Brand New Concept Flameless Gas Heater!

-IHI leading edge combustion technology produce the high efficiency closed flameless gas heater-

The new gas heater provides clean heating with its sealed structure by eliminating the exposed flame of the gas combustion. The heater is available radiation or conduction heating through its metal surface. The internal waste heat recovery makes both high efficiency and high combustion stability possible at the same time.

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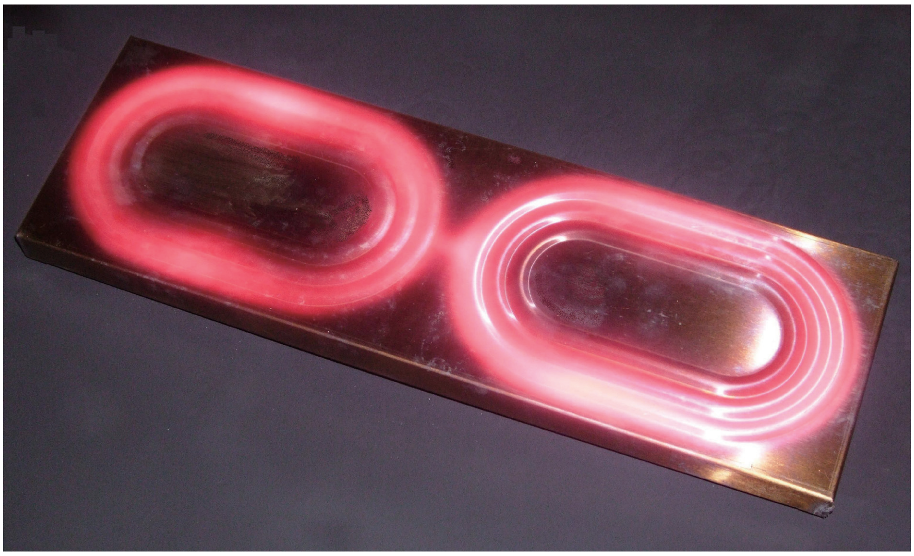


The look of confined gas heater

Heat and electricity

The industrial sector accounts for 43% of all energy consumption in Japan. Manufacturing consumes 90% of the energy in this sector. Most of the energy is used as heat. This heat is generated by electricity or the combustion of fossil fuels.

Meanwhile, in terms of contribution to electric power output in Japan, thermal power generation from fossil fuels such as coal, Liquefied Natural Gas (LNG), and petroleum accounted for 61.7% of the total in 2010. The share was expected to rise to around 70% in 2011 due to the impact of the Great East Japan Earthquake disaster. The thermal efficiency of electric power generation (receiving end) in thermal power generation, which is the ratio of currently accessible electricity to the amount of energy contained in fossil fuels, is a mere 36.9%. In other words, almost two thirds of the energy is lost. While it may appear more ecological to use electricity, the generation of heat using electricity is an extremely inefficient and ill-advised method. The most efficient method is to directly use the heat of combustion in the place where the use of the heat is desired. Moreover, reliance on electricity entails a risk of complete shutdown of the equipment during blackouts.

The greatest advantage of electricity as a heat source is its ability to produce clean heat without exhaust gas. That, however, is true only as far as the heat source is concerned. One must remember that a large amount of exhaust gas is discharged from thermal power plants, which produce 60% to 70% of all the electric power produced in Japan.

Clean heating by combustion

Some methods of using combustion to provide clean heating are already known, such as radiant tube burners. In this method, fuel is combusted in a steel tube with a diameter over 150 mm to obtain radiant heat from the heated tube.

Previously, however, this method could not be applied for small heat sources. The flame from the combustion in a small sealed space is deprived of its heat by the surrounding walls resulting in temperature decreases. Stable combustion is thus hindered, triggering problems such as carbon monoxide emission and accidental fire.

Micro combustor technology (combustion in a small space)

Micro combustor technology has been proposed as a solution to this challenge. Micro combustors contain a heat exchanger that recovers waste heat inside the combustor. The high-temperature of the waste gas can be used to preheat the premixed gas of air and fuel gas before it is supplied to the micro combustor. The flame temperature can thus increase by the amount it was preheated, which substantially improves flame stability. The advent of this micro combustor technology achieved combustion in a small sealed space. Swiss-roll type micro combustors exchange heat between exhaust gas and premixed gas through dual spiral shapes. Another advantage of micro combustors is the great heat efficiency achieved by waste heat recovery. Normally waste heat recovery requires a combustor and a separate structure for heat recovery, but micro combustors have a heat recovery mechanism built into the combustor, so no separate heat regeneration system is required.

Micro combustor created by IHI

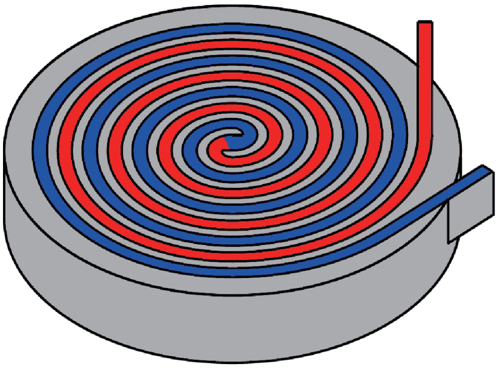
Sponsored by the New Energy and Industrial Technology Development Organization, IHI engaged in joint research and development of micro combustors with Tohoku University. The trial production of heaters up to a capacity of 400 W verified combustion stability and controllability. The project eventually succeeded in achieving stable combustion in an ultra-micro combustor the size of a 500-yen coin with an output of 20 W.

Moreover, the combustor marked more than double the heat efficiency of standard electric heaters in terms of primary energy (energy contained in fossil fuels).

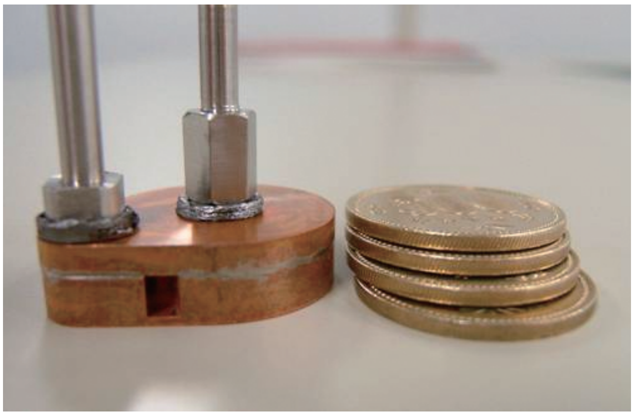
Still, the shapes of gas flow paths in swiss-roll type micro combustors are complicated and somewhat difficult to process. There was also the challenge of the output being too small as the flame is only concentrated in the center of the combustor. Thus, IHI pursued the development of a more powerful combustor with a simpler structure.

The resulting plate-shaped confined gas heater we developed heats up its entire metal surface and provides radiation or conduction heating for works. The structure of the confined gas heater is illustrated in the following figure.

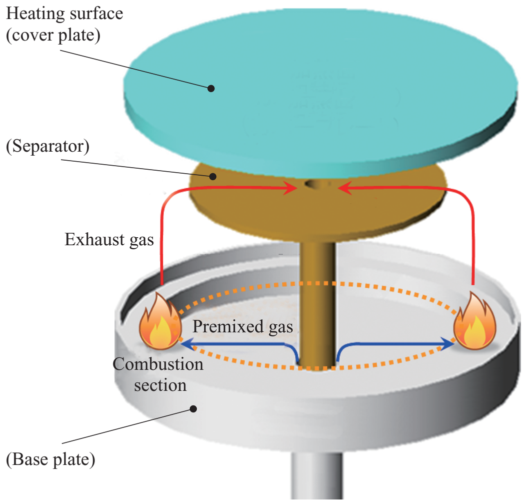
The confined gas heater comprises a cover plate which functions as the heating surface, a base plate as the basic structure, and a separator that performs heat exchange between the exhaust gas and premixed gas. Premixed gas of air and fuel gas are introduced into the heater through the inlet to the outer and inner tubes, pass underneath the separator, and form a flame along the edge. The combustion gas passes over the separator and heats the work from the heating surface. Later, the exhaust gas is discharged from the inner tubes after



Swiss-roll type micro combustor



Ultra-micro combustor



Structure of confined gas heater

Item	Unit	Features
Maximum output	kW	3.9
Surface temperature (max.)	°C	700
Heater size	mm	450 × 140

Features of gas heater

heat exchange takes place with the premixed gas through the separator. The premixed gas is ignited with a spark plug. Since the flame is invisible, it is detected electrically by a flame rod. There is a built-in safety mechanism that automatically shuts off the fuel when the flame goes out.

This combustor works on the same principle as swiss-roll type micro combustors, but without the complicated flow path. Yet the same benefit can be expected from its much simpler structure. The new sealed gas heater discussed at the beginning was made by reshaping the circular micro combustors into an oval shape and lining two of them up lengthwise.

Features of our sealed gas heater

The features of the sealed gas heater based on micro combustor technology are as follows:

(1) Sealed structure protects the works from combustion exhaust gas containing combustion products such as steam, NO_x, and SO_x. Despite being a gas heater relying on combustion, it achieves heating as clean as that of electric heaters.

(2) Waste heat is recovered inside the heater to achieve greater heat efficiency than conventional gas burners.

(3) High degree of combustion stability without increase in CO emission under low combustion load, which is suitable for a wide range of applications.

(4) The furnace to which the heater is mounted can be sealed to enhance the heat efficiency given the sealed structure of the heater and the discharge of exhaust gas from the piping. This can also contribute to an improved working environment in manufacturing plants.

(5) High-temperature exhaust gas can be recovered exclusively, without mixing with the surrounding air, which extends the possibilities for effective use of waste heat to drying, boilers, etc.

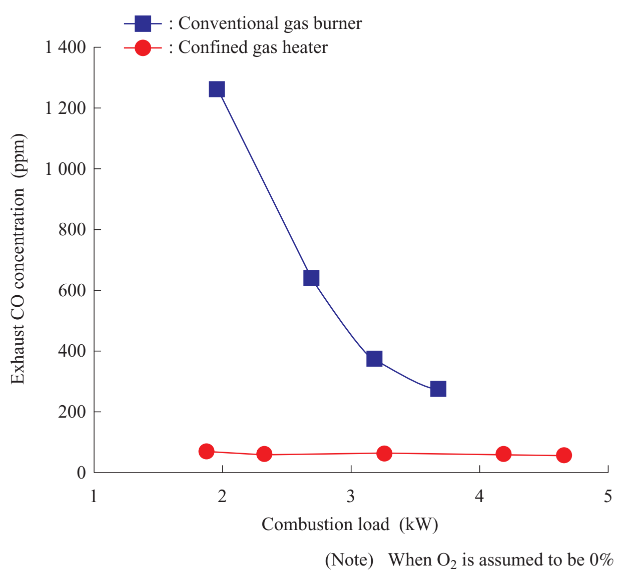
Combustion stability of the gas heater

In order to examine the performance of the sealed gas heater, carbon monoxide concentration in the exhaust gas was measured against the combustion load, and the obtained profile was compared with that of a conventional gas burner. The new sealed gas heater demonstrated low carbon dioxide emission for a wide range of combustion loads, making stable combustion possible. In contrast, the conventional gas burner exhibits a rise in carbon monoxide emission under low combustion loads and shows inferior combustion stability. The excellent combustion stability of the sealed gas heater across a wide range of loads implies that the gas heater's load can be set as appropriate to provide the necessary temperature for individual works.

Heating efficiency of the gas heater (fuel reduction by 80%)

In order to examine the performance of the new sealed gas heater as a heat source, a testing prototype was fabricated that made it possible to apply heat to works with multiple gas heaters from above and below.

The testing prototype comprises 6 units of sealed gas heaters, 3 units each above and below the centrally mounted metal mesh for placing works. This allowed us to change the intervals between gas heaters and the distance from the heater to the works, which makes it possible to assess the



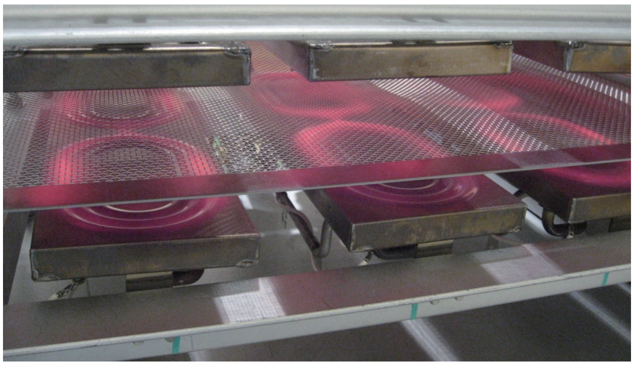
CO emission profile of confined gas heater surface temperature of the gas heater and the appropriate distance between the heater and the works.

This testing prototype was used to compare the performance with a conventional gas burner in terms of the necessary fuel consumption for maintaining a heated region at a certain temperature. A comparison of the resulting fuel consumptions needed to heat the works is shown below.

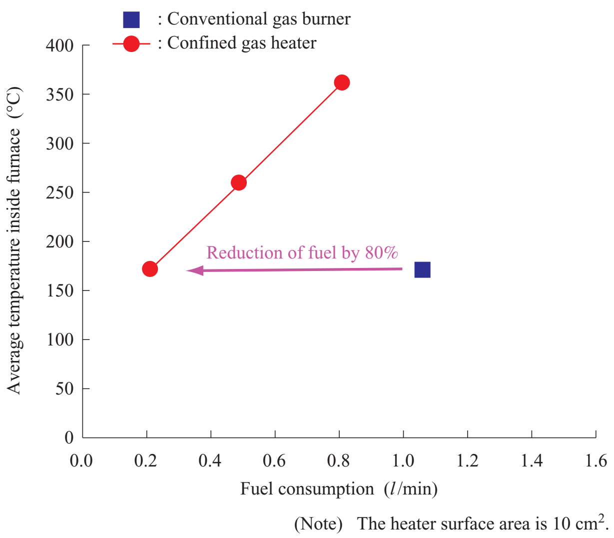
The obtained data indicated that it is possible to reduce the fuel consumption required to heat works to the same temperature by as much as 80% as compared to a conventional gas burner (fuel consumption reduction to one fifth).

Places where the sealed gas heater can perform

It is believed that application of this gas heater as a heat source for various heat treatments in the low- to medium-temperature range will facilitate energy-saving in many kinds of processes. In particular, energy-saving in heat treatment equipment using small- to medium-sized heat sources has been falling behind, leaving great need for energy-saving.



Furnace bodies of heating furnaces mounted with new confined gas heaters



Comparison chart of fuel consumption to conventional burners

This confined gas heater is envisaged to contribute greatly mainly in the processes of:

(1) Food baking and drying
(2) Paint drying
(3) Heat treatment of glass panels
(4) Heat treatment of polymer films
(5) Heat treatment of low-melting-point materials such as aluminum

Basically, the new gas heater can replace existing gas burners and electric heaters used for small- and medium-sized heat sources without introducing any special equipment. The high heat efficiency of the gas heater as a single unit can reduce fuel cost. The effective use of the exhaust gas recovered from the heater as a heat source for boilers, etc., can further energy-saving.

Future development

This article featured the new confined gas heater with excellent stability and heat efficiency with the application of micro combustor technology. As the next step, we will fabricate a testing prototype of a continuous furnace mounted with confined gas heaters (length 6 m, width 0.9 m) in order to examine its applicability to many kinds of processes starting from food baking to various drying processes, as well as heat treatments (metal parts, functional materials, semiconductors, etc.).

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