Design Your Energy 夢ある明日を
OSAKA GAS

Development of ***the high-efficient and low NOx Recuperative burner*** for industrial heating furnaces

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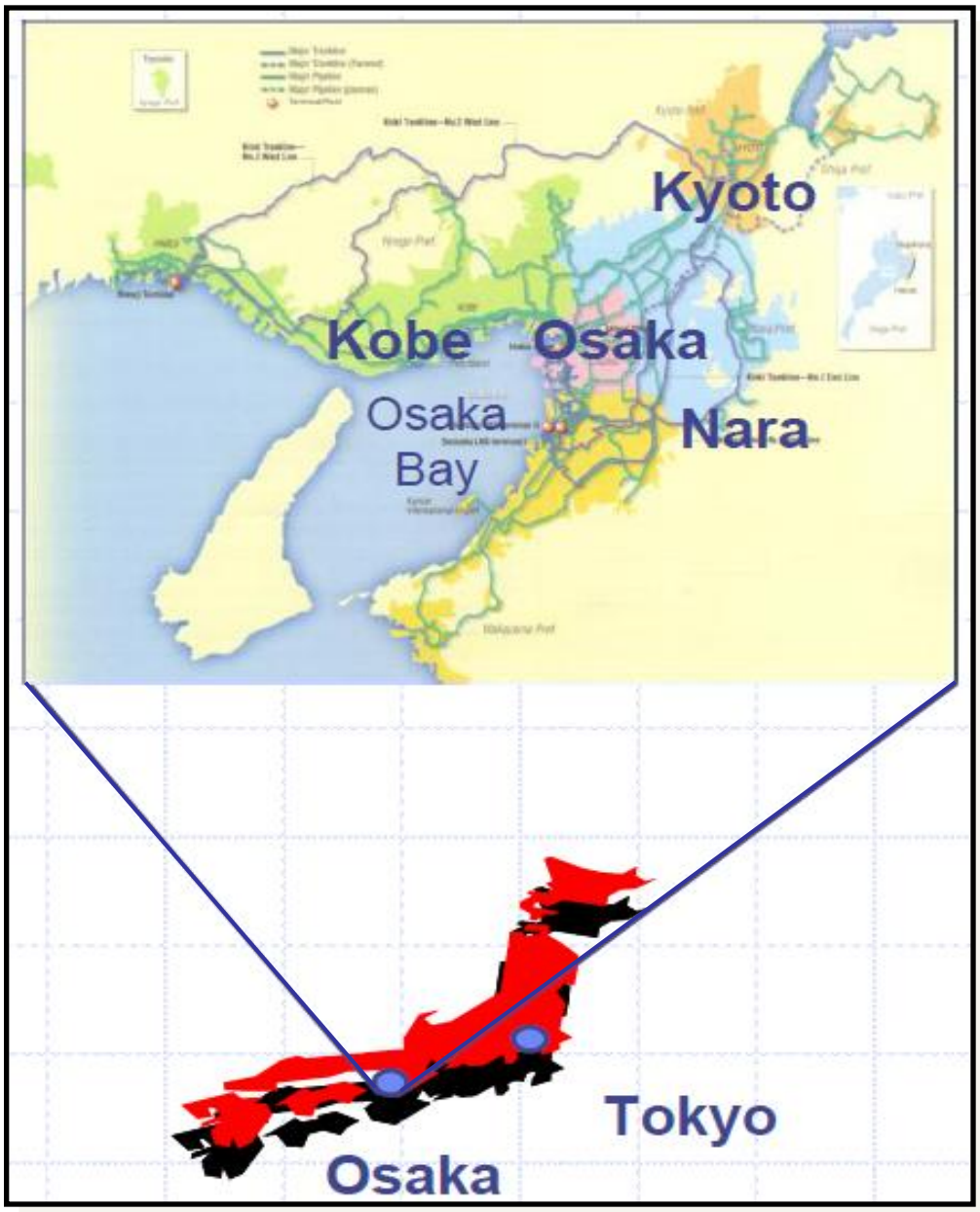


- ✓ Started business operations in **1905**
- ✓ Managing **60,000km** pipeline network
- ✓ Serving **7 million** natural gas customers

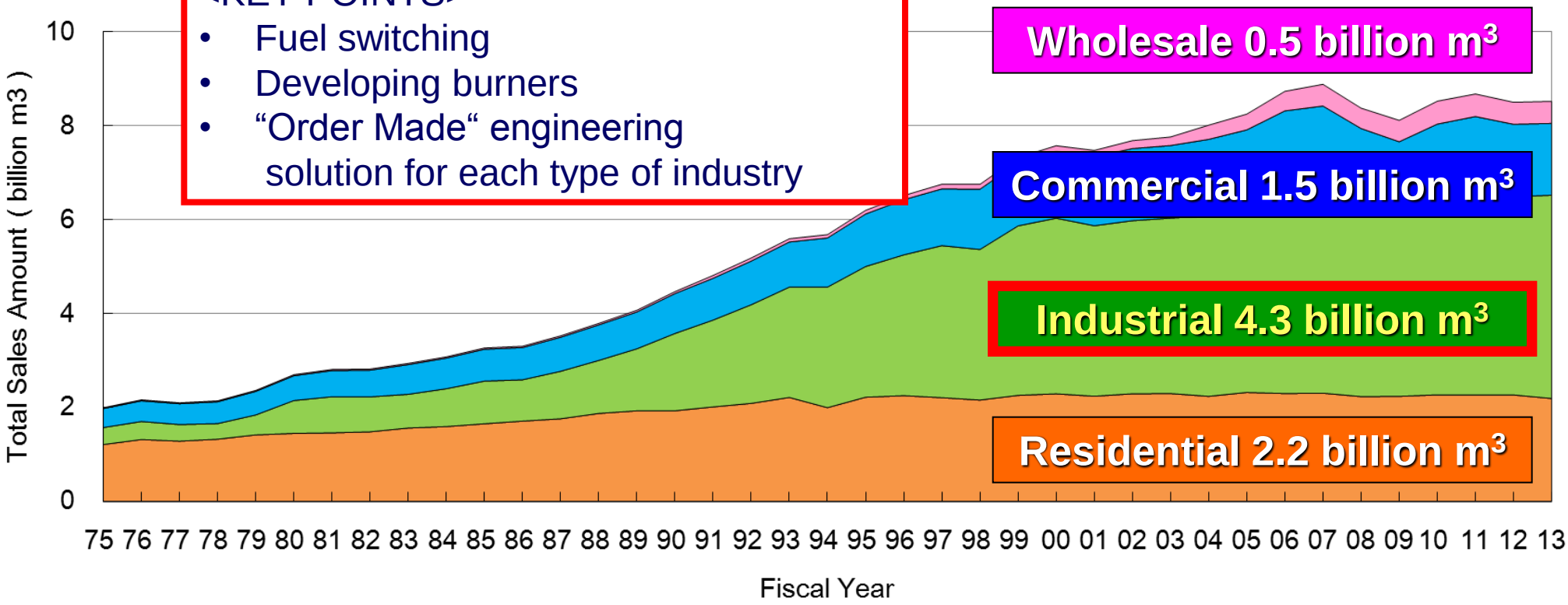
(**25%** of all gas sold in Japan)

1. About Osakagas

Osaka Gas Total Sales Amount

- ✓ Reaching **8.5 billion m³** by the end of 2013 fiscal year
- ✓ **Half** of sales : **Industrial** uses

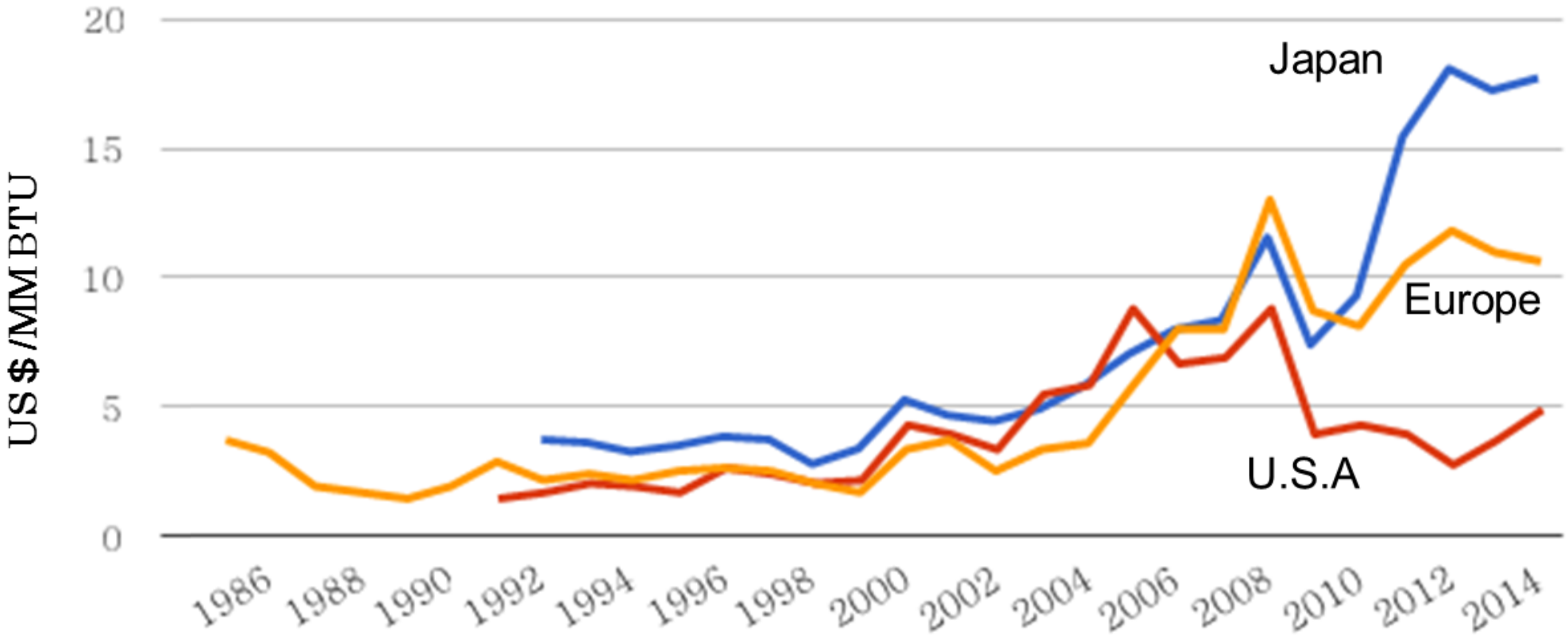
<KEY POINTS>
- Fuel switching
- Developing burners
- "Order Made" engineering solution for each type of industry



1. About Osakagas

Transition of the import price of natural gas

- ✓ **High price** compared with Europe and U.S.A
- ✓ Need of the high efficiency burners and the energy saving engineering



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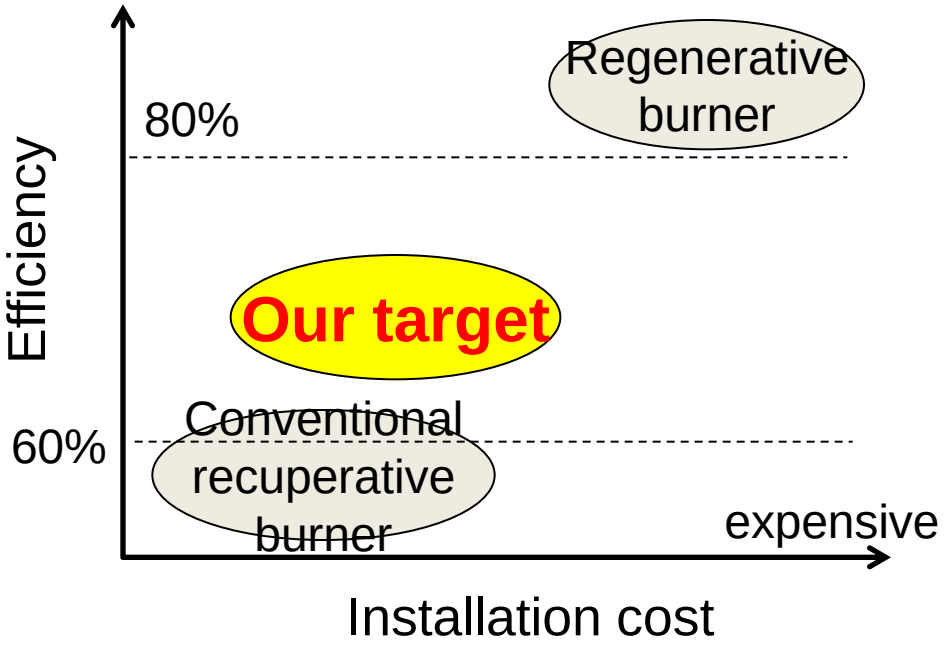
2. Recuperative burner

Purpose of development

- ✓ High efficiency
- ✓ Simple structure
- ✓ Low installation cost
- ✓ Small size



Target industrial furnaces

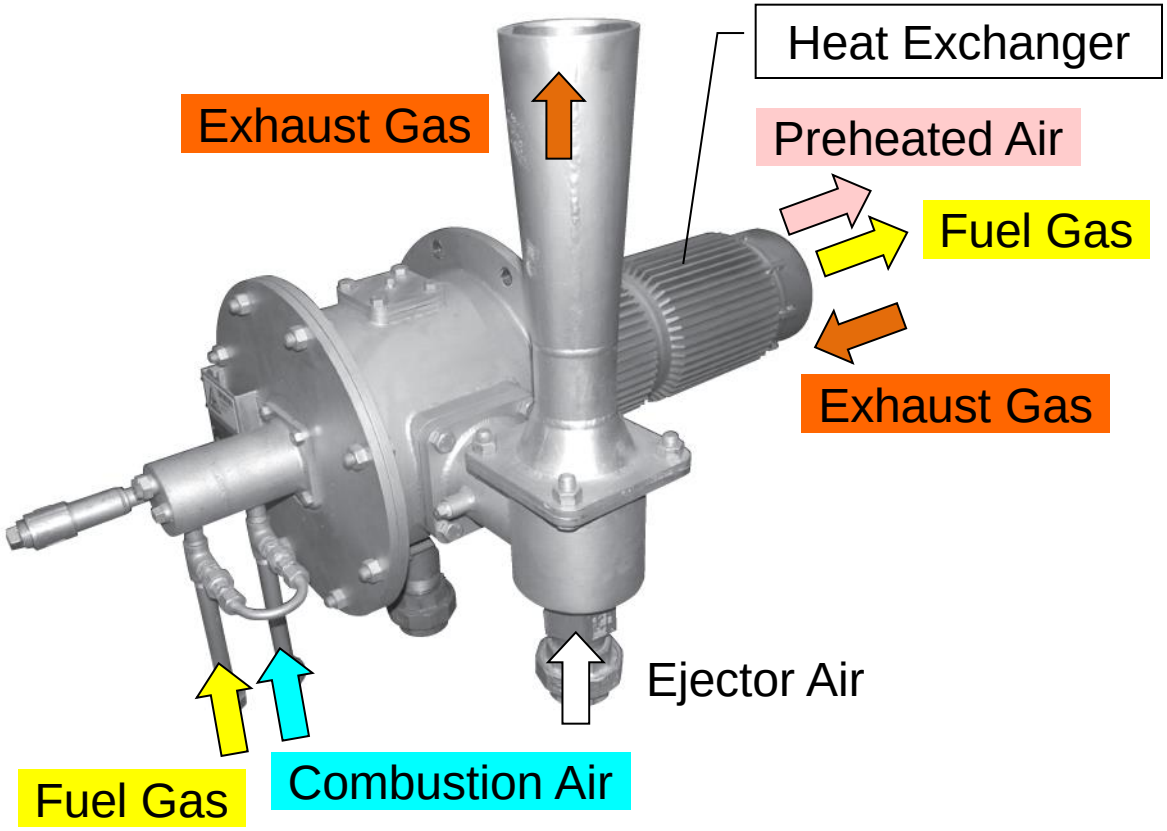
- ✓ Metal annealing furnace
- ✓ Aluminum melting furnace
- ✓ Heat treating furnace

Example of the industrial furnace

2. Recuperative burner

Appearance of the Recuperative burner

- ✓ Fin type heat exchanger made by casting
- ✓ Simple structure

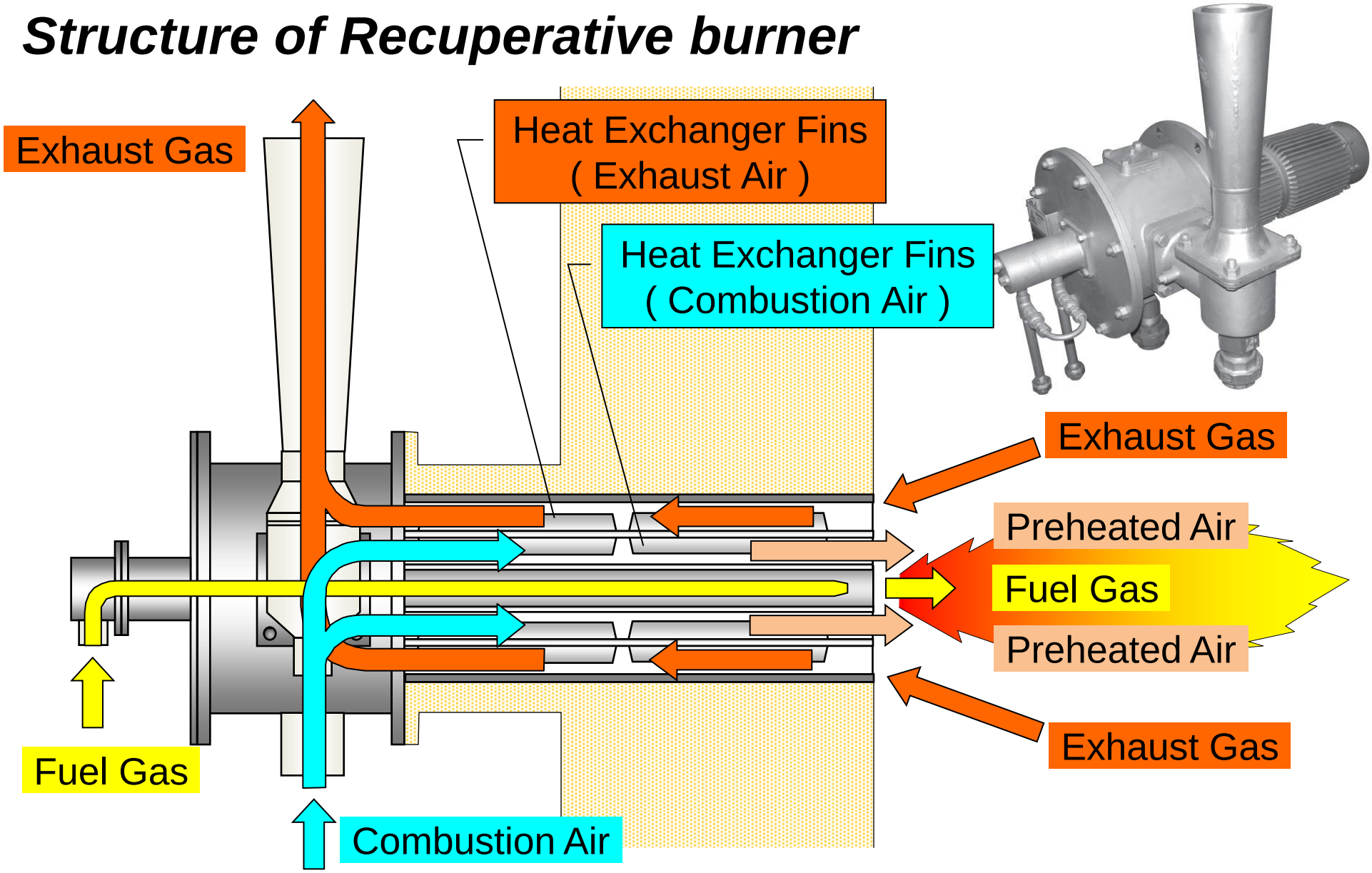


Appearance of burner

Top of Heat Exchanger

2. Recuperative burner

Structure of Recuperative burner



2. Recuperative burner

Performance target

✓ High efficiency

- Preheated air temperature over 500℃
- Efficiency is 68%

✓ Small size and low pressure loss

- A compact heat exchanger is inserted in a furnace wall.
- The complicated piping is unnecessary.
- Exhaust gas pressure loss is about 200Pa.

✓ Low NOx emission

- 100ppm (O_2 = 0%, Furnace temperature = 1,000℃)

✓ High speed preheated air

- Preheated air speed is about 80m/s.
- Temperature distribution in a furnace is good.

2. Recuperative burner

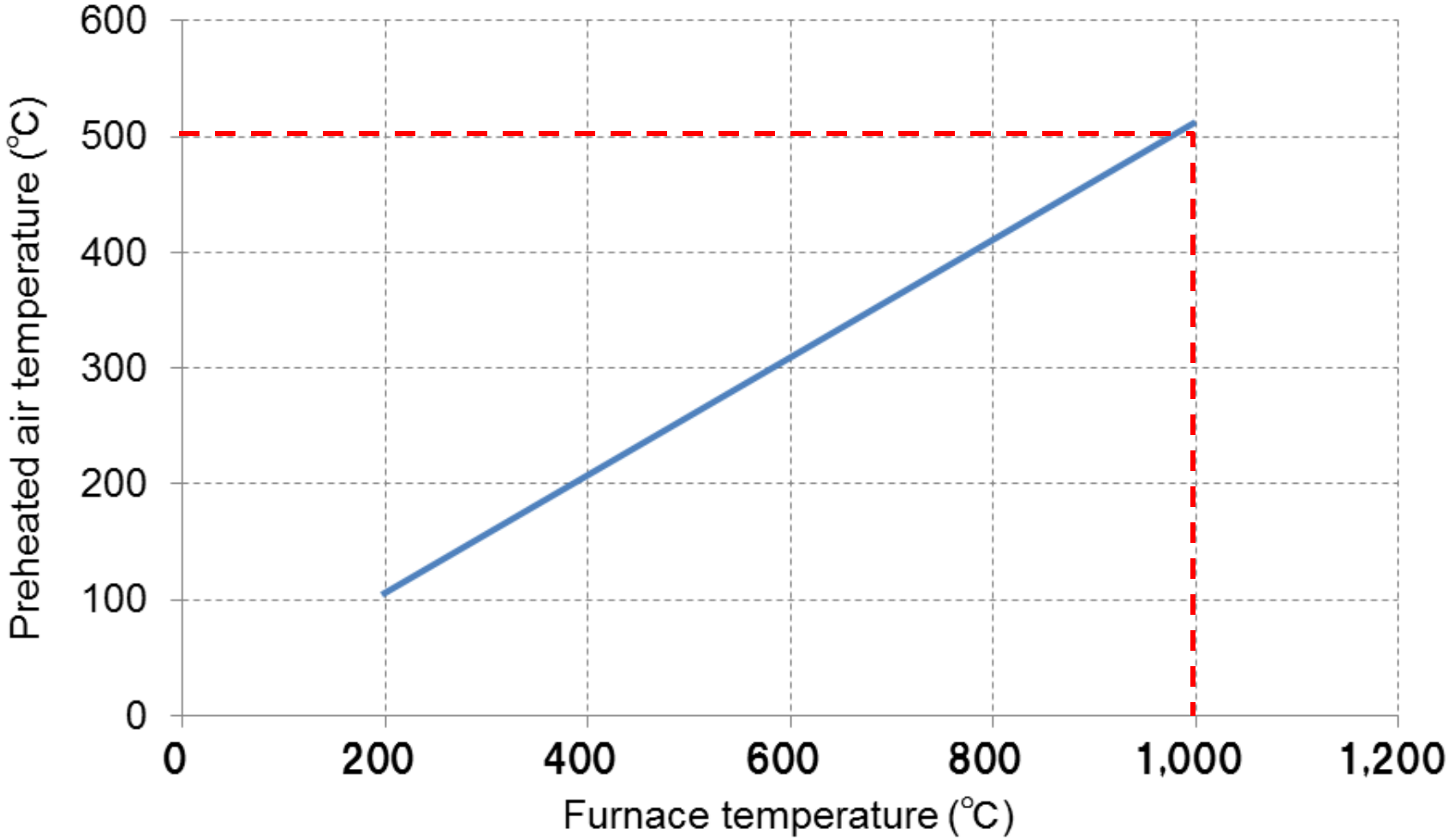
Specifications

Target		Performance	
Input		145kW	58kW
The highest furnace temperature	1,000℃	1,000℃	
Hot air temperature	500℃	508℃	509℃
Efficiency	68%	69%	69%
NOx (O_2=0%)	100ppm	84ppm	86ppm
Exhaust gas pressure loss	Exhaust fan unnecessary	Ejector use is possible (about 200Pa)	
Main air volume		151m^3*N*	61m^3*N*
Premix air volume		6m^3*N*	5m^3*N*
Ejector air volume		151m^3*N*	40m^3*N*

2. Recuperative burner

Preheated air temperature

✓ Achievement of temperature target



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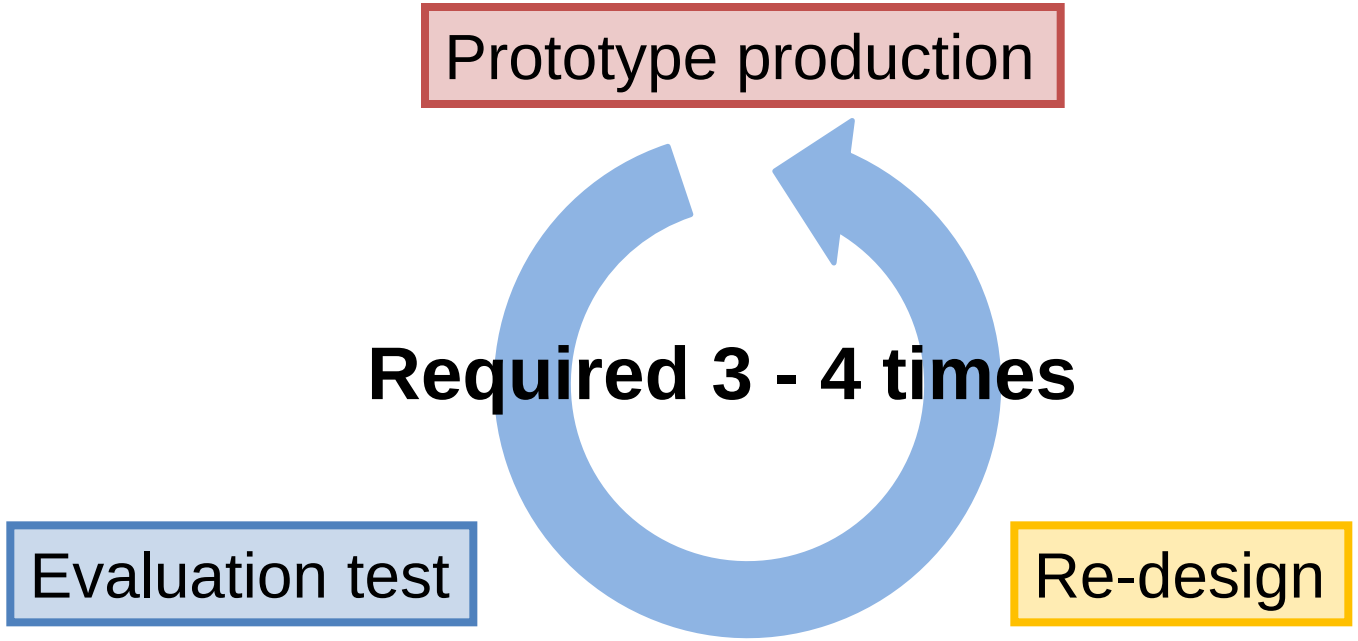
3. Simulation technology

The conventional method

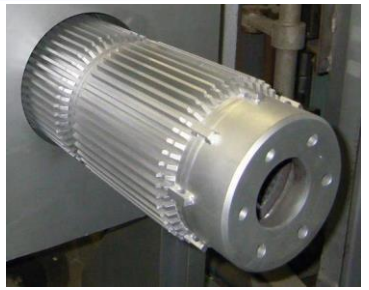
✓ Prototype production, test, prototype production, test, - - -



Apply a simulation technology

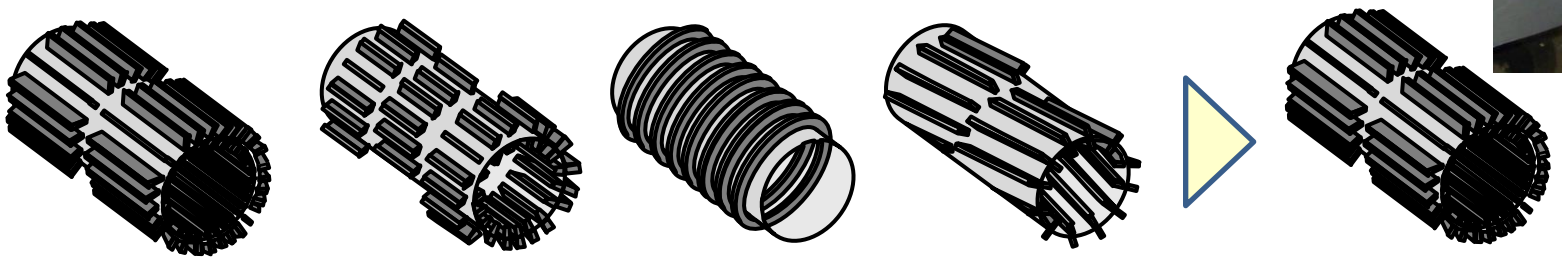
✓ To reduce the development cycle

3. Simulation technology



Our simulation utilization procedure

① Choose one type from candidate shapes



② Performance evaluation by simulation
(size, temperature, pressure drop)

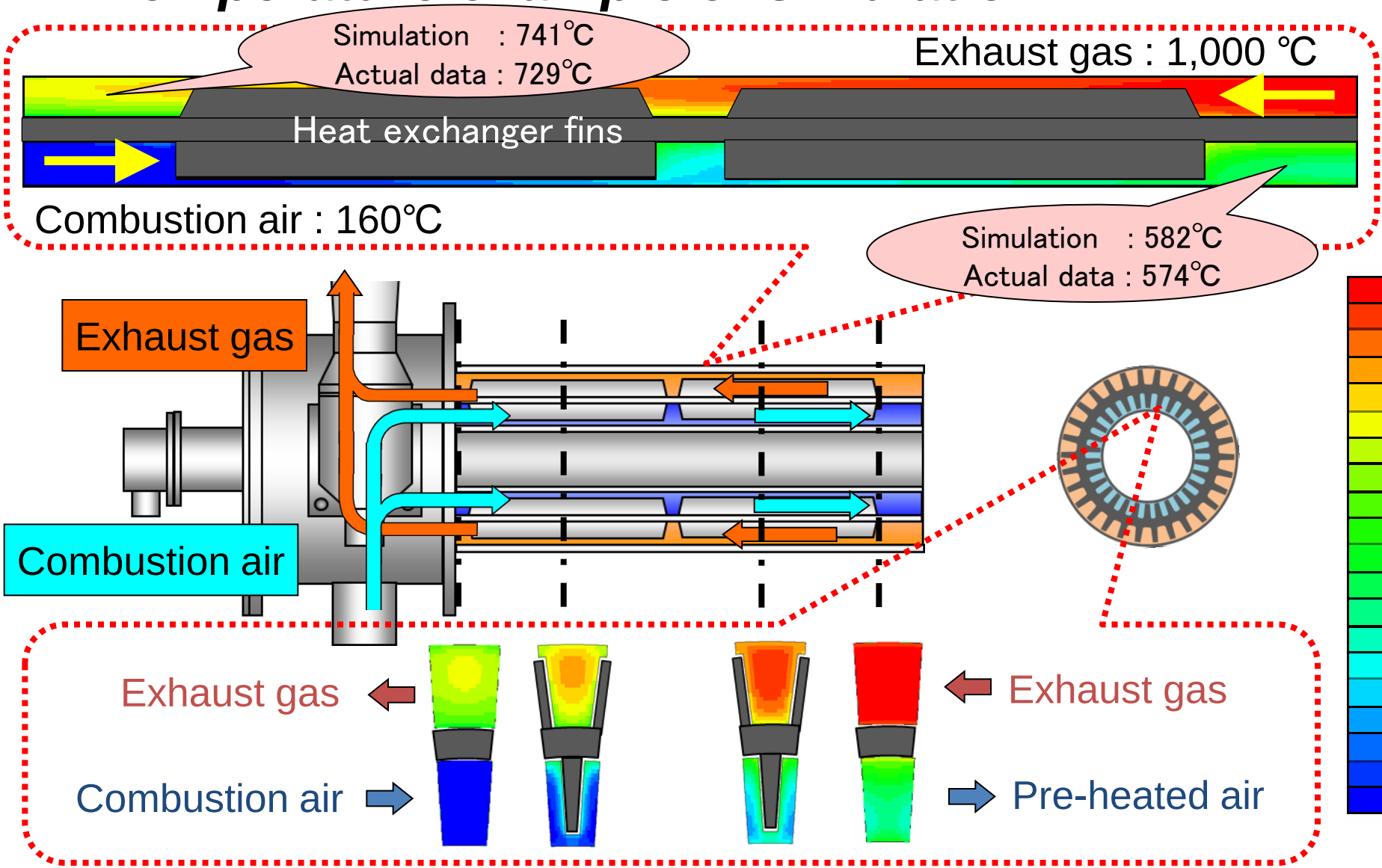
③ Prototype production and actual performance evaluation

④ Reflect test data to simulation

⑤ Determination of shape and size

3. Simulation technology

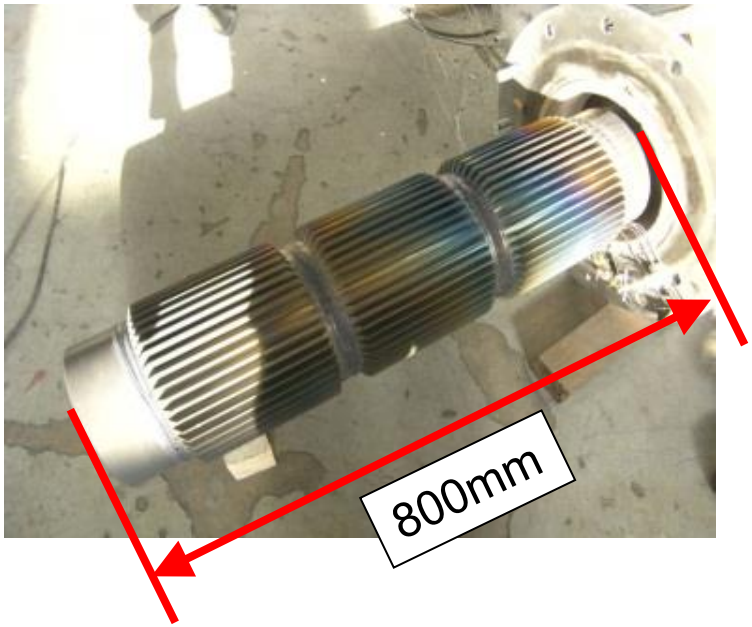
Temperature example of simulation



3. Simulation technology

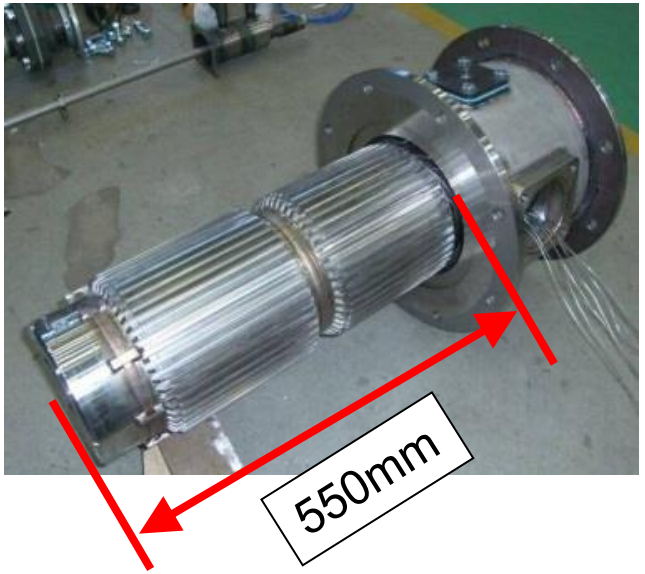
Effect of the simulation

- ✓ Optimization of the shape
- ✓ Reduction of the prototype production times



Initial shape

length about 2/3
(same diameter)



Final shape

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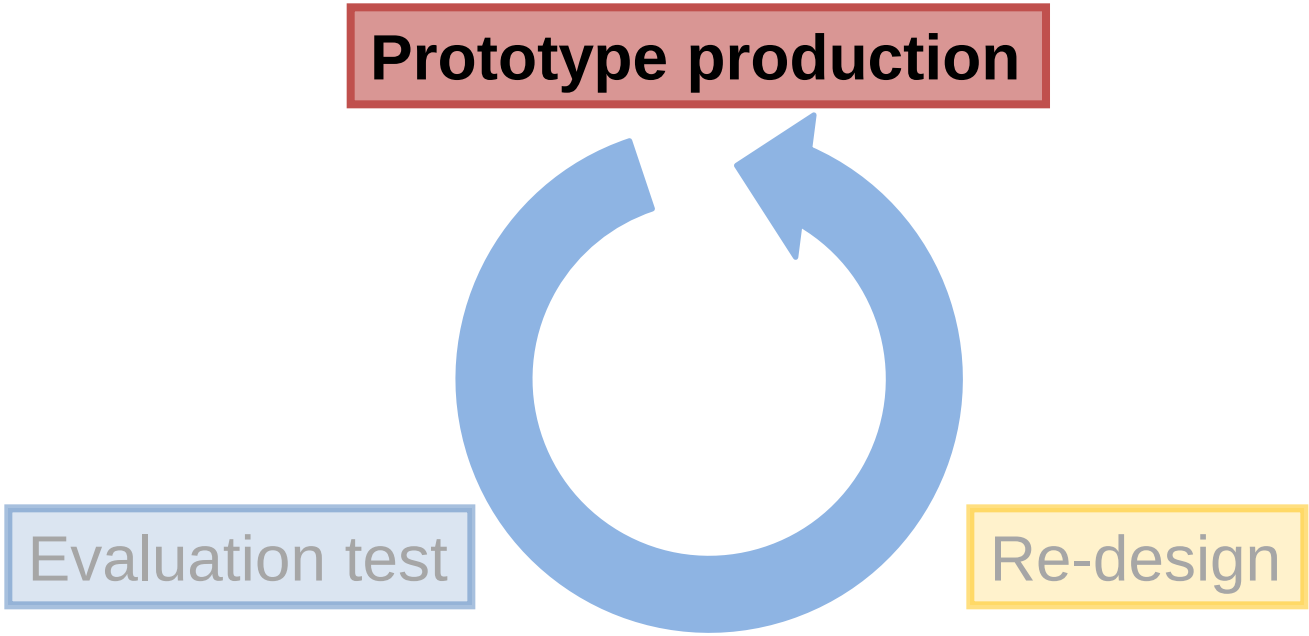
4. 3D printing

Prototype production

(Reduction of times of prototype production by simulation)

✓Production problem : A lot of time and costs



The conventional method (Prototype heat exchanger)

✓ Metal cutting

✓ Short term, but high cost

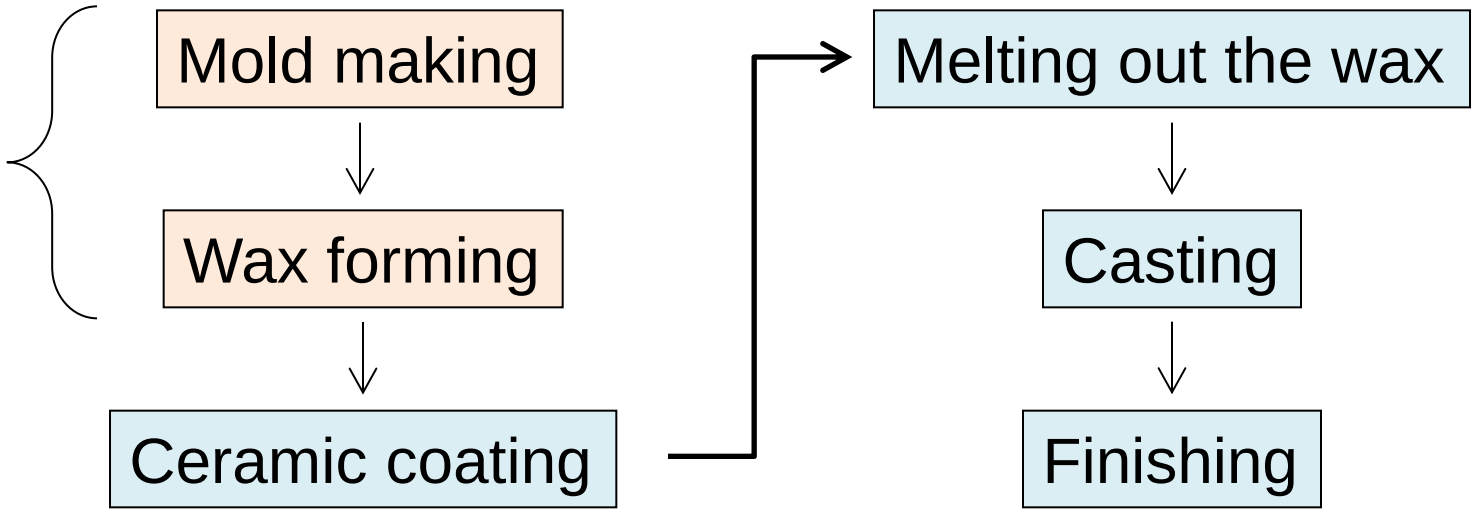
4. 3D printing

- ***New method "3D printing"***
  - ✓ To cut down period and cost of prototype heat exchanger
  - ✓ Making the resin model of lost-wax casting

Heat exchanger

- ***Utilization method (at lost-wax casting)***
  - ✓ Wax forming by 3D printing

3D printing
(resin model)



Lost-wax casting flow

4. 3D printing

The Result by 3D printing

Method	Casting (Use of resin model by 3D printing)	Casting (Use of metallic mold)	Metal cutting
Production period	3 weeks	12 weeks	8 weeks
Price	$8,000	$10,000	$40,000
Feature	Complicated form Size restriction	Metallic mold Mass production	Conventional method

Lost wax model by 3D printing (resin)

Product from lost wax casting

Contents

5. Conclusion

New technology

	Conventional development method	145kW	58kW
Simulation	-	✓	✓
3D printing	-	-	✓
Prototype times	3 times	2 times	1 time
Development period	3 years	2 years	1 year
Prototype production cost	Base (Metal cutting)	33% down (Metal cutting)	80% down (3D printing)

5. Conclusion

Recuperative burner

	Conventional recuperative burner	145kW	58kW
Efficiency	62%	69%	69%
Preheated air temperature	350℃	508℃	509℃
Suction the exhaust gas	Ejector or Exhaust fan	Ejector	Ejector

Thank you for your attention.