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APPROACH TO ENERGY CONSERVATION BY INTRODUCING HIGHLY EFFECTIVE EQUIPMENT FOR COMMERCIAL KITCHEN

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ABSTRACT

In this paper, we introduce you to the development of the highly effective gas infrared burner and heat exchanger, and describe the effect of energy reduction. In order to achieve energy conservation, the highly effective baking and drying infrared burner was developed newly for more efficient radiation heating than that of a conventional infrared burner. As a result, the amount of radiation from the burner surface and the wire net increased by a factor of 1.5 - 1.6 compared with the conventional model. On the other hand, the highly effective heat exchanger was also developed to exhaust heat from burners more effectively. It became possible to make the heat transfer area five times or more by improving way of bonding copper fins in the angular pipe of the heat exchanger. As a result, the temperature of exhaust gas was decreased to about 250℃, while the thermal efficiency greatly increased to 69% which was realized by the improvement of the thermal conductivity. These highly effective equipment have been introduced into the cooking appliances market and the gas input rating was reduced more than that of the conventional model. The introduction of the technologies we developed will lead to more energy saving and CO_2 reduction.

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1. INTRODUCTION

In a commercial kitchen, various cooking appliances such as gas kitchen equipment are set up. Various types of burners and heat exchangers are usually used for a gas cooking appliance. In order to achieve energy saving in your kitchen, it is important to improve the efficiency of these burners and heat exchangers. Effective heating is possible using an infrared burner where fire temperature is high. The infrared burner with the effect of ultra-red ray radiation has been used for the food heating. The burner was developed newly for more efficient radiation heating than that of a conventional infrared burner. The developed burner enables energy saving and CO_2 reduction, and therefore the fuel consumption is less than that of these conventional infrared burners. On the other hand, if exhaust heat from burners of various shapes can be used for heating with an efficient heat exchanger, more energy saving and CO_2 reduction can be achieved. The adoption of the efficient heat exchanger is expected in the business kitchen equipment. Setting up highly effective burners and heat exchangers in a variety of gas kitchen equipment decreases the energy consumed in the kitchen. In this paper, we introduce the development of highly effective gas infrared burner and heat exchanger, and describe the effect of energy reduction.

2. HIGHLY EFFECTIVE EQUIPMENT

About highly effective mechanism and the structure of equipment, we firstly introduce our highly effective infrared burner, and, then our highly effective heat exchanger.

Highly effective baking and drying infrared burner for energy conservation

According to Steffen Boltzmann law radiation emitted from an object is given by the following expression:

$$E = \varepsilon \cdot \sigma \cdot T^4 \cdot S \qquad (1)$$

E: Radiation [kW]

ε : Emissivity

σ: Steffen and Boltzmann constant 5.67×10^{-8} 〔$W \cdot m^{-2} \cdot K^{-4}$〕

T: Absolute temperature on surface 〔K〕

S: Radiation area 〔m^2〕

To increase the radiation:

A) In order to raise surface temperature (T) on the combustion side, the section in the plate on the combustion side has been improved by shaping like the pyramid. (Figure 1)

B) The opening space in the burner port was decreased to about half of the conventional design, and radiation area (S) was enlarged up to about 33%. The surface temperature of the combustion plate increased by 30 - 40℃ compared with the conventional model.

C) In addition, the space between the wire net and the combustion plate set up in the upper part of the combustion side was filled with the sidewall made of the sheet metal of L type. Therefore, most amount of exhaust gas was able to exhaust from the burner through the wire net. (Figure 2)

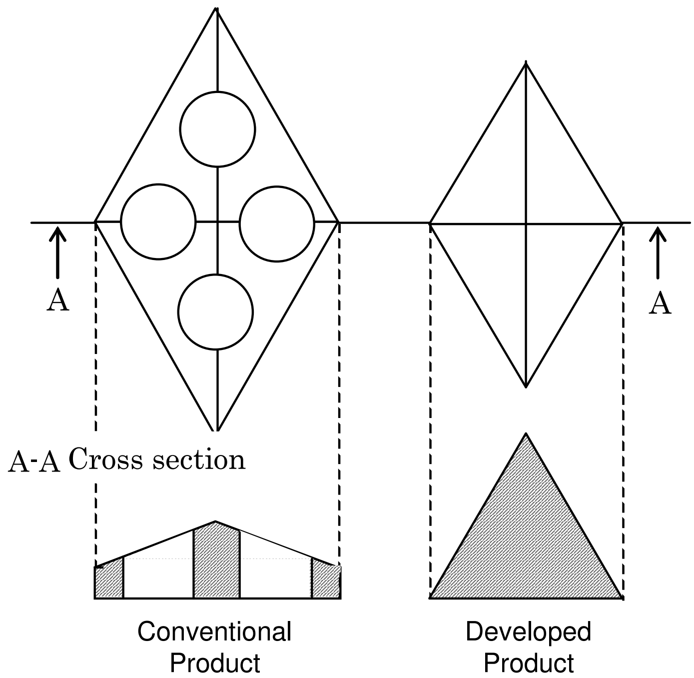


Figure 1: Shape of the plate surface

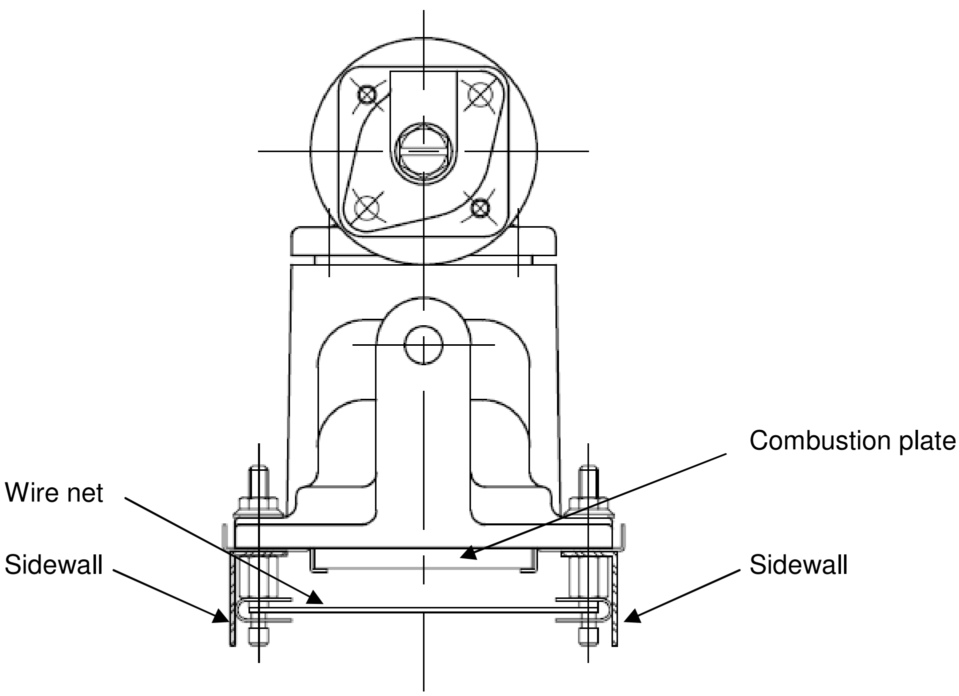
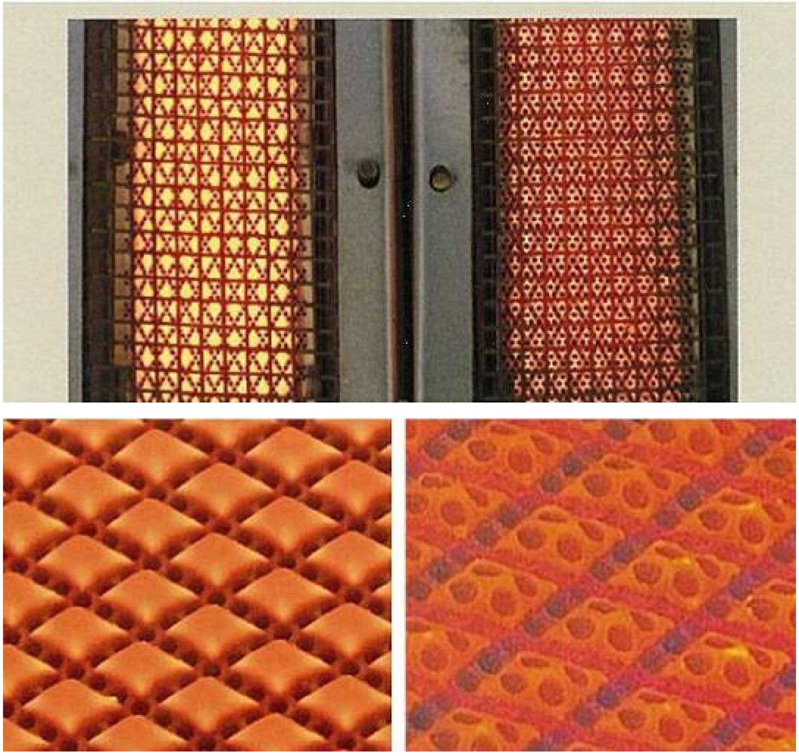


Figure 2: Section of Burner

As a result, the temperature of the wire net increased by 100℃ compared with the conventional model. The amount of radiation emitted from the wire net increased, and more highly effective heating became possible. Figure 3 shows the heated burner surface of the developed and the conventional products. According to Equation (1), the amount of radiation from the burner surface increased by a factor of 1.5 compared with the conventional model. The amount of radiation from the wire net also increased by a factor of 1.6 compared with the conventional model. Figure 4 shows the comparison of temperature of the burner surface between the developed and the conventional products according to combustion load. The combustion load was reduced to 11% on condition that the temperature of the burner surface remains the same. The energy consumed was reduced to 5 - 8% as a result of applying the burner to an actual baking oven.



Developed Product

Conventional Product

Figure 3: Heated burner surface of the developed and the conventional products

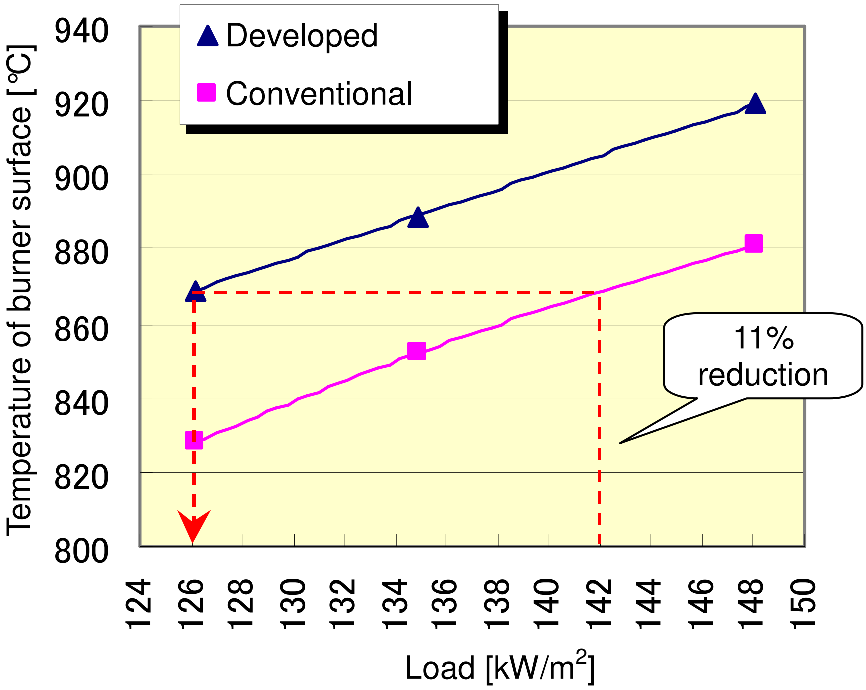


Figure 4: Comparison of temperature of the burner surface between the developed and the conventional products according to combustion load

Highly effective heat exchanger

For further improvement of efficiency, a heat exchanger was developed. For gas kitchen equipment such as a fryer and pasta boiler that heats liquid, a conventional heat exchanger was usually used to heat the flat bottom with the burner and transfer heat by passing exhaust gas through the iron pipe. However, in these methods, the heat of combustion of the burner was not transferred enough and part of the heat was dissipated as exhaust gas. Consequently, the temperature of exhaust gas was high from 260 to 400℃, and thermal efficiency was from 50% to about 55%. Therefore, we developed a submerged pipe of a highly effective heat exchanger by devising the profile and arrangement of copper fins, profile and processing method of pipes, and other components. Figure 5 shows the developed highly effective heat exchanger.

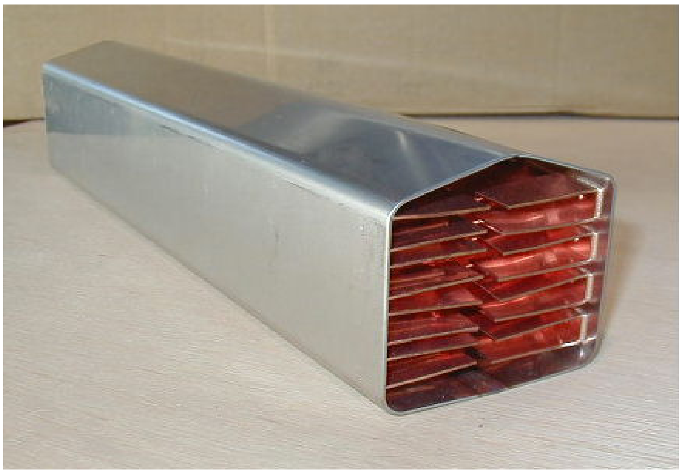


Figure 5: Highly effective heat exchanger

Figure 6 shows the internal structure of the highly effective heat exchanger. A stainless steel immersion piping was designed in pentangular section (A) in Figure 6 and resulted in a pointed shape which eliminates the collection of frying scraps. The adoption of pentangular piping permits the attachment of a large number of copper fins compared with the conventional circular pipe. Thus, it became possible to make the heat transfer area five times or more by bonding copper fins (B) in the pentagonal pipe in Figure 6. To avoid the temperature distribution on the surface of an immersion piping, the inclination of the copper fin was sequentially applied from the inflow side where the temperature of exhaust gas was high. As a result, the temperature of exhaust gas was decreased to about 250℃ and the thermal efficiency greatly increased to 69%, which was realized by improvement of the thermal conductivity.

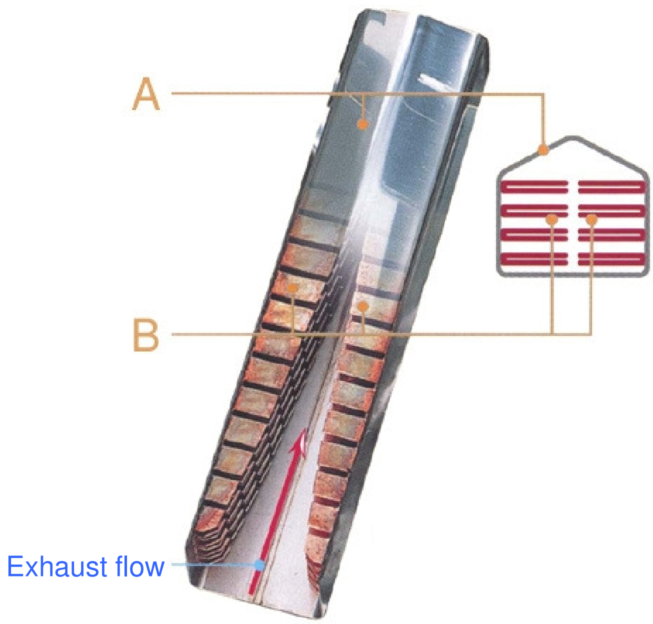


Figure 6: Internal structure of highly effective heat exchanger

This highly effective heat exchanger has been applied to gas kitchen equipment in a commercial kitchen. For an example, a gas fryer for business use is used for cooking “tempura” (Japanese deep-fat fried food) and other various fried food in restaurants, caterers, daily dish shops, taverns, and many other business shops. For a gas fryer with this heat exchanger, the performances were improved as shown in Table 1. In addition, its wide pitch of immersion piping improved ease of cleaning at bottom of oil vat because it was reduce the number of the pipes according to high efficiency. In other cases, a pasta boiler with this heat exchanger, the temperature of exhaust gas was decreased to about 156℃ and the thermal efficiency greatly increased to 77%. The gas input rating was reduced by about 36% per hour. Thus, the validity of this heat exchanger was clarified.

Table 1: Efficiency comparisons between the developed and the conventional gas fryers

	Gas consumption	Thermal efficiency	Oil heating time	Exhaust gas temperature
Developed product	9.3kW	69%	Approx. 12min.	Approx. 250℃
Conventional Product	11.4kW	Approx. 53%	Approx. 20min.	Approx. 500℃

※ Oil heating time required is defined as time necessary for heating from a room temperature of 20℃ to an oil temperature of 180℃.

3. CONCLUDING REMARKS

A method for energy conservation in the commercial kitchen will become important in the future. High effective and energy-saving infrared burner was introduced to the rice cracker factory for industrial use. Moreover, highly effective heat exchanger was introduced to commercial cooking appliances such as a pasta boiler and fryer. Thermal efficiency improves by using these burner and heat exchanger, and the energy cost can be reduced. The effect of introduction of the technologies developed is scheduled to be verified further.