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The Development of Safety Sensor Equipped Gas Stoves

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ABSTRACT

In Japan, 4,507 house fires were caused by gas stoves in 2007. To decrease the number of house fires, since 2008 it has been required that all gas stoves be equipped with a safety system, called “Si” sensors, to comply with the new safety codes and standards. “Si” is an acronym that is composed of the initial letters of four words: “Safety,” “Support,” “Smile,” and “Intelligent.” A “Si” sensor is made up of a thermocouple and a thermistor. The former serves to detect flames, whereas the latter monitors the temperature of the pot cooking on the burner. The thermistor also automatically turns off the gas when users forget to do so.

The use of “Si” sensors has helped prevent overheated cooking oil from igniting and causing fires. In fact, the Fire and Disaster Management Agency reported that the number of fires caused by overheated cooking oil decreased by about 17% between 2007 and 2009. In addition, the ratio of house fires caused by gas stoves to the total number of house fires has continued to decline over the past two years because of the increased distribution of gas stoves equipped with “Si” sensors. Cumulative shipments of gas stoves equipped with “Si” sensors were 8,000,000 in June 2010 (and are projected to be over 10,000,000 in 2011). We expect that by 2020, gas stoves equipped with “Si” sensors will have become commonplace.

In addition, some useful and safety functions were added to help users while they cook. A fail-safe function that turns off the gas stoves and prematurely cuts off the gas as a protective function is the result of Japanese industry-level self-regulation. Each gas stove also comes with added functions such as an automatic cooking function and cooking pot detection.

We have developed some new types of gas stoves in Japan, on which we have introduced some distinctive features.

Paper

1. Background

In Japan, 4,507 house fires were caused by gas stoves in 2007. To decrease the number of house fires, since 2008 it has been required that all gas stoves be equipped with a safety system, called “Si” sensors, to comply with the new safety codes and standards. “Si” is an acronym composed of the initial letters of four words: “Safety,” “Support,” “Smile” and “Intelligent.” As shown in Fig. 1, a “Si” sensor consists of a thermocouple and a thermistor. An ordinance requires that these be mounted on all gas stoves. Cumulative shipments of gas stoves equipped with “Si” sensors were 8,000,000 in June 2010 (and will be over 10,000,000 in 2011). We expect that by 2020, gas stoves equipped with “Si” sensors, as shown in Fig. 2, will have become commonplace.⁽¹⁾

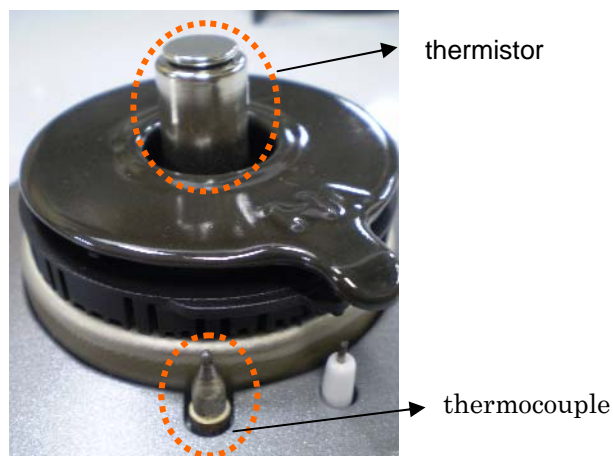


Fig. 1 Photograph of thermocouple and thermistor

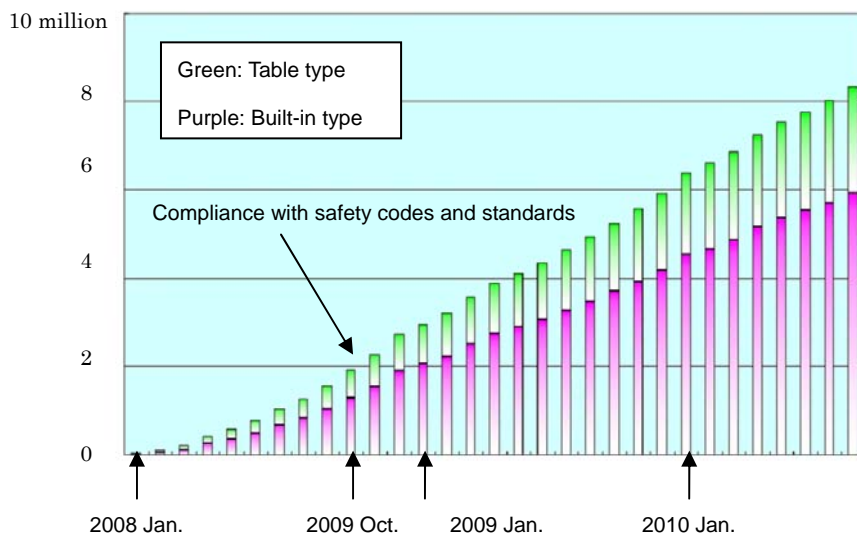


Fig. 2 Cumulative shipments of gas stoves equipped with “Si” sensors

2. Introduction of functions

2-1 Stove functions required by law

Table 1 shows the relationship between safety functions and regulations. All gas stoves that are equipped with a “Si” sensor provide the following two safety functions for cooking.

- Flame failure prevention device (Table1, 1)

This device monitors the live flame of the burner(s). When a flame is extinguished because of food boiling over or a strong wind, the thermal voltage of the thermocouple decreases, which automatically closes a solenoid-operated valve that turns off the gas. Household gas stoves equipped with this device have been on the market since 1983.

Category	Safety functions	Useful functions
Functions required by law	<ol style="list-style-type: none"> 1. Flame-failure prevention device 2. Prevention of overheating of cooking oil 	None
Japanese industry-level self-regulation	<ol style="list-style-type: none"> 3. Fail-safe function that turns gas stove off 4. Premature cut-off protective function 	None
Added functions	<ol style="list-style-type: none"> 5. Prevention of scorching 6. Ignition over a medium heat 7. Cooking pot detection 8. Automatic turn-off with seismoscope 	<ol style="list-style-type: none"> 1. Automatic cooking function 2. Burner innovations 3. Gas stoves equipped with grill

Table 1 Relationship between functions and regulations



Fig. 3 Schematic diagram of flame control

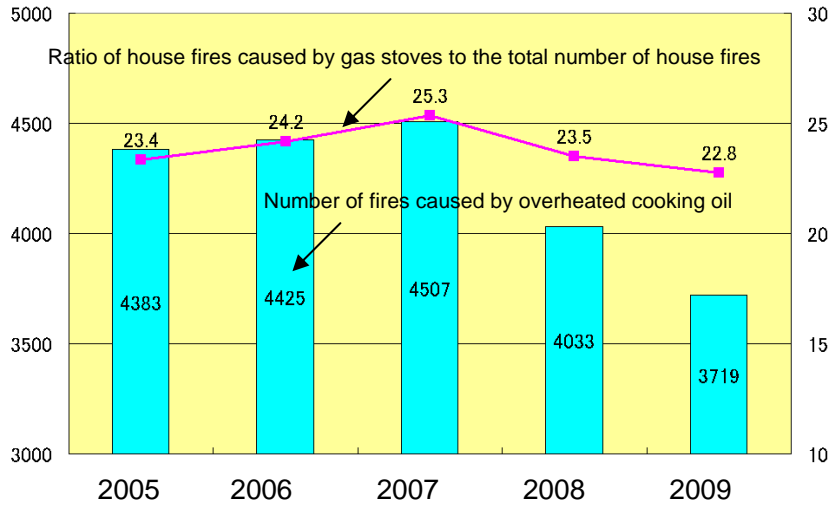


Fig. 4 Number of fires caused by overheated cooking oil

- Device for the prevention of overheating of cooking oil (Tables1, 2)

This device monitors the temperature of the pot as it cooks on the burner. When the temperature reaches about 250°C, a solenoid-operated valve is automatically closed to turn off the gas supply within a certain period of time (Fig. 3). This helps prevent overheated cooking oil from igniting and causing a fire. In fact, the Fire and Disaster Management Agency reported that the number of fires caused by overheated cooking oil decreased by about 17% between 2007 and 2009 (Fig. 4)⁽²⁾. It also reported that the ratio of house fires caused by gas stoves to the total number of house fires has continued to decline over the past two years because of the increased distribution of gas stoves equipped with “Si” sensors.

2-2 Japanese industry-level self-regulation

Because of their being equipped with “Si” sensors under industry-level self-regulation, all gas stoves are also equipped with other safety and useful functions.

- Fail-safe function that turns off a gas stove (Tables1, 3)

This also provides safety feature for people who tend to forget to turn things off because it comes with a fail-safe function that automatically turns off a gas stove two hours after it is turned on, as shown in Fig. 5 (blue line).

- Premature cut-off protective function (Tables1, 4)

This function helps users cook dishes that require a high temperature, such as stir-fried vegetables and fried rice, without extinguishing the flame during cooking. At an early stage of a cooking session, the thermistor sensor monitors the temperature gradient of the cooking pot on the burner. From the temperature gradient, a computer then determines whether the pot is being used for boiling or stir-fry. In the case of stir-fry, when the temperature reaches about 250°C, a mode switch quickly moves from manual flame control to programmed flame control. The programmed flame control then alternates between a high and a low flame for half an hour. In addition, users can select a mode in which the temperature threshold of the programmed flame control becomes 300°C, which is higher than the default temperature of 250°C, as shown as Fig. 5 (green line).

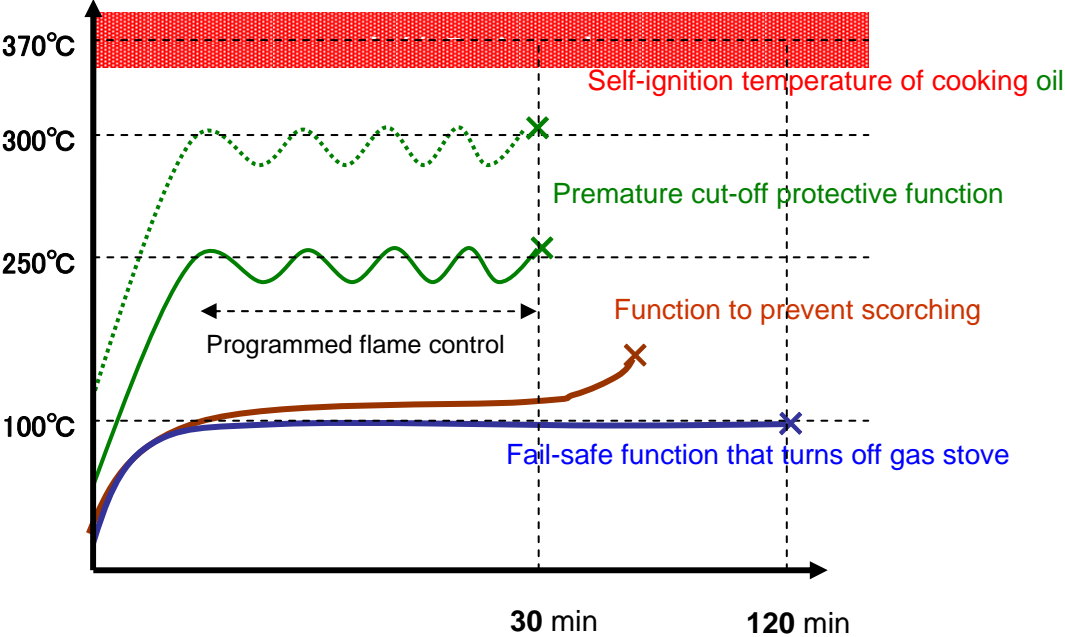


Fig. 5 Schematic diagram of sensor temperatures

2-3 Added safety functions

A number of safety functions beyond those required by law in Japan have been added to help stove users while they cook. Some of these other features include:

- A function to prevent scorching

If users forget to turn off the burner while boiling food, burnt deposits can build up inside the pot or pan. To prevent such scorching, the thermistor monitors the temperature of the pot or pan on the burner. In the case of a temperature that exceeds 100°C, as shown in Fig. 5 (brown line), the computer considers that scorching is taking place, and a solenoid-operated valve is automatically closed to turn off the gas supply.

- Ignition over a medium heat

In Japan, accidents caused by clothes catching fire have been reported in magazines and newspapers. Therefore, most burners designed for household use that have a high power output of about 4.2 kW are designed for cooking over a medium heat to help prevent this kind of an accident.

- Cooking pot detection

Cooking pot detection is one of the safety functions. To prevent clothes from catching fire, a reed switch detects the vertical movement of an embedded sensor caused by the removal of a pot/pan from the stovetop, and then controls the flame automatically.

- Automatic turn-off function with seismoscope

Since the Great Hanshin Earthquake in January 1995, all gas meters have been equipped with an automatic turn-off function that is triggered when an earthquake reaches a seismic intensity of 5. To provide additional consumer safety, some gas stoves come with a turn-off function that is also activated during an earthquake with a seismic intensity of 4.

2-4 Added useful functions.

- Automatic cooking function

This useful added function provides automatic cooking by means of programmed flame control. This function relieves users of the hassle and stress of constantly checking the temperature of cooking foods such as rice and boiled foods as shown in Fig. 6. Additionally, users can select the best temperatures for each of these dishes such as *Tempura (deep fried, Japanese style)*, steaks and pancakes in 10°C increments between 140°C and 200°C. Users can easily make pancakes, for example, without having to monitor the burner.



Fig. 6 Dishes for automatic cooking function

- Burner innovation

As befits an environmentally superior product, the thermal efficiency of gas stoves has been improved by the development of new types of burners. Recent technology for improving the burner tip and structure has also increased burner efficiency to 56%, which is 10% higher than that of the previous conventional burners. It also has a high turn-down ratio. To achieve a high thermal efficiency of 56%, the burner comes with a number of options. The first is that, to economically apply the power of the flame to the pan, we turn up the angle of the burner. Second, the burner diameter of the latest model is smaller than that of the previous models. Finally, the ratio of primary air of the latest model is greater than that of the previous model. The latest model also has also a high turn-down ratio between 4.2 kW and 0.42 kW due to the improved burner tip, which helps when cooking foods such as soups and stews.

- Gas stoves with a grill

In Japan, most gas stoves for domestic use come with a grill, as shown in Fig. 7. This is a standard feature because grilled fish has a prominent place in Japanese cuisine. Recent advances in technology have been accompanied by a number of safety and useful functions. In this paper, we discuss four great advancements that have been made in grilling. The first is that it is not necessary to turn the food over during cooking because the grill burners are arranged one above the other. Second, users do not need to put water in the bottom of the pan because there is no longer any risk of the oil igniting itself in the grill. The grill pan is cooled by the secondary air of the Bunsen burner. Third, users can also cook foods other than grilled fish, such as roasted turkey, pizza, toast, and Dutch oven dishes, as shown in Fig. 6. Finally, a grill also has safety function such as fail-safe function that turns off a gas stove and device for the prevention of overheating of dishes just like cook tops.



Fig. 7 Photographs of the grill dishes

3-2 User-friendly models

We have also promoted a universal design in gas stoves. Results of usability surveys indicate this particularly addresses the usage needs of the elderly and the visually impaired. In these models, the control panel is located in front on the top plate, and the stove is equipped with audio guidance (see Fig. 9). However, this design apparently makes it possible for the control panel to be excessively heated by the lit burners; this potential problem is resolved by the heat exchange between the heat sink of the panel and the primary air of the Bunsen burners.



Fig. 9 Photographs of user-friendly models

3-3 Easy-to-clean models

An enormous amount of technical invention has gone into the stovetop design to make the stovetop easy to clean. We recently adopted aluminum as a stovetop material, as shown in Fig. 10. The high thermal conductivity properties of aluminum (which has a thermal conductivity of about 200 W/mK) allow for the horizontal dispersion of heat from the gas burners. As shown in Fig. 11, the maximum temperature of the aluminum top plate reaches 114°C after a 24-cm pan filled with two liters of water is boiled. This is 70°C lower than the maximum temperature of a glass stovetop. Thus, the stovetop around the burners is not affected or thermally damaged in any way, and hence, burnt deposits do not accumulate. In addition, to make it even easier for users to take care of their stoves, the aluminum stovetop is coated with long-lasting and easy-to-clean Dupont™ Teflon® Platinum⁽³⁾. It thus becomes much easier keep the stove clean, as shown in Fig. 12. In October 2011, we plan to launch a number of new products that will offer color options other than black.



Fig. 10 Photograph of easy-to-clean model

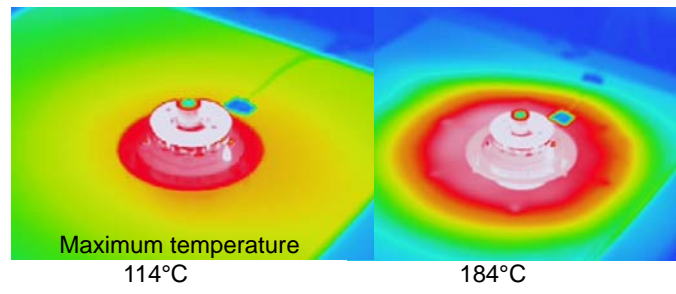


Fig. 11 Thermal image of stovetop (left side: aluminum; right side: glass)

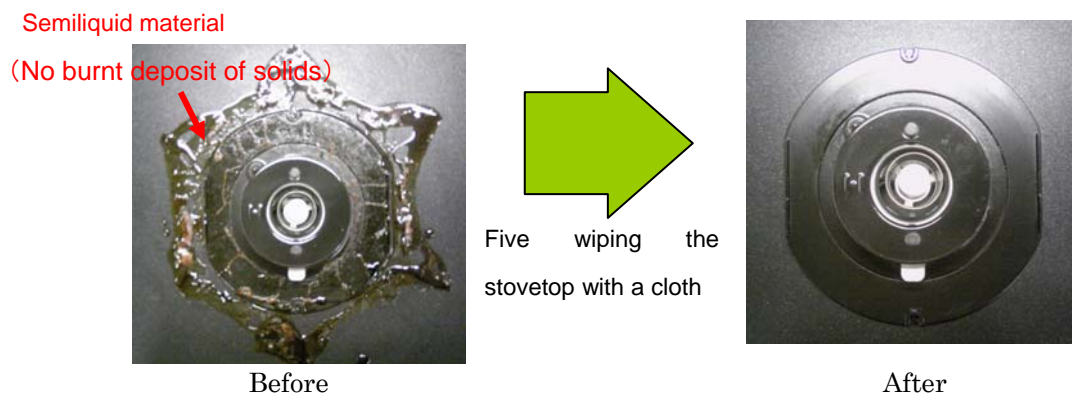


Fig. 12 Results of a stovetop wiped with a cloth after cooking

3-4 Three-abreast burner (Triple-wide gas stove)

In Japan, most gas stoves have either a two-abreast or a triangular burner arrangement. In the case of triangularly arranged burners, it is difficult for shorter users to use the small back burner. To solve this problem, we have launched a new gas stove that has a three-abreast burner arrangement with no back burner, as shown in Fig. 13. Three burners are lined side by side to use three pans easily. In addition, there is a place on the front of the stovetop where users will find it convenient to arrange their dishes.



Fig. 13 Photograph of a triple wide gas stove

4. Customer response

We have checked customer response after-sales on a routine basis.⁽⁴⁾ Collecting the opinions of the users is effective to develop new products. Results from the survey in 2009 showed the users are satisfied some safety and useful functions. The survey involved about people living in the capital sphere who bought the gas stove in 2008. The chart of Fig. 14 shows the rate of answering “satisfactory” about each function on top-end model. As you can see, useful functions such as automatic cooking function (deep fried), cooking timer of the grill, Liquid crystal panel displays and a tipped over grill without water are received well (over 50%).

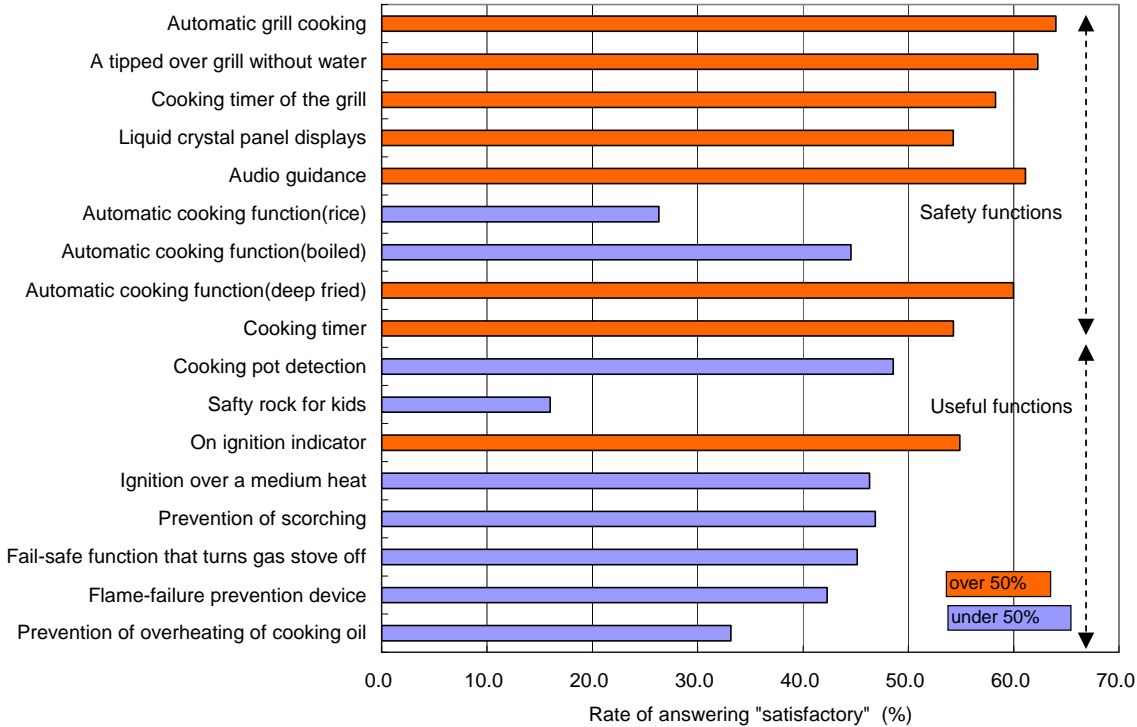


Fig. 14 Rate of answering “satisfactory” about each function

5. Introduction of new functions

We plan to develop new safety, useful features and design into the future as it always has been in the past. In this paper, we introduce one of new trial to create new functions and products for the future. We are conducting several ongoing research and development projects. For instance, Tokyo Gas Co. has promoted the development of a new gas stove named “Gas Pad,” which has several distinguishing characteristics, including a thin (44 mm), lightweight body and a stylish design to give the “Gas Pad” a sleek look. The “Gas Pad” will thus provide new value to customers. For example, the “Gas Pad” gives users a wider workspace in an undersized kitchen when it is not in use, and its countertop designs can offer increased space for storage racks because of the absence of a stovetop.

With innovations such as these, we will continue to provide new convenience, value, and joy to the cooking experience of all gas stove users.



Fig. 15 Photograph of the “Gas Pad”

References

- (1) The volume of shipments about gas stoves equipped with “Si” sensors, Japan Gas Association, (2010)
- (2) The report of approximate figure about fire disaster, Fire and Disaster Management Agency, (2009)
- (3) Dupont™ Teflon® Platinum, license for E.I. du Pont de Nemours & Company (Inc.)
- (4) After-sales survey data conducted by Tokyo Gas Co., Tokyo Gas Co., (2009)

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