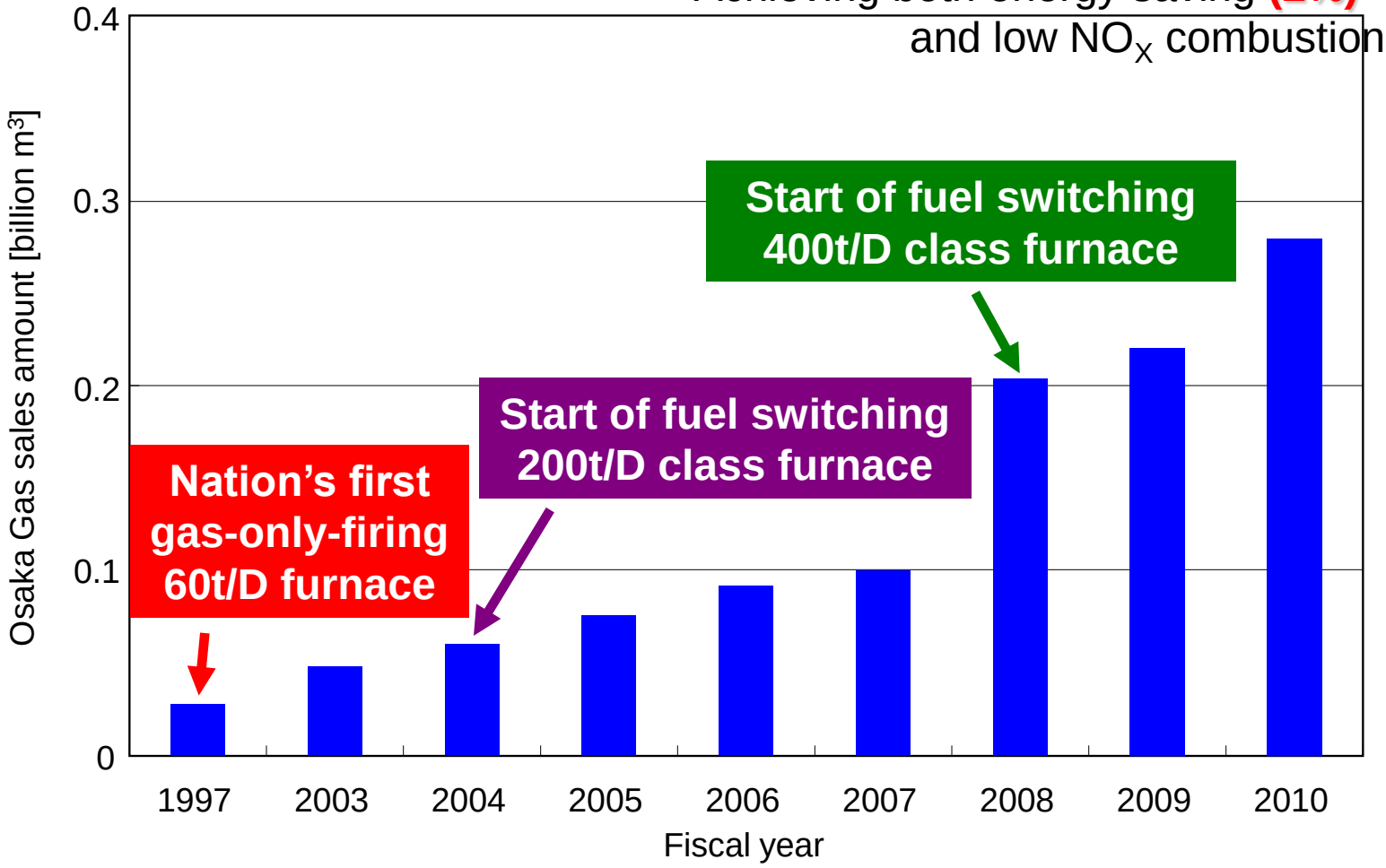
3. Gas Burners for Glass Melting Furnaces

Achievement and Forecast

31 furnaces switched from oil to gas
Achieving both energy saving **(2%)**
and low NO_X combustion **(10%)**



Osaka Gas market share has reached to 70% by the end of 2010 fiscal year.

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4. Low NO_X Burner for Textile

Development of Ultra Low NOx Burner

Especially for
"Gas Direct Heating Tumbler Dryer"

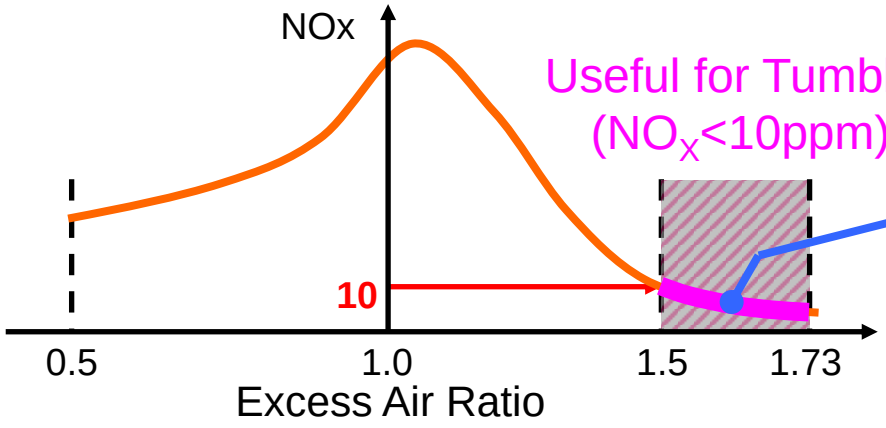
Premix High-turndown Low NO_X Burner (PHL)

- ✓ Perfect combustion at lean premix gas
- ✓ Ultra low NO_X : NO_X<10ppm (O_2=0%)
- ✓ Prevent textile from discoloring of anthraquinone dyestuff

  Anthraquinone dyestuff in textile is discolored to yellowish by chemical reaction with NO_2.
- ✓ Possible to apply to gas direct heating tumbler dryer

  Gas direct heating contributes to energy saving and high productivity.

NO_X characteristic of premixed combustion



Hardly burning

1. Heat temp. is low; not stable combustion.
2. Unburnt matter is come out.

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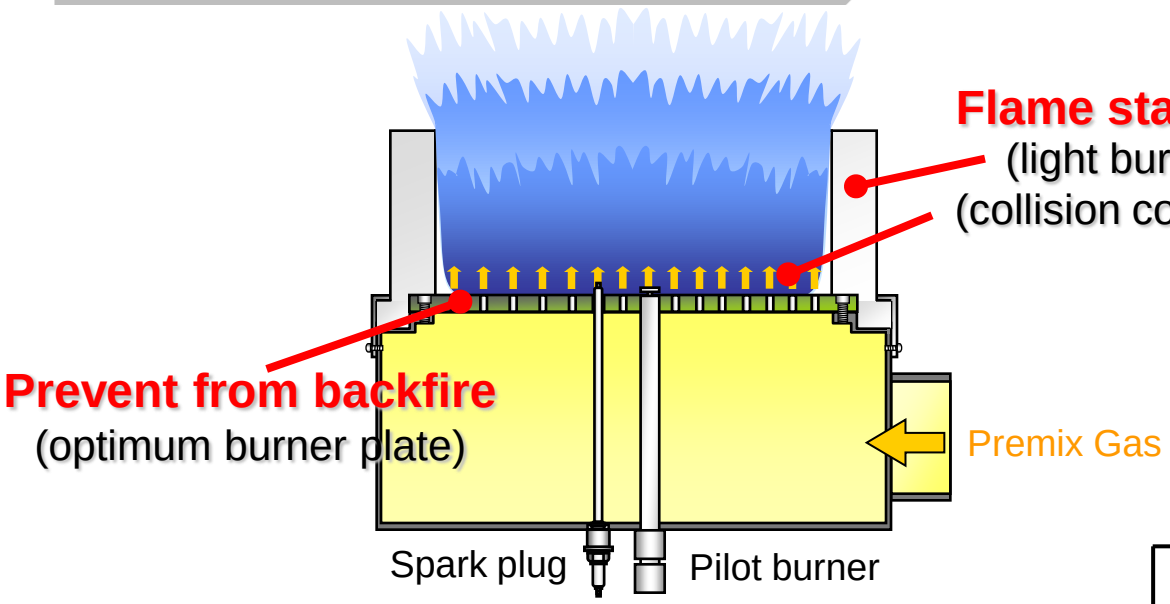
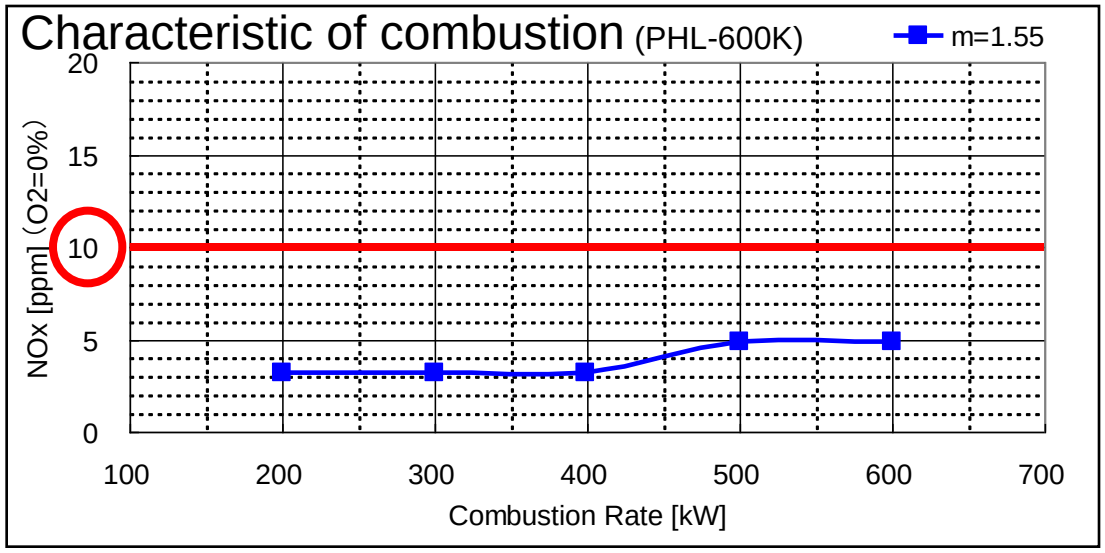
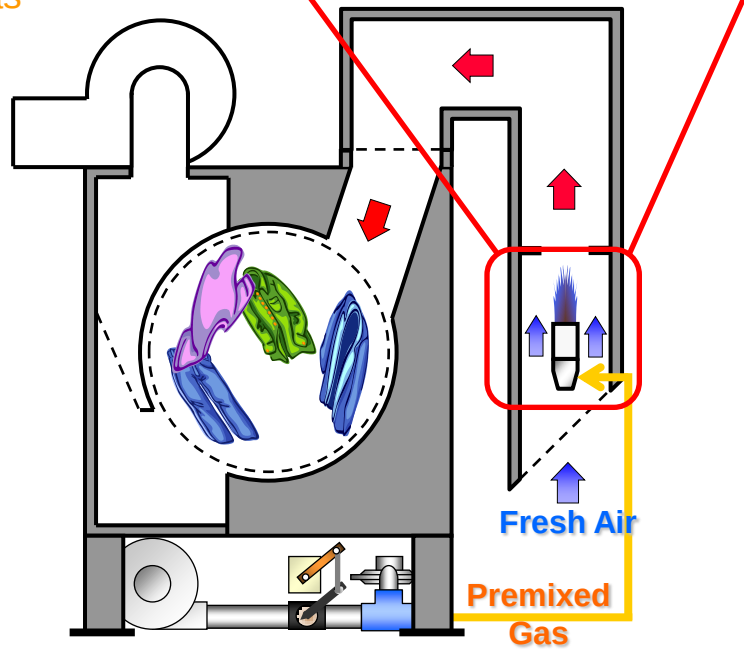
4. Low NO_X Burner for Textile

Characteristics of PHL Burner







Gas direct heating tumbler dryer

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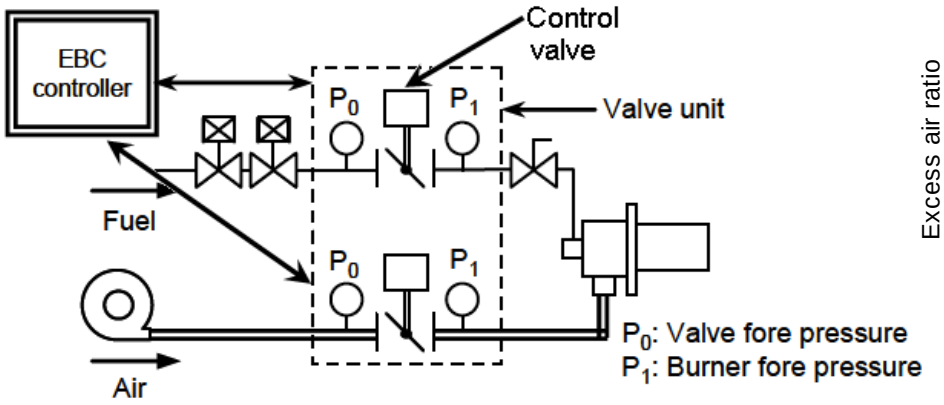
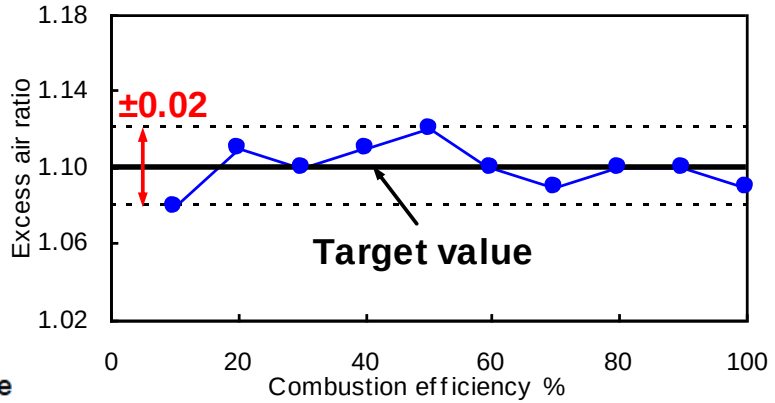
5. Other Applications

Development of Controlling System - Easy Burner Controlling System -

- ***High precision air control system***

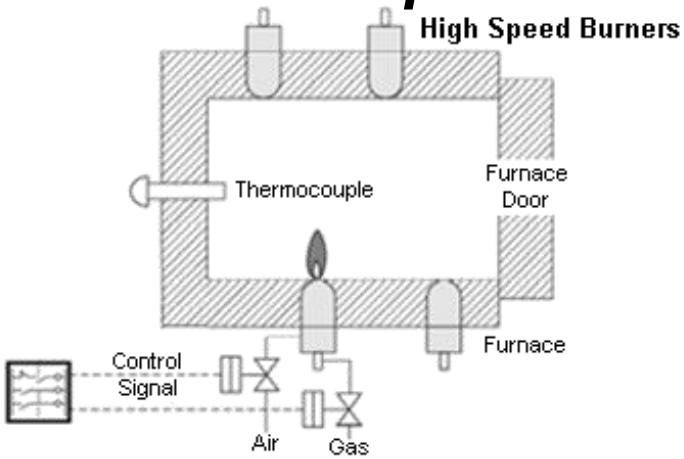


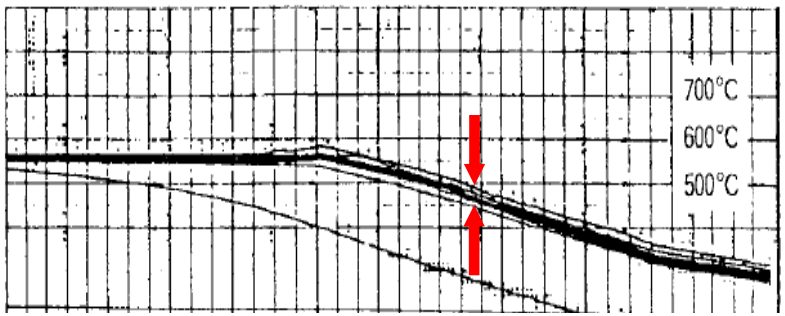


* Test conditions: Combustion efficiency: 10 to 100% (T.D.R.: 1:10)

Development of Controlling System - Impulse Burn System (IBS)-

- ***Uniform temperature distribution***





Temperature distribution with IBS

±12°C

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Conclusion

- ***Development of Regenerative Burners***
  - ✓Contributing to energy saving in medium and small size heat treating furnaces
- ***Development of Gas Burners for Glass Tank Furnaces***
  - ✓Achieving development of gas burners with equivalent flame luminance to oil burners and environmentally-enhancing
- ***Development of Ultra Low NO_X Burner***
  - ✓Contributing to production quality
- ***Development of Controlling Systems***
  - ✓Contributing to production efficiency and laborsaving

Osaka Gas will increase lineup of high efficient burners and expand the technology such as O_2 combustion.

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THANK YOU

FOR YOUR ATTENTION.