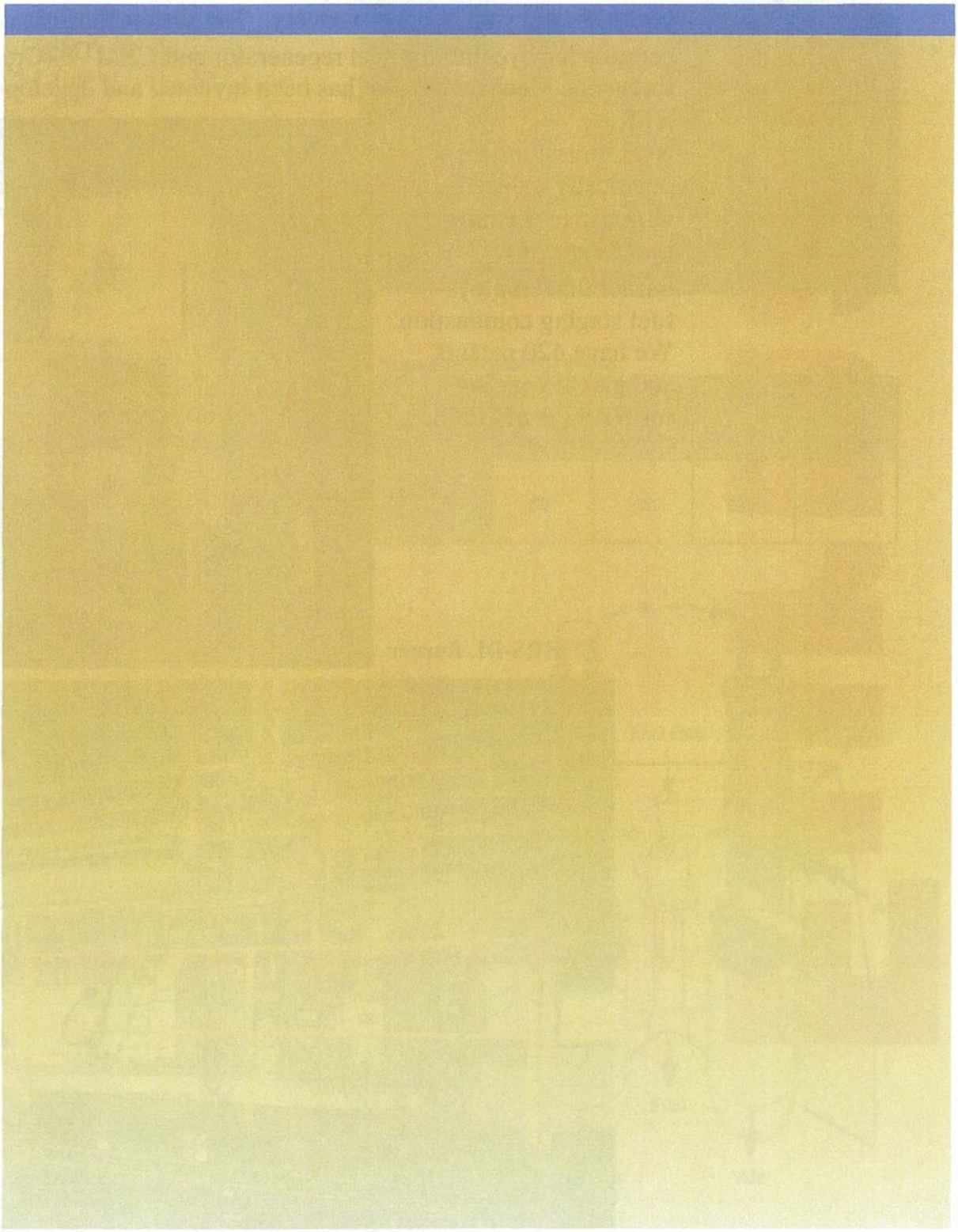
The most Advanced Energy Conservation Technologies

NFK-HRS Combustion System

(High-cycle Regenerative combustion System)



Furnace

NFK® Nippon Furnace Co., Ltd.

Furnace

The most Advanced Technologies Global Environment

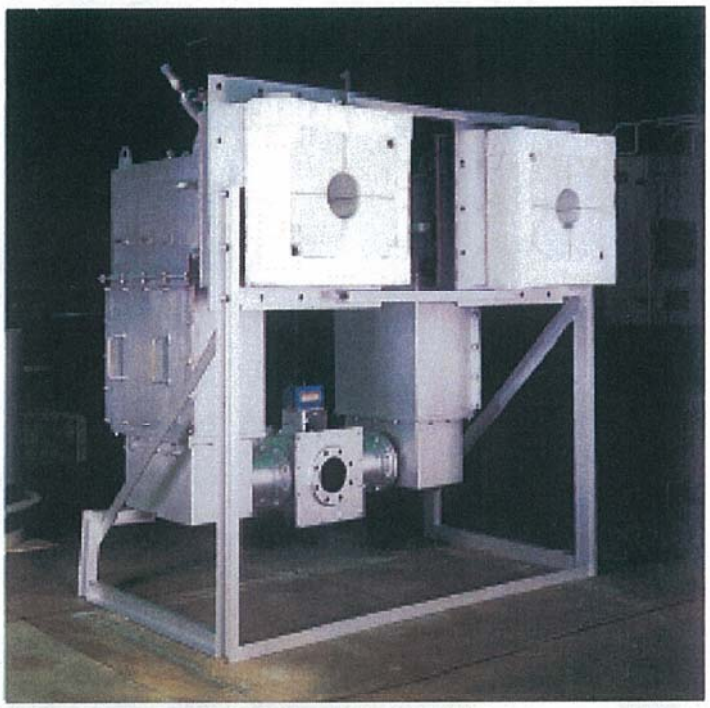
NFK-HRS ™ COMBUSTION SYSTEM

(High-cycle Regenerative combustion System)

Preface

NFK-HRS combustion system achieves the outstanding fuel saving by means of ultra high pre-heated air combustion and high efficiency waste heat recovery. The system consists of ceramic honeycomb for heat regenerator and CEM™ (Cross Exchange Mechanism) that has been invented and developed by NFK.

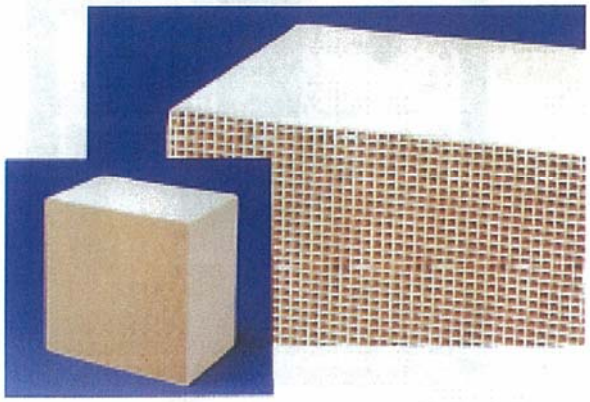
NOx emissions are drastically reduced with use of the ultra low NOx (ULN™) burner that employs fuel staging combustion. We have 420 patents and patent pending for HRS (as of 2002).



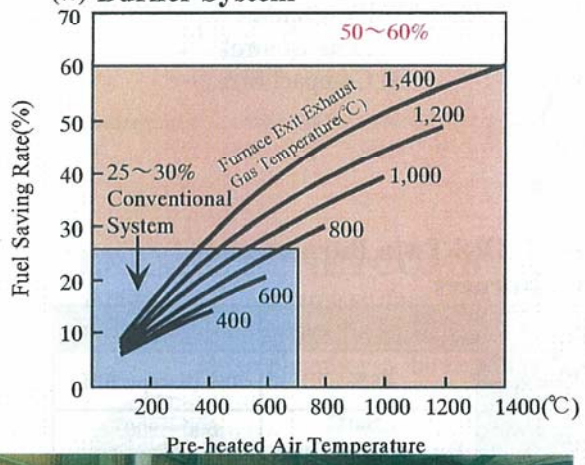
HRS-DL Burner

Roller Hearth Type Heat Treatment Furnace 5 t/h
Daiichi Netushori Steel Co., Ltd. Muroran, Hokkaido

Ceramics Honeycomb Regenerator



Fuel Saving Rate of NFK-HRS Burner System

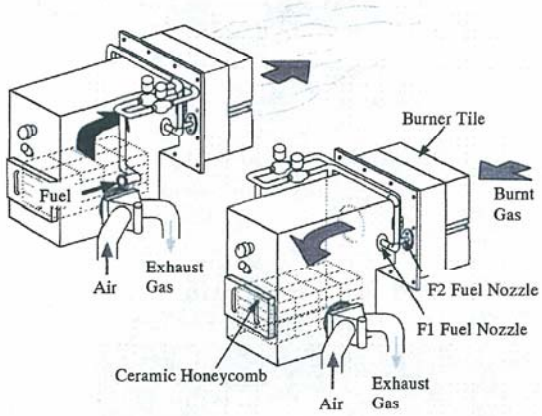


• Epoch-making High Efficiency Energy Conservation Technology

NFK will be able to provide the following three types of basis systems in order to comply with various furnace structures, temperature conditions, heating materials and heating processes:

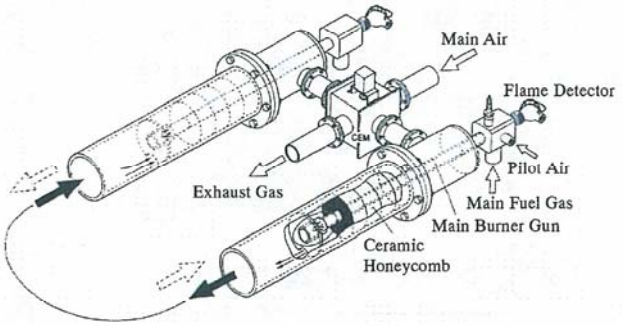
1. HRS DL Burner System

(Patent & Patent Pending: 85)



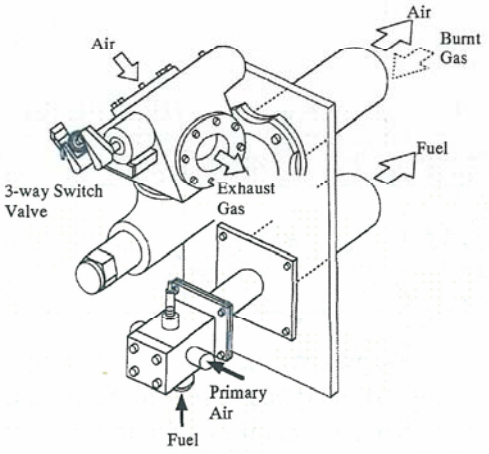
2. HRS-Radiant Tube Burner System

(Patent & Patent Pending: 20)

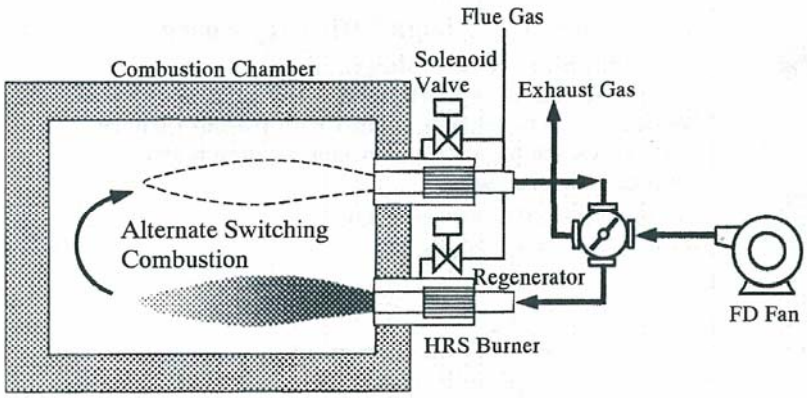


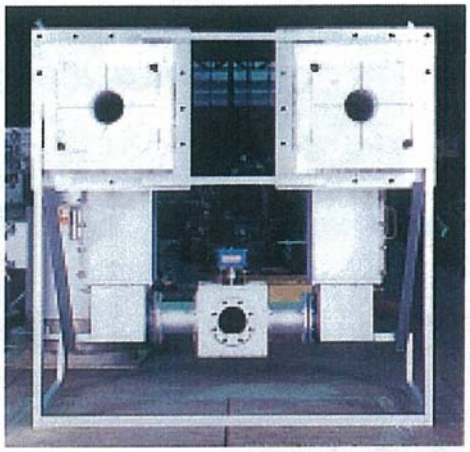
3. HRS U1/Ux Burner System

(Patent & Patent Pending: 3)

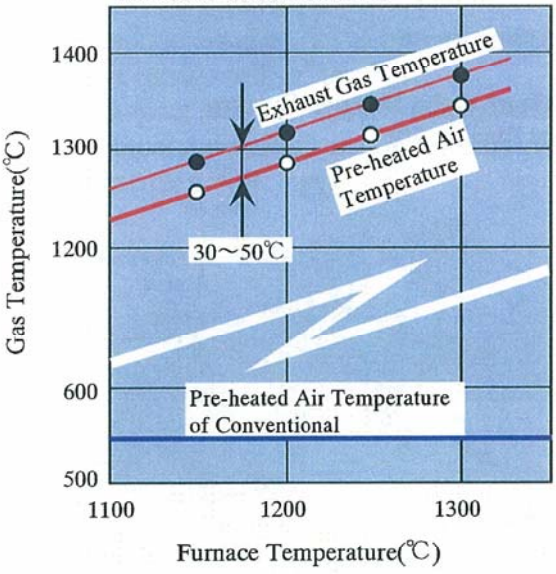


HRS DIRECT FIRING BURNER SYSTEM





Pre-heated Air Temperature of HRS Twin Burner



· System Advantages

1) Small & Simple Structure
2) Temperature efficiency: more than 90%
3) NOx:less than 60ppm(O_2 11%)

· Application Advantages

1) Uniform Temperature Distribution
2) Zone Control
3) Compact Size

Comparison of HRS Twin Burners and Competitor's Burners

	HRS Twin Burner	Competitor's Burner
1.Waste Heat Recovery	85 %	70% (Escape 20%)
2. Preheated Air Temperature	>1,200℃ Furnace temperature 1,300℃	800~900℃ Furnace temperature 1,300℃
3. NOx	<60ppm*	———
4. Pressure Loss	<3.0kPa	>3.0 kPa
5. Compactness	Ceramics honeycomb (Volume:1)	Ceramics ball (Volume:5)
6. Switching Methods	4-way, 3-way & Single valves	Single vales

*Furnace temperature is less than 1350℃ without fuel nitrogen

Standard Specification of HRS-DL (Fuel: LNG, Furnace temperature: 1,300 ℃)

Item / Spec	DL2	DL2.5	DL3	DL4	DL4.5	DL5	DL6	DL7	DL8	DL9
Capacity (kW)	150	340	605	1360	1815	2420	3060	3780	4570	5440

· Application

Various types reheating furnaces, heat treatment furnaces, casting and forging furnaces, ceramics firing furnaces and ladle preheaters.

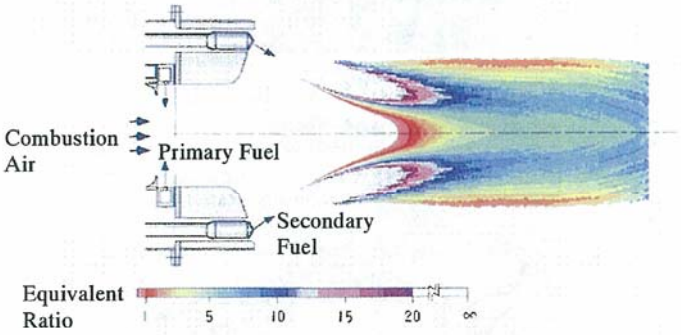
HARDWARE

HRS combustion system basically consists of three major hardwares such as burner, regenerator and switching device

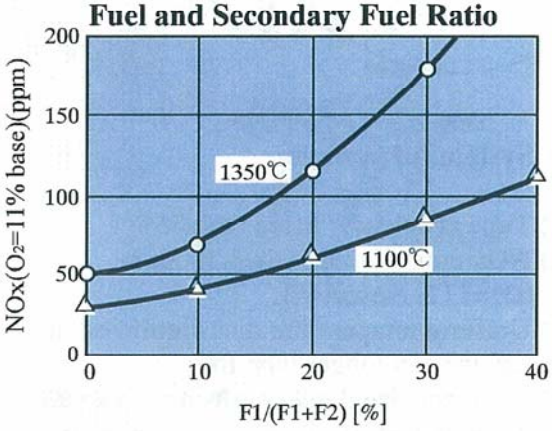
• BURNER (Patent & Patent Pending - 19)

Advantages: 1) Protection of coking and burning damages with use of outer fuel gun.
2) NOx emissions are drastically reduced with fuel staging concept developed by NFK.
3) Stable combustion and low NOx combustion for high, medium and low temperature furnaces.

Fuel Staging Low NOx Burner

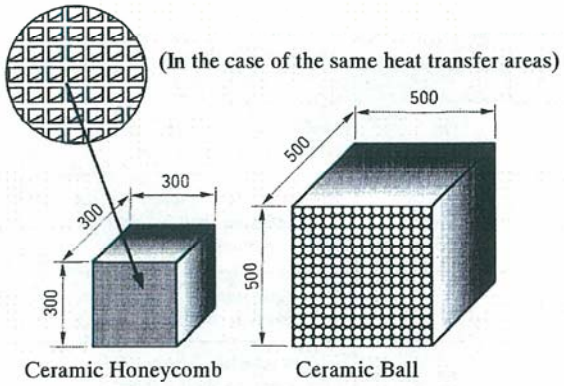


NOx Emission Versus Primary Fuel and Secondary Fuel Ratio



• CERAMIC HONEYCOMB (Patent & Patent Pending - 16)

Advantages: 1) Very large surface areas for the compact size of regenerator
2) Low flow resistance and low pressure drop due to honeycomb structures
3) No plugging in the regenerator because of straight through and reciprocal flow



Comparison of Ceramic Honeycomb and Ceramic Ball

(In the case of the same volume of regenerator)

Item / Media	Temperature efficiency	Pressure loss rate	Surface area	Weight rate	Plugging
Ceramic Honeycomb	90% level	1	5	1	No
Ceramics Ball	75% level	4	1	10	Yes

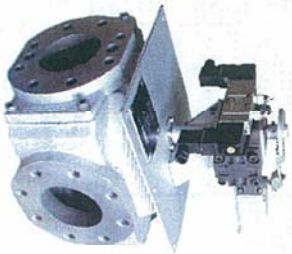
• CEM™

(CROSS EXCHANGE MECHANISM)

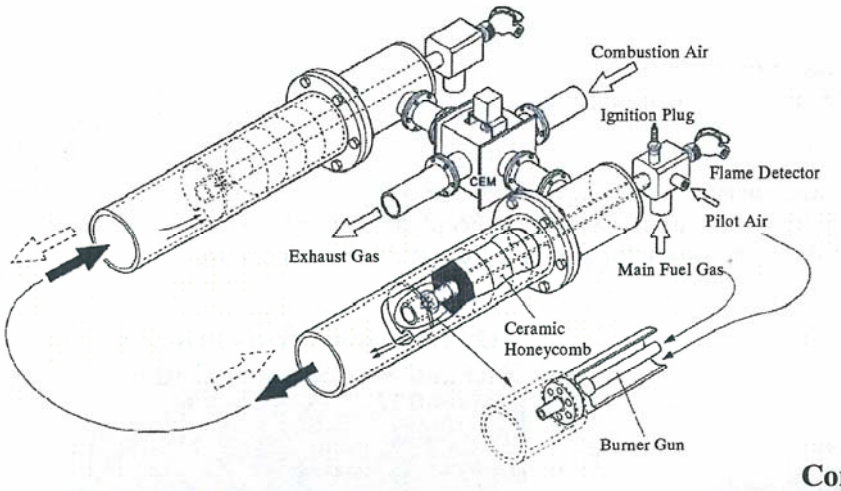
(Patent & Patent Pending - 8)

Advantages: 1) 4-way Switching Device (CEM) is adopted.
It is far simpler and smaller than single valves.
2) Leakage is less than 5 %.
3) High temperature stands for 400℃ and it is used for rapid cooling mode of radiant tube burners.

4-way Switching Device (CEM-80X-H)



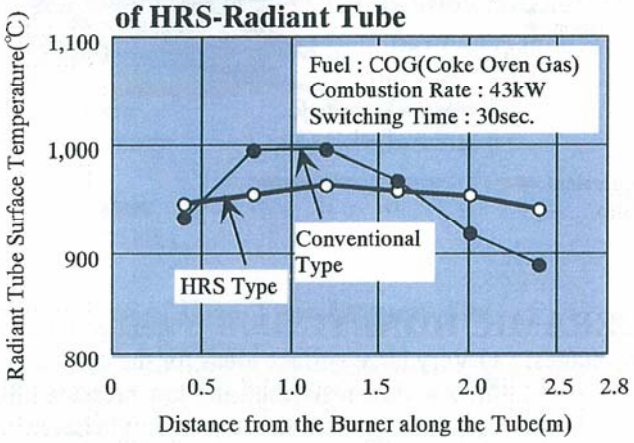
HRS RADIANT TUBE SYSTEM



• System Advantages

1) Tube efficiency: More than 85%
2) NOx emission: less than 120ppm (O_2=11% corrected)
3) Uniform temperature distribution on tube surface and longer tube life
4) Compact size due to built-in regenerator
5) Temperature efficiency of regenerator: more than 90%

Comparison of Surface Temperature of HRS-Radiant Tube



Comparison of Radiant Tube Performance

Item	U-Tube, W-Tube (with recuperater)	Single End Tube	HRS Burner	Advantages
Exhaust Gas Temperature	400~600℃	400~600℃	300~400℃	Fuel saving and improvement of working environment
Temperature Distribution on Tube Surface	Δt=50~150℃	Δt=50~80℃	Δt=20~30℃	High & Uniform Tube temperature. Electric heater shall be replaced (Lower running cost)
Surface Load	2.3~4.1W/cm²	2.3~4.1W/cm²	4.1~5.8W/cm²	Fewer and smaller radiant tubes (Less investment cost)
Thermal Stress on Tube	Large	Medium (outer)& Large (inter)	Small	Longer tube life. Lower grade tube materials shall be used
NOx Emission	More than 120ppm@400℃	More than 150ppm@400℃	Less than 120ppm@1000℃	Ultra Low NOx

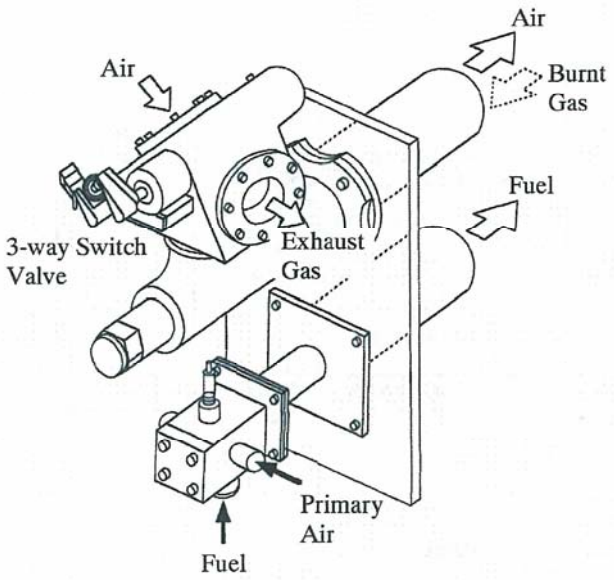
Standard Specifications

Type / Spec	HRS RT		HRS RT		HRS RT		HRS RT		HRS RT	
	U3	W3	U4	W4	U5	W5	U6	W6	U7	W7
Fuel Input (kW)	23		47		64		99		140	
Effective Output (kW)	20		40		55		84		119	

• Application

Atmospheric furnace and various types of indirect heating furnaces

HRS U1/Ux BURNER SYSTEM



• Advantages of U1 Burner

1) Compact package type of direct firing burner comprised of NFK's standards components.
2) Waste heat recovery rate=85%
3) NOx emissions=less than 15ppm at O2=11%, Furnace temperature 1,000℃

Standard Specification

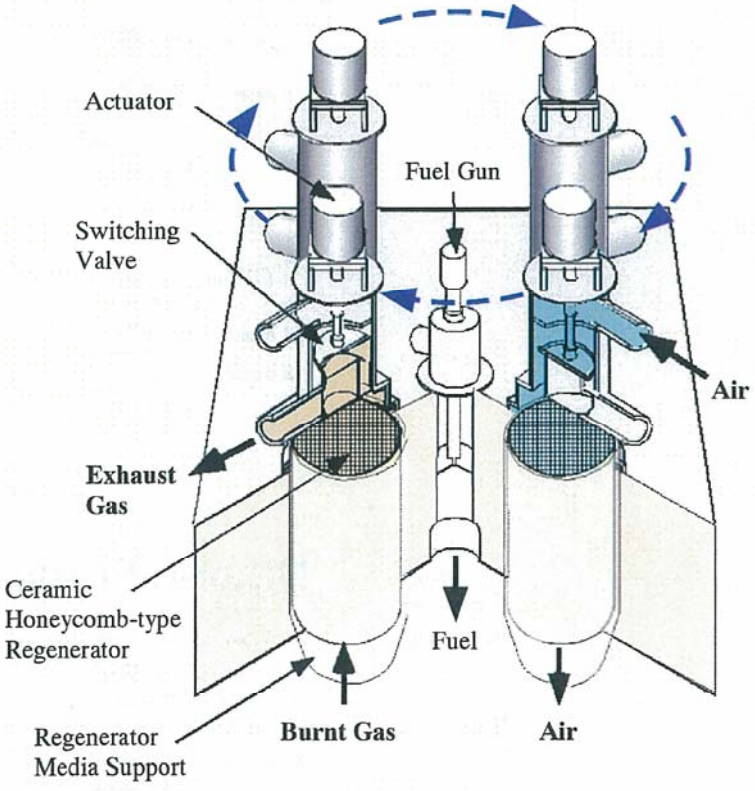
Type	HRS-U1			
	100d-G25	144d-G32	100d-B80	144d4-B90
Capacity (kW)	50	100	200	400

• Advantages of Ux Burner

1) The same components as U1 burner are adopted
2) Waste heat recovery rate 85%
3) NOx emission=less than 15ppm
4) Combustion capacity=93,201,309,463 and 847kW

• Application

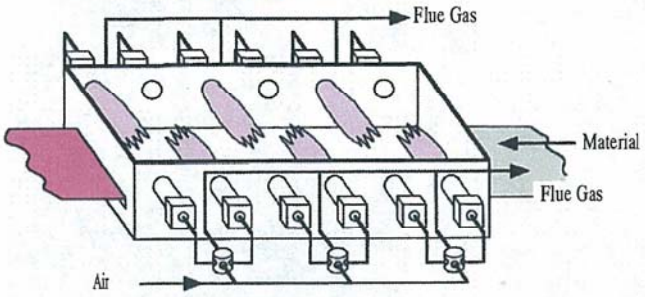
Heat Treatment Furnaces, Ceramics Firing Furnaces, Steel Reheating Furnaces and Hydrogen Reformers.

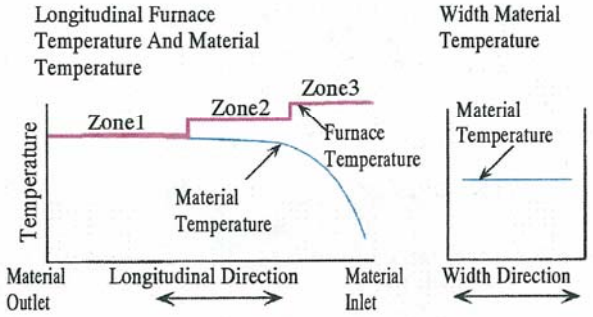


APPLICATION SOFTWARE

We are ready to supply all types of application software according to the requirements of how to treat heating materials, such as zone control, flow control and time interval control.

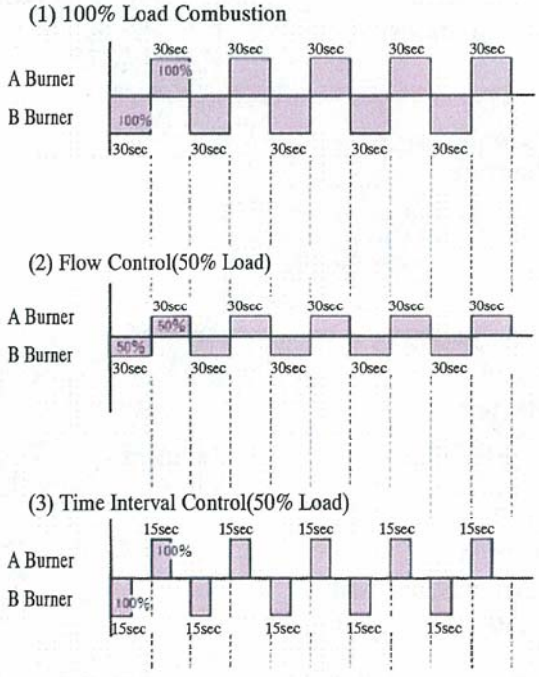
• Zone Control





• HRS Burner Temperature Control

(Patent & Patent pending: 5)



Nippon Furnace Co., Ltd.

Head Office: 2-6, Futatsuya-cho, Kanagawa-ku,YOKOHAMA 221-0823 JAPAN
TEL 045-872-8111 FAX 045-610-3940

URL: http://www.furnace.co.jp

Osaka Office: Room No. 604, Shin-Osaka Station Bldg., 3-20, Miyahara 1-Chome, Yodogawa-ku, Osaka 532-0003

2009.7