Hitachi Review
Volume 64 Number 2 March 2015

HITACHI
Inspire the Next

Home Appliances and their Role in Hitachi's Social Innovation Business

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From the Editor

Responsible for Smart Life and Ecofriendly Systems in Infrastructure Systems Group of Hitachi, Ltd. Hitachi Appliances, Inc. seeks to enrich people's ways of life and make them more convenient through comprehensive air conditioning equipment, home appliances, and environmental equipment. Our aim is to bring innovation to people's lives by contributing to society through the dedicated pursuit of "eco" qualities (meaning energy efficiency and reducing the load on the environment), and by offering products that incorporate new value. This issue of *Hitachi Review* focuses on our work in the field of home appliances.

To create new value, we undertake product development in Japan under the slogan "eco + unique value". By identifying the emergence of new values and consumer needs that change with changing lifestyles, we use new technology and new functions to deliver the value that people are genuinely looking for.

Outside Japan, we are pursuing a premium strategy based on products with high added value that incorporate "eco" and unique functions, supplying products packed with new technologies and functions developed for the very demanding Japanese market. Energy efficiency in particular is an important focus due to the accelerating trend toward such requirements as tighter regulations and the adoption of new standards, including in overseas markets. Consumers are choosing Hitachi's products because of the value we add through unique functions, while also adapting products to suit the different basic needs that arise from differences in culture, living practices, and social infrastructure.

In this issue's Expert Insights, Ms. Jasmine Lim of GfK Asia Pte Ltd. has contributed her views on the characteristics of markets in the Asia Pacific region and what consumer needs indicate about the future outlook for the home appliance market.

In Technotalk, we invited the General Manager of Hitachi's Design Division and the General Manager of the Mechanical Engineering Research Center at Hitachi Research Laboratory for a discussion of approaches to value creation from a consumer's perspective and future technical developments for achieving lifestyle innovation, covering such topics as consumer research and other activities at our Lifestyle Research Center, as well as development methodologies for unique functions that satisfy consumer needs.

In Topics, there are articles describing our design strategies.

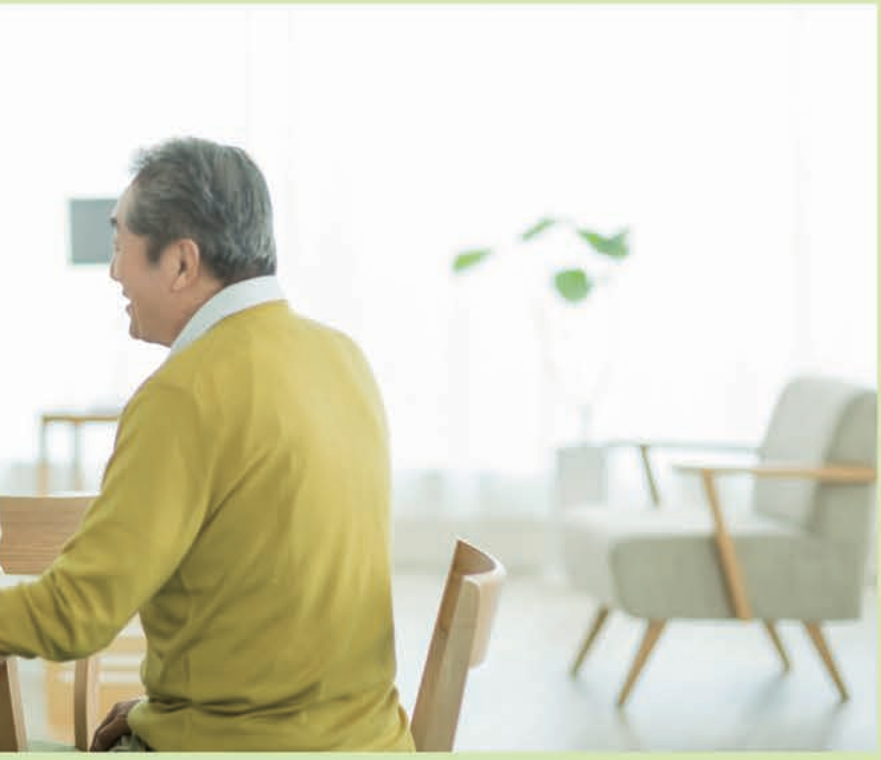
Hitachi Appliances intends to continue working on product development aimed at achieving lifestyle innovation and marketing these products throughout the world. I hope that this issue of *Hitachi Review* will prove useful to you.

Editorial Coordinator,
Home Appliances and their Role
in Hitachi's Social Innovation Business Issue

Takeshi Hoshino

General Manager,
Products Planning Division
Hitachi Appliances, Inc.

Home Appliances and their Role in Hitachi's Social Innovation Business



Home appliances are an integral part of our daily life, providing us with convenience and comfort. Meanwhile, environmental and energy problems that pose a challenge for global society mean there is a need to further reduce the load on the environment.
Hitachi develops and supplies home appliances in Japan and elsewhere that, in addition to their advanced energy efficiency performance, deliver the value that consumers genuinely want.
These products are designed to satisfy needs that are evolving along with changes in consumers' lifestyles and attitudes, and to suit differences in culture and values that vary between countries and regions.
Hitachi delivers lifestyle innovation through products that combine unique functions with environmental performance.
As part of its Social Innovation Business, Hitachi's home appliances will create new value.

Refrigerator

R-X6700E

Top-loading Washer Dryer

BW-D10XTV

Cyclonic Cleaner

CV-SA700

Room Air Conditioner

X Series

Microwave Oven

MRO-NBK5000

Rice Cooker

5.5-cup Model(RZ-VW3000M)/2.0-cup Model(RZ-VS2M)

Air Purifier

EP-KVG900

LED Ceiling Light for Home Use

LED Ceiling Light (LEC-AHS1810CC)
Light Guiding Ring Type LED Ceiling Light (LEC-DHS1230C)

Appliances for All-electric Home

IH Cooking Heater (HT-J300XTWF)

Natural Refrigerant Heat Pump
Water Heater for Home Use (BHP-FV46PD)

Residential Photovoltaic Power
Generation Systems (HSS-M210BB/HSS-P55BH)

Home Appliances to International Markets

Side-by-side Refrigerator

Top Loading Washer

Room Air Conditioner

Expert Insights

Future Outlook for Home Appliances

Jasmine Lim
Director, APAC, Home and Lifestyle Consumer Choices
GfK Asia Pte Ltd

- Over 50 million big household appliances sold in APAC in 2013
- Emerging market account for 49% of total dollar contribution
- Growth opportunities outside capital cities in developing countries
- Differing products to meet different consumer needs across APAC

For many years now, major domestic appliances such as air conditioners, refrigerators, and washing machines have continued to sustain its robust market demand in Asia Pacific (APAC), spurred predominantly by the emerging markets in the region. As developing countries advance, consumers there start to modernize and adopt technology to improve their lives. While developed markets have fully embraced such appliances, the households of India, Indonesia, Cambodia, Malaysia, Laos, Philippines, Thailand and Vietnam are still progressively being converted. For instance, GfK Roper report in 2013 revealed that less than 7 in every 10 (69%) middle high income households in Vietnam own a washing machine; a level significantly lower than the global average of 88 percent. The low penetration level translates to yet untapped potential for manufacturers in the developing markets.

Robust growth is anticipated to sustain in developing markets while rural regions are set to emulate the trends in capital cities. For example, higher growth for fridge is being seen in northern Thailand as it becomes increasingly common for Thais and foreign investors to get a home outside Bangkok. Similar trends are also observed in Indonesia as improving infrastructure in East and West Java are stimulating demand for refrigerators and front load washing machines.

Fragmentation in consumer behavior across APAC means manufacturers will need a range of products to cater to differing consumer needs.

In developed Asia region, the more saturated markets of Australia, Hong Kong, New Zealand, Taiwan, Korea and Singapore are exhibiting less volatility in demand and product mix. Design and color have become important features for house-proud owners and the more affluent ones are also buying into classy display kitchen. In these countries and regions, environmental conscious consumers are more willing to pay a higher price tag for value added features such as eco-friendly appliances.

Even within the same country, apparent differences in requirements exist in the same product. Higher disposable income households in Kuala Lumpur spurs demand for more premium vacuum cleaners or electric fans, whereas in the eastern part of West Malaysia, the best selling home appliances are those with basic features.

Increase competition is seen in most APAC countries with more and more brands entering the region, including those of European and Chinese origins. For brands to succeed, it is essential to continuously monitor the changing consumer trends and needs in each market. There definitely remains potential for further growth in APAC: emerging markets will mimic the trends of developing markets; and rural regions are likely to model after urban cities.

As the region' s political situation and economic environment recover over the next few years, consumer confidence is expected to improve in tandem, leading to increasing consumer purchases. They will also be more willing to pay a higher price for better appliances at home. This is the time when it becomes vital for manufacturers of high end goods to ensure that they communicate their products unique selling points to justify the higher price tag.

Technotalk

Contributing to Lifestyle Innovation by Creating New Value in Home Appliances

Kaori Kashimura General Manager, Design Division, Hitachi, Ltd.
Mayumi Fukuyama, Dr. Eng. General Manager, Mechanical Engineering Research Center, Hitachi Research Laboratory, Hitachi, Ltd.
Shinichi Uruma Senior Manager, Lifestyle Research Center, Products Planning Division, Hitachi Appliances, Inc.
Atsuhiko Urushihara Deputy General Manager, Products Planning Division, Hitachi Appliances, Inc.

As remarkable economic development continues, particularly in emerging economies, the question of how to resolve environmental problems while providing an enriching way of life is a challenge of global scale. Hitachi's Social Innovation Business seeks to provide safe and reliable infrastructure together with better regional societies. As part of Hitachi, Hitachi Appliances, Inc., which produces Smart Life and Ecofriendry Systems, is aiming to take up this challenge in the field of home appliances. In addition to helping overcome energy and environmental problems by supplying products with excellent energy efficiency, Hitachi is contributing to the creation of enriched and comfortable societies and ways of life by creating new value in home appliances to deliver lifestyle innovation.

Contributing to Society through Energy Efficiency in Home Appliances

Urushihara: Hitachi operates its Social Innovation Business globally, supplying safe and reliable social infrastructure that has been enhanced by information technology (IT). Home appliances, a familiar form of "infrastructure" that supports our way of life, also plays an important role in this business. With environmental problems having become a challenge for all of humanity, "eco" (meaning environmental consciousness such as energy efficiency) is among the first to be emphasized when it comes to contributing to society.

Fukuyama: Electricity statistics in Japan indicate that households account for approximately 30% of consumption. Factories and other industrial users are individually large, but collectively they make up only about 30% of consumption*1. Because there are so many more home appliances in use, overall energy consumption is large even if individual appliances do not consume much energy on their own. In this respect, improving the energy efficiency of home appliances is likely to be very effective in terms of the overall situation.

Urushihara: Sales figures for the Japanese market in FY2013 were approximately 4.8 million refrigerators*2

*1: Calculated from FY2012 energy use statistics published by the Agency for Natural Resources and Energy.
*2: From shipment statistics published by The Japan Electrical Manufacturers' Association.
*3: From shipment statistics published by The Japan Refrigeration and Air Conditioning Industry Association.

Kaori Kashimura

**General Manager
Design Division
Hitachi, Ltd.**

Since joining Hitachi, Ltd. in 1990, her work has included the use of user research for improving the usability and experience of products and services. She took up her current role in 2014.
Ms. Kashimura is a member of The Japanese Psychological Association, the Japanese Cognitive Science Society, and The Japanese Society for Cognitive Psychology.

Mayumi Fukuyama, Dr. Eng.

**General Manager
Mechanical Engineering
Research Center,
Hitachi Research Laboratory,
Hitachi, Ltd.**

Since joining Hitachi, Ltd. in 1987, she has worked on the research and development of reliability technology for social infrastructure. She took up her current role in 2014.
Dr. Fukuyama is a member of The Japan Society of Mechanical Engineers and the Science Council of Japan.

and 9.4 million air conditioners*3. So if new technology could reduce the energy consumption of each refrigerator by about 5%, equivalent to about 10 kWh over a year, it would provide annual savings of approximately 48 million kWh nationally. This means that the energy efficiency of each appliance is very important.

Uruma: Our Lifestyle Research Center conducts a variety of consumer surveys. In one of these, a regular survey of the factors purchasers consider most important in new appliances, energy efficiency is always among the most important for all types of appliances. From a consumer's perspective, electricity bills impact directly on household budgets and this creates a high level of awareness. It is anticipated that this trend will intensify in the future.

Urushihara: Energy efficiency is an area of expertise for Hitachi, not just in home appliances, and we receive a variety of technical support from our research laboratories. Thanks to that, we once again won energy efficiency awards in the 2013 Grand Prize for Excellence in Energy Efficiency and Conservation for a heat pump water heater, light emitting diode (LED) lighting, and a refrigerator. This was the second year in a row that we received an award for our refrigerators. Our other products also achieve levels of energy efficiency that are top class in the industry, and this is underpinned by Hitachi's own innovation and technical capabilities.

Fukuyama: Technical innovation is one of the judging criteria for the Grand Prize for Excellence in Energy Efficiency and Conservation. For example, Hitachi's unique Frost Recycling Cooling would likely have been one of the points in our favor when judging the refrigerators. The frost formed during cooling operation is conventionally simply eliminated by melting it with a heater. Frost Recycling Cooling works by utilizing the cooling potential of this frost while driving an air circulation fan. Along with reducing the use of the heater, this reduces the thermal load on the compressor and the moisture keeps the refrigerator interior moist. This technology was developed with the aim of optimizing the entire refrigerator system as well as improving the efficiency of its various components, such as the compressor, heat exchanger, and insulation material. In addition to home appliances and air conditioning, the Hitachi Research Laboratory also works with a wide range of technologies for improving efficiency in a variety of other fields such as electric power and industry. In the future, we intend to continue working in ways that can contribute to society by developing energy efficiency technologies that emphasize this approach of optimizing entire systems.

Complementing "Eco" Features with Unique Functions

Urushihara: Since home appliances are products that we use every day, energy efficiency is important, but so is how they can enrich our lives. Motivated by this, since FY2010, we have adopted a slogan for our product development that could be translated into English as "eco + unique value". We are offering things that are valuable from the consumer's perspective by complementing "eco" features with attractive unique functions, such as, in the case of washing machines, automatic tub-cleaning and the wind iron function that blows air through clothes during drying to remove wrinkles, the vacuum compartment function for refrigerators that uses a decompression environment to keep food fresh, and the multi-monitoring system function that achieves comfortable air conditioning by using sensors to

Shinichi Uruma

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Joining Hitachi, Ltd. in 1980, he now works in home appliance product planning and development.

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Joining Hitachi, Ltd. in 1979, he now works in home appliance product planning and development.

monitor rooms, people, furniture, and other objects.
Uruma: These can be thought of as providing value by alleviating consumer dissatisfaction and were developed in response to surveys of actual consumer needs and concerns.
Fukuyama: Wrinkles are clearly a cause for dissatisfaction with washer-dryers, and they present a difficult challenge. Blowing air at high speed to simultaneously stretch and dry the fabric represented a major shift in thinking. I understand that the researcher who developed it got the idea from seeing someone using a leaf blower on dead leaves in a park. The development involved the use of simulation technologies available at the research laboratory for things like developing the fan that produces the high-speed air flow or designing the flow passage, and also included a lot of experimental verification. It also required various attentive enhancements such as fitting a silencer to minimize the problem of the noise produced by the high-speed air.
Kashimura: Resolving consumer dissatisfaction involves not only physical factors but also resolving problems relating to how a product feels in practice or the impression it creates when handled. Concerns about the head of a vacuum cleaner feeling heavy, for example, naturally require it to be made physically lighter, but it is also important to work on things like shape and balance to make it feel light to users. Although reviewing the impressions that products make on consumers during the design process requires spending a lot of time and effort on a repeated cycle of coming up with suggestions on changes that might make it feel lighter and then producing prototypes to check these in practice, the easy-to-use grip we developed by this process has received favorable feedback for how it feels when used.

Continuous Creation of New Value

Urushihara: Along with the development of new functions to resolve dissatisfaction, we are also constantly thinking about how to create new value by using home appliances to enrich people's lives. In creating value for consumers, it is important that we are sensitive to people's lifestyle and other values.
Uruma: Over many years of conducting consumer surveys, we have found that living practices and other lifestyle factors have changed significantly. Up until 20 years ago, there was no problem with treating the standard family of husband, wife, and two children as the benchmark. Nowadays, on the other hand, there has been a notable increase in the number of smaller and elderly households, something that is reflected in how rice is cooked. A 2013 survey found that the majority of homes only cooked 2 cups or less of rice at a time despite having rice cookers with a 5.5-cup capacity, leading us to develop new products for low-volume rice cooking.
Kashimura: The Design Division and Hitachi Appliances, Inc. conducted a joint survey of living practices in 2012 in which designers and product planners visited people's homes to observe how they used home appliances and other aspects of their living environments. This provided numerous insights. While designers believe they know all there is to know about products that they use themselves, needs or other concerns that neither they nor the consumer were aware of became evident when they observed these products being used in practice. What designers noticed in this survey was that the washing machines that were intended to get clothes clean were themselves dirty. The result of this observation was a top-loading washer-dryer with a glass top design that was released in June. This overturned the fixed idea that consumers had that the washing machine becoming dirty was something they couldn't do anything about. Rather than just resolving a dissatisfaction, adopting a design aimed at keeping the washing machine itself clean can be thought of as creating a new sense of value that was prompted by an insight.
Urushihara: Ethnography is a very useful methodology for obtaining insights like this.
Kashimura: The Design Division undertakes activities aimed at developing new products or services that involve conducting ethnographic research at workplaces such as railway maintenance depots, factories, and construction sites. These activities have their origin in the lifestyle surveys conducted for home appliances. Compared to interview surveys, in which researchers can find out about only those problems that can be put into words, techniques that allow the researcher to act as a third party and observe the product being used in practice can identify latent needs and other underlying issues and has applications in the field of social infrastructure and other businesses. In developing home appliances, conducting field surveys of actual use and testing products while they are in use are things we have been doing for many years. Clearly, though, it is also essential that developers have a good understanding of things like the consumers who use their products and the places where they use them.

How to Contribute to Lifestyle Innovation

Urushihara: In pursuing its Social Innovation Business, Hitachi seeks to contribute to lifestyle innovation. For providing new value that leads to lifestyle innovations such as market-leading convenience or comfort on an ongoing basis, I believe the key lies in features that have attracted attention in recent times, such as integration with smartphones and the use of robotics or IT.

Fukuyama: Home appliances are already seen as precursors to the use of robotics. It is sectors like home appliances and automobiles that have driven the development of robotics and made the technology familiar to consumers, such as functions that are fully automatic or that use cameras and other sensors for sensing and control. We need to remind ourselves of this and use it to create new value from the consumer's perspective.

Uruma: A survey of smart home appliances (meaning appliances that can communicate with smart phones, tablets, and others) involving about a thousand participants found that people's current impressions of these products are not good. While functions such as using a smartphone to check remotely what is in the fridge, or to check the oven settings from the living room appear useful at first sight, many people see them as only creating more fuss. Even functions that seem useful are unlikely to be adopted unless they take detailed account of what users actually want and the rules of thumb that they use.

Kashimura: Am I correct in thinking that home appliances offering simple one-touch operation do not sell well?

Uruma: While features such as single-button or other simple button-based operation receive good feedback in questionnaire surveys, when models are built and compared, it is the products with more functions, in other words those with lots of buttons, that tend to be regarded more highly.

Urushihara: Simple operation is not the same thing as simple functionality. Products need to be simple to operate, but rather than cutting down on the available functions, what is needed, I believe, are simple ways to use many different functions.

Kashimura: Graphical user interfaces (GUIs) are one aspect of product operation. The more functions that are added, the more necessary are techniques for designing the operation display in a way that enables users to quickly select the function they want to use. In this respect, the use of IT is crucial, and this is an area where we at the Design Division want to make a contribution.

Fukuyama: Innovation is achieved only if the end result is genuinely useful in our lives. At the research laboratory, we are well aware of the importance of closely aligning our thinking with consumers as we go about our research.

Urushihara: When it comes to innovation, what matters most of all in the case of home appliances, which are closely associated with daily life, is to adopt a consumer's perspective. Along with maintaining our emphasis on basic performance factors such as energy efficiency, we intend to take the changing social structure of Japan into account, such as its low birth rate and aging population, and create new value based on such objectives as being simple, trouble-free, and healthy. Overseas, although characteristics such as the degree of maturity in markets and products and people's values vary from country to country and from region to region, I see our mission as being to identify latent consumer needs from a global perspective and deliver not only superficial novelty but also value that is of genuine use in consumer's lives. Taking advantage of the Design Division's methods for discovering value and its design capabilities, and the knowledge possessed by the research center, we will continue to strive to create lifestyle innovations that will help consumers enjoy an enriched future.

Overview

Pursuing “Value” in Home Appliances

Atsuhiko Urushihara
Yoshiko Kimura

PREMIUM STRATEGY FOR HOME APPLIANCES

HITACHI has consistently sought to achieve energy efficiency in its home appliances, seeing it as an important aspect of product performance. Since FY2006, it has also been pursuing a “premium strategy” that seeks to create products that provide consumers with “new value” as well as energy-saving performance.

In its product development practices, Hitachi has also used common concepts for development objectives across its range of home appliance products by selecting key words that express new value for each year, choosing “impressive value” in FY2006, “convincing value” in FY2009, and “practical value” in FY2011.

In addition to the universal requirement that home appliances be simple and convenient, Hitachi chose for FY2013 the key words “quality value,” by which it means it is seeking to create designs that are pleasant to use and convey a sense of quality.

The key words for this year (FY2014) are “empathetic value,” which means the use of unique technology to create attractive “value” that triggers a positive emotional response in consumers. This concept is embodied in all Hitachi’s product development (see Fig. 1 and Fig. 2).

In Japan, Hitachi has been researching people’s ways of life, attitudes, and values, which have been undergoing major changes in recent years, to identify which new functions will deliver “empathetic value.” Overseas, Hitachi is seeking to enhance product value not only through “Made in Japan” products developed and manufactured in Japan itself, but also by using core technologies developed in Japan as a base for the development at overseas sites of products for countries with diverse cultures and living practices.

Benefits of Selecting “Key Words”

Deciding what to develop is the most important aspect of product development. It is a useful practice to select “key words” to act as catalysts or objectives for the product development process, including the exploration of development concepts, the working through of ideas, and the sharing of concepts between developers.

Fig. 1—Premium Products for FY2014.
These premium products use unique technologies to achieve “empathetic value.”

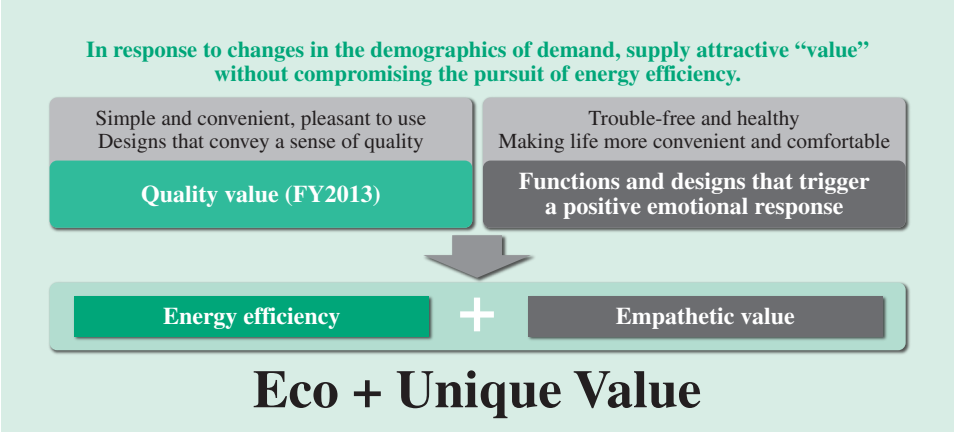


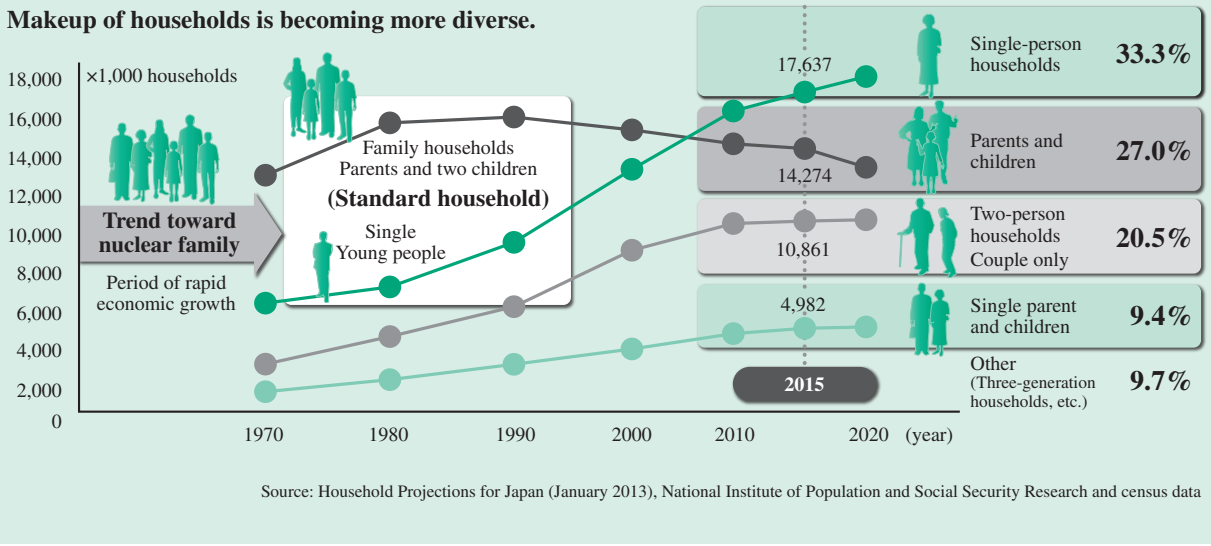
Fig. 2—Premium Strategy for FY2014.
In addition to energy efficiency performance, the key words are "empathetic value," which means attractive "value" that triggers a positive emotional response in consumers.

DEALING WITH INCREASINGLY DIVERSE WAYS OF LIFE

Japan is a mature market for home appliances with a high level of market penetration and a very demanding consumer base. As home appliances play an important role in daily life, changes in consumer lifestyles and attitudes are important factors in product development. Hitachi pays careful attention to these changes and works to offer forms of value that anticipate what consumers want by seeking out and giving shape to latent as well as explicit needs.

Due to the aging of the population and the falling birth rate, both of which have accelerated since around 2010 as the baby boom generation, which makes up the bulk of the population, approach retirement age, the fall in the number of people per household and the rise in the number of small households are also both accelerating. In particular, the number of single, married-couple, and other small households is rising, especially among the elderly. There has been a shift in requirements toward functions and other specifications that suit such households, the impact of which has been, in some cases, a major change in the breakdown of demand by product type.

Since the era of rapid economic growth in Japan during the 1970s, the "standard household" has been assumed to consist of a married couple with two children, and use by a four-person family household has been the reference criterion in product development for things like washing machine capacities and the ingredient quantities in microwave oven recipes.



Source: Household Projections for Japan (January 2013), National Institute of Population and Social Security Research and census data

Fig. 3—Changes in the Demographics of Demand.
The makeup of households is becoming more diverse, with the falling number of nuclear families made up of parents and children being accompanied by a rise in the number of small households such as those consisting of one person or a couple only.

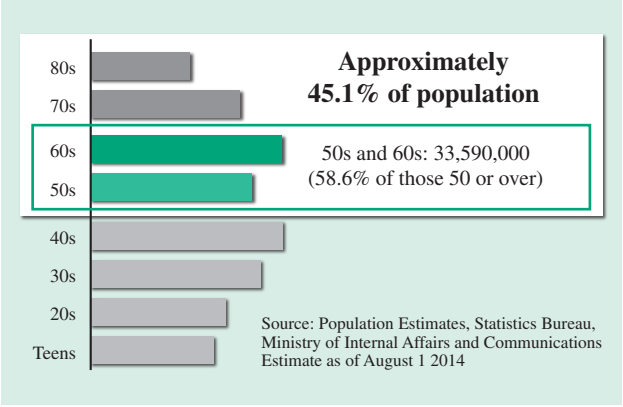


Fig. 4—Population by Age (August 2014).
Japan has become a "super aging society" in which roughly half the population (approximately 45.1%) is 50 years or older.

In practice, however, the number of single-person households has outstripped the number of parent and child households since 2005, with small households of one or two people accounting for more than half of the total in 2015, and it is predicted that this diversity of household structure will continue to grow (see Fig. 3).

As a consequence, parent and child households are no longer the majority and development criteria are being reassessed on the assumption that consumers are becoming more diverse.

Another major change is the rapid emergence of what is known in Japan as the "super aging society." As of August 2014, approximately 25.8% of the population are age 65 or over and 45.1% age 50 or over, meaning that roughly one in every two Japanese are in the 50 and over "senior" demographic (see Fig. 4).

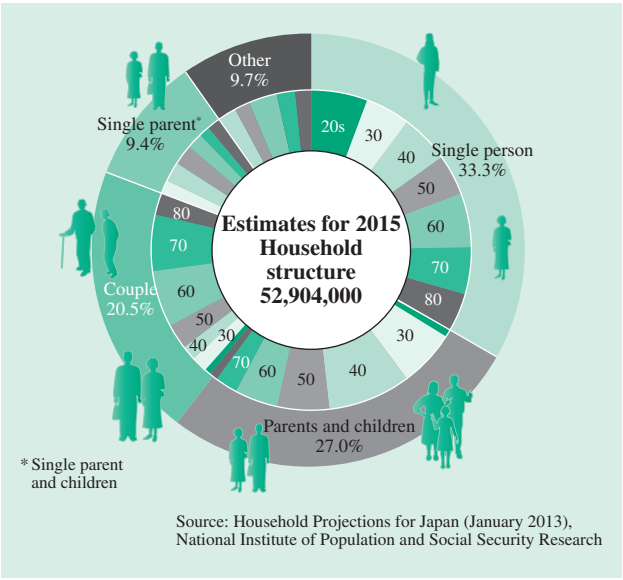


Fig. 5—Estimated Makeup of Households in 2015.
Hitachi surveyed people's living practices categorized by the number of people in the household and their age group.

While those in their 50s and 60s, who make up about 60% of the senior demographic, are active participants in hobbies and other leisure activities as well as work, they also tend to have a strong interest in health matters due to age-related fitness concerns, etc.

In seeking to undertake product development in ways that take account of this growing consumer diversity, Hitachi has carried out field surveys of consumers' attitudes and other living practices categorized by age group and number of people per household (see Fig. 5). Being trouble-free, healthy, and simple are recognized as playing an important part in consumers' needs, and Hitachi has adopted these as issues to address in its product development.

PRODUCT DEVELOPMENT FOR OVERSEAS MARKETS

Hitachi is also pursuing a premium strategy in overseas markets, which are crowded by the presence of numerous other competing suppliers, including Japanese, Korean, European, American, and Chinese companies as well as local manufacturers. With all of these manufacturers seeking to develop products that are appropriate for the market, there is an ongoing trend toward convergence in things like product specifications, design, and price.

To convey a clear sense of the "Hitachi" brand value in such a market environment, Hitachi develops premium products that provide consumers with new forms of value based around finely-honed functions, designs, and performance features developed in Japan, and their associated technologies.

"Made in Japan" products are the driving force behind this strategy because they are highly regarded for their high quality, performance, and functionality.

However, overseas markets with different living practices and cultures cannot be satisfied by building products that are all the same as those in Japan. In the case of refrigerators, for example, there is a need to develop products that take account of differences in culture and living infrastructure, such as markets that do not have established supply and distribution chains for products such as fresh or frozen foods; or the need to provide storage space in places where people eat a lot of vegetables. Rather than offering the same standardized products throughout the world, Hitachi develops products that are tailored to accurately reflect


Fig. 6—Lifestyle Survey in Viet Nam and Indonesia.
Researchers visited the homes of consumers to survey how they live and how they use appliances.

the circumstances in each market while still retaining the same core technologies.

Since the awareness of regional living practices and cultures is an important part of achieving this, there is a need to understand how the people in each country actually live and use their home appliances. And since seeing and hearing for oneself is the best way to determine the actual situation, Hitachi has been conducting consumer research in various countries and regions since 1996. Last year, this included a survey of living practices among upper-middle class and wealthy people in Viet Nam and Indonesia, categories that are growing in size (see Fig. 6).

Hitachi also keeps track of changes by regularly surveying attitudes, such as what people see as important when purchasing a product and what they are dissatisfied with, to identify and compare consumer needs in different countries. The aim of these activities is to improve product development.

In another example, a quantitative survey of washing machine use was conducted in Thailand, Malaysia, and Viet Nam to determine how people really use washing machine operating panels, which are full of buttons for different functions. Hitachi uses the results of surveys like this to try and develop washing machines that anyone can use without getting confused (see Fig. 7).

In the case of side-by-side refrigerators[(a)], it is common practice for non-Japanese manufacturers to use a direct connection to the water mains to obtain water for making ice. With regions where it is not safe to drink the water in mind, Hitachi has received widespread positive feedback from consumers for

Fig. 7—Operating Panel of Washing Machine Developed Based on Survey Results.
The operating panel was designed with consideration for layout and appearance, keeping the operation simple by only displaying as much information as needed.

developing a new type of refrigerator with an ice dispenser that works from its own water tank, as in Japanese refrigerators. When conducting a survey of actual living practices, Hitachi became aware of an owner of a conventional side-by-side refrigerator who had gone to all the trouble of connecting a large “gallon” water tank with its own pump to the refrigerator because it was not safe to use the mains water (see Fig. 8). Adopting a design with a built-in tank solves this problem.

International trends toward tighter energy conservation regulations and new standards are also intensifying competition over energy consumption, with changes also taking place in consumer attitudes. In response, Hitachi is achieving top-class energy

(a) Side-by-side refrigerator
A two-door refrigerator with doors that open to the left and right. It is called a side-by-side refrigerator because it has a freezer compartment on one side and a refrigerator on the other.

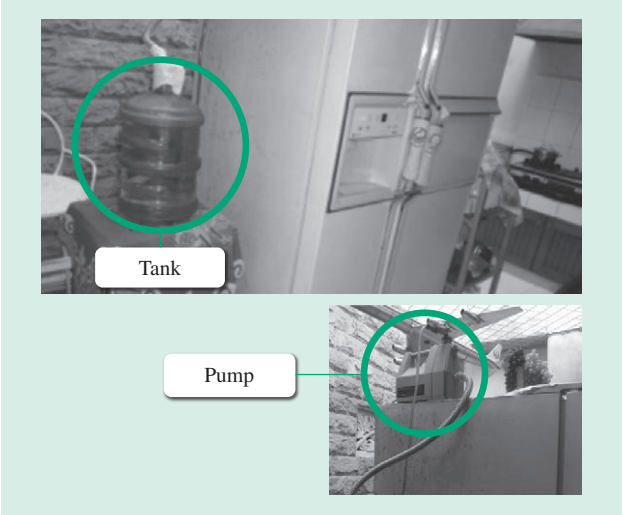


Fig. 8—Actual Refrigerator Use.
Because tap water is unsafe, a separate tank and pump have been fitted to provide water for making ice.

efficiency by developing unique energy-saving technologies.

The following sections summarize the articles in this issue of *Hitachi Review*, which describes what Hitachi is doing to pursue value for consumers, including the development of products that can keep up with changes in consumer living practices and that are designed to suit countries with different needs.

Refrigerator

With an increasingly aging population making people more aware of health concerns, there is growing demand from all generations, not just the elderly, for ways of keeping vegetables fresh.

This article describes how Hitachi has improved the ability of its FY2014 models to keep vegetables fresh by developing a photocatalyst preservation for the vegetable compartment(b) that uses photocatalyst preservation technology based on a vacuum compartment(c). The article also describes technologies for making products more energy-efficient and easier to use.

(b) Photocatalyst preservation for vegetable compartment
This function increases the concentration of carbon dioxide gas in the chamber by using an LED and photocatalyst to generate carbon dioxide from the ethylene gas released by vegetables. This is in addition to the carbon dioxide released by vegetable respiration. The higher concentration inhibits vegetable respiration, which is like putting the vegetables to sleep, keeping them fresh by slowing the rate at which they lose nutrients and dry out.

(c) Vacuum compartment
The term "vacuum" is used here to indicate a pressure below atmospheric pressure. Keeping the chiller compartment at about 0.8 atmospheres reduces the amount of oxygen around the food, suppressing oxidation, and slowing the rate at which food loses nutrients and changes color.

Top-loading Washer-dryer

There is strong demand for washing machines with a large capacity to enable an entire load of wash to be done at once, and to allow the washing of large items. Also, as consumers get older, they want washing machines that are easier to load and unload, and that are easier to operate.

An article describes the top-loading washer dryer, a washing machine with a large 10-kg capacity developed to meet these needs that features a high flow rate circulation wash(d) function for achieving a high level of washing performance while also saving water.

Room Air Conditioner

The "Imaging camera", which uses a camera to detect people's movements and control the flow of air accordingly, was developed in FY2012 with the aim of combining comfort and energy savings. The FY2014 models are fitted with the multi-monitoring system, which captures the temperature surrounding people and the layout of rooms and furniture as well as people. An article describes the detection and air flow control techniques used in the multi-monitoring system together with core energy-saving technologies.

Cyclonic Cleaner

By developing its own small and lightweight high-performance motors and a new dust collection design, Hitachi has created a high-power cyclone vacuum cleaner for its FY2014 range that achieves a suction power of 400 W despite its small size. This article describes these features together with the dust ejection mechanism and head, which feature improved ease of use.

Microwave Oven

What consumers want in microwave ovens is that they are healthy, suitable for small households, and provide faster cooking times. To satisfy these demands, Hitachi provides a full range of features that include healthy options such as oil-free stir-fry, low-oxygen cooking to minimize the oxidation of food, and meals that use fermented food; meals that can be prepared for just one or two people; and meals that are ready in just 10 minutes.

(d) High flow rate circulation wash
A function for minimizing uneven washing and ensuring that clothes are washed thoroughly by using a wide-angle spray with a very high 45 L/min flow rate to get the liquid detergent to permeate all through the clothes, and by using fins with a specially designed shape. The function is able to combine a high flow rate with low water use by using a circulation pump to save water.

The bakery function, meanwhile, satisfies the requirements for healthy eating and shorter cooking time with features that include a healthy bread-making function that kneads health-enhancing ingredients into the dough, and reduces the cooking time for a loaf of bread down to only 90 minutes.

Development of Products in Response to Changing Lifestyles

To keep pace with changes in the demographics of demand in Japan (aging population, fewer people per household), Hitachi has developed a rice cooker that is good at cooking small quantities of rice. By taking a global perspective to identifying consumer needs, Hitachi has also developed an air purifier that features a high level of dust removal performance (high flow rate).

Development of Appliances for All-electric Home and Residential Photovoltaic Power Generation Systems

Hitachi has incorporated its grill pan for easier grill cleaning into its induction heating (IH) elements for cooking. Energy-saving performance is the key feature of the natural refrigerant heat-pump water heater, and Hitachi has further improved this by insulating the storage unit with urethane foam. For its home photovoltaic power generation systems, Hitachi has developed an efficient high-output power conditioner that uses unique control techniques.

LED Ceiling Lights for Home Use

Hitachi has based the development of light emitting diode (LED) ceiling lights on the concept of combining brightness with energy savings. For FY2014 models, it has developed easy viewing function(e) lights that help the elderly see more clearly. This article describes these products along with light guiding ring type LED ceiling lights that use unique light guiding technology.

Global Deployment of Home Appliances to International Markets

Hitachi is implementing its premium strategy with a focus on the fast-growing economies in Asia and the Middle East by developing products with high added value that feature a high level of energy-saving performance, high-quality design, and unique functions.

This article describes the export strategy that forms part of this premium strategy, and also an example of development undertaken at an overseas production facility (in Thailand).

Development of Inverter Air Conditioner for Southeast Asia

The proportion of homes with room air conditioners in bedrooms is high in Southeast Asia where economic growth remains strong. This article describes the development of an air conditioner that uses the sleep support function, which is designed to provide comfortable air conditioning in bedrooms.

"Monozukuri" Technology for Home Appliances

Manufacturing technology underpins a high level of basic performance and distinctive added functions. An article describes examples of manufacturing that utilize technology for electric motors and inverters, cell manufacturing, and three-dimensional (3D) printers.

AIMING TO DELIVER "EMPATHETIC VALUE"

This article has shown how Hitachi is striving to develop products with high added value that seek to meet consumer needs by providing a high level of energy-saving performance achieved through unique technologies and that seek to deliver "empathetic value" that satisfies consumers in Japan and elsewhere.

In the future, Hitachi intends to be a pioneer for the future of home appliances by boldly taking up the challenge of developing products with new concepts that meet consumer needs.

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(e) Easy viewing function
This function uses LEDs that simulate the color of daylight and light bulbs, and that have a brightness that has been boosted by approximately 1.2 times. It achieves brighter natural lighting that is closer to sunlight by using these LEDs and by adding blue-green light. The function improves the light quality and makes it easier to read small print by controlling the light components as well as color and brightness.

Featured Articles

Development of the "Vacuum Compartment" Series of Large-capacity Refrigerators

—Adding Photocatalyst Preservation for Vegetable Compartment to Environmentally Conscious Features—

Shintaro Yamawaki
Atsuko Funayama
Hirobumi Nagumo
Akiyoshi Ohira, Dr. Eng.

OVERVIEW: Refrigerators consume the most electrical energy in the home, and the need for improved energy savings is great. With the rise of health consciousness, more attention is being focused on vegetables, leading to higher demand for refrigerator functions that preserve vegetable freshness. The new "Vacuum Compartment" series released by Hitachi in FY2014 improved the unique "Frost Recycle Cooling" technology developed in FY2009 and increased its energy-saving performance. Furthermore, the newly developed "Photocatalyst Preservation for Vegetable Compartment" function helps keep vegetables fresh while advances in the unique "Vacuum Compartment" function inhibit the oxidation of food items, thereby slowing the loss of nutrients and satisfying the cosumer's need for preserved freshenss.

INTRODUCTION

ACCORDING to data from the Agency for Natural Resources and Energy, electric refrigerators consume more power than any other device in the home (approximately 14%[*1]). Comsumers are paying close attention to the shift toward energy-saving in refrigerators, and Hitachi has been developing its own unique energy-saving technologies over the years as this trend has grown in importance.

These technologies are being highly praised, and the products released in FY2013 were awarded the FY2013 Grand Prize for Excellence in Energy Efficiency and Conservation (Product Category & Business Model Category, Reviewer's Prize)[*2]. Furthermore, technologies originally developed for large-capacity refrigerators (see Fig. 1) were incorporated into medium-capacity refrigerators in FY2014 products, and Hitachi continues to lead the industry in the promotion of energy-saving capabilities.

Because the increasing number of small-family households and the aging of the population are changing the structure of demand, Hitachi conducted a survey regarding comsumer priorities when purchasing refrigerators by household size and age range to help inform considerations of how to respond to these changes. The survey results indicated that regardless of household size and age range, many comsumers give priority to the basic performance of a refrigerator, including high capacity and energy savings, as well as preserving vegetable freshness.

In particular, although it was hypothesized that the need for capacity would be reduced due to the shift

Fig. 1—Large-capacity Refrigerator (R-X6700E).
In spite of its high capacity (rated capacity: 670 L), annual power consumption is only 200 kWh/year (JIS C 9801-2006).

*1 Based on "Breakdown of Energy Consumption by Device in the Home" from the 2009 Civilian Sector Energy Consumption Survey conducted by the Agency for Natural Resources and Energy (in Japanese).
*2 Award-winning models: "Vacuum Compartment FS" refrigerator series model R-G6700D and others, including 11 models total.

toward smaller households requiring less storage space, in actuality the survey results indicated that the demand for large-capacity refrigerators remains as strong as ever.

Also, due to a high level of health consciousness, preserving vegetable freshness is a high priority among both seniors and members of the child-raising generation (see Fig. 2).

To satisfy the high-priority need for preserving vegetable freshness, Hitachi took the unique “Photocatalyst Preservation” technology used to preserve food items stored in the “Vacuum Compartment” and applied it to the vegetable compartment as well.

The unique, highly praised “Vacuum Compartment” function has been used to successfully improve food item preservation performance even further by utilizing an antioxidant and a pungent component described hereinafter in combination with “Photocatalyst Preservation” technology to achieve a synergistic effect.

Hitachi will continue working to apply these advanced food preservation technologies to the development of products that satisfy consumer needs while inhibiting the loss of freshness and reducing food waste.

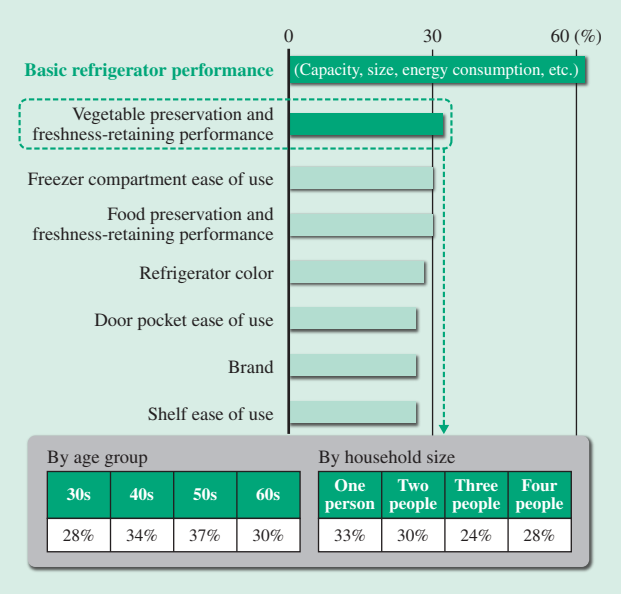


Fig. 2—Priorities in Purchasing (Multiple Responses) (Research by Hitachi in December 2013, Users of 401 L or Larger Refrigerators: n=418).
Vegetable preservation and freshness-retaining performance are given priority regardless of age or household size.

ENERGY-SAVING TECHNOLOGY

The increase of storing capacity and the improvement of energy-saving performance, both of which are major consumer needs, presents key technological challenges in the development of products.

Fig. 3 shows how annual power consumption has changed among the refrigerators Hitachi has released each year that have the largest rated capacity. The annual energy consumption of its FY2014 product (200 kWh/year) was reduced by approximately 71% compared to its FY2005 product (690 kWh/year), while rated capacity increased from 535 L to 670 L. These improvements in refrigerator energy-saving performance were achieved by using vacuum insulation panels to reduce the amount of heat conduction through the insulation walls, and by reducing input energy through the use of high-efficiency compressors. Furthermore, Hitachi also began applying energy-saving technology to its products by incorporating a view of system-wide optimization starting in FY2009.

One example of system-wide optimization technology is Hitachi’s unique “Frost Recycle Cooling” technology, which takes advantage of the frost that forms on the evaporator to help cool

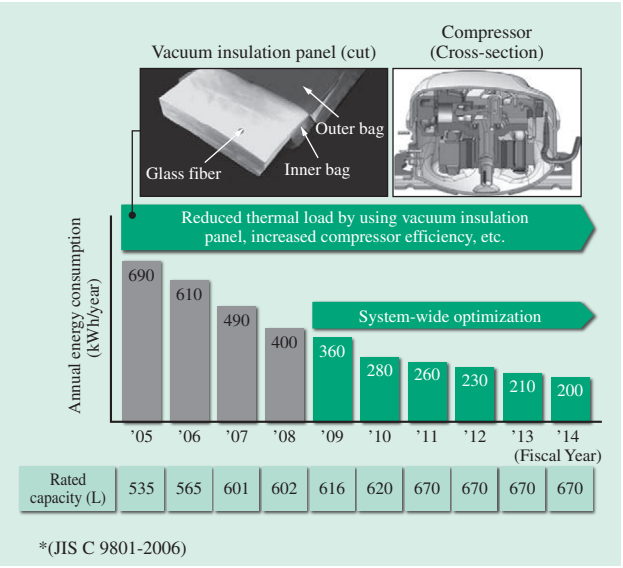


Fig. 3—History of Annual Power Consumption in Hitachi Refrigerators and Energy-saving Technologies.
Hitachi has achieved both high capacity and energy-savings through the use of unique energy-saving technologies.

the refrigerator and vegetable compartments while the compressor is stopped. In the past, frost on the evaporator would be merely periodically defrosted with a heater to melt it, and then discarded it because it deteriorates the evaporator’s performance. Starting with the FY2009 products, however, “Frost Recycle Cooling” has been applied to save energy by focusing

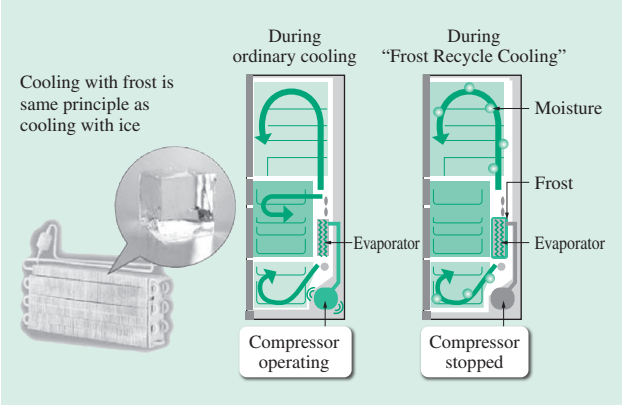


Fig. 4—"Frost Recycle Cooling."
Frost that forms on the evaporator is used to cool the refrigerator and vegetable compartments to save energy.

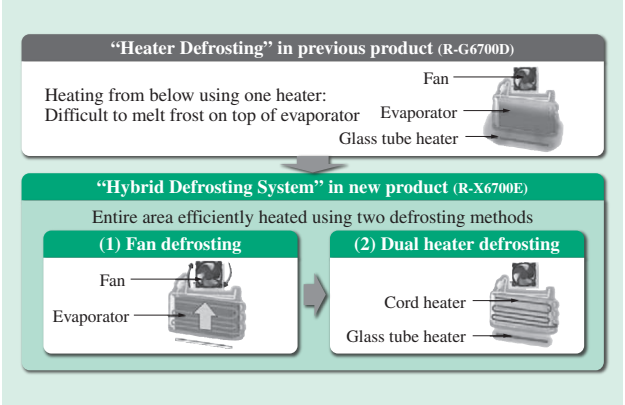


Fig. 5—"Hybrid Defrosting System."
Efficient defrosting is implemented through the use of two methods: "Fan Defrosting" and "Dual Heater Defrosting."

the cooling potential of the frost and diverting it for use in cooling the compartments of the refrigerator (see Fig. 4)[1].

A new "Hybrid Defrosting System", which evolved from "Frost Recycle Cooling", was also developed for use in products released in FY2014.

The defrosting operation based on the Hybrid Defrosting System first runs a fan, then it cools the refrigerator compartment with the frost that forms on the evaporator, thereby increasing the temperature of the frost (fan defrosting). Next, a glass tube heater and a cord heater directly attached to the cooler are both used to heat the evaporator (dual heater defrosting). This system makes it possible to efficiently increase the temperature of the evaporator during defrosting so that energy consumption can be reduced (see Fig. 5).

DEVELOPMENT OF VEGETABLE/CHILLED ROOM HIGH-FRESHNESS PRESERVATION TECHNOLOGY

To satisfy the need for "preserving vegetable freshness," which is a high priority for both the senior generation and child-raising generation due to health consciousness, Hitachi adopted unique "Photocatalyst Preservation" technology in FY2014 for use in the vegetable compartment to preserve vegetables by putting them in to a dormant state. Hitachi also worked to improve freshness preservation technology with its unique "Vacuum Compartment."

Photocatalyst Preservation Technology

Controlled atmosphere (CA) preservation[2] is a commercial preservation technology used to store fruits, vegetables, and other such products long-term in an extremely airtight refrigerating chamber with a gas composition adjusted to have a higher concentration of carbon dioxide (CO_2) and a lower concentration of oxygen than the outside air. Hitachi turned to CA while developing its "Photocatalyst Preservation" technology for adoption starting in FY2012, whereby Hitachi's unique "Vacuum Compartment" system uses "Photocatalyst Preservation" to break down the ethylene gas and odor components that emanate from food items into water and CO_2 using a light-emitting diode (LED) and photocatalyst.

Furthermore, in FY2014, a "Photocatalyst Preservation Space for Vegetables" was included that adopted the "Photocatalyst Preservation" function was included with an improved sealing in back of the lower case in the vegetable compartment.

Structure of Photocatalyst Preservation Space for Vegetables

The "Photocatalyst Preservation Space for Vegetables" was achieved through the application of the following three technologies:

(1) CO_2 generation

By placing the photocatalyst on the left side of the lower vegetable container, and the LED light source on the opposite surface of the photocatalyst, the ethylene gas and odor components that emanate from vegetables come into contact with the photocatalyst and CO_2 is generated as a gas and components are broken down by the light. Furthermore, the CO_2 concentration around the vegetables increases due to vegetable respiration, which in turn suppresses this respiration (see Fig. 6).

(2) Condensation control and a high-humidity environment

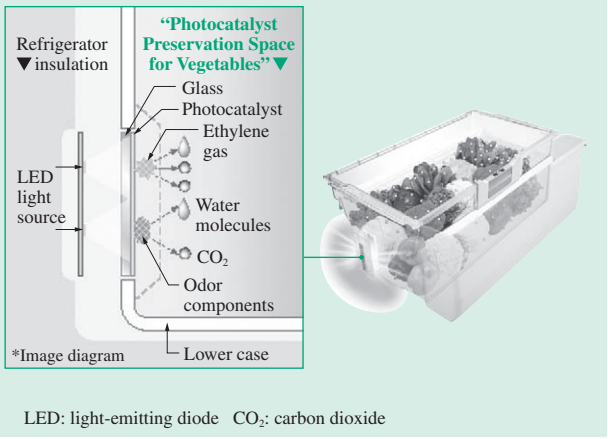


Fig. 6—CO_2 Generation Principle Used in “Photocatalyst Preservation Space for Vegetables.”
An LED light source and a photocatalyst are used to break down ethylene gas and odor components, thereby generating CO_2.

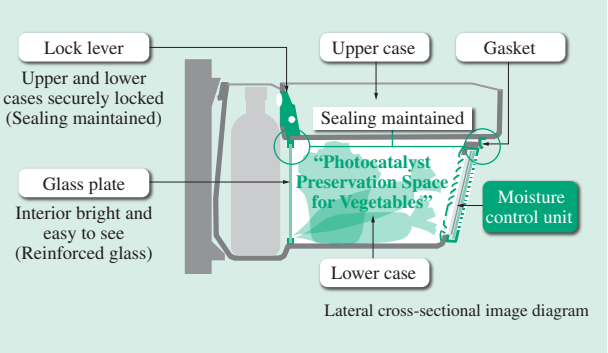


Fig. 7—Structure of Vegetable Compartment.
The seal is tightened using a “lock handle” and a “glass divider,” and condensation is suppressed using a “moisture unit,” achieving a high-humidity environment.

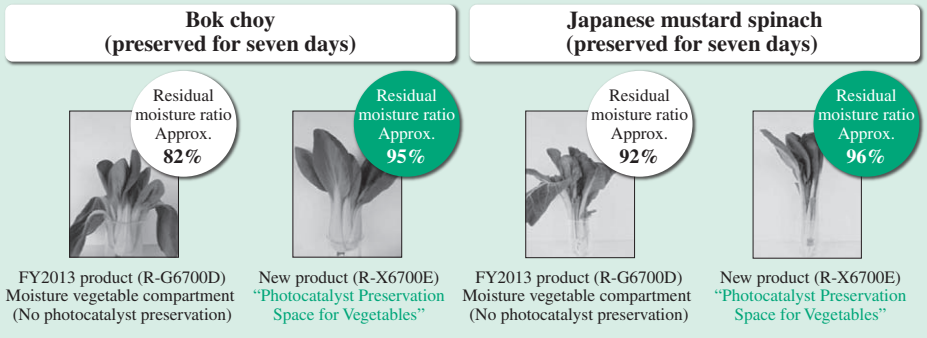
The strong seal maintains the high CO_2 concentration, while preserving moisture in the space, resulting in a high-humidity environment. However, this sealing also causes the moisture from the vegetables to condense and stick to the walls of the compartment. A “moisture unit” is used to evaporate this condensation outside the back of the lower case using cooling air, thereby achieving a high-humidity environment while controlling condensation (see Fig. 7).

(3) Strong sealing

The “lock lever” on the front of the upper case is locked in order to tighten the seal within the “Photocatalyst Preservation Space for Vegetables”, which makes up the area between the upper and lower cases, thereby suppressing the leakage of CO_2 and moisture from within this space (see Fig. 7).

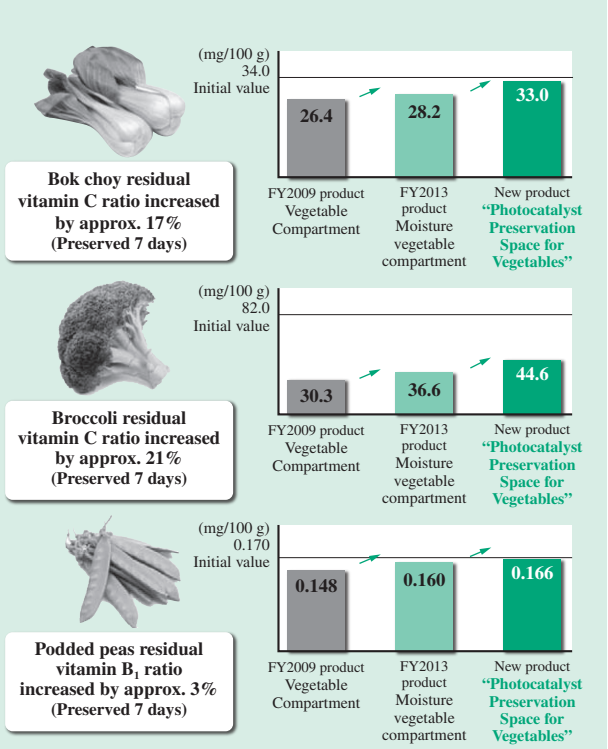
Preservative Effect of the Photocatalyst Preservation for Vegetable Compartment

The same amounts and types of vegetables were stored in a conventional vegetable compartment and in a ”Photocatalyst Preservation Space for Vegetables” for 7 days, and changes in weights were used to compute and compare residual moisture ratios. The results showed differences of approximately 13% for bok choy and approximately 4% for Japanese mustard spinach, indicating that drying had been inhibited. In this way, the “Photocatalyst Preservation for Vegetable Compartment” technology maintains the firmness and juiciness of vegetables, which is apparent in the external appearance of the vegetables (see Fig. 8). Similarly, when the nutritional content in the vegetables was compared after preservation, the loss of vegetable nutrients was reduced by approximately 17% for vitamin C in bok choy, by approximately 21% for vitamin C in broccoli, and by approximately 3% for vitamin B_1 in podded peas, providing evidence that vegetable nutrients are protected (see Fig. 9).



[Test Conditions] Ambient temperature outside refrigerator was 20°C, humidity was 70%, none of the vegetables placed in the R-X6700E’s “Photocatalyst Preservation Space for Vegetables” were wrapped, and they were preserved without opening the door. The same quantity of vegetables was stored in the R-G6700D moist vegetable compartment. Based on Hitachi testing. Effects differed depending on vegetable storage capacity, type, freshness, and other factors. There was no effect in terms of extending best-before/expiration date, and indicated preservation periods are not guaranteed.

Fig. 8—Effect of “Photocatalyst Preservation Space for Vegetables” (Comparison of Exterior Appearance and Residual Moisture Ratio). Drying is inhibited through “Photocatalyst Preservation for Vegetables” technology, and the firmness and juiciness of vegetables is maintained.



[Test Conditions] Ambient temperature outside refrigerator was 20°C, humidity was 70%, none of the vegetables placed in the R-X6700E's "Photocatalyst Preservation Space for Vegetables" were wrapped, and they were preserved without opening or closing the door. The same quantity of vegetables was stored in the R-G6700D moist vegetable compartment. Residual ratios were compared between the new R-X6700E product's "Photocatalyst Preservation Space for Vegetable," the previous year's R-G6700D product with moist vegetable compartment (without photocatalyst preservation, and with moisture preservation), and there was no nutrient increase or similar effect with respect to initial values. Graphs show a comparison between the new R-X6700E product's "Photocatalyst Preservation Space for Vegetables," the previous year's R-G6700D product with moist vegetable compartment (without photocatalyst preservation, and with moisture preservation), and the R-Z6200 product from five years ago with vegetable compartment (without photocatalyst preservation, and without moist preservation). Based on Hitachi testing.

Fig. 9—Effect of the "Photocatalyst Preservation Space for Vegetables" (Nutrient Comparison).
In addition to the residual moisture ratio, vitamin C, and other nutrients were also protected.

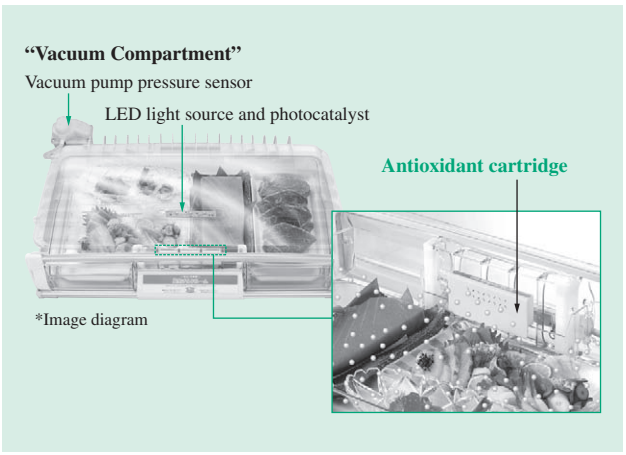


Fig. 10—Antioxidant Cartridge
An antioxidant and a pungent component are utilized in the antioxidant cartridge in order to improve preservation performance.

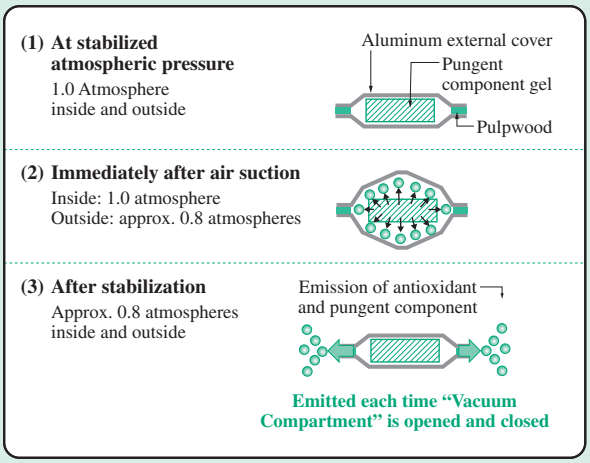
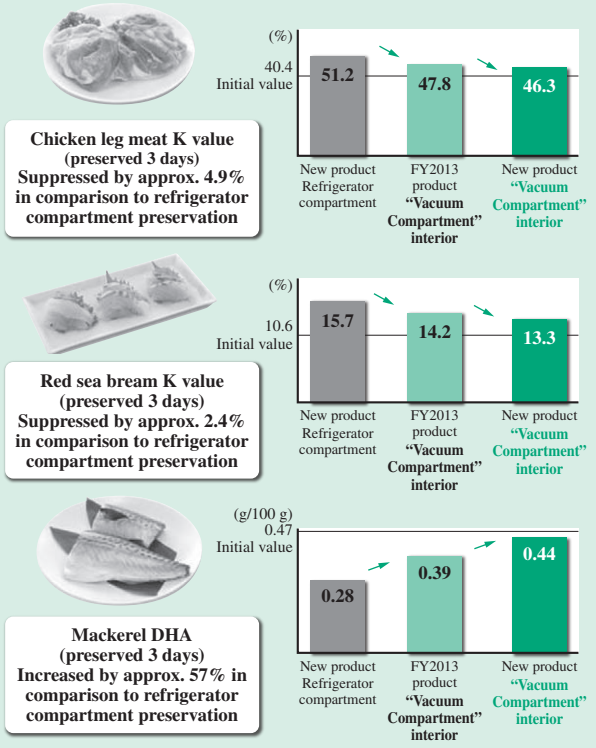


Fig. 11—Antioxidant and Pungent Component Emission Principle.
Vacuum suction in the "Vacuum Compartment" is used to emit the antioxidant and pungent component.

Improving Preservation Performance in the Vacuum Compartment

The highly praised "Vacuum Compartment" is a unique function that uses "Vacuum Preservation" and "Photocatalyst Preservation" technologies to suppress the oxidation of food items, while utilizing an antioxidant and a pungent component in the antioxidant cartridge for a synergistic effect that improves food preservation performance even further. When the interior of the "Vacuum Compartment" is decompressed, the antioxidant cartridge emits an antioxidant component (vitamin E), commonly added to butter and other food items along with a pungent component (allyl isothiocyanate), which is contained in food items such as wasabi (see Fig. 10). The suction of the air in the "Vacuum Compartment" lowers the air pressure outside the aluminum external cover enclosing the antioxidants and pungent components, thereby causing the external cover to swell. The external cover then shrinks once the pressure in the compartment stabilizes, and the antioxidants and pungent components are emitted through pulpwood and into the interior of the compartment (see Fig. 11).

This causes the antioxidant component to be oxidized instead of the nutrients in the food items. Oxidation in the food items is suppressed because the pungent component suppresses the action of enzymes while preventing protein degradation.



Comparison between refrigerator compartment in new R-X6700E product, “Vacuum Compartment” interior (set to the lower temperature mode), and “Vacuum Compartment” interior of previous year’s RG6700D product (set to the lower ice temperature mode). Ambient temperature outside refrigerator was 20°C, polyvinyl chloride wrapping was used, door was not opened or closed, and food items were preserved for 3 days. Based on Hitachi testing.
Since polyvinyl chloride wrap is permeable to moisture and gas, use/non-use of wrap does not affect vacuum preservation or photocatalyst preservation. Effects differ depending on food ingredient type, freshness, and other factors. There was no effect in terms of extending best-before/expiration date, and indicated preservation periods are not guaranteed.

DHA: docosahexaenoic acid

Fig. 12—“Vacuum Compartment” and Refrigerator Compartment Preservation Performance Comparison.
Nutrient loss in food items is suppressed through preservation in “Vacuum Compartment.”

When this method is compared with preservation in the refrigerator compartment, the K value[*3], which is used to represent freshness, is suppressed by approximately 4.9% for chicken breast meat, and in the case of docosahexaenoic acid (DHA), a nutrient contained in mackerel, increased by approximately 57% (see Fig. 12).

USABILITY IMPROVEMENT TECHNOLOGY

In response to the increase in food storage space provided by higher-capacity refrigerators, Hitachi has been working on developing technology to improve usability so that doors can be opened and closed easily even when the refrigerator is full of food.

The drawers used for the freezer and vegetable compartments require a great deal of force in the initial action to open them. Hitachi developed its own unique power-assisted drawers and started implementing them in products in FY2006 to reduce this burden.

The user lightly presses a button on the front of the power-assisted drawer to activate a power-assisted drawer, which then pushes out the drawer. Furthermore, consideration is given to how using the function feels to the consumer by ensuring that the drawer opens at the same speed regardless of how much food is in the refrigerator (see Fig. 13).

The storage capacity of the pockets in the refrigerator compartment doors is also increasing along with the shift to higher capacities. In response, Hitachi developed power-assisted doors for refrigerator compartments with motorized opening mechanisms for use in refrigerator compartment doors on both the left and right sides, and included them in the FY2013 version of its products.

The motorized opening mechanism pushes the door open when the user lightly touches the operating part of the refrigerator compartment’s power-assisted door, located on the door’s glass surface, thereby activating the refrigerator compartment power-assisted door unit mounted on the ceiling of the refrigerator. Both left and right doors can also be opened with a single operation by touching the operating part and sliding the finger. This functionality supports needs such as inserting large food items into the refrigerator,

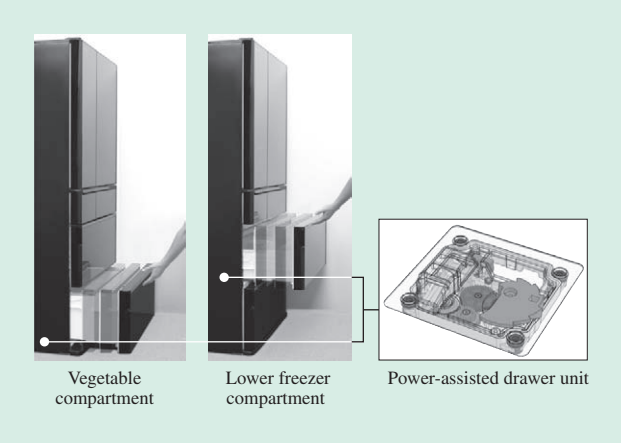


Fig. 13—Power-assisted Drawer and Power-assisted Drawer Unit.
A motorized opening mechanism was used to reduce the burden of opening and closing each drawer due to the shift towards high capacity.

*3 K value is an index that represents freshness, and is based on the ratios (%) of inosine and hypoxanthine, which are the final by-products of adenosine triphosphate with respect to the total amount of adenosine triphosphate-associated compounds. The lower the K value, the better the freshness level.

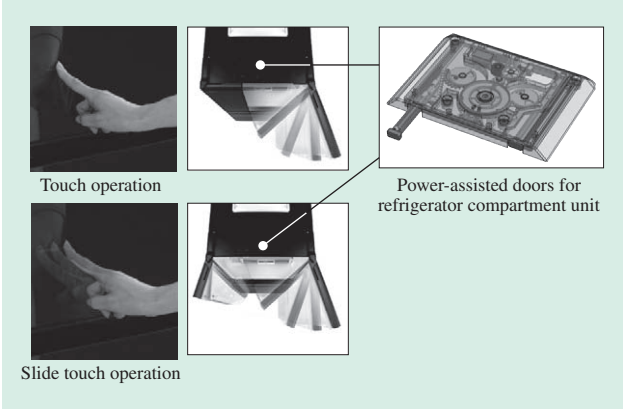


Fig. 14—Power-assisted Doors for Refrigerator Compartment and Power-assisted Doors for Refrigerator Compartment Unit. A motorized opening mechanism is also used for the refrigerator compartment doors, and the door can be easily opened by just touching the door glass surface.

or verifying the contents of both door pockets (see Fig. 14).

Furthermore, for the sake of safety, when the user inserts a hand or accidentally touches the door over a wide area, such as with the palm of the hand or the elbow, the door does not open (the door only opens when touched with fingertips or otherwise over a small area). The design also incorporates considerations that prevent the user's hand from getting stuck in the door.

A variety of design considerations have been implemented to ensure that not only can the drawer be easily and comfortably opened, they can also be used safely.

CONCLUSIONS

This article discussed energy-saving technologies for refrigerators, preservation technologies including "Photocatalyst Preservation for Vegetable Compartment" and the "Vacuum Compartment," as well as the Power-assisted drawer and the power-assisted door for refrigerator compartment functions, which improve the usability of large-capacity refrigerators.

Hitachi will continue to develop unique technologies with the goal of creating industry-leading products that earn the consumer's satisfaction.

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Featured Articles

Development of the Top-loading Washer Dryer

—Adding High Flow Rate Circulation Wash to Environmentally Conscious Features—

Kazutoshi Katane
Hiroyasu Tamagawa
Tetsushi Yoshida
Shuji Aita

OVERVIEW: Currently, the major demands for top-loading washer dryers are energy & water savings, and larger capacity (environmentally conscious performance). The top-loading washer dryer released in FY2014 features high flow rate circulation wash and the high-end model with a washing capacity of 10 kg uses pumps to increase the circulation flow rate and has a new shape for the agitating blades to achieve both water-saving performance (that is, environmental consciousness) and washing ability at the same time. This model meets the needs of senior consumers for ease of use, and, in addition to the previously adopted large opening and shallow washing tub, also offers a "glass top design" for increased cleanability, an "assistance mechanism" that reduces the effort required to open and close the lid, and other features that increase the product's user-friendliness even more.

INTRODUCTION

NEEDS for a top-loading washer dryer are varied, and include environmentally conscious performance in terms of saving energy and water, as well as high capacity, silent operation, washing ability, and user-friendliness in terms of ease of both laundry loading/unloading and operation. A user's survey by household size and age regarding the priorities they have when purchasing a washer dryer shows that although environmentally conscious performance, washing ability, and other aspects of basic performance are given priority regardless of household size or age, ease of use tends to be given a higher priority the older the respondent. The survey also shows that, even as the number of households with fewer people has increased, the need for high-capacity models has also grown, due to people's need for washing large items or washing a large number of items at the same time, regardless of the household size (see Figs. 1 and 2).

During the development of the FY2014 version of the top-loading washer dryer (high-end 10 kg model), Hitachi set a goal of providing "empathy value" in the sense that the product inspires an empathic connection with consumers. The model simultaneously achieves both water saving (environmental consciousness) and washing ability by applying a newly developed washing method made possible with its large 10-kg capacity, in which a high flow of water is circulated. Furthermore, to respond to the needs of the senior generation in terms of ease of use, Hitachi has also focused on developing a "glass top design" with high cleanability (comprised of a single flat lid for the top surface, made out of reinforced glass), as well as an "assistance mechanism" that makes it easy to open or close the lid with minimal force. In addition, it aimed

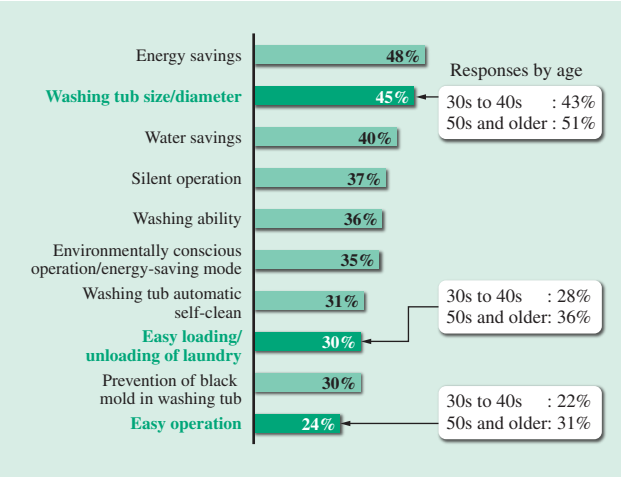

Fig. 1—Consumer Priorities when Purchasing a Top-loading Washer Dryer (Hitachi Survey from September 2013: n=410). Although a diverse range of needs exists with respect to washing machines, the need for ease of use increases according to the age of the respondent.

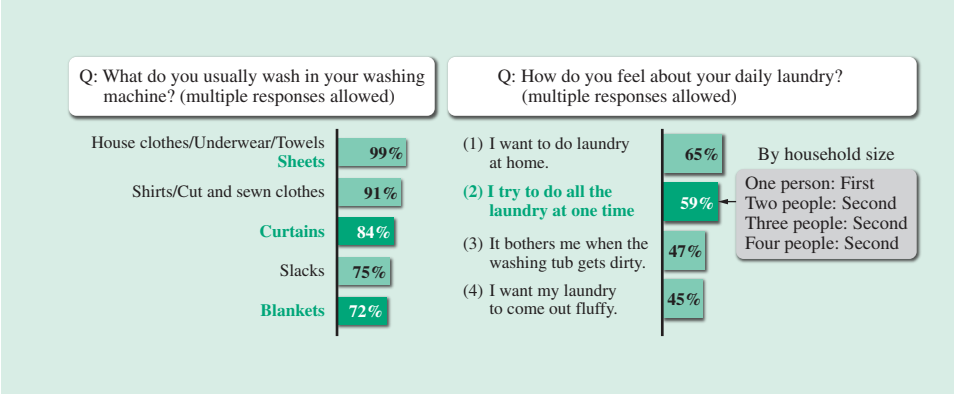

Fig. 2—Attitudes Regarding Laundry (Hitachi Survey from October 2013: n=832).
Even as households grow smaller, high-capacity machines are becoming more necessary due to the need to wash suits, curtains, blankets, and other large items (left), or to wash in bulk to reduce washing frequency (right).

Fig. 3—BW-D10XTV FY2014 Top-loading Washer Dryer (10-kg Capacity).
Also offers ease of use, while achieving both water-saving performance and washing ability at the same time.

at providing a highly functional, high-quality product (see Fig. 3) utilizing vibration reduction technology that reduces unpleasant shaking and noise that occurs while the water is draining.

The following section describes the new washing method for combining water savings with washing ability, the vibration reduction technology, and the pleasingly easy to use design (including the glass top).

A WASHING METHOD THAT COMBINES WATER SAVINGS WITH HIGHER WASHING ABILITY

The Washing Method

The basic method used to wash laundry in a top-loading washer dryer is the "fill and wash," whereby the washing tub is filled with a large quantity of water, and then the laundry is washed. Ever since it released its first model in FY2004, however, Hitachi has continued developing its unique washing method every year as a concept that enables the simultaneous achievement of both water savings (by washing with a small amount of water) and a high level of washing ability.

The three key elements required to produce high washing ability are detergent, the way water is supplied, and mechanical force.

The development of the technology used in the "water-saving circulation pump" adopted for the high-end model released in FY2014 (BW-D10XTV) is described below.

Developing High Flow Rate Circulation Wash to Simultaneously Provide Both Water Savings and Washing Ability

To further improve the washing ability of its FY2014 product (BW-D10XTV), Hitachi made advances in the way water is supplied and the mechanical force components of its high flow rate circulation wash method while still saving water (environmental consciousness) at the same time.

(1) Advancing the way water is supplied

In order to further advance the way water is supplied, the circulation flow rate was increased with a "water-saving circulation pump," and performance was improved by increasing the spray width of the circulated water. This caused the high flow of circulated water to evenly pour from the top over the clothes in the washing tub, which then caused the liquid detergent to more thoroughly penetrate and clean dirt off of the clothes. The increased circulation also soaks the clothes in water, thereby successfully incorporating the characteristics of a top-loading washing machine's method of washing with a large amount of water while still saving water overall.

The achievement of a high flow rate involved issues in terms of both reducing pressure loss in the piping system and improving pump performance. Pressure loss was reduced by expanding the pipe diameter to an inner diameter of 30 mm (approximately 1.5 times the

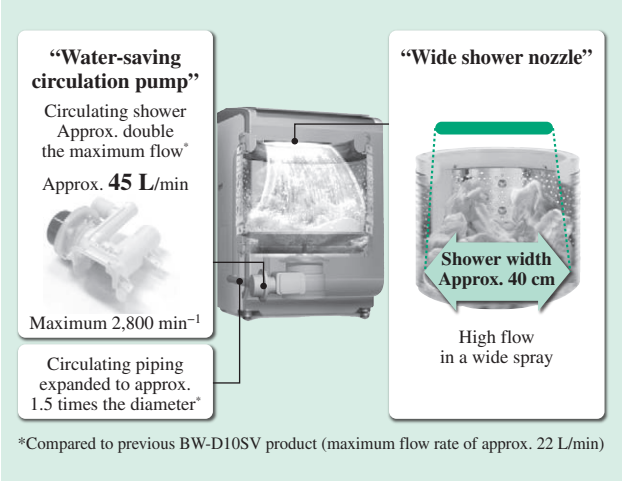

Fig. 4—High Flow Rate Circulation Wash
Washing ability is improved by circulating a small amount of water with a "water-saving circulation pump" and spraying water evenly over clothes with a "wide shower nozzle."

previous ratio*), which is the maximum size that can be fit within the current body. Furthermore, pressure loss was also reduced in parts where the pipe bends and other places where the flow becomes complex inside the piping, for a total reduction in pressure loss of approximately 26% for the entire piping system*.

In terms of pump performance, measures such as increasing the efficiency of the impeller shape successfully enabled operating the circulation pump motor at a rotation speed of approximately 1.2 times the previous ratio (2,300 min^{-1} increased to 2,800 min^{-1})*.

Through these modifications, it was possible to achieve a maximum circulation flow rate of approximately 45 L/min, which amounts to approximately double the previous ratio* (see Fig. 4), all while still using a small amount of water (standard water usage of 86 L when laundering 10 kg).

Hitachi also developed the high flow rate wide shower to distribute the flow of circulated water throughout a wide range inside the washing tub, and this enables the uniform permeation of clothes with water regardless of the load size (see Fig. 5).

(2) Advances in mechanical force

In order to achieve advances in the mechanical force, Hitachi developed a new X-shaped agitator blade that improves performance. Each time the agitating blades reverse spinning direction at the bottom of the washing tub, the clothes are moved up and down (washing through pushing, beating, and kneading), drawn inward, shifted from top to bottom, and pushed outward. Movement of the clothes was improved inside the washing tub in the inward, outward, upward, and downward directions (see Fig. 6).

The aforementioned advancements in the way water is supplied and the mechanical force were used to achieve the new high flow rate circulation wash method. High flow rate circulation wash improves washing performance by approximately 5% while still using the extremely small amount of water (86 L) that is required for a top-loading washer dryer*, and at the same time reduces uneven washing by approximately 20%*. Although this method requires power to operate, because it uses a pump, it lowers the total running costs by reducing the required amount of water.

VIBRATION REDUCTION TECHNOLOGY FOR USE IN TOP-LOADING WASHER DRYERS

This section describes the vibration-reduction technology used to maintain the consumer's level of comfort.

* Compared to the FY2013 product, BW-D10SV.

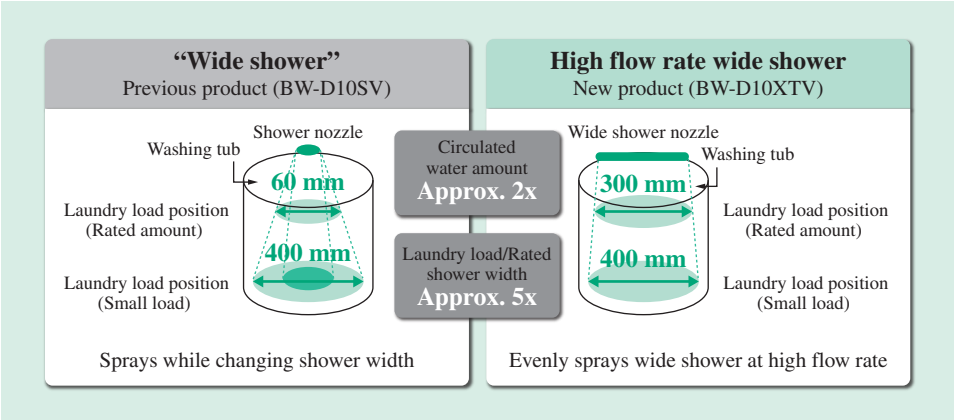

Fig. 5—High Flow Rate Wide Shower
Water is uniformly sprayed over clothes at a high flow rate regardless of load size.

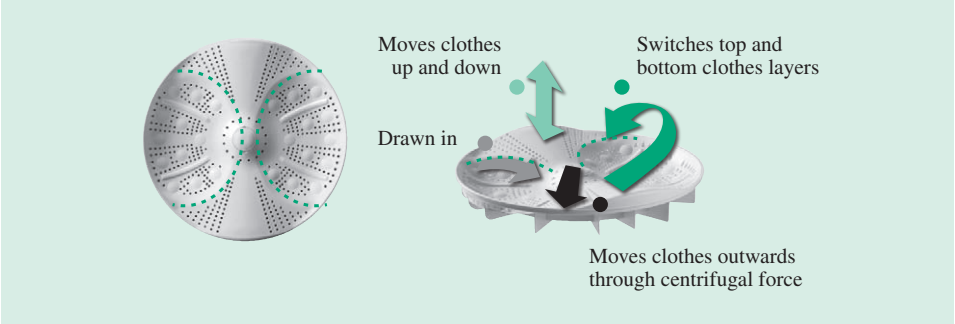

Fig. 6—New X-shaped Agitating Blades.
In addition to the effects of "pushing, beating, and kneading", which have been previously adopted, the new X-shaped blades are improved to add movement in the inward, outward, upward, and downward directions.

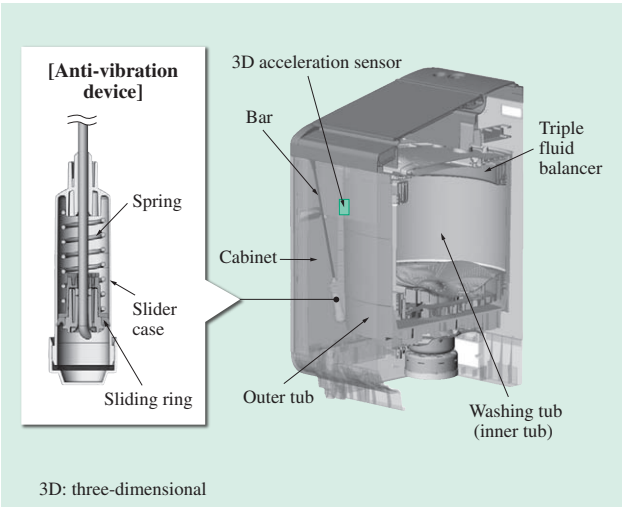

Fig. 7—Overview of Top-loading Washer Dryer Structure.
The outer tub is suspended from the cabinet using four bars. In order to reduce vibrations, the bars are equipped with vibration isolation and fluid balancers. 3D acceleration sensors are used to constantly monitor vibrations.

The low-vibration structure of the top-loading washer dryer is shown in Fig. 7. The liquid inside the triple fluid balancer shown in the diagram reduces the unbalancing effect of the clothes by moving to the opposite side when it occurs. When stratification occurs in the radial direction, the effect, which is equivalent to including multiple fluid balancers, grows stronger. The outer tub is suspended from the cabinet with four bars. Anti-vibration devices are attached to the bottom of these bars in order to provide the outer tub with flexible support and a damping effect, while springs flexibly support the weight of the outer tub.

Consumers ordinarily wash a mixture of clothes that have a variety of different sizes and cloth types. For this reason, the amount of water content will also differ depending on the clothes, and uniformly pressing the mass of the clothes against the inside of the washing tub during spin drying becomes a challenge when it comes to reducing vibration. Also, even if the mass is evenly distributed at the start of spin drying, the clothes can become increasingly unbalanced as moisture is removed. To solve this, a three-dimensional (3D) acceleration sensor is used to constantly detect complicated vibrations in the outer tub during spin drying, and to control the operation in such a way as to reduce the vibrations.

IMPROVEMENTS IN EASE OF USE

Hitachi has worked to develop a wide range of improvements in terms of ease of use, including cleanability, ease of opening/closing the lid, and the user interface (control panel).

Glass Top Design

The easy-to-clean "glass top design" was developed by forming a single large lid from tempered glass in a flat shape, with no irregularities or gaps (see Fig. 8).

Issues during the development of the "glass top design" included avoiding damage to the glass by falling objects, etc., durability against scratches, and other reliability factors, so a 4.0 mm thick sheet of tempered glass was used. In addition, the inclusion of an air layer between the glass and the base parts allows for deformation that may occur when a load is placed on the glass, this feature improves both the strength and the durability even further. Drop tests

Fig. 8—Glass Top Design.
The flat "glass top design" makes it easy to wipe off dirt.

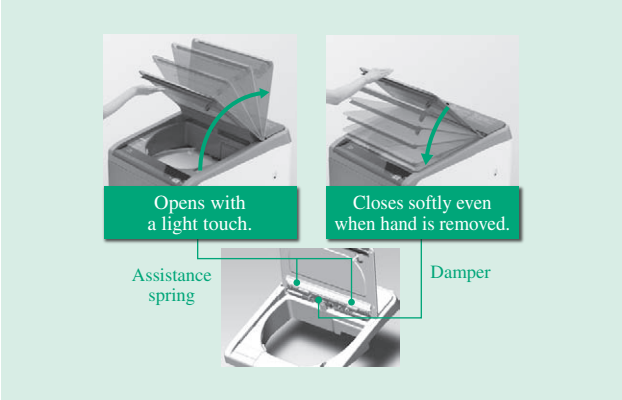

Fig. 9—Lid Opening and Closing "Assistance Mechanism." Dampers and assistance springs enable the lid to be smoothly opened and closed with a small amount of force.

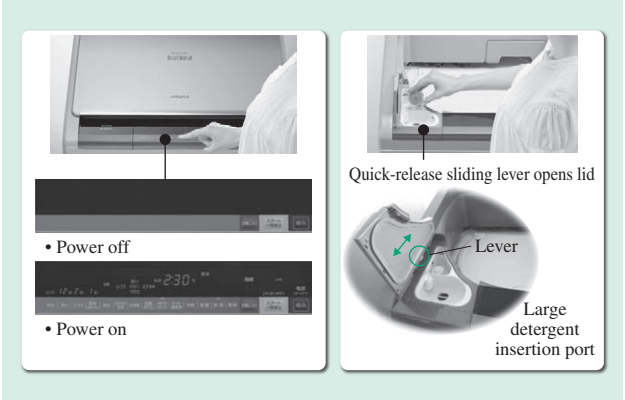

Fig. 10—Control Panel and Detergent Insertion Port. The control panel (touch panel) located in front is more user-friendly (left), while the wider aperture of the detergent insertion port makes it easier to insert detergent and other agents (right).

as established by Japanese Industrial Standards (JIS) confirmed that when this glass top is incorporated into a washing machine, dropping a 1-kg iron ball from approximately three times the required height (3 m) does not damage the glass.

Lid Opening/Closing "Assistance Mechanism"

Since the lid is heavier due to adoption of tempered glass, an "assistance mechanism" was developed to make it easier to open and close, with two types of dampers and assistance springs included on the hinge, in the opening and closing directions. This mechanism successfully reduces the amount of force required to open or close the lid from the approximately 22 N required for the previous type (BW-D10SV, the FY2013 version of the product), to approximately 7 N for the glass lid, or about one third the force. Furthermore, if the user's hand looses its grip while closing the lid, a damper will take over once the lid reaches a predetermined angle to adequately decelerate the lid before it closes (see Fig. 9).

"Touch Panel," "Favorites" Button, and "Detergent Insertion Port"

For the user interface, a touch panel was implemented with a display that stays on only while the power is on (see Fig. 10, left). The control panel was moved from the previous position in the center to the front of the lid, and this proximity makes it easier to see and operate the device without the need to extend the arms. In addition, to save the effort of selecting settings, a new "Favorites" button was added that can be used to remember the user's three favorite operation course settings. By registering the most frequently

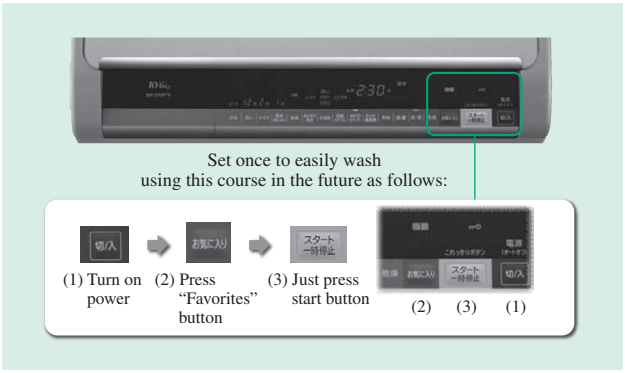

Fig. 11—"Favorites" Button. Favorite washing course, can be easily selected after setting them once.

used operation courses, all the user needs to do to start the washing operation is to press three buttons: the power on/off button, "Favorites," and then start/stop (see Fig. 11).

The insertion ports for the detergent and for the softening agent (fabric softener) have been expanded in size and located up front to make it easier to insert the detergent and other agents. Furthermore, the detergent tray and detergent lid are constructed in such a way that they can be removed and washed if the area around the insertion port becomes dirty (see Fig. 10, right).

CONCLUSIONS

Hitachi has brought to life various innovations in the washing machine market by aggressively pursuing "values" that the consumer finds attractive, including an automatic tub-cleaning function that cleans the

washing tub after each operation, and a “Wind Iron” function that removes wrinkles using jet air in a front-loading washer dryer.

Hitachi will continue to pursue the values that customers seek.

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Featured Articles

Development of Room Air Conditioners

—Adding Multi-monitoring System to Environmentally Conscious Features—

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Tetsuya Tadokoro
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Tomohiro Komatsu
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OVERVIEW: There is a demand for further energy savings and electricity conservation in room air conditioners, which consume a large amount of electrical energy in the home. The stainless/clean room air conditioners that was released in FY2014 features unique energy-saving technology along with a multi-monitoring system that provides comfort through the use of an "imaging camera", a "thermal imaging camera", and a "near-infrared camera". This system detects not only surrounding temperature and the positions of people, but also the positions and shapes of furniture and the layout of the room, and identify airflow paths. The system blows warm air toward the feet when heating, and circulates cool air to cool the entire room when cooling, using fine-tuned control over the direction of air to achieve comfortable air conditioning all year round.

INTRODUCTION

AS concerns mount over global warming and the cost of electricity rises, the need for products with excellent energy-saving performance continues to grow. The "annual performance factor" (APF)[(1)] is an index used to represent a room air conditioner's energy-saving performance. Many companies are developing room air conditioners with higher APF values each year by improving basic technologies such as compressors, heat exchangers, fans, and the inverter circuits used to drive motors.

According to surveys, however, in addition to consumer complaints such as "my electricity bill is too high," there are also many complaints that "it doesn't warm my feet" when heating, and "it doesn't cool the whole room" when cooling (see Fig. 1).

To respond to these needs and complaints, and to save electricity while improving comfort at the same time, Hitachi developed the "Imaging camera", making it the first time a visible light camera was used as a sensor in an air conditioner. This technology, which detects the movements of people within a living space to achieve comfortable electricity-saving control

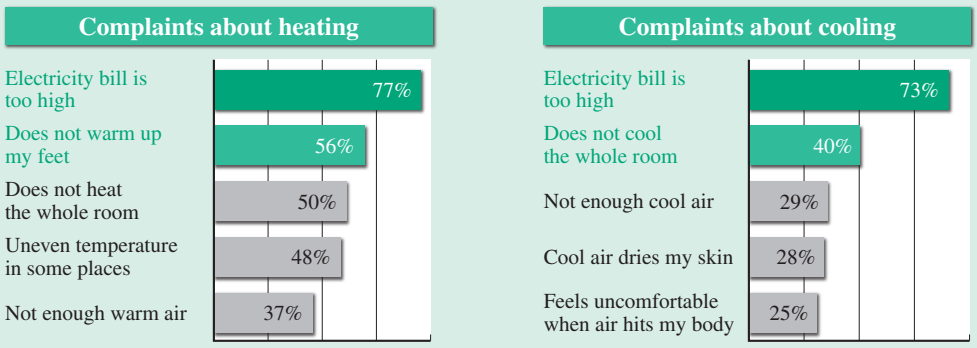

Fig. 1—Complaints about Room Air Conditioners (Hitachi Survey from May 2014: n=515).
Along with "my electricity bill is too high," complaints included "it doesn't warm my feet" for heating, and "it doesn't cool the whole room" for cooling.

Fig. 2—Room Air Conditioner (X-series) Released in FY2014. This model included the multi-monitoring system and a three way front flap. Comfortable air conditioning is achieved by finding airflow paths.

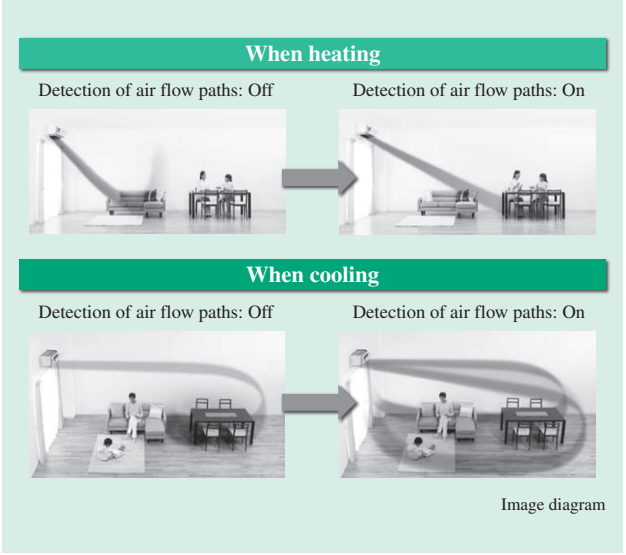

Fig. 3—Improved Handling of Airflow Blocked by Furniture. Comfortable air conditioning is achieved by controlling the airflow based on consideration of the shapes and positions of furniture.

that suits the situation, was adopted for use in high-end models released in FY2012.

Furthermore, in FY2013 a thermal imaging camera using a thermopile was included in addition to the imaging camera, and a monitoring system with these cameras could detect the temperature around people and achieve electricity-saving functionality that was more accurate and comfortable.

For the product released in FY2014, the multi-monitoring system was developed even further based on the premise of energy-saving performance with a goal of providing comfort that would resonate with consumers. This article describes an airflow control function that utilizes the sensing technology of the stainless/Clean Room Air Conditioners released in FY2014, and technology that improves energy-saving performance (see Fig. 2).

COMFORT TECHNOLOGY BASED ON MONITORING WITH CAMERA

Room air conditioners are frequently used in the home, and living room/dining room/kitchen (LDK) floor plans with living rooms where large models are installed are the norm for homes. Family members gather together in the living rooms of such homes, which depending on the time period, are characterized by a wide variety of situations. Unlike other rooms, living rooms have sofas and dining tables, and in Hitachi's surveys, consumers have complained that "when heating the room, the sofa or the dining table blocks the airflow, preventing the warm air from reaching my feet," or that "when cooling the room, the whole room is not cooled, and the temperature is uneven."

Detection Technology of Monitoring System

The monitoring system includes an imaging camera that looks at the number of people in the room, their activity levels, and positions, as well as factors such as distance and layout of the room,[(2)] and a thermal imaging camera that looks at the temperatures around people in the room. By more closely examining the states of both people and the living room, this system achieves a higher level of comfort in air conditioning while precisely responding to a wide range of situations.

Furthermore, by focusing on the aforementioned challenges that are unique to the living room, Hitachi considered methods for achieving the important goal of ensuring that air currents find paths to reach people even when there is furniture in the way (see Fig. 3). Near-infrared images are utilized to detect the positions and shapes of furniture. This technology has been developed to improve comfort and to contribute to electricity conservation with the one button for all operation*.

Multi-monitoring System

With a camera mounted in the center of the indoor unit, and only when near-infrared images are acquired in front of the central imaging camera, a filter that is transparent to near-infrared wavelengths is moved by

* This automatic electricity-saving function maintains an even, comfortable temperature based on the number and positions of people, the surrounding temperature, the amount of activity, and the amount of sunlight.

a shutter system to cause the camera to function as a near-infrared camera. A near-infrared light-emitting diode (LED) is used to provide the illumination necessary to acquire near-infrared images.

Processes such as noise removal, edge detection, and area segmentation are applied to the acquired near-infrared images to detect candidate pieces of furniture. The furniture characteristics (shape, size, etc.) are then used to narrow down these furniture candidates. The lengths of furniture legs and the areas of open space are computed to determine whether airflow can pass through them, in order to identify furniture that blocks air and furniture that does not (see Fig. 4).

Airflow Control Using Three Way Front Flaps

To control the airflow emitted from the indoor unit so that the airflow paths identified by the method outlined above can be used, the front one of the two vertical flaps of the previous products were split further into three for the newly developed three way front flap (see Fig. 5). This enables the fine-tuned control of the air direction toward the airflow paths, the blowing of airflow toward the feet when heating, and the circulation of cool air in such a way that the formation of stagnant region is inhibited when cooling, thereby achieving comfortable air conditioning.

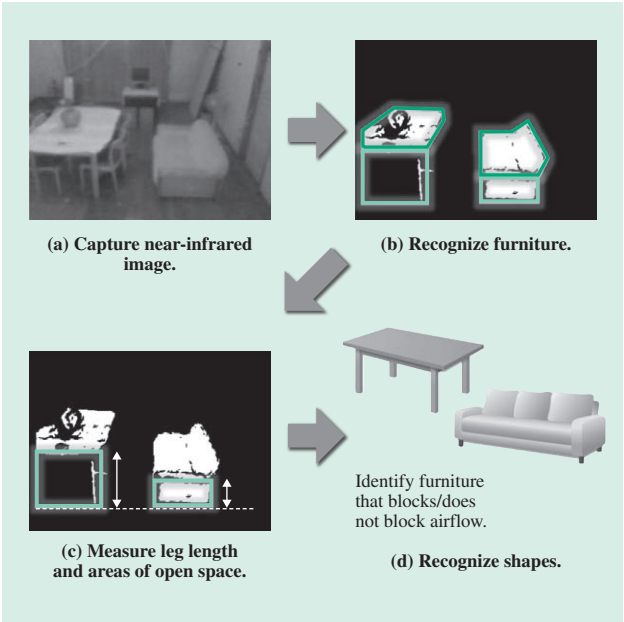

Fig. 4—Furniture Detection Using Near-infrared Images and Image Processing.
Edge processing and pattern recognition are used to detect the characteristics (shapes) of furniture, and furniture that airflow can pass through is differentiated from furniture that blocks airflow.

Furthermore, foot detection technology was developed using visible light images to detect feet regardless of their temperature or state (regardless of whether slippers, thick socks, or other clothes are worn; see the left side of Fig. 6).

Based on the above information, airflow paths are identified as shown in Fig. 6 (right) for directing airflow toward the feet when heating. Airflow paths that can circulate throughout the room without being blocked by furniture are also identified when cooling (see Fig. 7).

IMPROVING ENERGY-SAVING PERFORMANCE

High-efficiency Scroll Compressor

Preventing leaks in the seals between adjacent compression chambers is important when it comes to improving the efficiency of scroll compressors. The

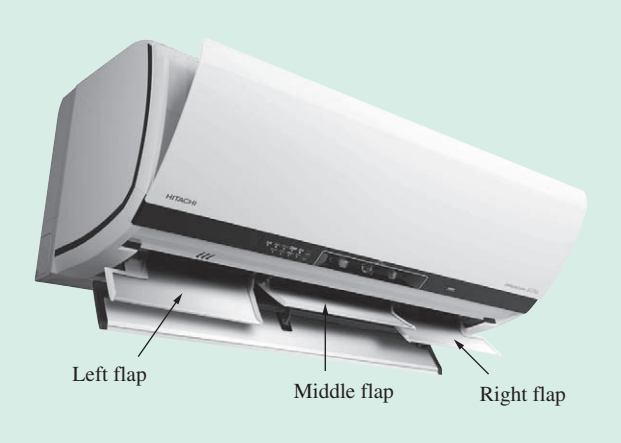

Fig. 5—Three Way Front Flaps.
The three way front flaps move independently to provide fine-tuned control of air direction.

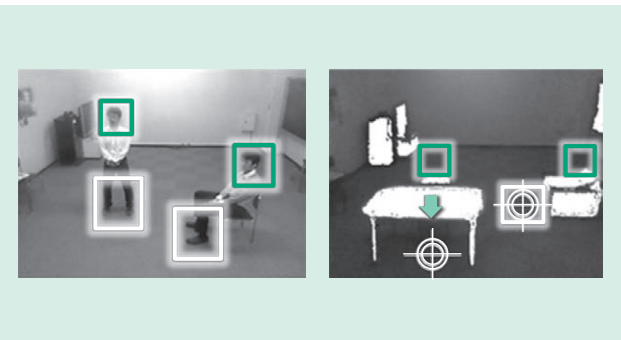

Fig. 6—Foot Detection (Left) and Identification of Airflow Paths when Heating (Right).
The imaging camera detects feet, and the near-infrared camera function identifies airflow paths.

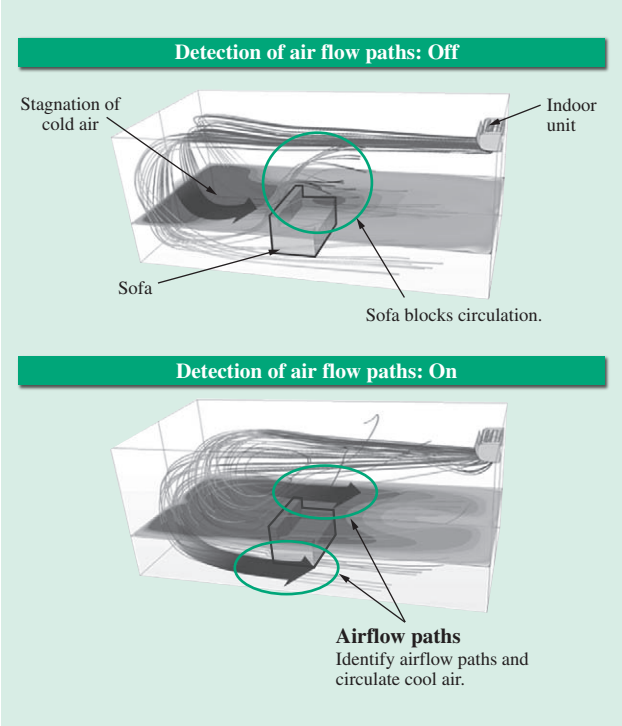

Fig. 7—Detection of Airflow Paths when Cooling.
The system detects a sofa that blocks airflow and controls the flow efficiently.

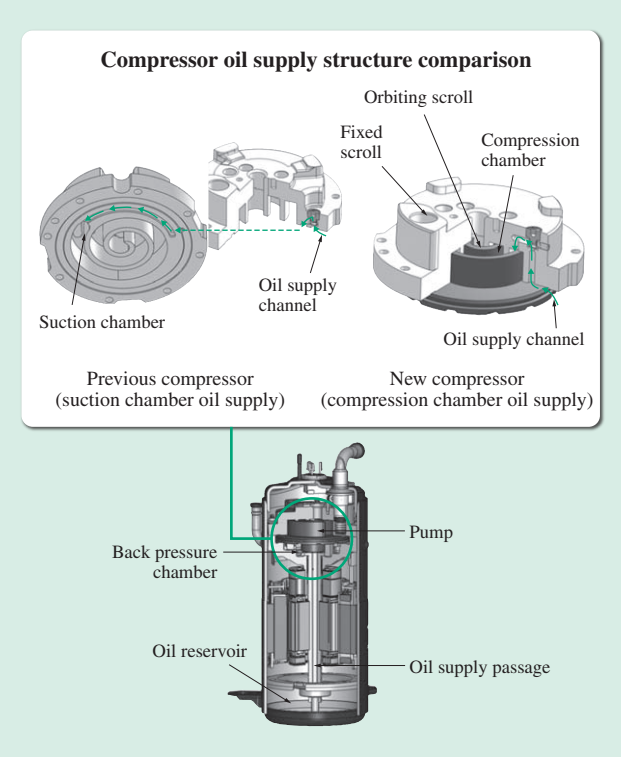

Fig. 8—High-efficiency Scroll Compressor.
Efficiency was improved by revising the oil supply structure.

R32 refrigerant that is used has a small molecular size, and tends to pass through gaps easily. For this reason, previously oil was supplied from the oil reservoir at the bottom of the compressor through an oil supply passage inside the shaft, after which it was fed through the back pressure chamber (used to force the orbiting scroll on the fixed scroll) into the suction chamber. Although this method was an effective means of preventing leaks, it also caused loss due to heating of refrigerant in the suction chamber, and tended to increase mechanical loss as oil became jammed between the fixed scroll and the orbiting scroll when large quantities of oil were inserted into the pump. This is why Hitachi used a new structure to supply oil to the compression chamber that can inhibit increases in leakage loss while also reducing both heat and mechanical loss, thereby improving the APF value (see Fig. 8).

Indoor Unit

To improve the cross-flow fan's efficiency while reducing blowing power, the outer diameter of the fan blades was widened from the previous diameter of 115 mm to 118 mm. When the fan diameter is widened to improve its efficiency, ensuring blowing stability becomes an issue. This is why Hitachi's development focused on both improvements in the cross-flow fan blades and nose configuration as well as reductions in flow resistance.

In other words, the previous 30 blades arranged around the circumference were increased to 32 in order to ensure stability when blowing, and the blades were reduced to 91% of the previous thickness in order to secure the pitch between the thinner blades, thereby preventing an increase in friction loss. The front nose configuration was also optimized to increase blowing stability by stabilizing the circular vortex that occurs near the front nose of the cross-flow fan, and to prevent reverse flows from occurring in the gap between both edges and the front nose of the fan (see Fig. 9).

Outdoor Unit

Like those in the indoor units, the propeller fan, the passage, and the heat exchanger in the outdoor unit were also numerically analyzed with the goal of reducing blowing power and effectively utilizing the heat exchanger.

The propeller fan was expanded by 5% to improve efficiency, and the center of the trailing edge, where the flow concentrates, was cut into a V shape to inhibit flow separation and improve fan efficiency (see Fig. 10).

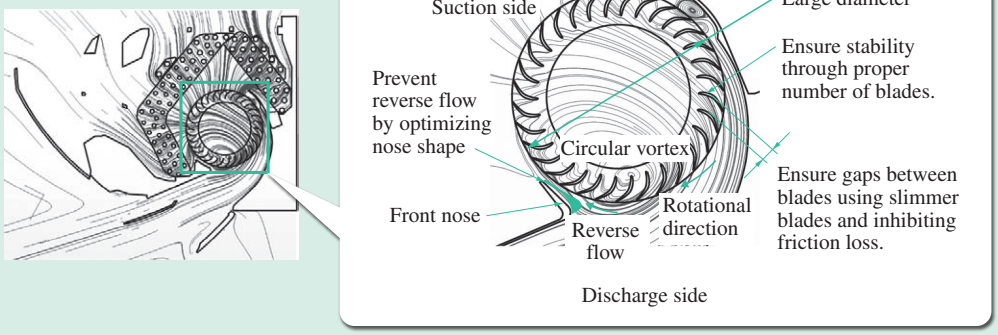

Fig. 9—Indoor Unit Blowing System.
Numerical simulations were used to optimize the shape and part layout to improve efficiency.

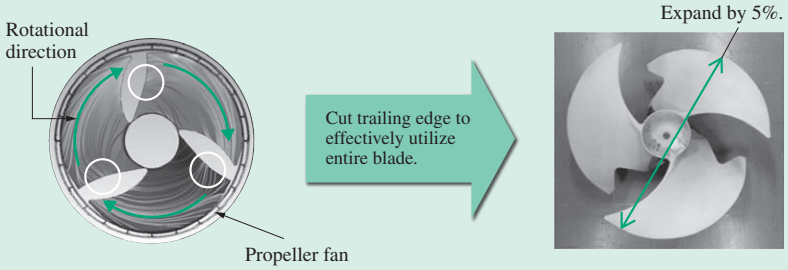

Fig. 10—Outdoor Unit Propeller Fan for Outdoor Unit.
The diameter of the fan was expanded, and the blade shape was optimized through numerical simulations.

CONCLUSIONS

Although each of the energy-saving basic technologies described above provides only a tiny effect when estimated separately, by continuously focusing on technological development, Hitachi has steadily improved energy-saving and electricity-conservation performance on an annual basis. Saving energy in room air conditioners, which consume much of the power used in the home, is a universal consumer need, as is environmental consciousness in products. Hitachi will continue mobilizing all of its technological prowess in developing room air conditioners.

With respect to electricity-saving functions that also pursue comfort, Hitachi has put forth a variety of solutions to match changing consumer lifestyles along with advances in sensing devices. Hitachi will continue its development efforts while remaining constantly aware of the new value consumers seek.

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Featured Articles

Developing the High-power Cyclonic Cleaner

—Adding "Powerful 420 W Suction" to Environmentally Conscious Features—

Keiichi Yabe
Koji Shirakawa
Shigenori Sato
Taiji Tajima
Shiro Obayashi

OVERVIEW: The demand structure of the vacuum cleaner market has been changing in significant ways and, as demand has shrunk in the high-volume cylinder-type segment of the market, cordless, handy, robotic, and other types have been increasing in popularity. Hitachi is developing a wide variety of different vacuum cleaners against this background of diversifying demand, however this article discusses the development of a cylinder-type that belongs to a market segment for which competition is growing increasingly intense. To satisfy consumer needs, the high-power cyclonic cleaner released in July 2014 uses a newly developed compact and lightweight high-power fan motor along with a new dust-collecting structure based on a compact design to achieve a light and compact body and powerful suction at the same time.

INTRODUCTION

SMALL and double-income households have been increasing in number recently. As a result, lifestyles are changing as well, with light cleaning being done on weekdays while thorough cleaning is left for weekends and holidays. A survey of consumer priorities when purchasing cyclonic cleaners has revealed that even though times have changed, many consumers still emphasize ease of carrying and a lightweight body in addition to the traditional basic performance of a vacuum cleaner, specifically easy dust removal and suction power [*1] (see Fig. 1).

This article discusses how we achieved both compactness and a light weight along with powerful

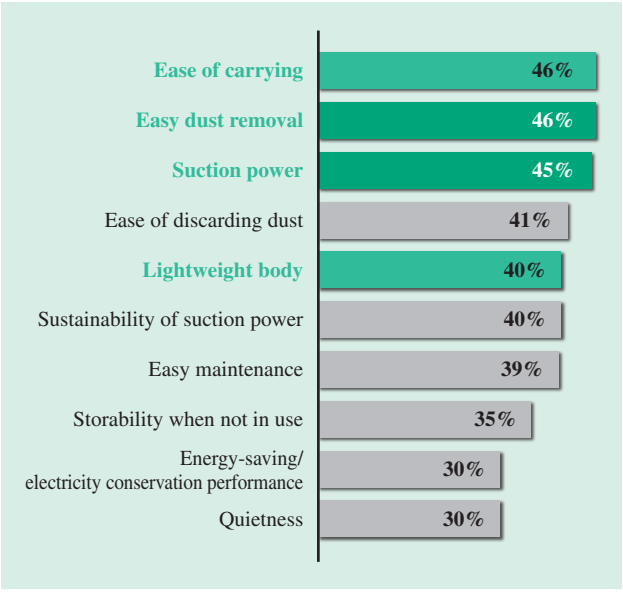

Fig. 1—Priorities when Purchasing Cyclonic Cleaner (Multiple Responses) (Hitachi Survey from October 2013: n=307). In addition to basic performance, ease of carrying and a lightweight body were both emphasized.

*1 Suction power guidelines established by JIS standard.

Fig. 2—High-power Cyclonic Cleaner (CV-SA700) (2014). Powerful 420 W suction in a compact and lightweight product is achieved with the adoption of a new dust collector structure.

suction in the cyclonic cleaner, which also offers improved ease of use and the ability to clean easily and efficiently (see Fig. 2).

ACHIEVING A COMPACT, LIGHTWEIGHT BODY AND HIGH POWER

To achieve both a compact and lightweight vacuum cleaner body as well as high power, Hitachi set two major development objectives: a high-performance fan motor as the heart of the product, and low loss in the dust collector.

Developing a High-power Fan Motor

The fan motor consists of a fan with both impeller and diffuser, and a motor with both rotators and stators, where the rotators drive the impeller to suck air (see Fig. 3). The impeller impart kinetic energy to the air, and the diffuser decelerate the air to convert this kinetic energy to static pressure.

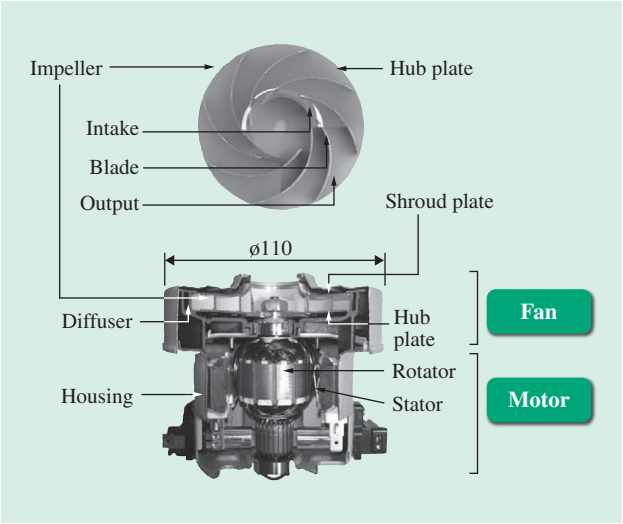

Fig. 3—Fan Motor Cross-section and Impeller. Light weight is achieved by changing the housing material from steel plate to aluminum.

As shown in Fig. 3 and Fig. 4, the blades of the previous impeller had a two-dimensional shape and were oriented vertically with respect to the hub plate. Since it became evident that the air flow was becoming separated near the center of the blades resulting in a low-velocity zone, the newly developed impeller features a three-dimensional blades with the intake-side shape of them twisted up in the rotational direction between the hub plate and the shroud plate. This smoothly expands the flow passage area between blades, and reduces the low-velocity zone, thereby improving efficiency of the impeller. Furthermore, by adjusting the number of blades, not only was the efficiency increased, but the harsh noise based on blade-passing frequency was successfully reduced. Magnetic field simulation technology was applied to the motor, the stator shape was optimized, and fan efficiency was improved to reduce loss and to increase output.

The housing material was switched from steel plate to aluminum, which has a low specific gravity, thereby resulting in a weight that is approximately 100 g lower than that of the fan motor in the previous product (CV-SY500).

Developing a New Dust Collector Structure

Reducing pressure loss in the body of the vacuum cleaner is important when it comes to effectively utilizing fan motor output. In the previous product (CV-SY500), pressure loss in the dust collector amounted to approximately 40% of the total, while

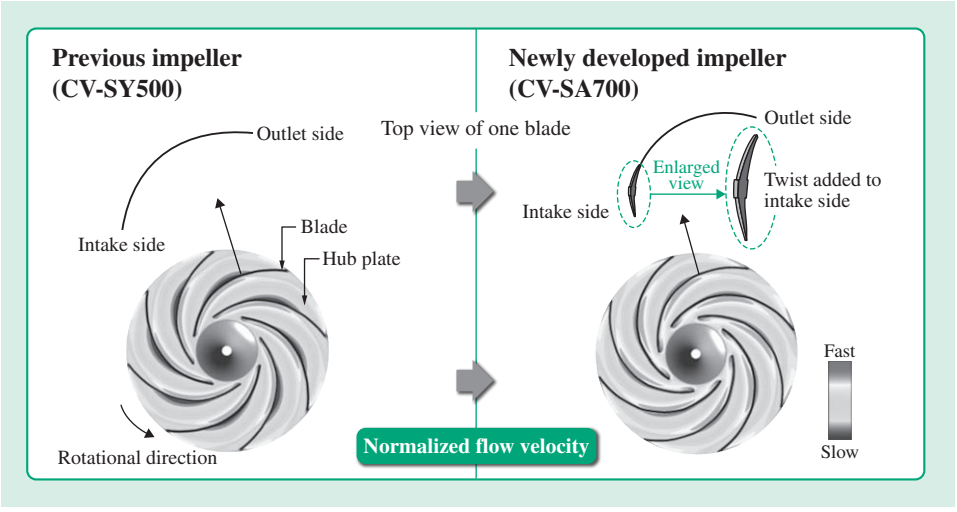

Fig. 4—Internal Flow Velocity Distribution of Impeller (Numerical Simulation Results). Although the previous impeller had a two-dimensional blades perpendicular to the hub plate, the newly developed impeller has a twisted three-dimensional blades.

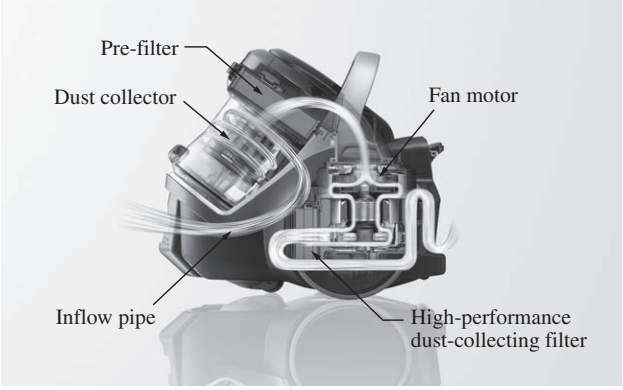

Fig. 5—Body Structure and Air Flow (CV-SA700).
Air from the fan motor is emitted through a high-performance dust-collecting filter.

loss in the filtering system amounted to approximately 30%. The achievement of clean exhaust is important in a filtering system (exhaust performance with a dust collection efficiency of 99.999%*2 is achieved using a high-performance dust-collecting filter), and it is difficult to reduce pressure loss in this area. Reducing pressure loss in the cyclone dust collector is the crucial factor in achieving both clean exhaust and powerful suction (see Fig. 5).

The cyclone dust collector is mainly comprised of external and internal cylinders, where the upper separates the dust from the air, and the lower collects the dust in a storage chamber. These mechanisms trap the dust using centrifugal separation (see Fig. 6).

As the arrows in Fig. 6 show, the flow inside the cyclone dust collector involves air entering the inlet opening of the external cylinder and then forming a swirling flow around the outside of the internal cylinder, where centrifugal force acts on the dust, which is heavier than air. The dust then passes into the storage chamber, while the air passes through the meshed opening of the internal cylinder before arriving at the fan motor. The main causes of increased pressure loss in the cyclone dust collector are the high flow velocity of the air at the inlet opening and the inside of the internal cylinder, and, disturbances in the swirling flow of air.

Although pressure loss can be reduced by increasing the aperture area of the inlet opening, this results in a trade-off with lower dust-separation performance. The shape of the inlet opening was optimized by applying methods such as computational fluid dynamics and robust design(1).

The shapes of the external and internal cylinders were also optimized, achieving both dust-collecting performance in combination with low pressure loss.

As described above, optimization of the shapes of the inlet opening as well as both external and internal cylinders allowed for the development of a cyclone dust collector with a new structure that reduces pressure loss compared to the previous product (CV-SY500). When combined with the increased output of the previously described fan motor, this enabled the achievement of a powerful 420 W suction power.

*2 Measured by third-party agency under conditions compliant with IEC 60312-1:2010 (Edition 1).

IMPROVING EASE OF USE

Dust Ejection Mechanism

In the cyclone dust collector with the new structure, the bottom cover opens to discharge dust. Because the adopted external and internal cylinder shapes increase

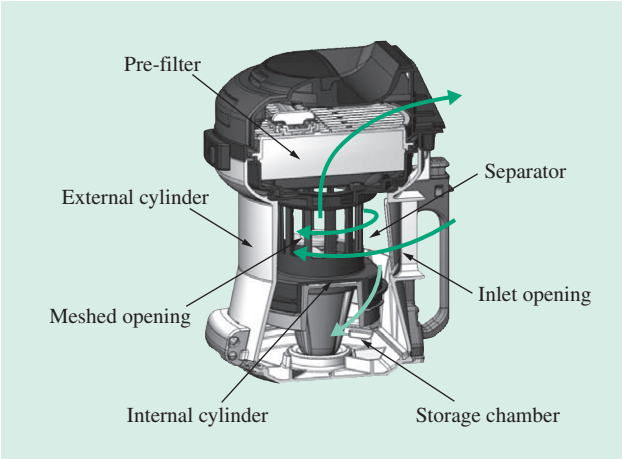

Fig. 6—New Dust Collector Structure.
The arrows show the flow of air after it enters the inlet opening.

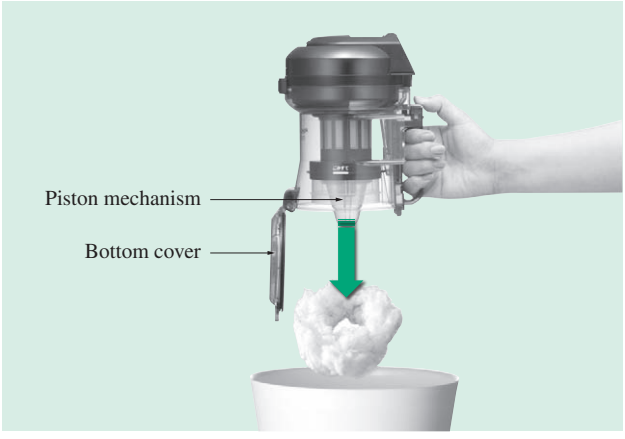

Fig. 7—Dust Ejection Mechanism.
The movement of the piston mechanism in the internal cylinder causes the compressed dust to be ejected.

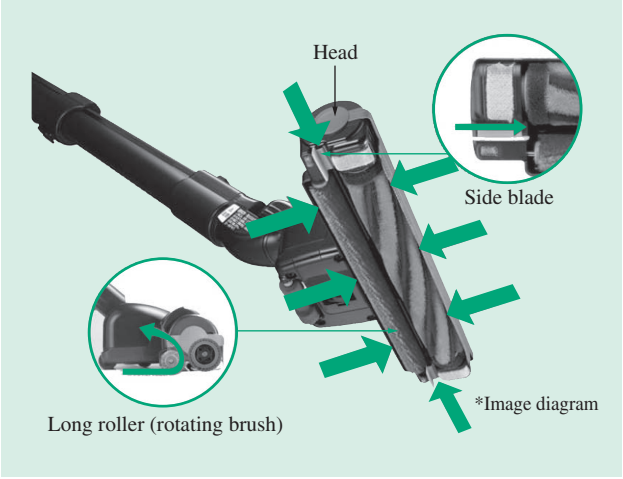

Fig. 8—Four-way Suction Mechanism (Front, Back, Left, and Right).
Four-way suction is achieved with a long roller (rotating brush) and a side blade.

in diameter towards the bottom, dust discharges readily. The piston mechanism built into the internal cylinder expels the dust. This unique dust ejection mechanism makes dust ejection easy (see Fig. 7).

"Smart Head with Four-Way Suction"

The "smart head with four-way suction" was developed to reliably suck dust from the front, back, left, and right directions (see Fig. 8).

A mechanism attached to the rotating brush halts rotation when the head moves forward, and restarts the rotation when the head moves backward. This allows for suction to hold the sucked dust inside the head to prevent it from slipping out the back of the head when the head moves forward, while sucking the dust behind the head and directing it into the head

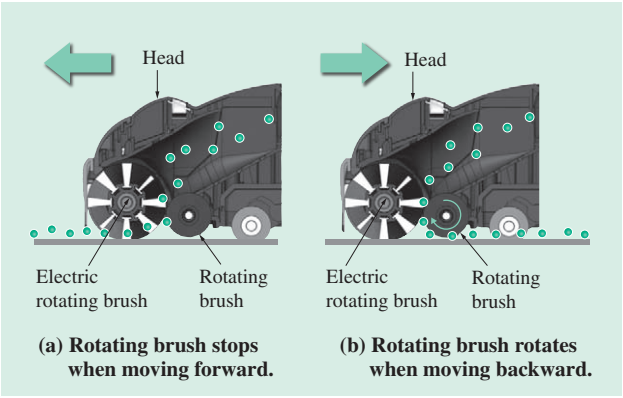

Fig. 9—Front/Back Dust Suction Mechanism with Rotating Brush.
A rotating brush that only rotates when moving backwards enables the backward collection of dust.

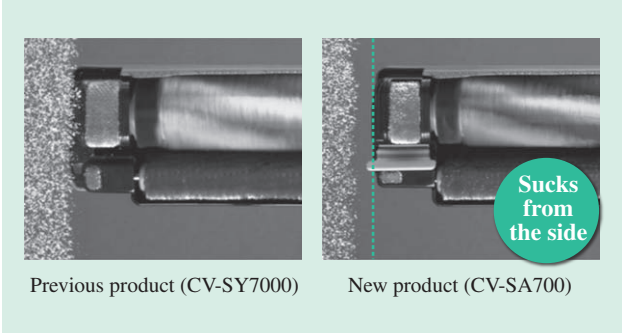

Fig. 10—Comparison of Suction Performance in Horizontal Directions.
The side blade greatly improves suction performance in horizontal directions.

with the rotation of the brush when the head moves backward (see Fig. 9).

The flow guide structure on the side of the head was formed with expanded aperture with "side blade" (see Fig. 8). Fig. 10 shows a comparison between the dust-collecting performance in lateral directions with respect to the head of the new product that uses this side blade, and the head of the previous product that did not. This induces the effective flow on the side of the head, and greatly improves dust-collecting performance in lateral directions.

The development of these functions has made it possible to suck dust in four directions (front, back, left, and right), which makes cleaning around walls, in the corners of rooms, on stairs where it is difficult to change head direction, and around the legs of furniture like tables and chairs quicker and easier. Furthermore, to achieve easy operation despite the strong suction, a powerful self-propelling function uses the driving force of the rotating brush so that dust can be reliably suctioned with a light touch.

"ONE BUTTON FOR ALL" FEATURE, WITH ENERGY-SAVING TECHNOLOGY

The "one button for all" feature uses a sensor to detect the type of floor during cleaning and automatically controls the power level of the fan motor in the vacuum cleaner body and the rotational speed of the electric rotating brush on the head. Since dust is reliably suctioned even in "one button for all" mode, power consumption is reduced by up to approximately 75% when compared to cleaning at full strength[*3]. In

*3 Comparison of power consumption between "one button for all" mode and full-strength operation after six minutes of cleaning on a wooden floor surface.

addition, power is automatically reduced when the head is not moved during cleaning, and if the head remains stationary for a certain amount of time, the power is switched off. Hitachi will continue including this idling and stopping functionality in order to help conserve electricity.

CONCLUSIONS

This article discussed the high-power cyclonic cleaner. Even as the structure of domestic demand changes, the needs for both compactness and light weight in vacuum cleaners is expected to increase even further.

Hitachi will continue creating unique technologies that lead the industry in both performance and functionality, while developing products that provide the value consumers demand.

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Featured Articles

Development of Microwave Oven with Bakery Functions

—Adding Healthy Cooking to Environmentally Conscious Features—

Akira Miyataka
Hideki Ban
Kiyoshi Ozawa
Sachi Tanaka

OVERVIEW: As microwave ovens have developed over the years, cooking functions have evolved as a means of satisfying the universal consumer need for "healthiness." Along with enhancements for healthy cooking functionality in FY2014, recipes for one or two people were added to cooking menus that had previously been designed for three or four people (in the FY2013 model, MRO-MBK5000). Furthermore, the model's bakery functions, which are unique in the industry, were enhanced while making progress in satisfying the need for shorter cooking times. Energy-saving performance has also been improved through the development of new technologies, including improved efficiency in the microwave control and oven heaters used in microwave ovens.

INTRODUCTION

AS health consciousness has increased due to factors such as the aging of society, the need for microwave ovens that can cook in a healthy fashion is intensifying. Also, although cooking for three or four people has traditionally been the default setting, cooking devices must now respond to changes such as the increase in small households, and the accompanying increase in occasions to cook for fewer people.

Furthermore, factors such as the increase in two-income households have reduced the amount of time available for cooking, thereby intensifying the need for reduced cooking time.

It is based on this background that microwave oven development in FY2014 had been proceeding based on the themes of "enhancing healthy cooking", "developing and improving the convenience of menus for small households," "reducing cooking time," and "improving energy-saving performance."

The unique steamed grilling function enables healthy cooking by combining a variety of different heat sources. In FY2014, we took advantage of this function in order to realize healthy "fried food" that does not use oil, and for "steamed vegetables" that lose less vitamin C through low-oxygen cooking[*1]. Furthermore, we developed menus that satisfy the need for healthy cooking with fermented food by removing excess fat and salt, by frying without oil, and in other ways. We also developed and included new menus for one or two people in order to address the needs of small households, while working to expand the "ten-minute cooking menu" in order to address the need for shorter cooking time.

In addition, we developed microwave transmission loss reduction technology and highly efficient heating technology for use in convection oven heaters as energy-saving technologies.

In FY2012, we launched the only microwave oven in the industry with the added value of a bakery function that can automatically bake bread, including adding ingredients, kneading, fermenting, and finally baking. We are also developing new functionality

Fig. 1—MRO-NBK5000 Microwave Oven with Bakery Function Released in FY2014.
The exterior of the superheated steam microwave oven is shown above. The oven has a bakery function to satisfy the need for home-baked bread and a wide-ranging "Healthy Cooking" menu.

*1 The weight of vitamin C in 100 g of raw broccoli is 88.0 mg, of which 62.9 mg remains after cooking using the "steamed broccoli" menu option, or 50.4 mg in the case of baking (based on Hitachi's research).

for new products that offer shorter baking time for a single loaf of bread as well as a "healthy bread menu," in addition to improved convenience and ease of use (see Fig. 1).

This article describes the efforts involved in the development of these unique functions.

ENHANCED HEALTHY MENUS

The "grill plate" and "steam lid" inside the microwave oven are used in a steamed grilling system offered only by Hitachi that cooks by combining the following heat sources: superheated steam, steam, oven heater, microwave, and plate heated by microwave superheated steam, the grill plate underneath (see Fig. 2). This system produces healthy fried food (see Fig. 3) and provides an automated menu that makes it easy to cook recipes with adjustments of heating power and duration.

For the FY2014 product, we sought to enhance the healthy menu by taking advantage of the characteristics of this configuration. By filling the inside of the steam lid with steam, it is possible to rapidly reduce the concentration of oxygen inside the lid (see Fig. 4). This enables cooking under a low oxygen environment, which prevents oxidation of nutrients such as vitamin C during cooking. A new "steamed vegetables" menu was developed based on this method (see Fig. 5).

We also responded to consumers' health needs by providing a lavish healthy menu that includes cooking with fermented food, cooking with superheated steam that removes excess fat and salt, "non-fried cooking" that fries without oil, and other options (see Fig. 6), while ensuring that anyone can cook healthy food conveniently.

MENU DEVELOPMENT

Development of Menus for a Smaller Number of People

To design menus that support small households, we revised the heating patterns and heating duration for each heat source based on weight, thereby developing menus for one or two people (see Fig. 7) while also revising the liquid crystal display (LCD) touch panel. The addition of a "Menus for One or Two People" button on the initial screen makes it possible to select menus for a small household from the touch panel

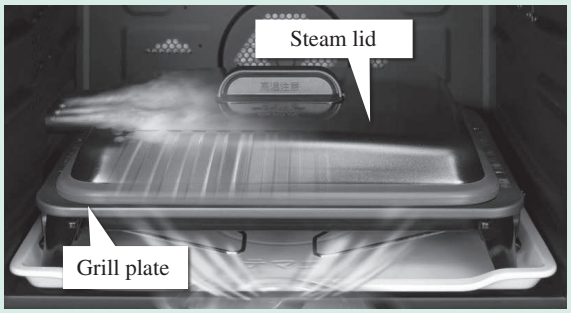

Fig. 2—Steamed Grilling System.
This unique cooking method uses a grill plate and a steam lid.

Fig. 3—"Fried Food" without Oil.
Goya-champuru, yakisoba, and other dishes can be cooked in a healthy fashion without the need for frying oil.

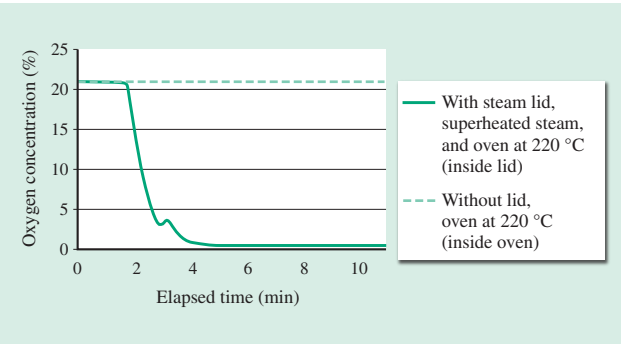

Fig. 4—Changes in Oxygen concentration under the Steam Lid.
The oxidation of food items is prevented by filling the steam lid with steam in order to lower the oxygen density.

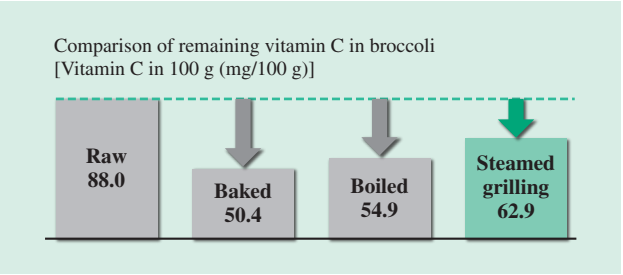

Fig. 5—Comparison of Remaining Vitamin C: Broccoli Cooked Using the "Steamed Vegetables" Menu Option.
The "Steamed Vegetables" menu option, which activates the steamed grilling, reduces the loss of vitamin C when compared to baking vegetables using conventional oven heating.

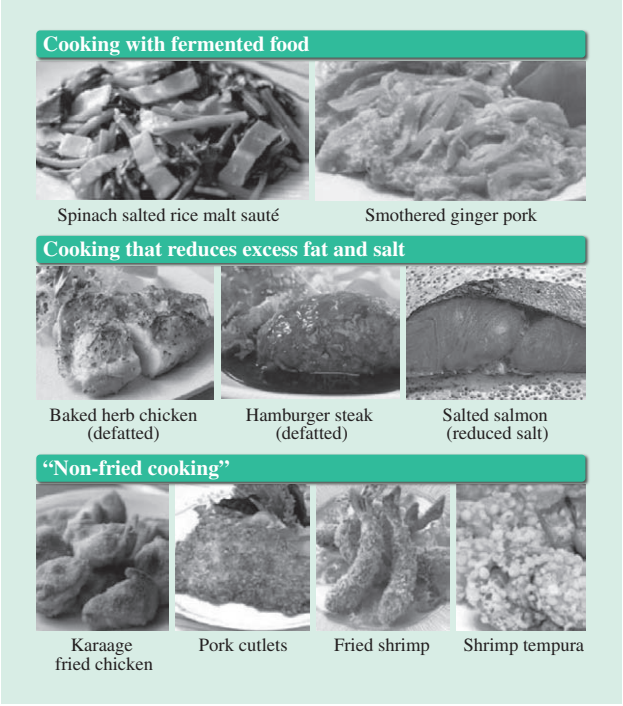

Fig. 6—Wide Range of Healthy Menu Options [161 Healthy Menu Options (MRO-NBK5000)].
Menu options are available for cooking with fermented food and other healthy food items, cooking that reduces excess fat and salt, and healthy "non-fried cooking" that does not use oil.

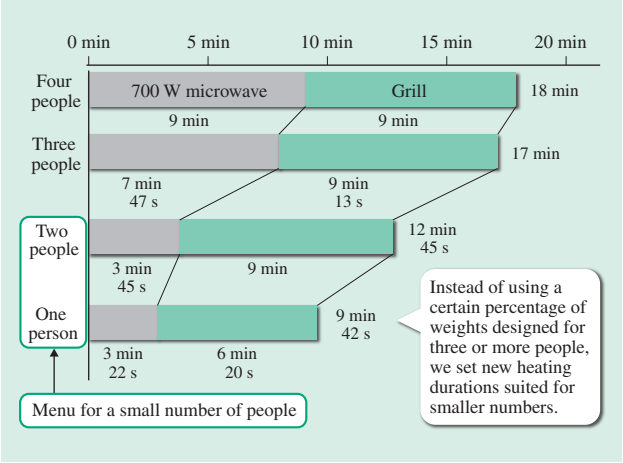

Fig. 7—Number of People and Heating Duration for "Baked Herb Chicken."
Microwave heating times are adjusted when cooking for three or more people, and grill heating times are adjusted when cooking for fewer people.

without hesitation (see Fig. 8).

The previously adopted "Tips for Skilled Use" display button that shows tips for how to use the oven and the "Show Ingredients" display button that can be used to verify ingredient weights have also been modified to support menus for a smaller number of

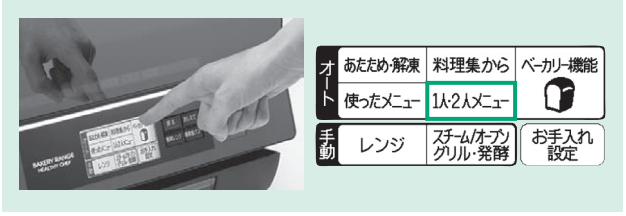

Fig. 8—One or Two People Menu Screen.
The addition of a new button on the initial screen makes it easy for users to select the right menu option without hesitation.

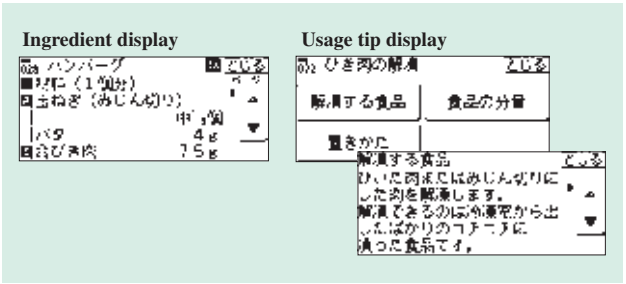

Fig. 9—Ingredient and Usage Tip Display.
Recipe ingredients and usage tips are displayed, thereby enabling cooking without the need to read a cooking guide or manual.

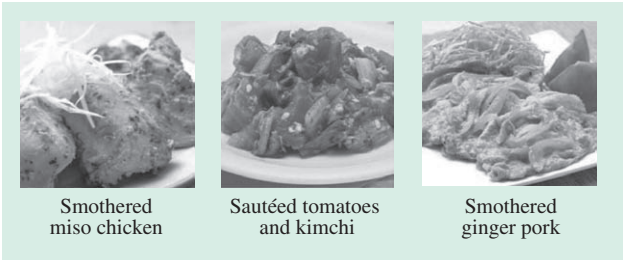

Fig. 10—Ten-Minute Menu Examples.
Lavish menu options that have been prepared in order to satisfy the need for reduced cooking time.

people, and a touch panel can now be used for menu selection (see Fig. 9).

Development of Menus for Shorter Cooking Time

We developed a ten-minute menu in order to respond to the need for reduced cooking time. This menu provides a wide range of dishes, including "smothered miso chicken," "sautéed tomatoes and kimchi," "smothered ginger pork," and others (see Fig. 10).

DEVELOPMENT OF UNIQUE FUNCTIONS

Bakery Function

In FY2012 we released a microwave oven that offered a bakery function that was unique in the industry. Not only could it knead, ferment, and bake

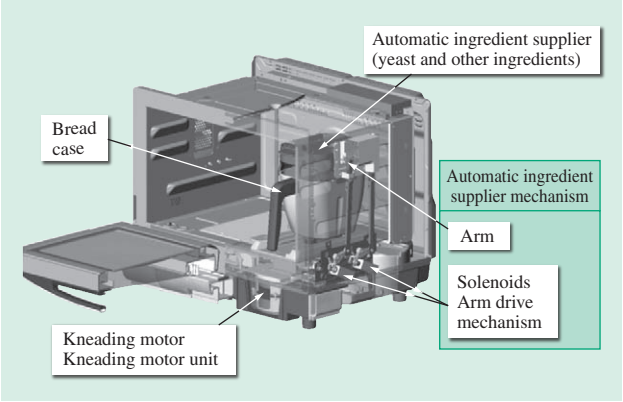

Fig. 11—Bakery Function Framework.
Yeast and other ingredients are automatically supplied by the "automatic ingredient supplier."

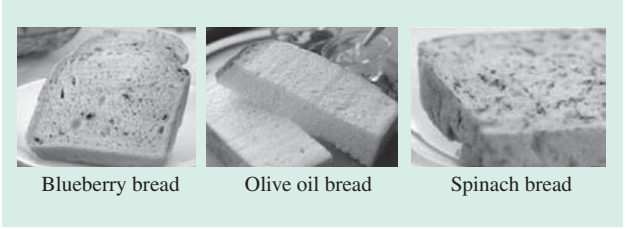

Fig. 13—"Healthy Bread Menu."
Healthy bread can be baked by adding healthy ingredients to the mix.

bread automatically inside the oven, it also included an industry-first "automatic ingredient supplier" developed by Hitachi that enabled it to automatically add yeast and other ingredients into the bakery case inside the microwave oven (see Fig. 11).

Responding to Needs for Shorter Cooking Times and Healthier Cooking

Based on research we performed at the start of development of the bakery function, it was known that home bakeries that were already commercially available could generally bake a loaf of bread in approximately four hours using the "standard course," or in approximately two hours using a "quick baking" mode, and so it was evident that reducing the cooking time even further would be an issue. It was at this point that Hitachi started focusing on reducing the time required for the bakery function. The product we released in FY2012 could bake a single loaf of bread in approximately two hours, whereas the FY2013 version reduced that to 100 minutes, while the FY2014 version achieved a baking time of approximately 90 minutes through stronger kneading, changing the ingredient composition, and increasing the temperature of the baking process (see Fig. 12).

Furthermore, we developed a bakery menu that satisfies the need for healthy options. This healthy menu provides a wide range of newly developed recipes, including "calorie-cutting bread" that is baked deliciously with less butter and other such ingredients using a convection oven technology, "vegetable/fruit bread" with healthy ingredients included in the mix, "olive oil bread," and others (see Fig. 13).

ENERGY-SAVING TECHNOLOGY

The technologies used for improving energy-saving performance in microwave and oven functions are described below.

Reduced Microwave Transmission Loss

The energy-saving performance of the microwave function is evaluated by heating a specified weight of water (heated load) from 10 ± 1°C to 70°C, while measuring the energy consumption and extrapolating in order to determine the energy consumption equivalent to one year of use. We worked to improve energy-saving performance by developing a new low-loss waveguide to use for microwave heating inside

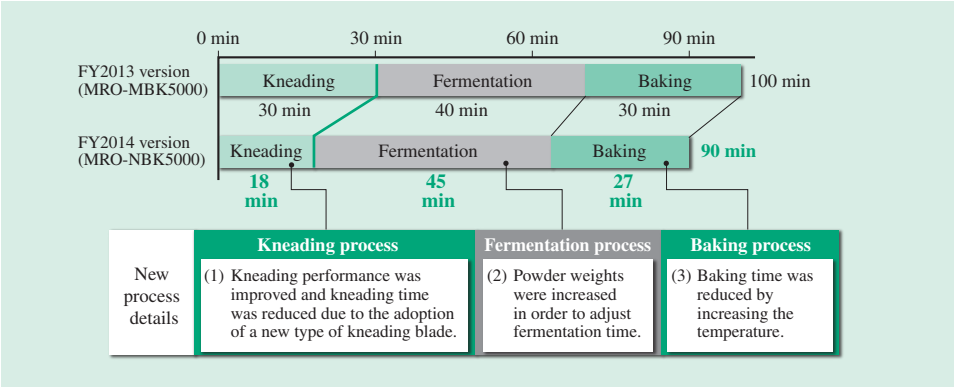

Fig. 12—Bakery Process Chart.
Both kneading and baking processes were improved in the FY2014 version of the product, thereby reducing the required time.

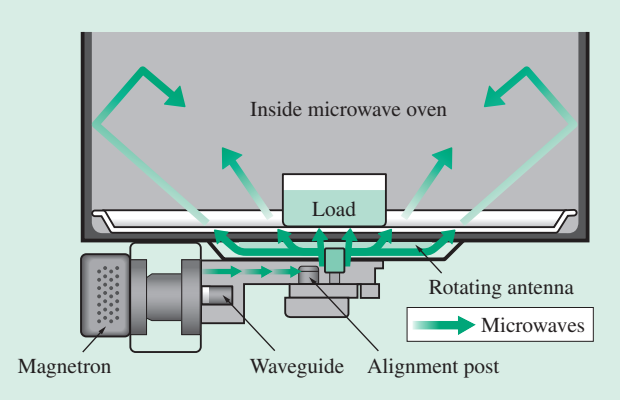

Fig. 14—Microwave Transmission Path.
The structure has been successfully constructed so as to reduce transmission loss.

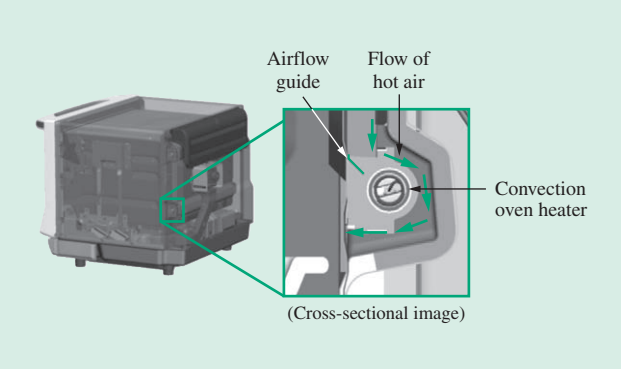

Fig. 15—Structure around Convection Oven Heater.
The structure of the area around the convection oven heater was optimized utilizing thermal fluid simulation in order to improve energy-saving performance.

the oven (see Fig. 14).

Energy-Saving through High-Efficiency Heating with a Convection Oven Heater

The energy-saving performance of the oven function was evaluated by adding the amount of energy consumed while increasing the oven's internal temperature from the initial temperature (23 ± 2°C) up to 177°C, to the energy consumed by then maintaining this state continuously for 20 minutes, and extrapolating in order to determine the energy consumption equivalent to one year of use. By adding an airflow guide to the back plate of the heating chamber, we constructed an efficient pathway for the heat from the convection oven heater to be transferred to the air (see Fig. 15). This reduces the warm-up time of the oven by approximately 60 seconds, and successfully improves energy-saving performance.

CONCLUSIONS

This article described the development of healthy cooking functionality that was achieved utilizing unique technologies, as well as the development of menus designed for smaller numbers of people, reduced cooking times, and energy-saving technologies. In the future, Hitachi will continue working to offer attractive added value in our microwave ovens while remaining closely attuned to changing trends in demand.

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Featured Articles

Development of Products in Response to Changing Lifestyles

Kazuhiro Ishida
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Yoichi Shioya

OVERVIEW: Due to changes in the structure of demand in the domestic Japanese market, with an aging population and a shift toward smaller families, changes are also being seen in lifestyle with respect to clothes, eating habits, and living. In terms of eating habits, approximately half of households only cook 2 or less cups of rice at a time. It is based on this background that Hitachi developed a rice cooker that can make delicious rice even in small amounts. After examining consumer needs from a global perspective, Hitachi developed an air purifier with high dust-collection performance (high flow rate). As interest in the influence of PM2.5 continues to grow, Hitachi will continue to respond to the trend toward further emphasis on dust collection performance.

INTRODUCTION

HITACHI conducts a variety of different surveys in order to grasp changing consumer lifestyles. As these surveys are used to dig deeper into the actual state of consumer lifestyles, many new discoveries are made.

When rice cooking behavior is examined within Japan, it becomes apparent that approximately half of all households only cook 2 cups[*1] of rice or less at a time. Almost all rice cookers in current use have a capacity of 5.5 cups, and an awareness survey has shown that consumers feel that large-capacity rice cookers produce rice that is not very tasty when cooking in small amounts. This is why Hitachi has developed rice cookers that specialize in cooking delicious rice in small amounts (see the left side of Fig. 1).

Hitachi currently sells home appliance products in approximately 50 different countries, so it is imperative that we accurately assess the needs of consumers in all of these markets, including Japan.

As part of its market research in target countries, Hitachi has visited homes to observe actual lifestyles (see the middle of Fig. 1), observed how well products sell in sales outlets, and postulated and then researched and verified hypotheses during

*1 A cup corresponds to a volume of 0.18 L.

Fig. 1—New-concept Rice Cooker that Responds to Changing Demand Structure, and Global Model of an Air Purifier.
External appearance of the 5.5-cup rice cooker (RZ-VW3000M) that can cook delicious rice in small amounts and the small-amount 2.0-cup rice cooker (RZ-VS2M) (left), international lifestyle survey (middle), and the global model air purifier (EP-KVG900) designed to satisfy the needs of consumers in Japan and other Asian countries (right).

the development process. Although the air purifier described in this article (see the right side of Fig. 1) has only just been introduced in Asia and the Middle East, it was developed based on activities such as those listed above, on the sense of dependability and the expectations regarding "made in Japan" products expressed by consumers, and on factors such as an increasing consciousness regarding cleanliness and health as well as the living environment in each country.

This article describes a new concept rice cooker aimed at responding to the changing demand structure of the domestic Japanese market, and the global model of an air purifier.

DEVELOPING PRODUCTS THAT CREATE NEW MARKETS BASED ON NEW CONCEPTS

Rice Cooker that Responds to a Changing Lifestyle

A domestic Japanese survey of rice cooking revealed that for approximately 51% of households, 2 or fewer cups of rice are cooked each time without any differences in either household size or age (see Fig. 2).

Furthermore, approximately 60% of respondents are dissatisfied with the manner in which small amounts of rice are cooked by large-capacity rice cookers (5.5 cups or more), responding that rice cooked in such a way does not taste good (see Fig. 3).

Although there are induction heating (IH) models on the market that have a capacity of 3 or 3.5 cups, they only amount to approximately 8% of the units sold.[*2] Possible reasons for the lack of low-capacity rice cookers on the market include the fact that current models of this type are low specification products, or that they are similar to the 5.5-cup models without outstanding features. Group interview surveys revealed two different types of consumers. One type of consumer cooks a small amount of rice and eats all of it each time, whereas the other type cooks extra rice for storing in the freezer and then reheating in the microwave oven later. The product discussed in this article was developed for the first type of consumer.

Two Product Concepts

Two types of products were considered when constructing the new development concept. The first is the 5.5-cup model, which has a capacity of 5.5 cups of rice, but can also cook delicious rice in small batches.

The second type of product is aimed at consumers who cook only small batches of rice. During the group interviews, the monitor's words "rice is delicious when you scoop it out of the ohitsu (wooden serving container for rice) while eating at a Japanese inn" were used as the basis for the new 2.0-cup model concept of a compact and lightweight low-capacity model that can cook between 0.5 and 2 cups of rice. This product allows the consumer to take the rice right to the dining table and serve it freshly-cooked and hot with an "ohitsu" feel (see Fig. 4).

Since the 2.0-cup model is a new concept, an acceptability survey was conducted. Mock-ups similar to the product were presented along with a concept validation video (see Fig. 5), product features were

*2 From The Japan Electrical Manufacturers' Association (JEMA) shipment statistics for FY2013.

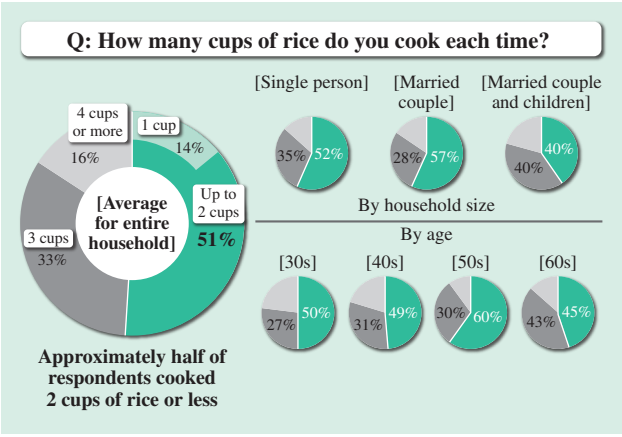

Fig. 2—Rice Cooking Amount Survey (Hitachi Survey from March 2014: n=279).
The state of rice cooking was surveyed by both household size and age.

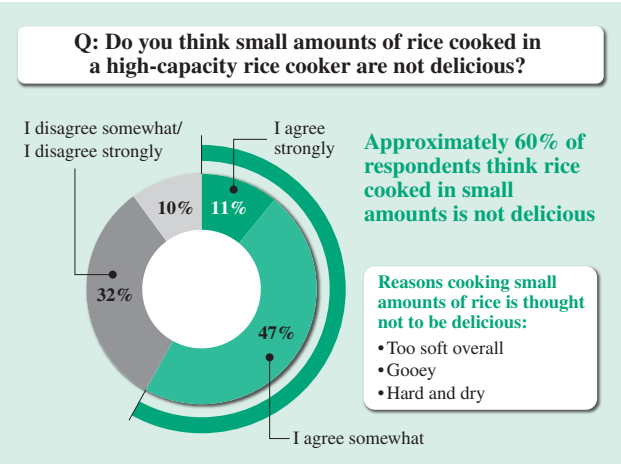

Fig. 3—Rice Cooking Impression Survey (Hitachi Survey from January 2014: n=312).
Impressions about cooking rice in small amounts were surveyed.

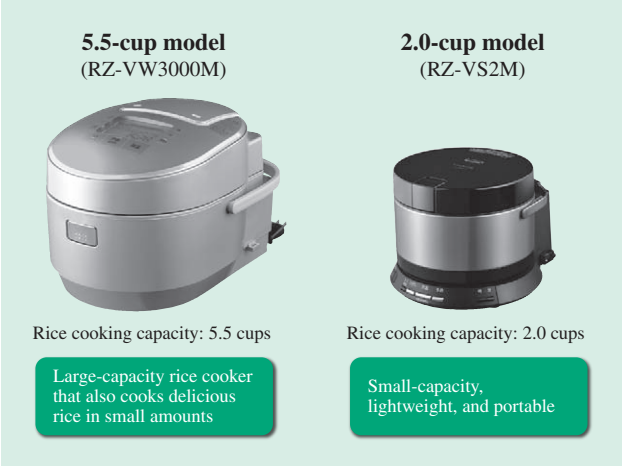

Fig. 4—Two Product Types.
Hitachi developed a rice cooker with a 5.5-cup capacity, and a rice cooker with a 2.0-cup capacity.

Fig. 5—Concept Validation Video.
The product concepts were explained with an easy to understand video featuring usage scenarios.

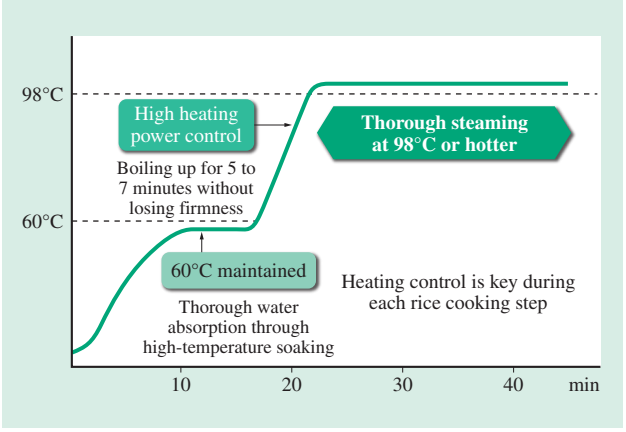

Fig. 6—Process for Cooking Delicious Rice.
A high temperature of 98°C or hotter is maintained while steaming.

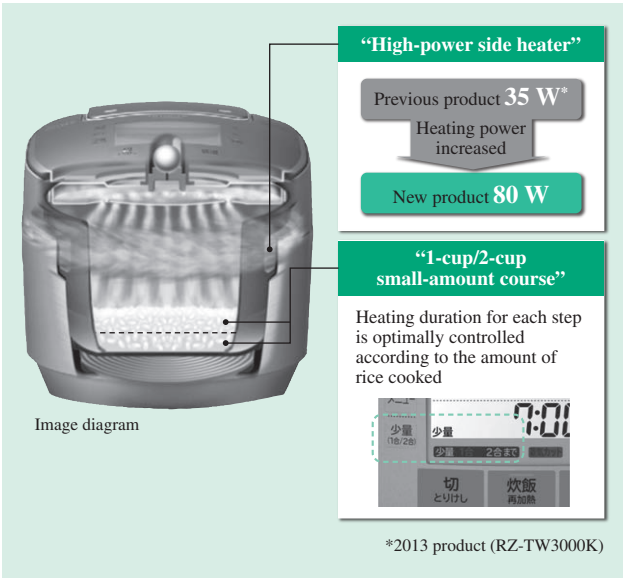

Fig. 7—Measures for Making Small Amounts of Rice Delicious.
The temperature of the inner pot is appropriately maintained with the high-power side heater to ensure deliciousness.

explained, and homemakers were asked for their opinions. It was discovered that the attractiveness of this new concept was praised not only by the small households that were the initial targets, but by families as well.

The Process of Cooking Delicious Rice

Cooking delicious rice requires a rice cooking process (including both temperature and heating duration) that matches the characteristics of the rice, whether in small or large amounts. Cooking rice involves soaking, boiling, and steaming steps (see Fig. 6). For the steaming step, the rice must be cooked at a high temperature of 98°C or higher for 20 minutes or longer. Therefore, the rice is heated after boiling until the water dries up, and then the high temperature is maintained for an appropriate time period by steaming. Because the heat capacity of rice itself is insufficient when cooking small amounts, the temperature tends to decrease during steaming, which makes heat control a challenge.

5.5-Cup Rice Cooker Cooks Delicious Rice in Small Quantities

When cooking a small amount of rice in a 5.5-cup large-capacity rice cooker, there is more empty space in the inner pot, which makes it difficult to adjust the heat to cook delicious rice. Therefore, when cooking a small amount of rice, this rice cooker has a small-amount course that can be set, which will heat up the internal space using the high-power side heater to produce delicious rice, making this rice cooker good at cooking small amounts as well (see Fig. 7).

2.0-cup Rice Cooker Specializes in Cooking Small Amounts of Rice

One of the challenges that must be addressed when cooking small amounts of rice is adjusting the heat. Because the heat capacity of rice is low, it is important that the structure is designed to maintain the correct heat level and that heating is controlled.

(1) Thick thermal sprayed iron for cooking small amounts of rice

The optimal dimensions for the inner pot were verified to reduce uneven cooking, and the inner pot was designed to enable the cooking of delicious rice whether there are 2 cups, 0.5 cups, or 1 cup of rice. Melted iron particles are quickly sprayed on the base material to form the thick thermal sprayed iron pot with a multilayered structure that offers superior heat storage performance (see Fig. 8).

An iron pot with a thickness of 3.6 mm (at the thickest part) is used to provide high thermal capacity which effectively inhibits temperature drop during steaming.

(2) Full-circumference heat insulation container

A ball-type pressure regulator is mounted on the steam port to ensure that the hot steam in the inner pot does not escape during steaming, which would reduce the temperature.

Insulation material, manufactured the same way as flexible vacuum insulation panel[1] developed for use in refrigerators, is used on the sides of the rice cooker. This insulation was developed specifically for use in rice cookers to ensure that performance can be maintained in a high-temperature and high-humidity environment, without raising the temperature of the packaging film due to electromagnetic induction.

A two-layer structure is used in the top lid, including an air insulation layer with fiberglass insulation on the bottom. The full-circumference heat insulation container is used to inhibit heat leakage over the entire circumference (see Fig. 9).

(3) Separable structure

In order to achieve delicious “just-cooked” rice at the dining table, the serving container unit is separable from the heat source unit (see Fig. 10).

This structure makes it possible to keep the serving container lightweight at approximately 2.0 kg (2.7 kg when cooking 2 cups of rice), so that it can be easily carried to the dining table.

Also, the previously described full-circumference heat insulation structure retains freshly-cooked and hot state of the rice even after the serving container is carried to the dining table, ensuring that the rice is kept at the proper serving temperature of approximately 70°C or more for two hours, in the case of 2 cups of rice (see Fig. 11).

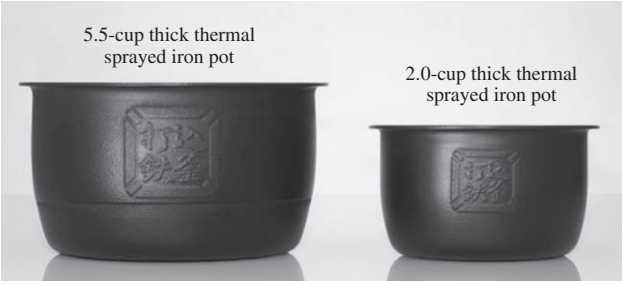

Fig. 8—Thick Thermal Sprayed Iron Pots.
A 2.0-cup inner pot was manufactured using the same method as the one used to manufacture a 5.5-cup inner pot for cooking rice.

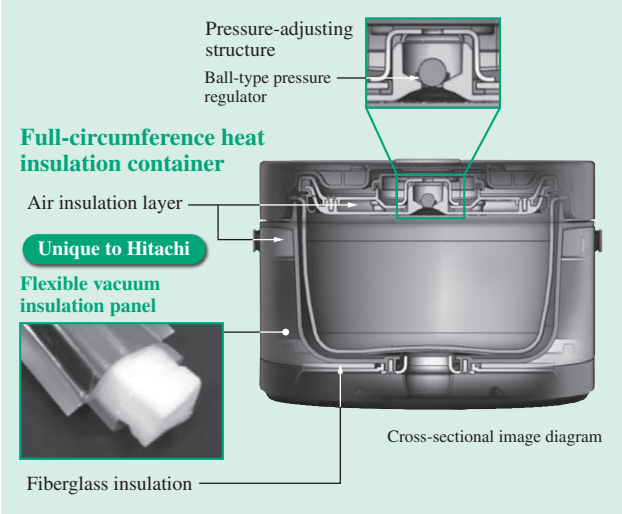

Fig. 9—Full-circumference Heat Insulation Container.
This container was implemented using a special flexible vacuum insulation panel designed for rice cookers along with an air insulation layer and fiberglass insulation.

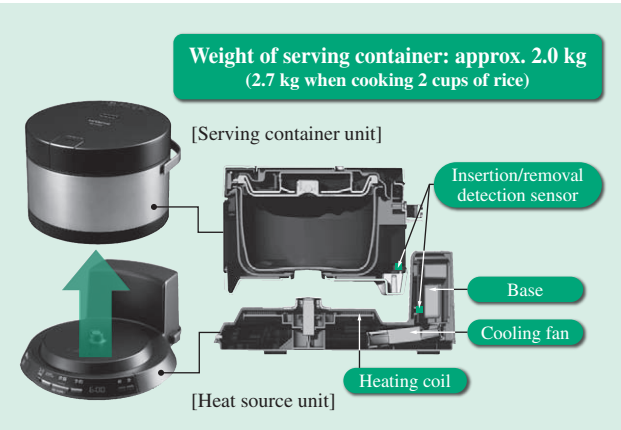

Fig. 10—Separable Structure.
The serving container unit and heat source unit are separable.

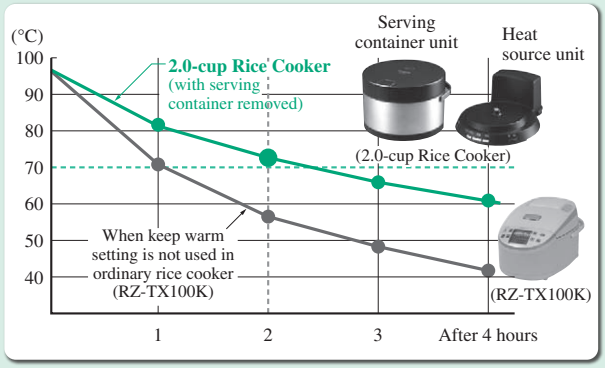

Fig. 11—Changes in Rice Temperature after Cooking (2 Cups). After the serving container unit is separated, a temperature of approximately 70°C is maintained even after two hours.

This product has a number of features aimed at user-friendliness, including simple and easy-to-use controls, an internal lid that can be removed for complete cleaning, and a measuring cup designed for cooking small amounts of rice.

DEVELOPING PRODUCTS IN RESPONSE TO NEEDS FROM A GLOBAL PERSPECTIVE

Hitachi has developed a new-concept air purifier with the goal of simultaneous deployment in Japan and in international markets.

Air Purifier Designed for Global Deployment

Consumer surveys conducted in international markets have shown that rooms are not generally divided into smaller areas in Southeast Asia, the Middle East, and other regions, so there is comparatively more space (see Fig. 12). Therefore, support for larger spaces, that is, the expansion of applicable floor space,[*3] is seen as a major sales point.

Due to the influence of particulate matter 2.5 (PM2.5),[*4] interest in air purifiers is extremely high, especially in China. Furthermore, as consciousness grows with respect to both cleanliness and health, demand is being seen in Southeast Asia for solutions to house dust allergens and haze (smoke pollution). In all cases, the common thread is that dust collection efficiency is seen as the number one priority.

In certain regions, "made in Japan" products are well accepted.

*3 Item stipulated by the JEMA standard (JEM1467), indicating the size of a room for which a prescribed concentration of dust can be cleaned in 30 minutes.

*4 Particulate materials with a size (grain diameter) of 2.5 μm or less that float in the air.

Fig. 12—Lifestyle Surveys (Indonesia [Top Left], Thailand [Top Right], Saudi Arabia [Bottom Left], Kazakhstan [Bottom Right]).
There is a lot of wide space with tall ceilings, and rooms are not often divided into smaller areas.

In the domestic Japanese market, although ion emission functions have been emphasized, increasing numbers of consumers have been emphasizing dust collection performance (applicable floor space) due to rising concerns about PM2.5. According to surveys conducted by Hitachi, approximately 40% of consumers mentioned applicable floor space as a priority for their next purchase (see Fig. 13).

It is based on this background that Hitachi developed a new air purifier for export, with the high dust-collection efficiency necessary to satisfy shared domestic and international needs.

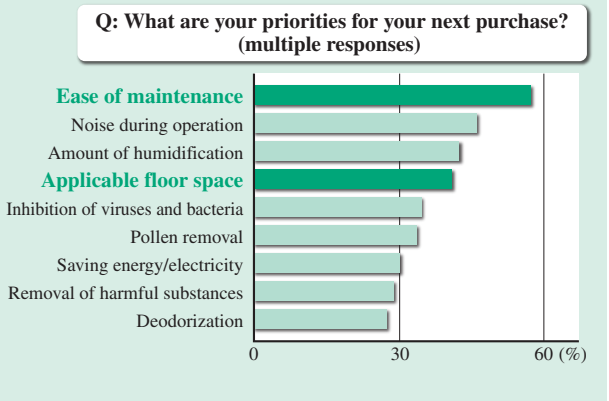

Fig. 13—Priority Survey (Hitachi Survey from October 2013: n=191).
Results are shown for a survey of priorities as expressed by consumers regarding their next purchase of a humidifying air purifier.

Technology for Achieving High Dust Collection Performance

An air purifier's dust collection performance is determined based on the amount of floor space it can cover. Hitachi set as its development target improving the previous model's applicable floor space of 40 m^2 (EP-JV700) to support a space of 68 m^2, which would make it the top of its class both in Japan and overseas. High flow rate is a must for expanding applicable floor space, and the improvement of fan performance and the reduction of flow resistance are challenges. The fan performance was enhanced by adopting a high-torque motor and a compact, high-efficiency fan, along with optimization of the outlet scroll passage of the fan. Flow resistance was reduced by moving the suction area from its previous location in front to the back, and the opening area was expanded by 50% over the previous 2013 model (EP-JV700). This increased the air flow rate and successfully achieved an applicable floor space of 68 m^2 (EP-KVG900) (see Fig. 14).

Furthermore, Hitachi developed a high flow rate dust collection system that takes advantage of high flow rate characteristics. In this system, the flow pattern is optimized to discharge upward and to suck into the suction area in the back from a wide area, thereby achieving quick operation with reliable dust collecting performance (Fig.15).

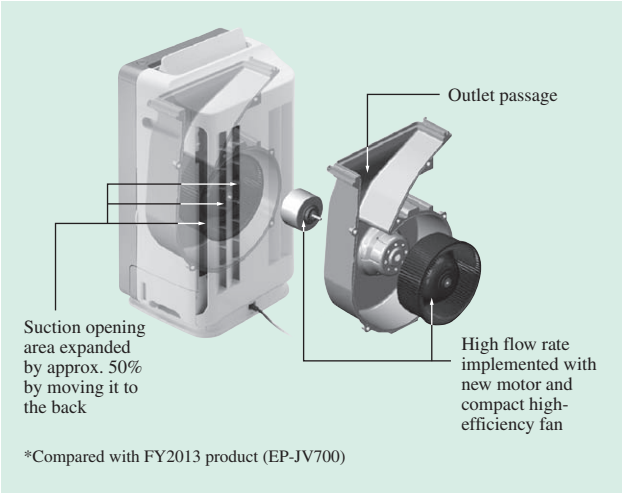

Fig. 14—Mechanisms Implementing High Flow Rate Dust Collection System.
High flow rate was implemented by using a new motor, a compact high-efficiency fan, and an optimized blowing passage. Flow resistance was also reduced by expanding the area of the suction opening.

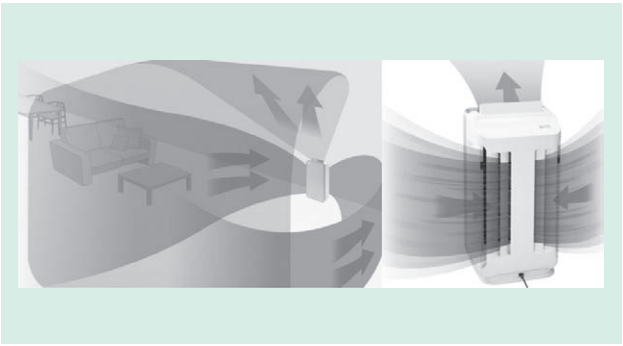

Fig. 15—Wide Range Air Intake.
Airflow control that can take advantage of the large air capacity was achieved.

Sensing Technology

Hitachi applied a previously used dust sensing method toward the development of "PM2.5 sensing" control.[*5] With "PM2.5 sensing" control, flow rate is automatically controlled in association with the concentration of microparticles. When the concentration of microparticles is high, the high flow rate enables the system to quickly clean the room's air. Once the room's air is clean, the air flow is reduced so that the sound is no longer noticeable. The room is monitored in this state, and the cleanliness level is displayed using three colors (red, orange, and green) based on the concentration of microparticles (see Fig. 16).

It was confirmed that the microparticle removal speed with "PM2.5 sensing" control implemented is approximately twice as fast as automatic air purification operation without "PM2.5 sensing."[*6] (see Fig. 17).

*5 Sensor detects microparticles that are 0.5 μm or larger.
*6 Comparison of time required to reduce initial concentration of approximately 1000 μg/m^3 to 35 μg/m^3. Automatic air purification operation: approximately 38 minutes, PM2.5 sensing control: approximately 20 minutes. Tested particle: tobacco smoke.

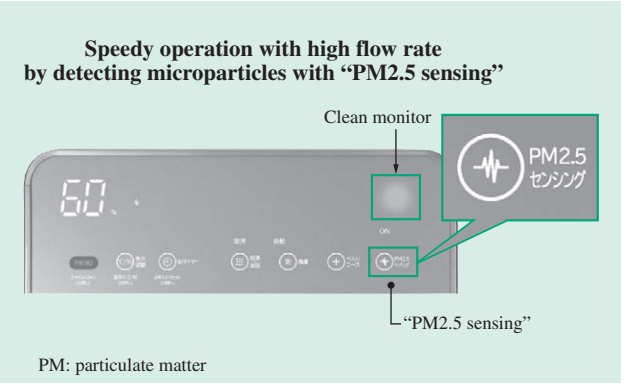

Fig. 16—PM2.5 Sensing Control (EP-KVG900).
Sensing technology that can take advantage of high flow rate characteristics was developed.

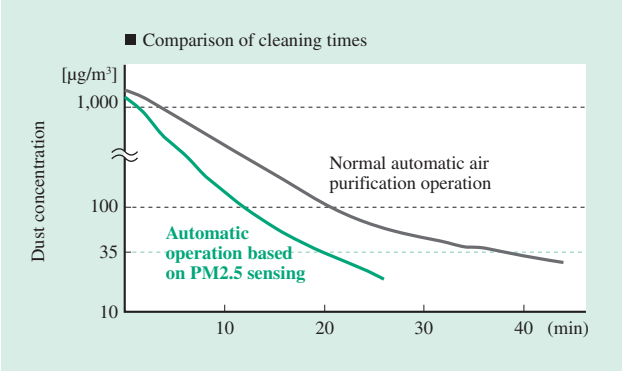

Fig. 17—Cleaning Performance Comparison.
Approximately twice the cleaning speed of automatic air purification operation was achieved with the automatic PM2.5 sensing operation.

Maintainability and Cleanability

According to the results of Hitachi's surveys, approximately 60% of consumers mentioned ease of maintenance as a priority for their next purchase (see Fig. 13). Not only does the air purifier capture a room's dust, but it also has a three-layer structure with a high-efficiency particulate arrestance (HEPA) air filter that captures bacteria, mold spores, and other minute particles,[*7] a deodorization filter that adsorbs odors, and a prefilter that captures large dust clumps. Of these layers, the prefilter is the one that needs to be maintained most frequently. To improve the maintainability of this prefilter, a stainless coated filter with a smoother surface has been applied to make it easier to clean dust and stubborn oily smoke residue than was the case with previous prefilters. As for the maintainability of the humidification water tank, the lid of this tank has an easy-to-remove structure that allows for easy access to all internal corners for easy cleaning.

High-quality Glass Touch Panel

This newly developed EP-KVG900 model offers superb ease-of-use features such as high-quality design and cleanability, and uses reinforced glass that already has a track record in refrigerators and other products, as well as an electrostatic capacitive glass touch panel control system. The use of reinforced glass helps prevent scratching while providing excellent cleanability at the same time (see Fig. 18).

The air purifier described above (EP-KVG900) was developed to meet the needs of consumers in Japan and other Asian countries, and was released in Japan in October 2014. Hitachi plans to modify the detailed specifications of this base product and gradually introduce it into international markets in the future.

*7 High-performance filter that is used to remove minute grit and dust particles from the air.

Fig. 18—High-quality Glass Design (EP-KVG900).
The use of reinforced glass provides a high-quality feel along with improved cleanability.

CONCLUSIONS

This article described a rice cooker aimed at satisfying the changing needs of Japanese lifestyles, and an air purifier developed from a global perspective to meet both Japanese and international needs.

Although these examples were quite different, developing products from the consumer's perspective is a common theme for all product development. Hitachi will continue uncovering new consumer needs and developing products to satisfy them.

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Featured Articles

Development of Appliances for All-electric Home and Residential Photovoltaic Power Generation Systems

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Naoto Kishimoto
Yutaka Enokizu
Kenji Hattori
Hirofumi Tanaka

OVERVIEW: In addition to creating appliances for all-electric home use such as IH cooking heaters and the natural refrigerant heat pump water heater, Hitachi Appliances, Inc. is involved in the residential photovoltaic power system business. Hitachi's IH cooking heaters increase the maximum IH heating power to 3.2 kW (input value) while offering automatic double-sided cooking in the oven compartment, which has a grime-resistant internal structure, thereby reducing the time and effort needed for cooking and cleaning. The urethane foam-filled heat insulation structure utilized by the hot water storage unit in the natural refrigerant heat pump water heater for home use greatly improves energy-saving performance. Residential photovoltaic power generation systems contribute to energy generation by monitoring changes in sunlight and reliably generating power with a high-efficiency power conditioner.

INTRODUCTION

AWARENESS of the needs for saving energy and reducing energy consumption has been growing since the Great East Japan Earthquake of 2011. At the same time, as the population ages, expectations for a safe and secure lifestyle are also on the rise. It is against this background that appliances for all-electric homes such as induction heating (IH) cooking heaters and natural refrigerant heat pump water heater are expected to continue growing in popularity, thanks to their high energy consumption efficiency and the safety provided by avoiding the use of open flames. Not only do these products offer a high level of performance, they also enable the creation of new value from the perspectives of taste, amenity, and ease of use.

"Zero-energy houses" and other new types of homes are currently attracting a great deal of attention. The use of renewable energy as represented by photovoltaic power is a necessary part of achieving such homes, and Hitachi launched its own residential photovoltaic power system business in August 2012. This article discusses Hitachi's efforts surrounding three such products.

IH COOKING HEATERS

As products for FY2014, Hitachi developed the IH cooking heater HT-J300T (double all metal supporting three-burner IH) with a dedicated grill pan and high-power 3.2 kW (input value) IH heating, as well as the HT-J200T (all metal supporting three-burner IH) and HT-J100T (three-burner IH) series (see Fig. 1).

Featuring the Grill Pan

These products further advance oven cooking functionality while satisfying the need to be easy to clean, as emphasized by consumers when purchasing, by not only adopting a new oven structure that makes grime easy to remove, but by also combining delicious cooking results with reduced time and effort when cooking and cleaning.

This product uses a dedicated grill pan inside the oven to automatically cook both sides of the food, and this makes it possible to cook even hamburgers, grilled fish, and other dishes for which it is difficult to control the heat level appropriately, without needing to flip the food. In addition, 220 different oven recipes[*1] have been achieved, including 153 automatic menu types such as non-fried cooking, smothered cooking, bread, and others using the grill.

Temperature sensing was an important part of achieving an automatic menu using the grill pan. The temperature sensor mounted on the inside front of the oven is used to measure the amount of time required for the temperature to rise inside the oven,

*1 Number of recipes included in the "Oven Cooking Guide."

Fig. 1—Top Model in the HT-J300T Series (HT-J300XTWF [W]) (Top) and Grill Pan with Special Lid (Bottom).
Automatically cooks both sides of dishes such as hamburgers and grilled fish without requiring the time and effort for flipping the food. Automatic cooking also supports shrimp tempura without oil (non-fried cooking) and acqua pazza using the special lid (smothered cooking).

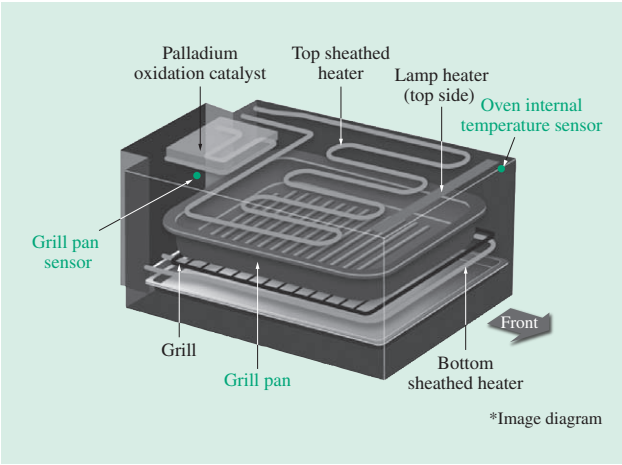

Fig. 2—Oven Unit Configuration Diagram.
An internal oven temperature sensor determines the amount of food being cooked, and the grill pan sensor determines how well the food is cooked.

which is used to compute the cooking time based on a determination of the amount of food being cooked. Furthermore, the grill pan's sensor is used to detect increases in temperature and determine how well the food is cooked to provide fine-tuned temperature control (see Fig. 2).

The grill pan uses a sheathed heater to cook food with a far-infrared and near-infrared radiation ratio

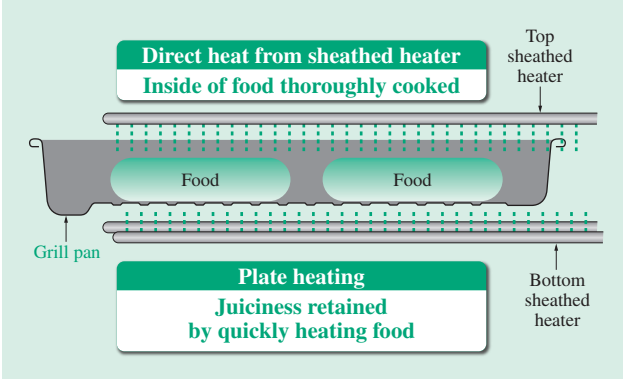

Fig. 3—Heater Image Diagram Using Grill Pan.
Heat is carefully applied from the top and bottom for delicious results.

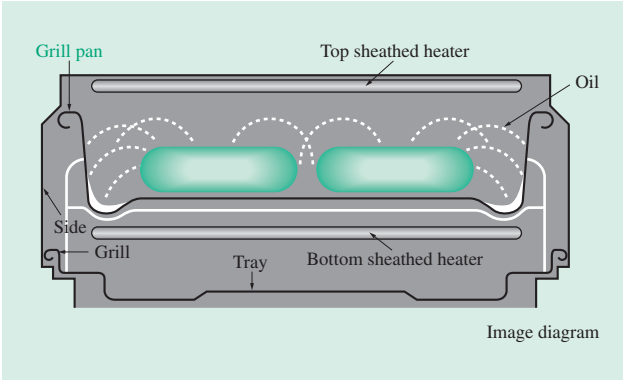

Fig. 4—Image Diagram of Reduced Grime in Oven.
The grill pan prevents oil from spattering and reduces grime on sides of oven.

of 8:2 (close to the ratio used during charbroiling), by grilling the top of food with direct heat while thoroughly cooking the inside. Next, a plate with good thermal responsiveness is used to heat up the grill pan to quickly transfer heat to the bottom of the food, thereby preserving juiciness. Top and bottom heaters are alternately powered in this way to meticulously control heating and provide delicious results (see Fig. 3).

When cooking with the grill pan at its depth of approximately 5 cm, this guards against the spattering of oil from the food, reducing the amount of grime that sticks to the inside of the oven after cooking. In addition, the grill pan is lightweight at approximately 500 g, and has a smooth fluorine coating that enables easy cleaning (see Fig. 4).

IH Heater with Powerful 3.2 kW-Input Heating

The biggest attraction of IH cooking heaters is the way they combine high efficiency with powerful heating capabilities, and the maximum heating power

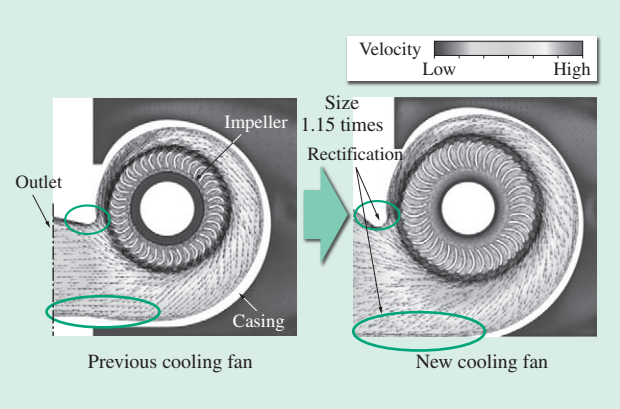

Fig. 5—Comparison of Computational Results of Previous and New Cooling Fans.
The new cooling fan has uniform velocity distribution at the outlet by rectifying along the casing.

of the left and right IH heaters in these products was increased from the previous 3.0 kW to a powerful 3.2 kW (when heating iron and stainless steel pots).

When it comes to providing strong heating power, the challenge lies in increasing the generation of heat in the inverters and coils. Inverter loss was reduced by lowering the capacity of the left and right IH inverters' resonance capacitors by 5% and bringing the circuit's resonance frequency closer to the inverter frequency. The cooling configuration features a new larger fan with an impeller diameter of approximately 1.15 times greater than before. The large-diameter impeller and large number of blades not only reduces noise, but it also provides 1.1 times as much cooling air. It also rectifies flow along the casing and homogenizes velocity distribution at the outlet, thereby improving the cooling effect on the electronic parts located downstream (see Fig. 5).

This stronger heating power satisfies the need for a shorter cooking time while speeding up the process of boiling large amounts of water for pasta and other such dishes.

NATURAL REFRIGERANT HEAT PUMP WATER HEATER FOR HOME USE

Approximately 30% of the energy consumed in the home goes toward the supply of hot water[(1)], so the promotion of energy conservation occupies an important position in the field of hot water supply. Natural refrigerant heat pump water heater for home use was newly added to the list of products covered by Top Runner standards in March 2013, as stipulated by the Energy Saving Act (Act on Temporary Measures for Promotion of Rational Uses of Energy and Recycled Resources in Business Activities) with a target year of FY2017, and so even greater efficiency is expected in the future.

It is against this background that Hitachi is focusing ongoing efforts on the development of improved energy-saving performance in natural refrigerant heat pump water heater for home use. The technology of products released in FY2013 garnered praise, earning Hitachi the Grand Prize for Excellence in Energy Efficiency and Conservation (Product Category & Business Model Category) in FY2013 as well as the Director-General's Prize, the Agency for Natural Resources and Energy[*2].

Innovations in products for FY2014 resulted in the development of an industry-first[*3] urethane foam-filled heat insulation structure in a hot water storage unit that provides up to approximately double the heat insulation performance[*4]. The high flow rate hot water supply series of high-efficiency models (see Fig. 6) combines a hot water storage unit with a urethane foam-filled heat insulation structure, vacuum heat insulating panels, and a high-efficiency heat pump

*2 Award-winning models: natural refrigerant heat pump water heater BHP-FV46ND for home use and others, for a total of 55 models.
*3 As of the release date of October 20th, 2014. Based on Hitachi research into natural refrigerant heat pump water heater hot water storage units for home use.
*4 Comparison of thermal resistance with previous Hitachi BHP-FV37ND product (2013 model, based on Hitachi research).

Fig. 6—Natural Refrigerant Heat Pump Water Heater BHP-FV37PD (Hot Water Storage Capacity: 370 L).
From the upper left: kitchen remote control, bathroom remote control, heat pump unit, and hot water storage unit exteriors.

unit to achieve the best energy-saving performance[*5] in terms of annual water heating and heat-retention efficiency (JIS) two years in a row, at 3.9.

High-efficiency Hot Water Storage Unit Technology

Reducing heat loss in the hot water storage unit, or in other words, improving heat insulation performance, was indispensable when it came to improving the efficiency of the natural refrigerant heat pump water heater.

Previous hot water storage units (see the left side of Fig. 7) implemented heat insulation by combining segments of expanded bead polystyrene foam[*6] (referred to as "expanded polystyrene (EPS)" hereinafter) around the body of the can used to store water (referred to as the "tank" hereinafter). To further improve the heat insulation performance of this product, Hitachi focused on developing and applying the "urethane foam-filled heat insulation structure" technology it has cultivated over many years in refrigerator manufacturing.

In the new heat insulation structure at the hot water storage unit (see the right side of Fig. 7), the tank is enclosed by a box-shaped outer panel, and liquid urethane is injected as a foam between the outer panel and the tank. In this way, the industry-first urethane foam-filled heat insulation structure with integrated enclosure was achieved. Heat insulation performance is greatly improved over EPS, not only by using urethane foam with its excellent heat insulation performance, but also by completely filling the enclosure to cover the entire tank (see Fig. 8).

Fig. 9 shows a comparison of the heat retention performance of the previous hot water storage unit and

*5 Current as of October 31st, 2014. For general-region home-use heat pump water heaters (1) annual water heating and heat-retention efficiency (JIS) 3.9 (three models including BHP-FV37PD, with hot water storage capacity equal to or greater than 320 L and less than 460 L), (2) annual water heating and heat-retention efficiency (JIS) 3.8 (three models including BHP-FV46PD, with hot water storage capacity equal to or greater than 460 L and less than 550 L).

*6 Foamed plastic formed by foam molding using polystyrene resin and a hydrocarbon-blowing agent (generally referred to as "expanded polystyrene").

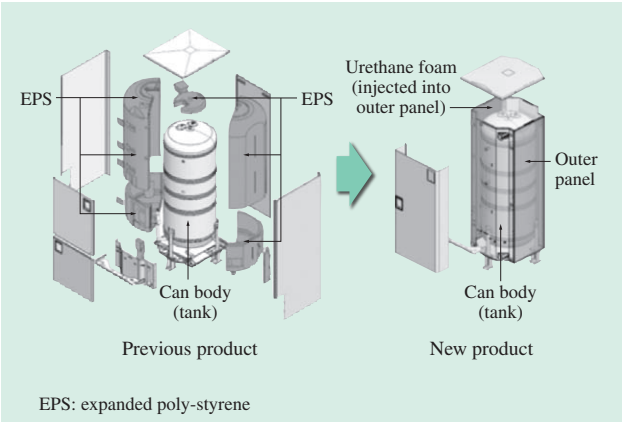

Fig. 7—Comparison of Hot Water Storage Unit Heat Insulation Structures.
The new heat insulation structure involves injecting liquid urethane between the outer panel and the tank, and then causing it to foam.

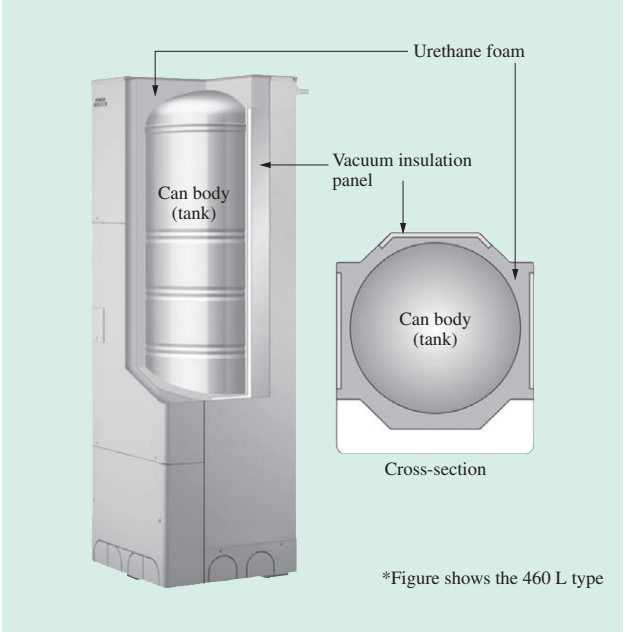

Fig. 8—Image of Urethane-insulated Storage Unit Structure (High-efficiency Model).
The entire tank is covered with urethane, without gaps. The high-efficiency model utilizes a structure that combines the urethane with vacuum insulation material.

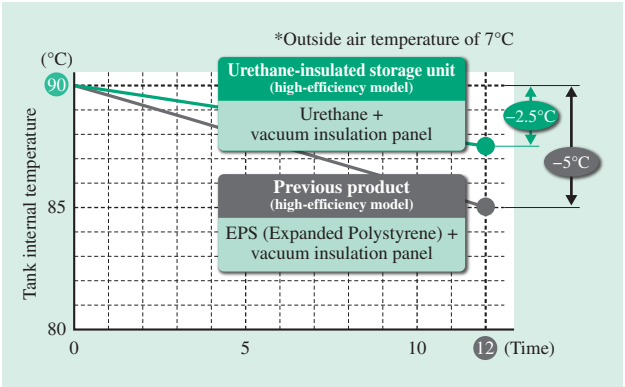

Fig. 9—Comparison between Heat Retention Performance of Urethane-insulated Storage Unit and Previous Product (High-efficiency Model).
In the case of the urethane-insulated storage unit the hot water only lost approximately 2.5°C when left for 12 hours at an external temperature of 7°C.

the urethane-insulated storage unit in high-efficiency models that improve heat insulation performance by combining vacuum heat insulating panels. Water is stored inside the tank at 90°C, and the figure shows how the water temperature decreases when the external temperature is kept at 7°C. Although the previous EPS heat insulation already offered good heat retention performance with a loss of approximately 5°C after 12 hours, the temperature inside the urethane-insulated storage unit only decreased by approximately 2.5°C, showing greatly improved heat retention performance.

Urethane foam filling and other improvements were used to strengthen the legs as well, and although a three-legged structure was retained for easy installation, it still achieved class S earthquake resistance*7.

High-efficiency Heat Pump Unit Technology

Performance was improved in the elemental technologies (compressor, evaporator, etc) of the refrigeration cycle to increase efficiency in the heat pump unit (see Fig. 10).

A scroll compressor for carbon dioxide refrigerant with a unique oil supply structure that offers improved efficiency was adopted. Because oil is efficiently supplied in the compression chamber and other parts, sliding loss and heating re-expansion loss were reduced. Furthermore, the gap between fixed scroll and orbiting scroll was optimized to lower leakage loss, and overall efficiency is increased as a result.

Air-side heat transfer and the pressure loss characteristics of the evaporator were improved by optimizing the number of refrigerant pipe branches, the diameter of the refrigerant piping, and the shape of the aluminum fins. Generally refrigerant piping causes the increase of refrigerant pressure loss, and in order to solve this problem, equal refrigerant distribution was achieved with multiple branches by developing mist flow distribution technology whereby the refrigerant in the mist flow state is branched immediately after the expansion valve. Heat transfer performance was also improved by optimizing the refrigerant flow path and arranging the paths at a high density while keeping the wetted and superheated flow paths apart from each other.

Tap Water Direct Pressure Hot Water Supply Method and Amenity Functions

Products in the high flow rate hot water supply series use tap water pressure without decompression to instantly supply water by using a tap water direct pressure method exclusive to Hitachi (see Fig. 11). This system enables, for instance, the simultaneous use of hot water in two locations such as the shower in the bathroom and the kitchen, while still providing hot water at high pressure in the shower. Application of this tap water direct pressure technology has enabled Hitachi to provide a lineup of products that also support both well water and hard tap water.

The high-efficiency model released in FY2014 not only ranks first in energy conservation, it also provides a rapid hot water filling function that can fill a bath with hot water within about five minutes (approximately 50% faster than standard bath-filling time*8), as well as a "comfortable bubble bath" function that combines a water jet with bubbles for a pleasing effect (see Fig. 12). This product provides both ease of use and a high level of amenity.

*7 Class S earthquake resistance means that the design standard for an earthquake intensity of 2.0 is met from the "Building Equipment and Device Design Standard Earthquake Intensity Based on the Local Earthquake Intensity Method" of the "Seismic Design and Construction Guide for Building Equipment" (Building Center of Japan). Test condition: Confirmation that the device can withstand having a continuous load of twice the mass of a full tank of water in the direction of the weak axis on the center of gravity, while fixed using the method described in the installation manual with a full tank of water in the device. (Models with class S earthquake resistance: P series 460 L released in October 2014, in 370 L hot water storage unit [N series 460 L and 370 L models have class A earthquake resistance, and other models have class B earthquake resistance].)

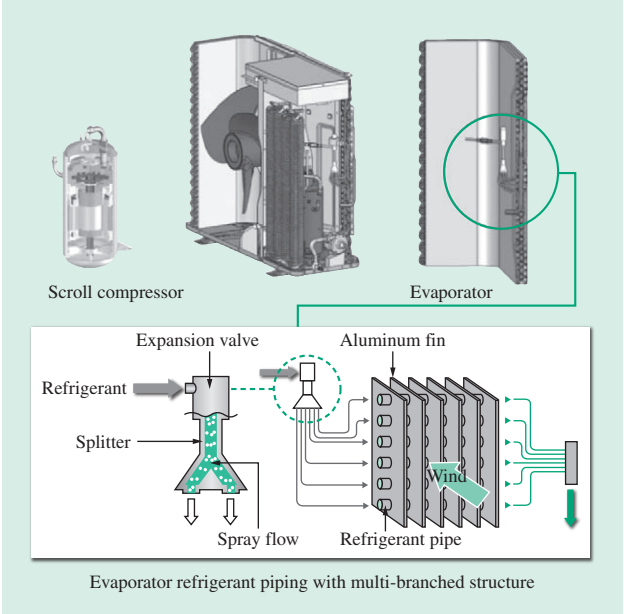

Fig. 10—High-efficiency Heat Pump Unit Technology.
High efficiency is achieved by applying ingenious techniques to various parts inside the unit.

*8 Pipe diameter 15 A, 5 m straight pipe, water supply pressure 300 kPa. Tank hot water temperature 80°C, cold water temperature 17°C, bath filled to 180 L at a temperature of 40°C, requiring approximately 5 minutes 45 seconds.

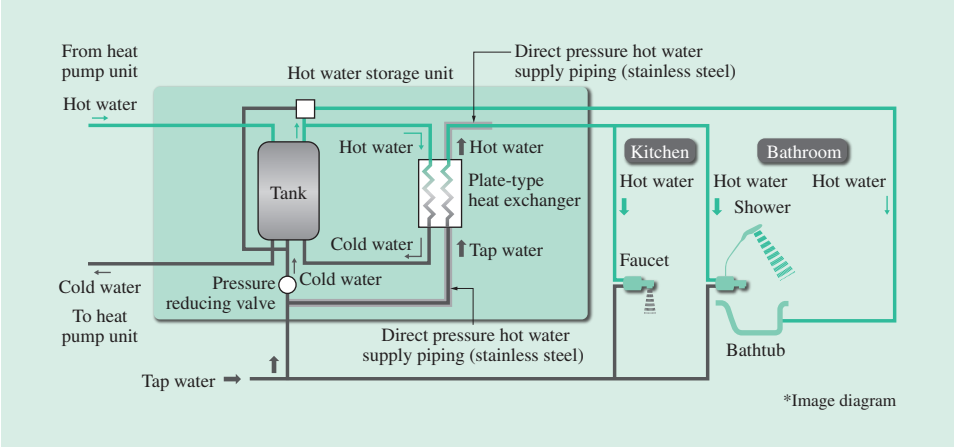

Fig. 11—Tap Water Direct Pressure Hot Water Supply Mechanism.
A plate-type heat exchanger is used to instantly heat water and supply hot water while essentially leaving the tap water's pressure and water quality as is.

Fig. 12—"Comfortable Bubble Bath" Jet and Bubble Image.
Jet and bubbles provide a soothing bath.

Fig. 13—Power Conditioner Roles.
A power conditioner converts direct current power generated by the photovoltaic module into alternating current power.

All models support connection to a Home Energy Management System (HEMS)[*9] (a HEMS adapter for connecting to a water heater is required and sold separately).

HIGH-EFFICIENCY POWER CONDITIONER FOR USE IN RESIDENTIAL PHOTOVOLTAIC POWER GENERATION SYSTEMS

Power conditioners provide two functions by drawing direct current power from photovoltaic modules and converting that direct current power into alternating current power. Hitachi sought to develop a product that could maximize power generation in both functions (see Fig. 13).

Function for Producing Direct Current Power

The amount of photovoltaic power that is generated will depend on factors such as the weather, with different amounts generated on sunny and cloudy days. Partial shadows of trees, utility poles, buildings, and other objects falling on photovoltaic modules can also have an effect.

Using general maximum power point tracking (MPPT) control[(2)], which produces power from photovoltaic modules, the voltage is changed in order to search for the photovoltaic module's power generation peak point. When partial shadows occur at this time, multiple peak points exist in the power-voltage (P-V) characteristic curve of the photovoltaic module, and this may make it impossible to find the peak point for maximum power, with the result that the generated power is less than the actual power generation capacity.

This is why Hitachi has developed a unique "HI-MPPT (Hitachi's unique MPPT)" control system that enables the generation of more power, even when partial shadows occur.

With HI-MPPT control, the fluctuation of power generation peak points is monitored during MPPT control, and when a fluctuation due to partial shadowing is detected, the overall P-V characteristic curve is evaluated to determine multiple peak points and resume MPPT control at the peak point, with the highest level of power generation (see Fig. 14).

By monitoring fluctuations in power peak points due to changes in sunlight, this function reduces loss in power generation and provides reliable electric power.

*9 A system designed to enable the efficient use of energy by connecting devices in the home via a network.

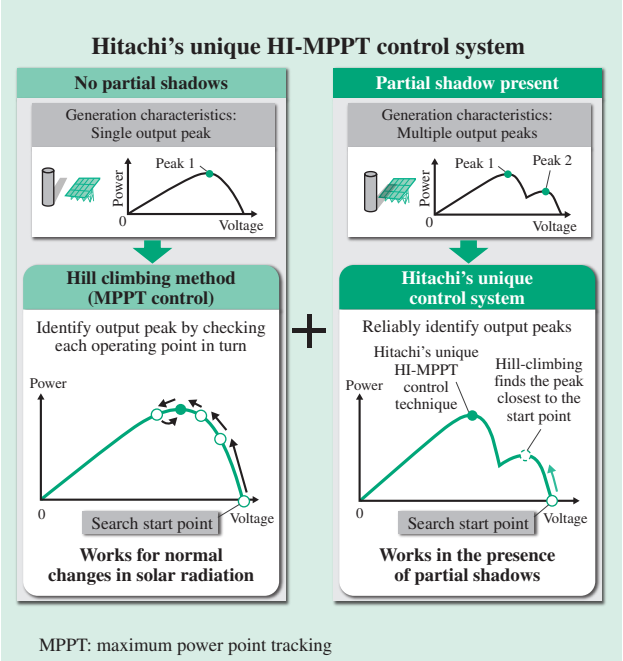

Fig. 14—HI-MPPT Control Characteristics Due to Power Generating Characteristics of Photovoltaic Modules.
HI-MPPT monitors fluctuations in electric power peak points due to changing sunlight in order to generate power.

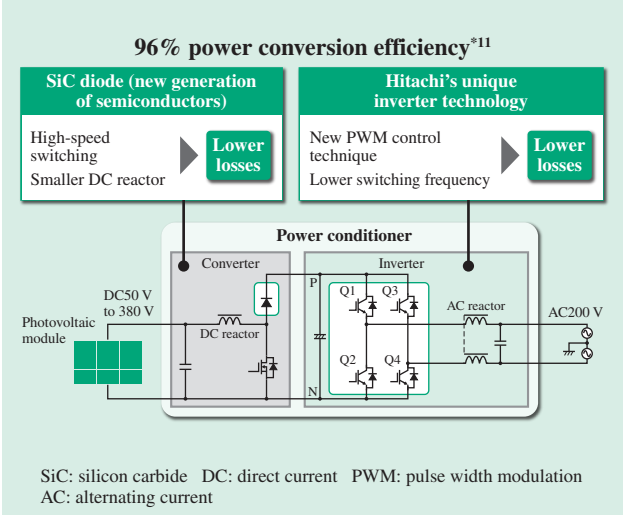

Fig. 15—Improvements to Power Conversion Efficiency of Power Conditioner.
Unique inverter technology is used to efficiently convert direct current power into alternating current power.

Function for Converting Direct Current to Alternating Current Power

A silicon carbide–Schottky barrier diode (SiC-SBD) is used in the converter that performs step-up transformation on the direct current power generated by photovoltaic modules to greatly reduce recovery loss during switching. This makes it possible to increase the switching frequency to 40 kHz, and reduces loss through implementation of a compact direct current (DC) reactor.

Hitachi developed a new pulse width modulation (PWM) control method to inhibit waveform distortion in the output current of the inverter that converts direct to alternating current power, while lowering the number of switches down to one-quarter of that used previously. This enabled implementation of a power conditioner that achieves a rated conversion efficiency of 96%*10 (see Fig. 15).

CONCLUSIONS

The three products discussed in this article (appliances for all-electric homes and photovoltaic power generation systems) are still relatively new, but they are already contributing a great deal toward conservation of the global environment, and the societal responsibility involved is heavy. Even further improvements in performance will be required. Hitachi will continue developing products that satisfy the demands of society and consumers from a unique perspective.

*10 Rated load efficiency as stipulated by JIS C 8961.

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(2) E. Trishan, et al. "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques," IEEE Transactions on Energy Conversion, Vol. 22, No. 2, pp. 439–449 (2007).

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Featured Articles

Development of an LED Ceiling Light for Home Use

Keiichi Fujimori
Takeshi Hoshino
Yoshifumi Sekiguchi

*OVERVIEW: The percentage of energy consumption attributed to lighting is high, with approximately 13% of energy consumed by lighting in the case of residential consumers[*1], and approximately 21% in the case of office buildings and other such facilities[*2]. This has increased the demand for LED lighting due to its excellent energy-saving performance. Hitachi is developing products based on the fundamental concept of simultaneously achieving both brightness and energy-saving performance. Our FY2014 residential LED ceiling light includes a new easy viewing function, which provides a level of brightness preferred by older consumers. Also, by taking advantage of light-guiding technology, Hitachi has developed a new category of products that add new value to ceiling lights.*

INTRODUCTION

HITACHI is developing its residential light-emitting diode (LED) ceiling lights based the fundamental concept of simultaneously achieving both brightness and energy-saving performance. In FY2013, for the types of its products with their respective indicated largest room sizes from 13 m^2 to 23 m^2 room type, Hitachi achieved the maximum brightness stipulated by the Japan Lighting Manufacturers Association in its standard brightness ranges for fixtures based on room size, as well as excellent energy-saving performance with energy consumption efficacy ratings of 102 lm/W or higher. The performance offered by these products has been highly praised, and in FY2013 Hitachi received Chairman's Prizes, the Energy Conservation Center, Japan at the presentation of the 2013 Grand Prize for Excellence in Energy Efficiency and Conservation (in the product and business model category)[*3].

According to a survey conducted by Hitachi as part of the process of developing products for FY2014, both energy-saving performance and brightness are given priority when making a purchase. These results confirmed that the fundamental concept behind Hitachi's development efforts matches consumer needs. Furthermore, when the survey results were analyzed by age group, a new trend was discovered showing the older the respondent, the greater the emphasis the respondent placed on brightness (see Fig. 1).

It is for this reason that in addition to improvements in brightness and energy-saving performance, Hitachi has started developing the easy viewing function, which achieves the level of brightness preferred by older consumers.

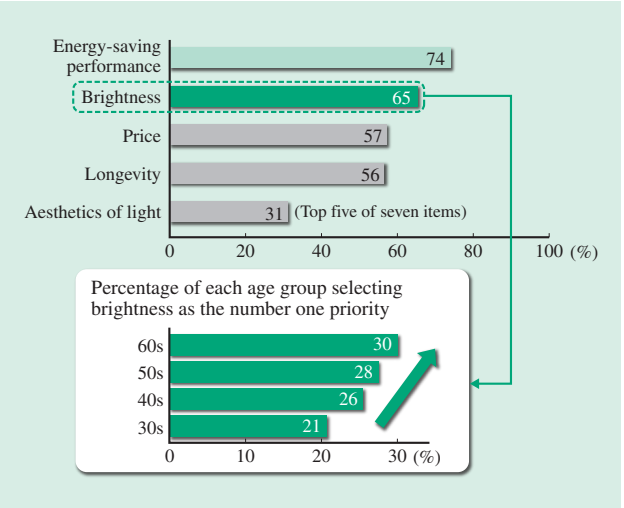

Fig. 1—Priorities in Selecting LED Ceiling Lights (Multiple Responses) (Research by Hitachi, March 2014: n=328). The older the consumer, the greater the emphasis placed on brightness during the selection of LED ceiling lights.

*1 From the Agency for Natural Resources and Energy's civilian sector energy consumption survey "Breakdown of Energy Consumption Amounts by Device in the Home" (FY2009) in Japanese.
*2 From the Energy Conservation Center, Japan's document "Energy Conservation in Office Buildings" (FY2009) in Japanese.
*3 Award-winning models: 22 models, including the LEC-AHS1410B LED ceiling light.

Fig. 2—Left: LED Ceiling Light (LEC-AHS1810CC), Right: Light Guiding Ring Type LED Ceiling Light (LEC-DHS1230C). The new easy viewing function has been adopted in order to achieve the level of brightness preferred by older consumers (left). A light different from those lights used in the past was developed through the use of the new light guiding technology called unique light guiding technology (right).

This article discusses the LEC-AHS1810CC, a residential LED ceiling light that uses this easy viewing technology (see the left photo of Fig. 2), as well as the LEC-DHS1230C, an light-guiding ring-type LED ceiling light that uses unique light guiding technology in order to provide sparkle illumination (see the right photo of Fig. 2), which differs from that offered by diffusion-type lights that use the traditional milky white cover.

A HIGH-INTENSITY ENERGY-SAVING LED CEILING LIGHT WITH EASY VIEWING FUNCTION

Developing Easy Viewing Function

On the assumption that brightness is given priority due to the need for easy viewing of objects and easy reading, in FY2014, Hitachi worked on developing technology targeting the components of light. In general, the ability of the pupils of the eyes to widen deteriorates as a person ages, and this necessitates brighter lighting. Another phenomenon that occurs is yellowing of the lens, which can make blue colors difficult to see[1]. This is why LEDs with the easy viewing function (see Fig. 3) not only shine at a higher brightness, equivalent to approximately 1.2 times the brightness of the full intensity setting when either daylight-color or light-bulb-color LEDs are used, but also emphasize energy-saving performance at full intensity while providing a stronger blue-green component in order to make up for the somewhat lack of intensity of that color in other bulbs. The result is a natural light that is closer to sunlight (see Fig. 4).

The resulting clear white light improves contrast so that fine print is easy to read, and causes the colors of photographs and other objects to appear more vivid.

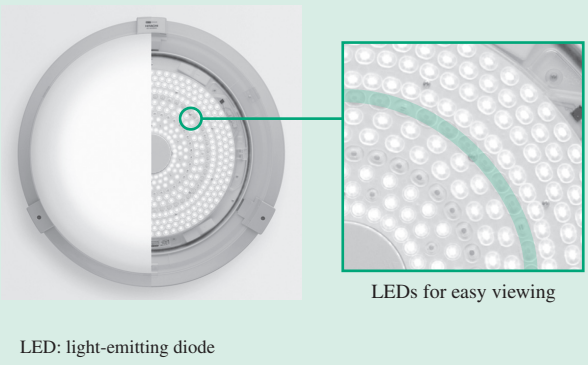

Fig. 3—Activation Image of LEDs for Easy Viewing
When the easy viewing button is pressed, the LEDs for easy viewing are activated and blue-green light is added to the mix.

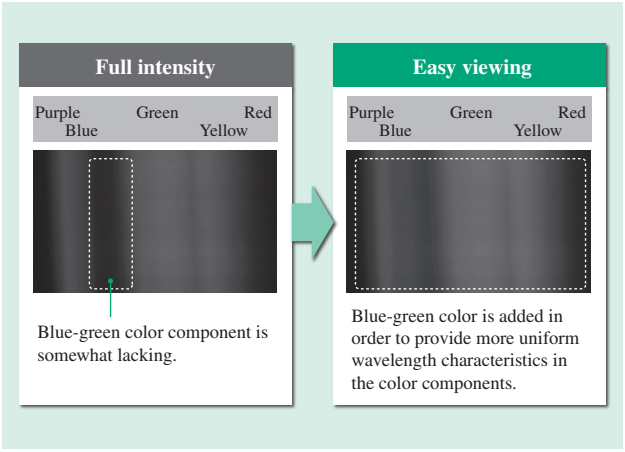

Fig. 4—Light Wavelength Component Comparison (Prism Spectroscopy).
The addition of the blue-green color makes the components uniform, resulting in a natural light that is close to sunlight.

Testing Easy Viewing Function

To test the easy viewing function from the two perspectives of visibility and ease of viewing, Hitachi enlisted 24 participants with ages ranging from the 30s to the 70s. The tests were carried out at full intensity in order to compare legibility of text, ease of differentiating between pale colors, and vividness of colors.

As a result of these tests, the effectiveness of the easy viewing function was demonstrated with approximately 79% of all participants reporting that the easy viewing function makes it easier to recognize colors and read text than the full intensity setting (based on testing performed by Hitachi in July 2014, n=24).

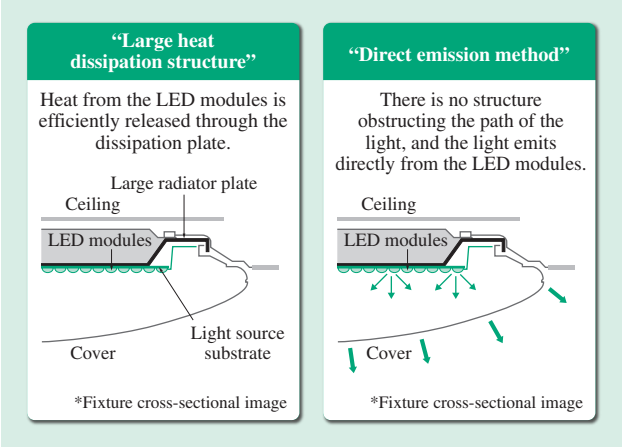

Fig. 5—"Large Heat Dissipation Structure" and "Direct Emission Method."
Hitachi has achieved both high light output and energy-saving performance at the same time.

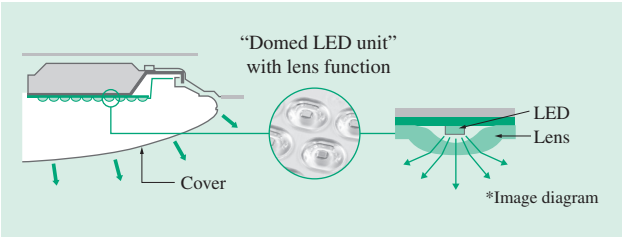

Fig. 6—"Domed LED Unit" with Lens Function.
Light output from the LED is efficiently diffused.

Providing High Light Intensity and Excellent Energy-Saving Performance at the Same Time

LED modules are characterized by a reduction in efficiency that occurs when the temperature rises due to the heat that is generated in conjunction with the emitted light. Also, direct light radiation is an effective means of reducing the loss of light emitted from the light source.

Hitachi therefore developed a "large heat dissipation structure" in order to efficiently release the heat generated by LED modules, and a "direct emission method" to directly emit light from the LED's light source through the cover (see Fig. 5).

In general, when a method is utilized where the light from a light source is radiated directly through a cover that has a low amount of light transmission loss, various issues may occur such as the light failing to spread out, the LED granules (LED modules) being visible, or only the area directly underneath the LED ceiling light being lit.

In response to these issues, Hitachi developed a "domed LED unit" with a unique lens function that covers each individual LED module, so that light efficiently covers a wide angle and the LED granules cannot be seen (see Fig. 6).

There are other issues surrounding the improvement of energy-saving performance, including the number of LEDs and positioning on the light source substrate. For instance, in the case of the brightest 30 m^2 room type model (defined by Hitachi)[*4], the number of LEDs was greatly increased over the previous product (LEC-AHS1810BC), and the amount of heat generated was reduced by running the LEDs at a lower power level. Furthermore, heat distribution was homogenized by evenly arranging the LED modules on the light source substrate. These measures successfully reduced the rise in temperature, thereby improving the LED luminance efficiency. In addition, the ratio of more efficient daylight-color LEDs was increased over light-bulb-color LEDs in order to improve energy-saving performance (see Table 1).

These technologies have enabled Hitachi to achieve a top-class luminance rating in the industry for an 30 m^2 room type model (defined by Hitachi) at 8,000 lm, and to achieve the maximum brightness in the brightness standard range for room size in the lineup, from the new 10 m^2 room type to the 23 m^2 room type model[*5] (see Fig. 7).

Furthermore, Hitachi achieved excellent energy-saving performance of 123 lm/W or higher for room size from 10 to 30 m^2. For instance, the 23 m^2 room type model consumes less than half the power of a

TABLE 1. Comparison of Previous and New 30 m^2 room type LED Ceiling Light Products
The number of LEDs was increased in order to improve luminance efficiency.

		Previous product (LEC-AHS1810BC)	New product (LEC-AHS1810CC)
Room size		30 m^2 room type model (Defined by Hitachi)	30 m^2 room type model (Defined by Hitachi)
Total flux		7,290 lm	8,000 lm
Power consumption		86 W	63.6 W
Fluorescent luminaire efficacy rating		84.8 lm/W	125.8 lm/W
Number of LEDs	Daylight-color	160	275
	Light-bulb-color	160	141
	(Blue-green color)	–	(41)
	Total	320	416 (457)

*4 Hitachi independently defined the standard for the 30 m^2 room type models.
*5 "Residential catalog applicable room size standards" (guide 121: 2011) established by the Japan Lighting Manufacturers Association.

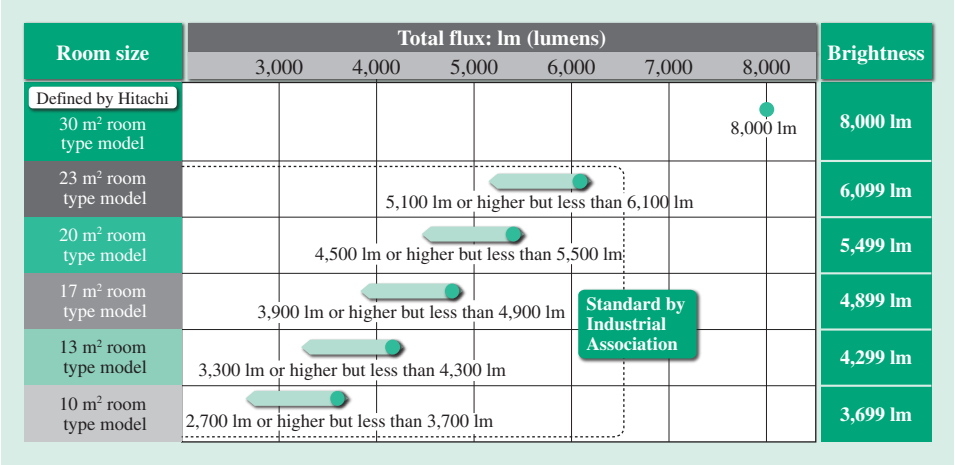

Fig. 7—Brightness Standard Range by Room Size and Total Flux Value from 10 to 30 m² Room Type.
Hitachi achieved maximum brightness within the brightness standard ranges (dotted lines) for room size according to the Japan Lighting Manufacturers Association.

high-efficiency fluorescent lamp, and even reduces power consumption by approximately 14% when compared to the LEC-AHS1410B model, which was awarded the Grand Prize for Excellence in Energy Efficiency and Conservation in FY2013 (see Fig. 8).

DEVELOPMENT OF THE INNOVATIVE LIGHT GUIDING TYPE LED CEILING LIGHT

The innovative new light guiding type LED ceiling light developed by Hitachi marks a clear departure from previous lighting fixtures, and it features a new type of shining illumination that spreads light throughout the room, a high-quality design, and easy viewing technology.

Unique Light Guiding Technology

Unique light guiding technology was newly developed, and is characterized by a transparent cover to which light is guided from LEDs arranged along the periphery of the fixture, and by light guiding rings on the surface that efficiently emits the light while controlling light distribution at the same time. Using this light emission principle, light is spread out and a "sparkling" shine is achieved.

The light guiding ring gap is narrow in the middle and wider toward the periphery so that the transparent cover is uniformly bright from the center to the periphery (see Fig. 9).

The sparkle of the light is achieved by varying level of luminance in the part where the light guiding rings is located on the cover surface and in the other transparent parts. The spreading of light through the room from the ceiling light is achieved by optimizing the output luminance characteristics of the light guiding rings. A sufficient amount of extracted light is directed towards the floor, but light is also emitted in the directions of the walls, so that all of this light can be used together to brighten the entire room (see Fig. 10).

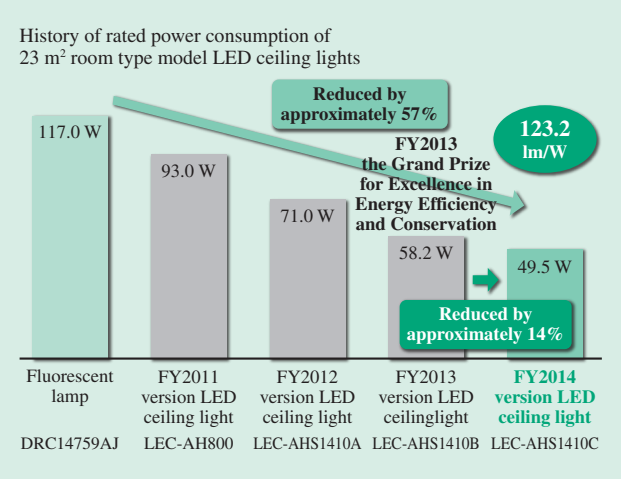

Fig. 8—History of 23 m² Room Type Model LED Ceiling Light Energy-saving Performance.
Power consumption of less than half has been achieved compared to high-efficiency fluorescent lamp.

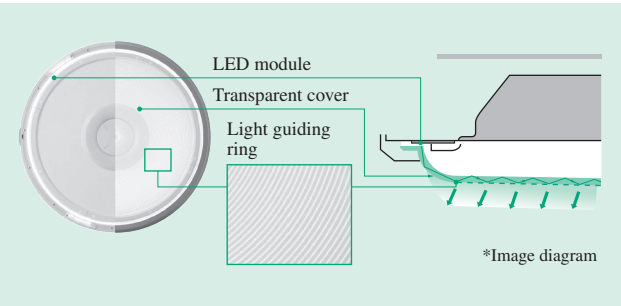

Fig. 9—Unique Light Guiding Technology Structure and Light with "Sparkle."
The light guiding ring spreads out the light in order to achieve light with "sparkle."

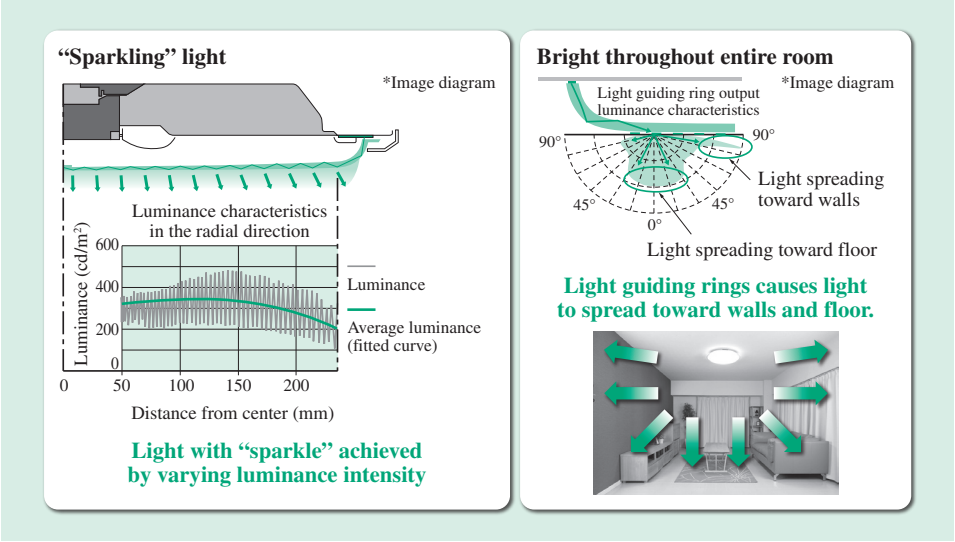

Fig. 10—Unique Light Guiding Technology Characteristics. This technology brightens the entire room by emitting light toward both the floor and the walls.

To improve the energy-saving performance of this kind of mechanism, the LED light that passes through the cover via the light guide path must be extracted uniformly.

In the case of a general light guiding plate, which scatters particles, the concentration of scattering particles included in the plate must be high in order to extract sufficient light. When the concentration of scattering particles is high, however, a large amount of light is emitted near the LED, and the luminance drops off farther away from the LED, making uniform light emission impossible. On the other hand, when light is extracted using reflection, it is necessary to place the light extraction portion on the inside of the light guiding rings, so the light reflects off the surface after reflecting off the light extraction portion first, resulting in a greater loss.

The unique light guiding technology developed by Hitachi controls the arrangement of the transparent cover and the light extraction structure (light guiding rings) of the surface in order to efficiently extract uniform light. Also, the light extraction structure that is used is based on the surface's transmitting material, and since the light diffuses while transmitting through the light guiding rings, it can be output efficiently with less light returning (see Fig. 11).

This system has enabled Hitachi to achieve an industry-leading 90.7 lm/W by its light guiding method, a rated luminous flux of 5,499 lm, and a maximized brightness (20 m^2 room type).

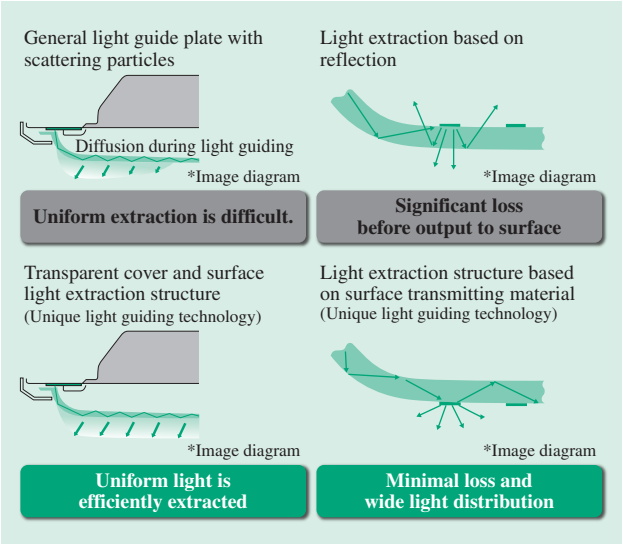

Fig. 11—Differences in Efficiencies of Structures Extracting Light.
Unique light guiding technology efficiently extracts uniform light while reducing loss.

High-quality Design

Unique light guiding technology makes the milky white cover that has been used to diffuse light in previous LED ceiling light models no longer necessary. This technology achieves a slim-design fixture height of 72 mm that accentuates the ceiling

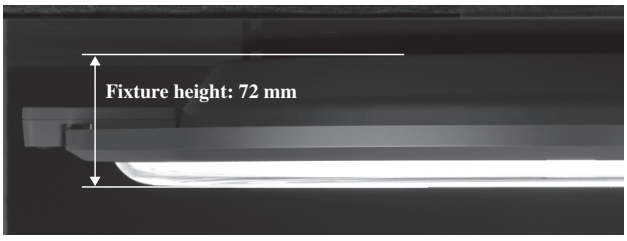

Fig. 12—Slim Design.
A slim fixture design with a height of 72 mm has been achieved.

while making the room appear more spacious (see Fig. 12).

CONCLUSIONS

Expectations for LED lighting with its excellent energy-saving performance will only grow stronger in the future. To provide lighting that can earn the support of consumers based on this background, issues that must be given consideration in addition to energy-saving performance include lighting quality and how objects and colors appear, shape and mass considerations in the design of a slim and lightweight product, and a construction that makes both installation and removal easy to perform.

We will continue mobilizing the technologies of the Hitachi Group and applying them to the rapid development of LED lighting products that satisfy consumers, while contributing to society through our lighting business.

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Featured Articles

Global Deployment of Home Appliances to International Markets

Yukihiro Endoh
Pornsak Jiamsawas
Yoshihiro Suzuki
Pairoj Kanchart
Paiboon Potajatikul
Koichi Shibata

OVERVIEW: Both Asian and Middle Eastern regions are experiencing a high level of sustained economic growth, and are promising consumer markets. The need for energy conservation is growing as environmental consciousness increases. Consumer priorities have also been shifting from cheap, good-quality products to products with specific added values as desired by each consumer. Hitachi mainly sells home appliances on these markets that have been either produced at its Thailand base or Made in Japan, all based on a premium strategy pillar. By locally developing products with unique functions suited to the changing markets and high added value, featuring high energy-saving performance thanks to inverter technology along with the good-quality design one expects from a Japanese manufacturer, Hitachi is deploying products that are helping it establish a position of superiority in global markets.

INTRODUCTION

AS Hitachi improves its global brand value, business expansion through the international deployment of home appliances is occupying an increasingly important position. It is based on this background that Hitachi has been moving forward with the global deployment of home appliances with a focus on the rapidly growing Asian and Middle Eastern markets, while mainly targeting both the upper and middle classes in each country. This global business includes products chiefly manufactured at Hitachi's largest international production base of Hitachi Consumer Products (Thailand), Ltd. (hereinafter HCPT), as well

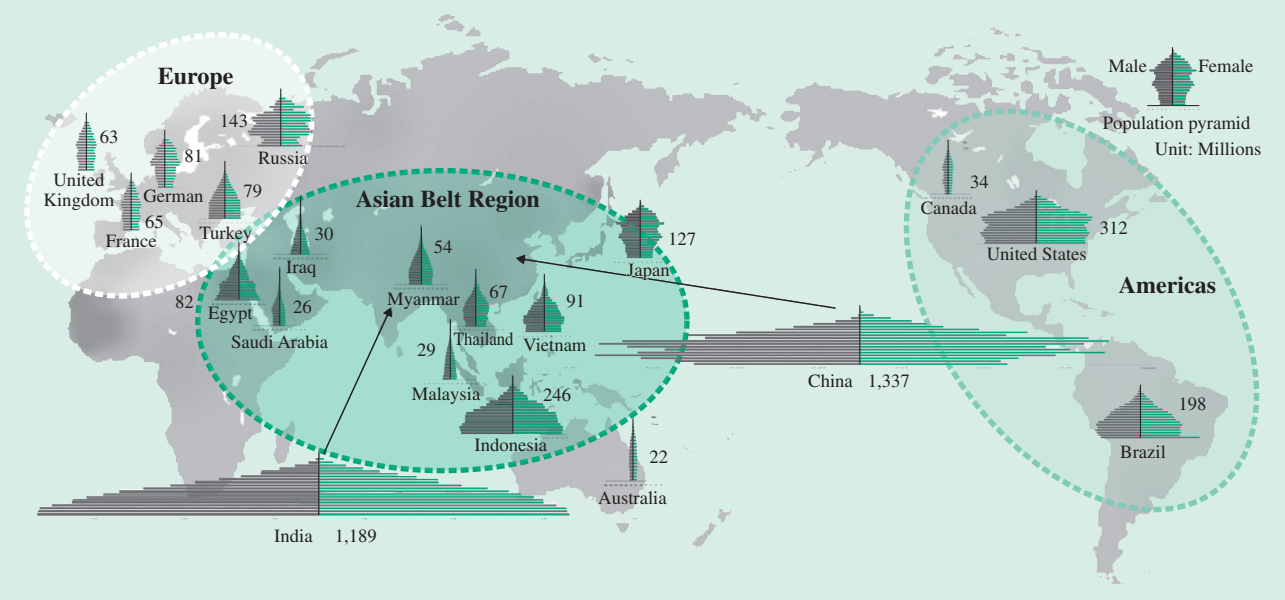


Fig. 1—Population Pyramids for Various Countries and Regions.
Countries in the Asian Belt Region have large populations and high young generation population ratios.

as Made in Japan products that are manufactured in Japan for export.

The Asian and Middle Eastern regions are experiencing sustained high economic growth and a growing middle-income class, and are seen as consumer markets that will continue to hold promise into the future. At the same time, product energy and resource saving performance have been drawing more attention globally than before in recent years from the perspective of protecting the global environment.

HCPT takes elemental technologies in fields such as energy-saving and noise reduction from Japan, develops products that add unique Hitachi values suited to local needs, and introduces items to the market, including a highly innovative side-by-side refrigerator, and a 16 kg (load size) large-capacity fully automatic washing machine.

This article describes a Made in Japan export strategy based on the aforementioned market conditions, and introduces examples of refrigerators, washing machines, and vacuum cleaners that have been developed at HCPT.

MARKET TRENDS AND BUSINESS STRATEGIES

The Asian Belt Region's Expanding Upper and Middle Classes

The main markets comprising this global business are part of an Asian Belt Region that includes China, Southeast Asia, India, and the Middle East. Although parts of the Middle East are suffering from economic stagnation due to political unrest, demand in countries such as the United Arab Emirates (UAE), Saudi Arabia, and others remains strong. In Asia, India, Indonesia, and the other economies in the Association of Southeast Asian Nations (ASEAN) are experiencing sustained high economic growth.

As each of these national economies has grown, their middle classes have been expanding as well, and consumer priorities have been shifting from "cheap, good-quality products" to "products I want" (products in which added value can be found). Also, since these regions have large young population segments, their populations are expected to continue growing in the future. Furthermore, since home appliance penetration rates are low, and the trend towards comparatively new products is extremely strong, further market expansion can be expected (see Fig. 1).

As environmental consciousness grows stronger and energy prices rise sharply in these regions, not only is the need for lower energy consumption growing, each country's government is also leading the way from the perspective of global environmental protection by conserving energy (including electric energy and water) while also strengthening regulations related to the conservation of resources.

Hitachi's Premium Strategy

Added values that are in demand include unique functions that satisfy market needs, energy-saving performance based on a high level of basic performance, and the high-quality design one expects from a Japanese manufacturer based on the concept of the Simple & Stylish/Usability & Universal/Basic & Belief (SUB) design. New products with a high level of added value are developed together by HCPT and its mother factory, Taga Works, in Japan along with Tochigi Works and research laboratories and others who work together to continuously introduce new products to the market every year. This is referred to as the premium strategy (see Fig. 2).

PREMIUM STRATEGY THAT TAKES ADVANTAGE OF STRENGTHS

The Made in Japan Strategy

In the past, home appliances that were made in Japan had an international reputation for being highly dependable, high quality, and high performance (including energy-saving performance), but they were expensive and did not necessarily satisfy local needs. As upper and middle classes expand rapidly in the Asian Belt Region amidst remarkable growth, however, markets for Japanese products are set to grow.

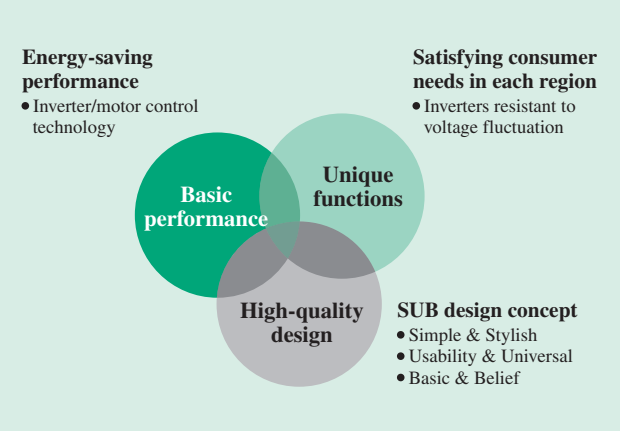


Fig. 2—Premium Strategy Concept.
The premium products of this concept are deployed to each region to build the brand.

Fig. 3—Made in Japan Export Product Lineup.
The Made in Japan aspect is aggressively promoted to improve Hitachi's image as a premium brand image.

Based on this background, Hitachi began aggressively exporting the Japanese products that enjoyed a top-class share in the highly competitive Japanese market approximately 10 years ago as part of a premium strategy. At first, Hitachi focused its exports on Taiwan, where Japanese products are well accepted, starting with refrigerators but also including washing machines, vacuum cleaners, and cooking appliances, offering not only the aforementioned high dependability, high quality, and high performance, but also making image-conscious sales promotion. Also, by working to release products on the Taiwanese market simultaneously with domestic releases, Hitachi recorded sales that greatly exceeded expectations, and is still enjoying solid growth today.

Next, Hitachi expanded its exports to countries and regions other than Taiwan, starting with the Chinese region of China and Hong Kong, followed by Southeast Asia, the Middle East, and Russia (see Fig. 3). Also,

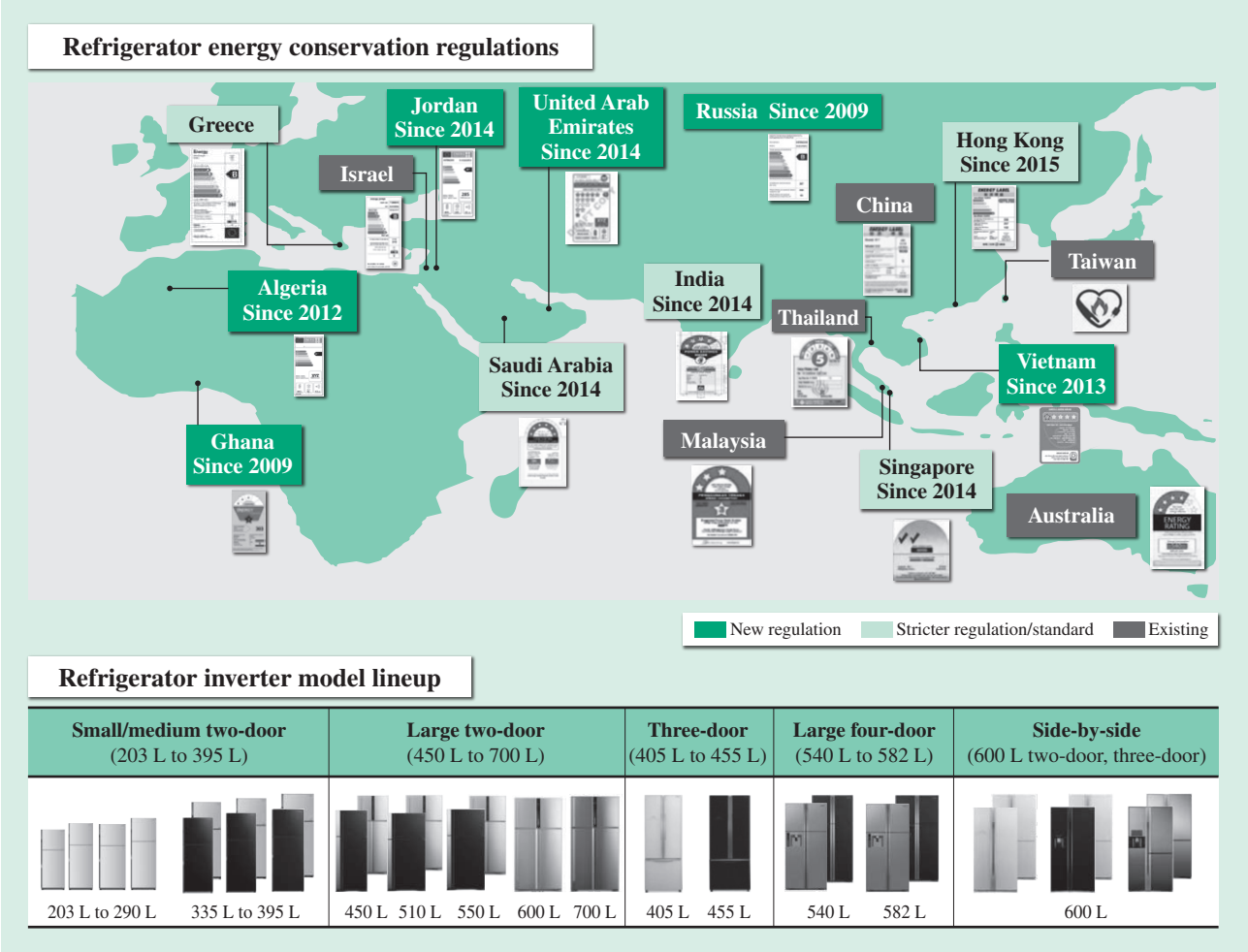


Fig. 4—Refrigerator Energy Conservation Regulation Trends in each Country and Region and Expanding Inverter Lineup.
All refrigerators now, whether small or large, use inverters and meet the energy conservation needs, regulations, and standards of each country and region.

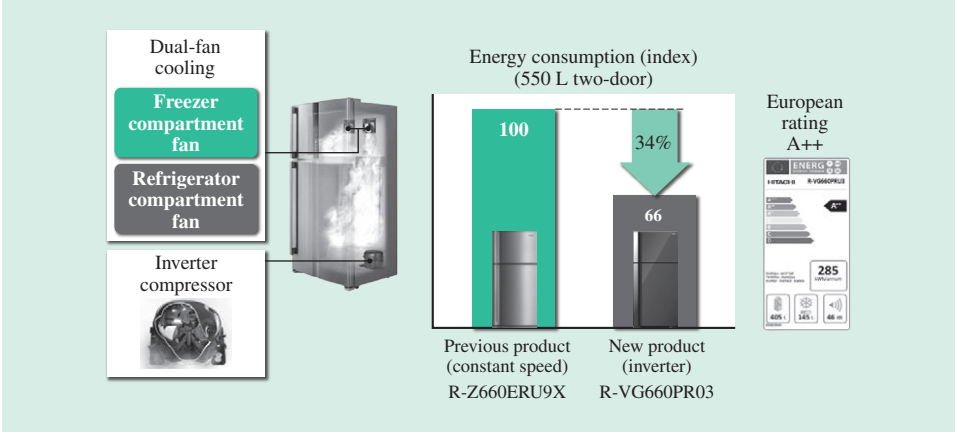


Fig. 5—Hitachi's Unique Inverter and Dual-fan Cooling. Although the compressors used in previous models operated at a constant speed, models with the new type of inverter reduce energy consumption by 34% and have achieved an A++ rating in Europe.

as health consciousness has been growing in recent years, and atmospheric pollution has been worsening, air purifiers made in Japan were introduced to various countries three years ago and have been well accepted.

Deploying Inverter Refrigerators Made by HCPT

Supporting Each Country's Energy Conservation Needs

As has already happened in Japan, international refrigerator demand has shifted from one door to two and three doors, with larger refrigerators and a trend towards increased energy consumption. On the other hand, as environmental consciousness has also grown and energy costs have soared, the demand for energy-saving performance is also increasing. Energy conservation regulations are also growing stricter in each country, and the introduction of new regulations is accelerating as well.

Based on this market environment, Hitachi has been deploying the inverter technologies it cultivated in Japan to international markets as well, and started switching its HCPT-made lineup of refrigerators to inverters starting in 2012 (see Fig. 4).

Refrigerators that use inverter technology were rare in the international markets of 2012, and this is when Hitachi used its unique technology to develop dual-fan cooling, a feature that achieves high-efficiency cooling by applying a unique cooling fan system to both freezer and refrigerator compartments.

This system, when combined with inverter technology, successfully achieved top-class energy-saving performance, earning a A++ grade under the strict European standards (see Fig. 5).

Customizing Inverter Technology for International Refrigerators

Internationally, the installation environments (air temperature, etc.) and the usage conditions of each refrigerator compartment vary greatly depending on the destination.

The refrigerators that use this type of inverter along with dual-fan cooling can change the compressor's rotating speed from slow to fast to efficiently cool using fans in both freezer and refrigerator compartments, thereby achieving stable cooling performance over a wide range of ambient temperatures (room temperatures) both high and low. For instance, these refrigerators provide powerful and stable cooling

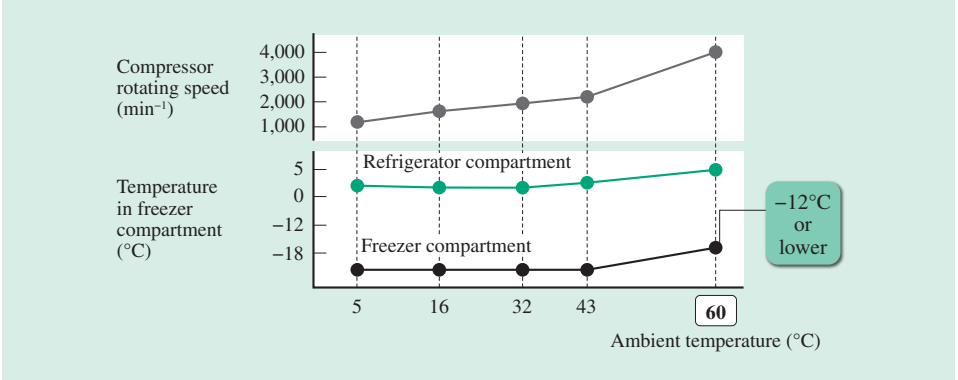


Fig. 6—Powerful Cooling Performance. Powerful cooling performance is provided that maintains a freezer compartment temperature of −12°C or lower under an ambient temperature of 60°C.

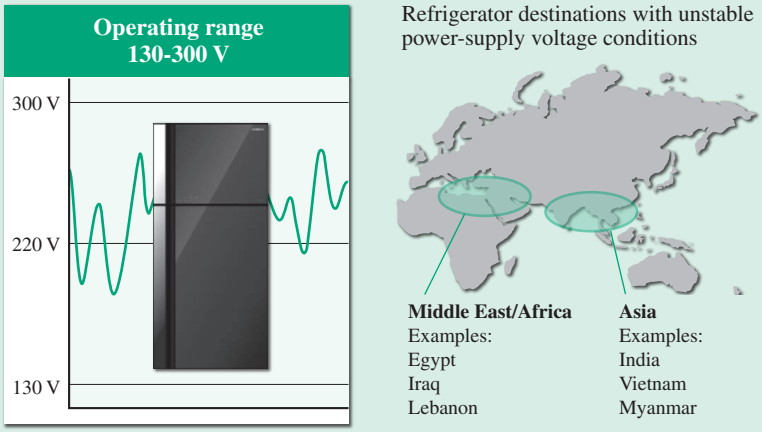


Fig. 7—Stable Operation is Possible even without a Power Stabilization Device. Cooling operation continues even if the voltage fluctuates over a wide range between 130 V and 300 V.

performance in the Middle East and other high-temperature environments, and offer the appeal of having achieved two-star freezing performance even under a 60°C environment* (see Fig. 6).

Inverter circuits can also handle the unstable power-supply voltage conditions that are occasionally seen in Asia, the Middle East, Africa, and other regions, and Hitachi deals with major power fluctuations through methods such as developing software to change compressor startup control and optimizing the power supply (see Fig. 7).

Hitachi's Unique Style in French Bottom Freezer Refrigerators

In addition to the aforementioned functions, Hitachi also develops premium products that satisfy the diverse needs of each country while providing both good design and ease-of-use. A representative example of this is the French Bottom Freezer Refrigerator, which was first introduced in 2013 (hereinafter French Bottom).

This French Bottom model uses a french style door on top for the refrigerator compartment, and a drawer style freezer compartment on the bottom, and features a large vegetable case inside the refrigerator compartment (see Fig. 8).

This unique design with its easy-to-use upper refrigerator compartment is accepted not just in Asia, but in the Middle East as well. The market for this refrigerator is expected to grow tremendously, and the appeal of the large vegetable case is expected to be strong in the Indian market as well due to the large amount of vegetables in the Indian diet.

* Freezing performance guideline that indicates the ability to store frozen food for approximately one month while maintaining a temperature of −12°C or lower.

Introduction of Fully Automatic Washing Machines with New Inverters (Made by HCPT)

Background and Aim of Development

As global momentum toward energy and water conservation and the need for larger capacities grows, each country has been steadily strengthening its regulations with regard to energy conservation labels (see Fig. 9).

Although all companies are focusing on the development of products that emphasize energy-saving performance, some competitors have been early adopters of inverter models. Not only has Hitachi introduced the unique automatic tub-cleaning function that has been highly praised in the Japanese market to the international market, it has also developed a new high-efficiency inverter drive system that offers

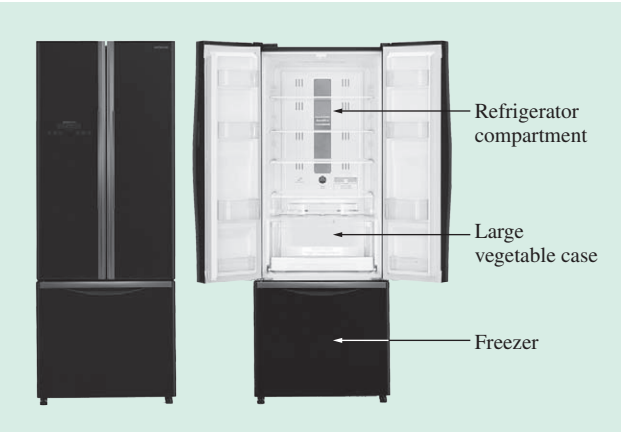


Fig. 8—French Bottom Freezer Refrigerator. Lineup includes two different net capacities (405 L and 455 L). The signature design and ease-of-use have earned this product praise.

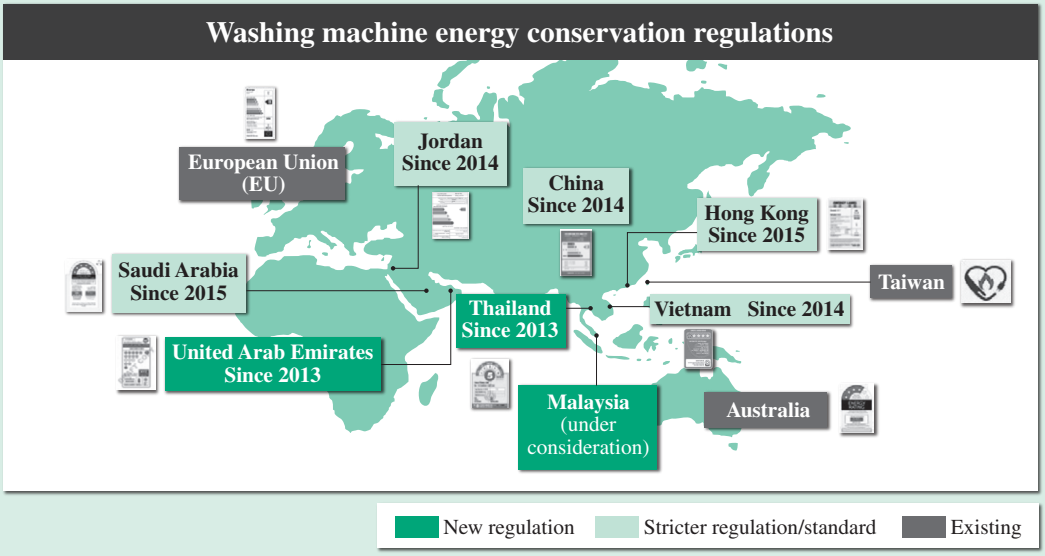


Fig. 9—Trends in Washing Machine Energy Conservation Regulations in Different Countries and Regions.
Regulations were launched in 2008 in the EU, Taiwan, China, Hong Kong, and Australia.
Existing standards were made stricter in 2013, and new energy conservation regulations came into effect.

advantages for energy-saving performance. Starting in October 2014, Hitachi released four new inverter models (with loading capacities between 13 and 16 kg) with the goal of expanding market share in the high-end/large-capacity market segment.

Development Policy and Product Concept

(1) New high-efficiency inverter drive system

Energy consumption was greatly reduced through the development of a new inverter motor with a belt-type drive. By reducing the speed of the belts and gears, it is possible to achieve the low motor torque required to wash clothes inside the washing tub, which has enabled the use of smaller motors. Development of this new inverter motor required the cooperation of related works and research laboratories, and a reduction of 25% in weight over previous motors was achieved through its compact and high-efficiency design (see Fig. 10).

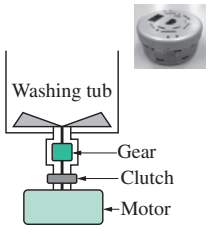
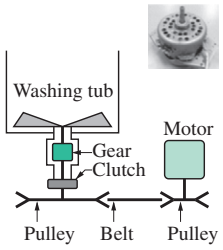
		Previous inverter drive system	New high-efficiency inverter drive system
			
Motor specifications	Maximum torque	4.90 N·m	2.55 N·m
	Stator dimensions Diameter (ø) × thickness (t)	160 mm × 25 mm	117 mm × 30 mm
	Rotor Dimensions Diameter (ø)	97 mm	67 mm
	Mass	**3.5 kg**	**2.6 kg**

Fig. 10—Comparison between New and Previous Inverter Drive System.
A new inverter drive system was developed that offers both washing ability and energy-saving performance at the same time.

Based on this inverter drive system, Hitachi pursued washing ability, water usage, ability consumption, and other basic washing machine performance levels that made it top class in the labeling schemes of each country (see Fig. 11).

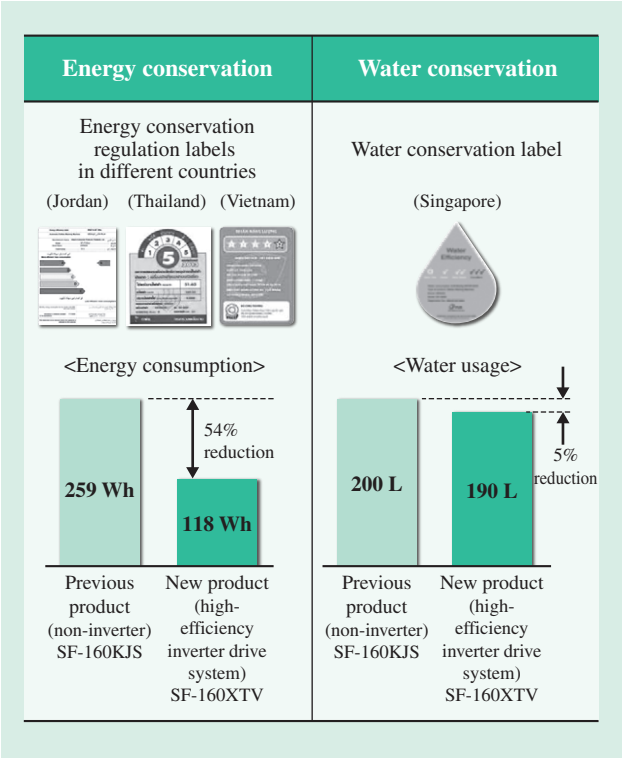


Fig. 11—Inverter Drive System's Energy and Water Conservation. Both energy consumption and water usage have been greatly reduced compared to the previous product.

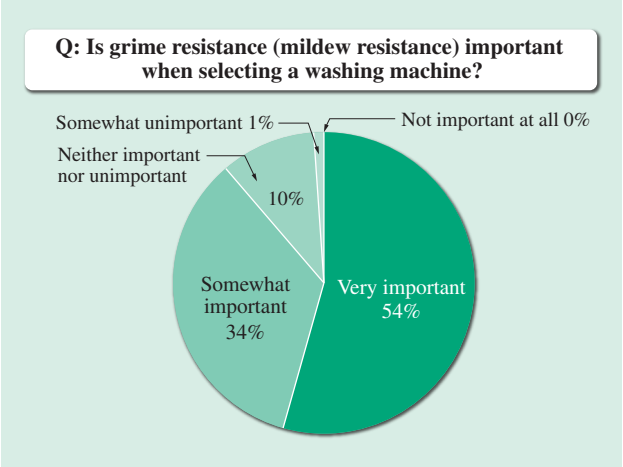


Fig. 12— Washing Tub Grime Resistance (Mold Resistance) in Washing Tub Priority Level when Purchasing in Thailand, Malaysia, and Vietnam (Hitachi Survey from December 2012: n=664).
Approximately 90% of consumers prioritized grime resistance when purchasing a washing machine.

(2) Inclusion of unique automatic tub-cleaning function and pursuit of ease of use

Market surveys conducted in Thailand, Malaysia, and Vietnam, have shown that approximately 90% of consumers are concerned about the washing tub getting dirty, just like in Japan (see Fig. 12), so the unique Hitachi automatic tub-cleaning function was included. In addition, a user-friendly new loading opening, a push-open glass lid, and easy-to-operate buttons were also adopted. Another unique function was also added that provides the ability to adjust water flow as desired with a single button during operation.

(3) Adoption of a high-quality external appearance

A high-quality design was adopted that features a simple unified glass lid, a glossy metallic coating, and a sheet insert molding panel for the control interface (see Fig. 13).

Development of Vacuum Cleaners for the Middle Eastern and African Markets (Made by HCPT)

Background of Development of Cylinder-type Vacuum Cleaners

The key value-added points sought by consumers in the Middle East region for a vacuum cleaner are high power and large dust-collecting capacity. For the Saudi Arabian vacuum cleaner market, which has continued to grow in demand recently, Hitachi has been expanding its sales on a yearly basis by providing a full lineup of barrel-type vacuum cleaners that are characterized by high power, large capacity, and a steel can structure (see Fig. 14).

Fig. 13—External Appearance of the Fully Automatic Washing Machine with New Inverter (SF-160XTV).
The newly developed design achieves both a high-quality external appearance as well as excellent ease of use.

Fig. 14—Barrel-Type Vacuum Cleaner (CV-975YR).
This vacuum cleaner satisfies the needs of the Middle Eastern market for both high power and large capacity.

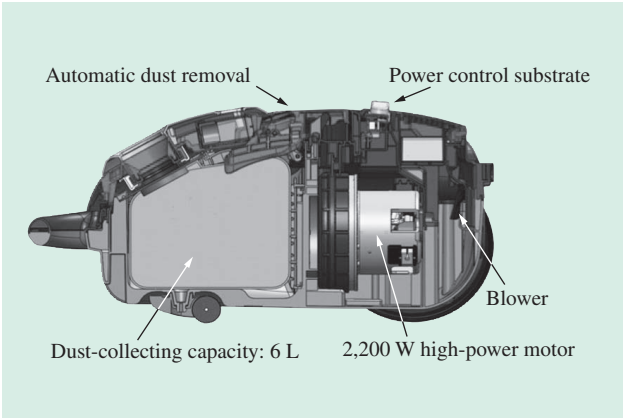


Fig. 16—Structure of New Cylinder-Type Vacuum Cleaner (CV-BA22V).
(Three-dimensional [3D] cross-section diagram)
Large capacity is achieved while maintaining high density in the arrangement of motor and other electric parts.

To expand sales in the African market, however, the important market of Egypt must be addressed with its large total demand. The need for cylinder-type vacuum cleaners is strong in Egypt, and so the sale of such products was needed. In addition, now that air purifiers that can collect sand are on sale in this desert region, support for products that can handle sand is also needed.

For this reason, Hitachi included its unique automatic dust removal function in a high-power motor with powerful and continuous suction and a large dust-collecting capacity that is top in its class, thereby launching a cylinder-type model that can handle sand on the vacuum cleaner market (see Fig. 15).

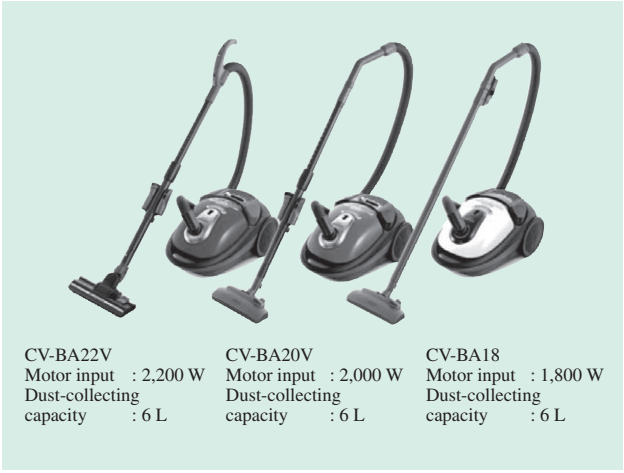


Fig. 15— New Cylinder-Type Vacuum Cleaners.
(CV-BA22V [Left], CV-BA20V [Middle], and CV-BA18 [Right])
Hitachi developed new high-power, large dust-collecting capacity cylinder-type vacuum cleaners in 2014.

Combining High Power with Compactness

To improve a vacuum cleaner's ease of use, the key is to make the body compact while providing high power and large dust-collecting capacity. Hitachi used a high-density 3D computer-aided design (CAD) system to develop a new cylinder-type vacuum cleaner. Specifically, it has a dust collection capacity of 6 L, a high-power 2,200 W motor, a power cord winding mechanism, a power control substrate, and a blower, all of which are arranged in the rear of the main unit with a high density (see Fig. 16).

The automatic dust removal function was also newly developed and included to ensure that suction power and large capacity are maintained even after dust and sand particles are suctioned up.

In general, when a vacuum cleaner is used continuously, dust fills the vacuum bag and blocks the flow of air, thus reducing suction power (flow rate). The automatic dust removal function of this new cylinder-type vacuum cleaner automatically removes any dust that is blocking the flow of air whenever the cord is pulled, thereby alleviating the reduced flow rate and maintaining suction power (see Fig. 17).

Starting in the second half of 2014, the new cylinder-type vacuum cleaner described above was released on markets centered in the UAE, Saudi Arabia, and Egypt.

Environmental Consciousness of Future Vacuum Cleaners

Different energy conservation standards are being formulated in Europe for each product, and gradual introduction of standards for vacuum cleaners

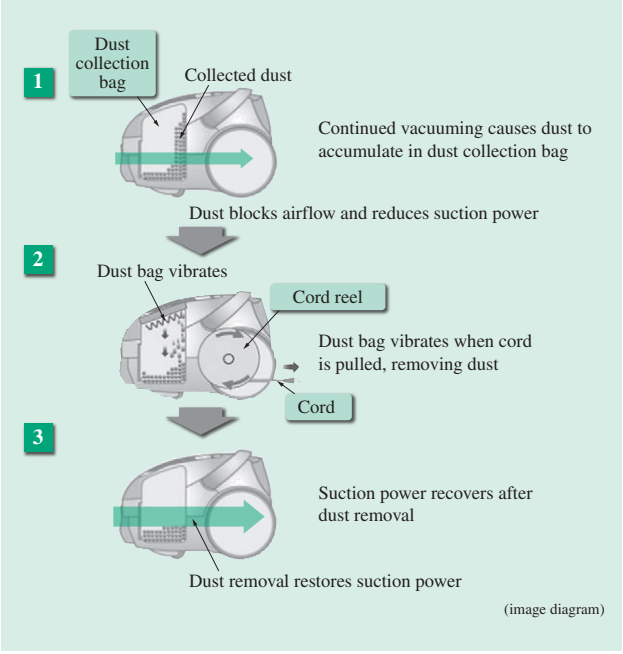


Fig. 17—Automatic Dust Removal Principle.
Suction power is recovered every time the cord is pulled.

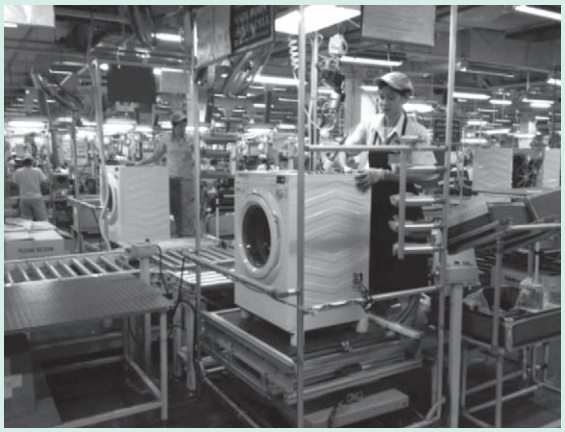
started in September 2014. Energy consumption, input power, dust pick-up ratio, and other ratings are being established as energy conservation standards, and Hitachi has already begun shipping vacuum cleaners with energy labels to Europe as well. As part of the next step, standards will become even stricter in September 2017 as regulations for dust re-emission ratios, noise, and others are also added to the standards, and Hitachi plans to respond in part by developing new motors.

Since environmental consciousness has grown stronger and energy conservation regulations have been introduced in Europe, this trend is expected to influence Asia and the Middle East as well. Hitachi will continue planning and developing products suited for each market by meeting a variety of different needs, including those stemming from product specifications and energy conservation regulations.

CONSTRUCTION OF A FLEXIBLE MANUFACTURING SYSTEM AT HCPT

HCPT uses cell production in its assembly process. Starting in 2008 with vacuum cleaners and followed by expansion to all products in 2013, this Hitachi-style cell production method enables flexible production of many different models in small batches (see Fig. 18).


(Refrigerator assembly line)


(Washing machine assembly line)


(Vacuum cleaner assembly line)

Fig. 18—Cell Assembly Lines for Refrigerators, Washing Machines, and Vacuum Cleaners.
A cell production system was adopted that is suited to amount fluctuations and small-lot production.

CONCLUSIONS

This article described the global deployment of Hitachi's home appliances with a focus on the Asian and Middle Eastern markets, including both export strategies and development case examples featuring

refrigerators, washing machines, and vacuum cleaners made by HCPT.

Although expanding business in a highly competitive international environment requires strong basic performance, the prior development of unique functions that consumers see as having value is also key. For this reason, Hitachi will continue engaging in even closer cooperation between international bases, and mother factories and research laboratories in Japan, while also strengthening local product planning, design, and development.

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Featured Articles

Development of the Inverter Air Conditioner for Southeast Asia in FY2014

Takao Nagata
Juhri Yasin
Yasuhiro Kishi
Ayumi Wada

OVERVIEW: Hitachi has released 2.8 kW and 3.7 kW cooling-only inverter air conditioners featuring sleep support function in Southeast Asia, where the demand for room air conditioners for home use is accelerating, due to economic growth. In Southeast Asia, a high percentage of room air conditioners are used in the bedroom. Hitachi developed these products by narrowing down the focus to actual consumer needs, such as a sensor on the air conditioner to detect human movement in a dark room in order to automatically detect when users are sleeping so that the temperature setting can be automatically controlled after users fall asleep. The air conditioner also features a cross-flow fan with undulating blades to reduce the wind noise of the cross-flow fan. Although Hitachi has already been working to improve energy-saving performance (as energy conservation regulations are being strengthened in various Southeast Asian countries), Hitachi is now focusing its development efforts even further, including an indoor unit with improved blowing efficiency, a high-efficiency compressor, and other developments.

INTRODUCTION

IN Southeast Asian countries in 2013, the demand for room air conditioners for use in the home was 821,000 units in Malaysia, 1,072,000 units in Thailand, and 1,103,000 units in Vietnam, representing an increase of 34% over the past three years.[1] The main type of room air conditioner sold in these markets is a constant-speed type that uses an induction motor for the compressor. However, as energy conservation regulations have been coming into effect in each country, the demand for inverter-type air conditioners is starting to rise.

In response to this growth in the Southeast Asian markets, Hitachi is expanding its room air conditioner business based out of Hitachi Air Conditioning Products (Malaysia) Sdn. Bhd. (HAPM) (see Fig. 1).

This article describes air conditioning control technology that enables comfortable sleep through the use of sensors in the inverter air conditioner targeted at Southeast Asia (see Fig. 2), and technology aimed at improving the basic performance in terms of energy conservation.

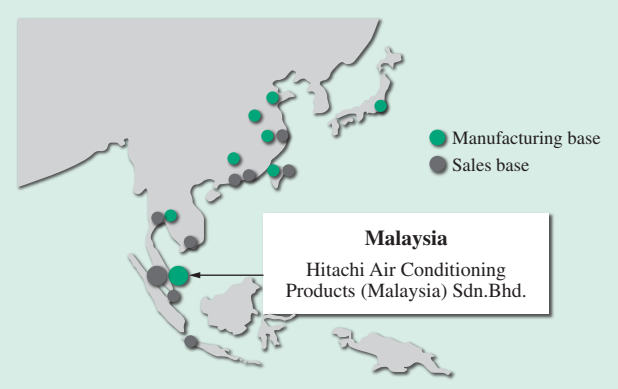

Fig. 1—Hitachi Air Conditioning Products (Malaysia) Sdn. Bhd. (HAPM).
Manufacturing and sales bases for room air conditioners and rotary compressors in Southeast Asia are shown.

DEVELOPING TECHNOLOGY FOR COMFORTABLE SLEEP

Because the demand for room air conditioners for master bedrooms and the family's private rooms (individual bedrooms) is high when considered together as a "bedroom demand" factor in both Malaysia and Thailand, Hitachi has developed a room air conditioner that uses inverter technology to enable comfortable sleep along with a high level of energy-saving performance (see Fig. 3).

Fig. 2—Cooling-only Inverter Air Conditioner for FY2014. The included sleep support mode determines when the user is sleeping, and automatically controls the temperature setting to provide comfortable sleep during operation.

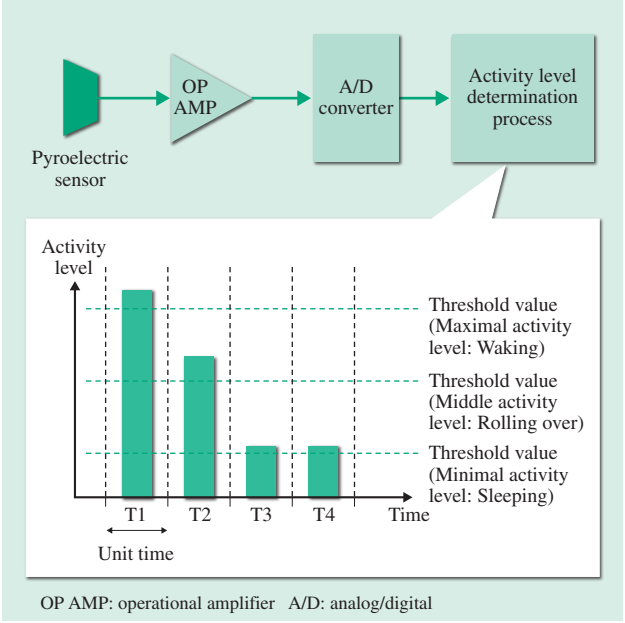

Fig. 4—Activity Level Determination Process Block Diagram. A system was included to convert the user's activity state into data.

For the room air conditioner to provide comfortable sleep in the bedroom, it must be able to determine the sleeping state of the user in a dark room, so that it can control the temperature setting automatically. This sleep support mode control system is described below.

Sleep-state Detection Technology

To detect the user's sleep state, it was decided to use a non-contact method of detecting the user's movement from the room air conditioner's indoor unit. Since it is also necessary to detect the user when the bedroom is dark, a pyroelectric sensor is used to detect the infrared light radiated due to the user's body heat. This pyroelectric sensor does not respond when user is motionless, and responds once again when the user moves. After the sensor output undergoes analog/digital (A/D) conversion, an activity determination processor computes the sensor response integration value for each unit of time, and classifies the activity level based on previously set threshold values (see Fig. 4).

Temperature Setting Shift Control

It is said that a way to ensure quality sleep is to gradually increase the room temperature.[2] For that reason, when the aforementioned sensor determines that the user is sleeping based on their activity level,

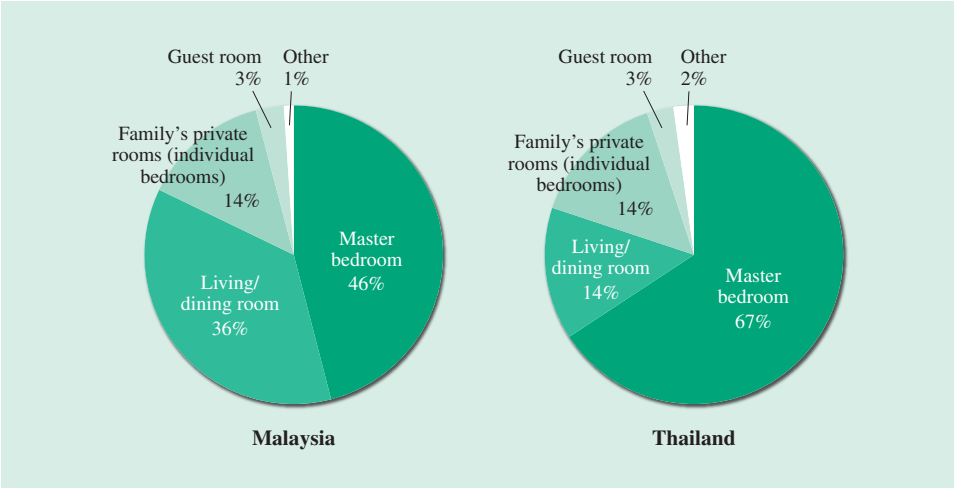

Fig. 3—State of Air Conditioner Installations in Malaysia and Thailand (Hitachi Survey from March 2013: n=309/country). The demand for air conditioners for use in the bedroom is high in Malaysia and Thailand.

the temperature setting is automatically increased by 1°C after one hour passes, and by another 1°C time after two hours. The rotational speed of the cross-flow fan is also reduced in synchronization with the temperature setting shift.

The cross-flow fan's blade shape has been redesigned from the previous trapezoidal shape to a new undulating shape, and the blade pitch was arranged using a sine function to reduce noise to 19 dB* (see Fig. 5).

* Measurement conditions: Sleep support mode, based on JIS C9612:2005.

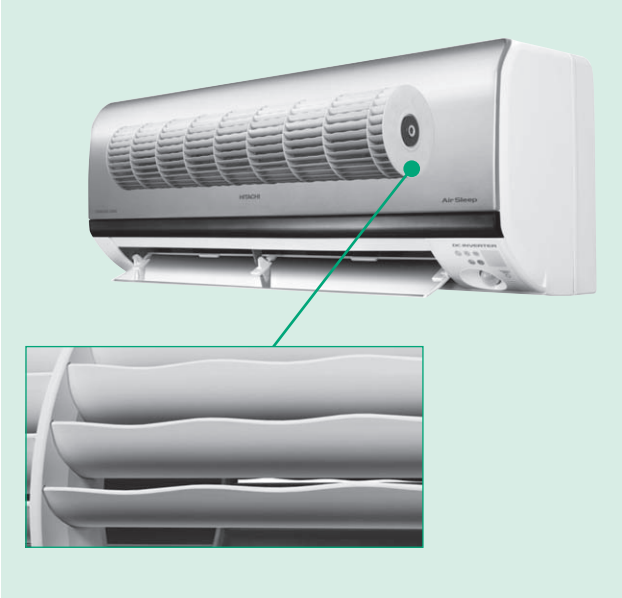

Fig. 5—External Appearance of Cross-flow Fan with Undulating Shape.
A cross-flow fan with an undulating shape was used to reduce the noise of blowing air in sleep support mode.

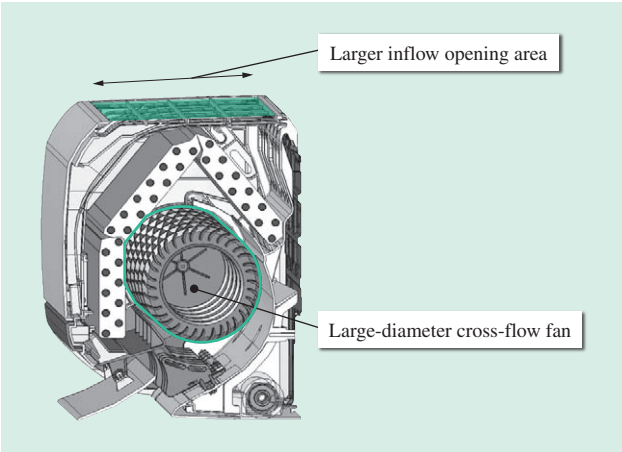

Fig. 6—FY2014 Indoor Unit Cross-Section.
The indoor unit's cross-sectional structure was designed to homogenize the flow velocity distribution passing through the heat exchanger.

ENERGY-SAVING TECHNOLOGY

The energy efficiency ratio (EER) is mainly used as an energy conservation index for room air conditioners in Southeast Asian countries, and to improve performance, the efficiency of blowers, compressors, and other basic components must be increased.

Indoor Unit

To homogenize the velocity distribution of the air flowing through the heat exchanger, and to improve heat exchange efficiency, the area of the indoor unit's top inflow opening was expanded. Blowing power was also reduced by setting the diameter of the cross-flow fan to ϕ115 (see Fig. 6).

Compressor

The following technologies were developed to achieve high efficiency in the rotary compressor.

Unlike the neodymium (rare earth) motor that was previously used, the included motor uses a bathtub-shaped ferrite magnet with an expanded surface area and thereby secures the required level of magnetism (see Fig. 7). Also, the shaft diameter was reduced to improve the efficiency of the compressor by reducing sliding loss. Furthermore, improvements were made including using the oil flow channel

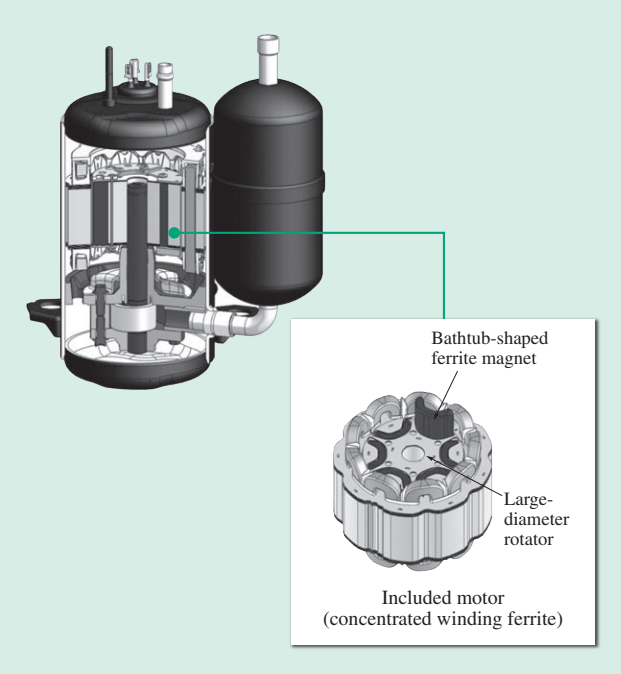

Fig. 7—FY2014 Rotary Compressor Motor.
A motor with a new structure was developed using a ferrite magnet with a new bathtub shape.

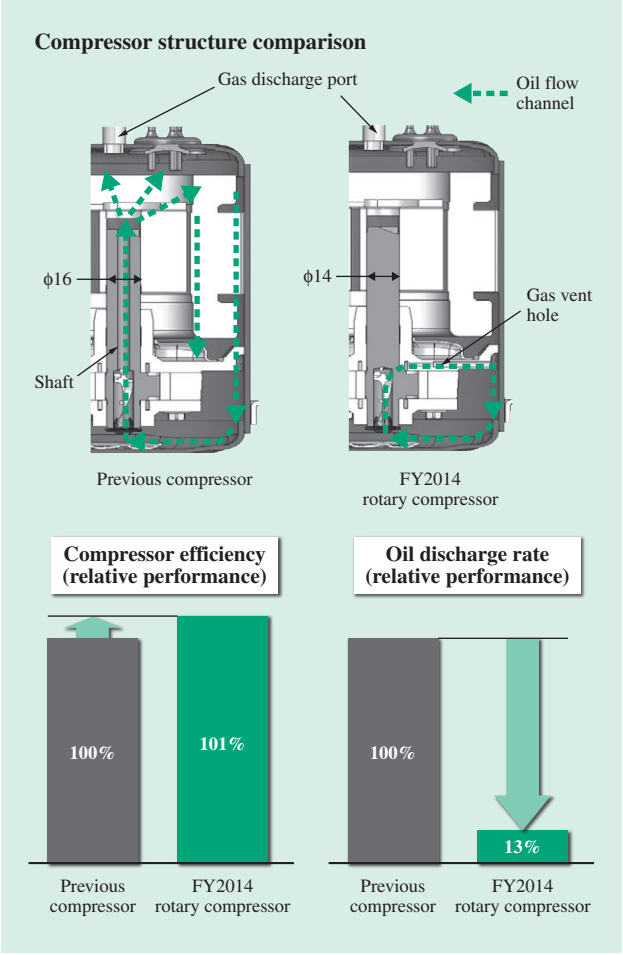

Fig. 8—Performance Comparison between Previous Compressor and FY2014 Rotary Compressor.
The newly developed rotary compressor improves compressor efficiency by approximately 1% over the previous compressor, and reduces the oil discharge rate by approximately 87%.

inside the compressor as the oil circulation method in the compressor bottom far from the gas discharge port, and greatly reducing the amount of discharge oil because this reduces the air conditioner's heat exchange performance (see Fig. 8).

TECHNOLOGY FOR RESPONDING TO THE STATE OF THE POWER SUPPLY

Power supply is not always stable in some Southeast Asian countries, so dealing with instantaneous power failures and other such issues is one way to improve consumer satisfaction levels.

Instantaneous power failures and other sudden voltage fluctuations can cause pulsations to occur in the compressor's motor current, which may activate the overcurrent detection function. This is why changes in voltage are constantly monitored, and if a change in voltage per unit time is large the compressor is temporarily brought to a normal stop and the system is restarted. The indoor unit continues blowing air during the compressor's temporary normal stop, reducing the user's feeling of discomfort.

Fig. 9—5.2 kW Inverter Air Conditioner with Imaging Camera Made in Japan.
An inverter air conditioner with heating and cooling capabilities and a imaging camera was introduced to the Thailand market.

CONCLUSIONS

The demand for room air conditioners is expected to continue growing in Southeast Asian countries, with the use of such devices spreading from the bedroom to the living room. For this reason, Hitachi has began selling a model featuring monitoring system using an imaging camera, which was previously released on the domestic Japanese market, as a premium model in April 2014 (see Fig. 9).

Hitachi will continue developing products aimed at achieving comfortable air conditioning during both day and night while improving the basic performance of room air conditioners and deploying reasonable price models that employ imaging camera to Southeastern Asia.

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Featured Articles

"Monozukuri" Technology for Home Appliances

Toru Ozawa
Shinichi Wakui, Dr. Eng.
Mitsuhisa Kawamata
Hisaya Sakazaki

OVERVIEW: This article discusses "motor technology" as a core technology behind home appliances, and "inverter technology", which is used to control motors and electric power, introducing issues and unique technologies by exploring the example of washing machines (front-loading washer dryers). The "cellular manufacturing" method of manufacturing washing machines and vacuum cleaners is also introduced as a production technology that can be used to very efficiently manufacture developed products, along with a new "Monozukuri" (manufacturing) production technology based on using molds fabricated with 3D printers. These monozukuri technologies support the realization of new value in Hitachi's home appliances, along with a high level of basic performance and unique features.

INTRODUCTION

AS one might expect from the old saying "Hitachi is motors," one of the core technologies that supports Hitachi's home appliances is motor technology. Motors have evolved from induction motors into permanent magnet motors, and the inverter circuits and control software used to rotate the motors have become a new type of core technology.

Inverter technology is also a necessary part of the electromagnetic induction heating used in cooking appliances. Power conditioners for residential photovoltaic power generation systems based on this inverter technology have also been commercialized.

On the manufacturing side, Hitachi has been advancing cellular manufacturing year after year, for which it received the Nikkei "Monozukuri" Award in 2008, and has constructed a unique cellular manufacturing system that is ideally suited for the scale and form of Hitachi's products.

This article discusses washing machine motors as an example of motor technology, inverter technology and control software, cellular manufacturing of washing machines and vacuum cleaners, and mold fabrication that uses the new "Monozukuri" technology of three-dimensional (3D) printers.

MOTOR TECHNOLOGY

Motors in Home Appliances

Many motors are used in home appliances, and the types of motors applied in each product are determined based on the characteristics required for that specific product. For instance, single-phase alternating current commutator motors are generally used in vacuum cleaners because the characteristics specific to these motors are suited to the operating conditions of vacuum cleaners. In the case of refrigerators and washing machines, however, there is a strong demand for energy-saving appliances, and so although permanent magnet motors are mainly used in both cases, due to differences in operating conditions, installation space, and other limiting factors, their motor configurations differ significantly. Therefore, motors of various different types and configurations are adopted based on the application. The next section introduces the configuration of the type of motor used to drive a washing machine tub and the main requirements it must satisfy, taking a front-loading washer dryer as an example.

Motors in Front-loading Washer Dryers

The main requirements of a washing machine motor are high efficiency and low noise. In a front-loading washer dryer, the power of the motor is transferred to the washing machine tub using a direct drive method to reduce noise. Although this method is highly effective in terms of noise reduction due to the lack of parts, such as gears and belts, it also must be bulky, since the motor is directly coupled to the load during washing and spin drying. The motor that drives the washing machine tub is located at the bottom of the washing machine tub, however (see Fig. 1), and so although there is room in the radial direction, it cannot

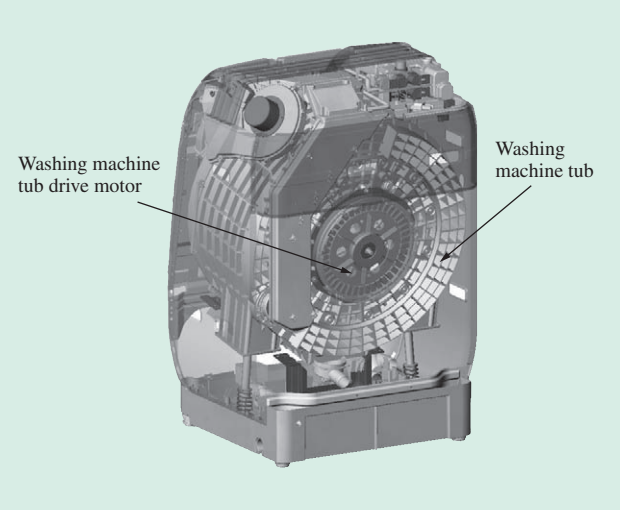


Fig. 1—Structure Image of Front-loading Washer Dryer.
The drive motor is located at the bottom of the washing machine tub.

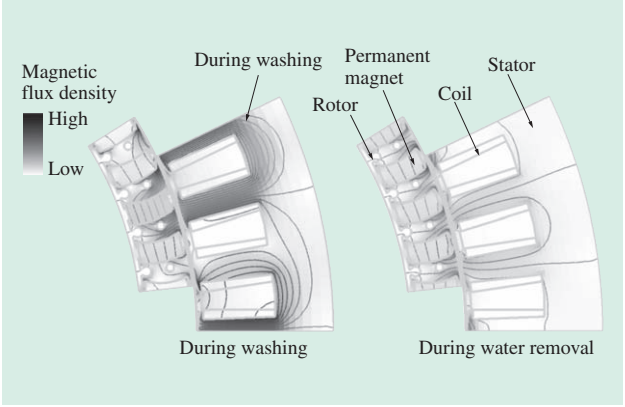


Fig. 2—Magnetic Flux Density Distribution during Washing and Spin Drying.
Magnetic flux density distribution is shown for low-speed, high-torque washing, and for high-speed, low-torque water removal. Field-weakening control is used during water removal to lower the magnetic flux density.

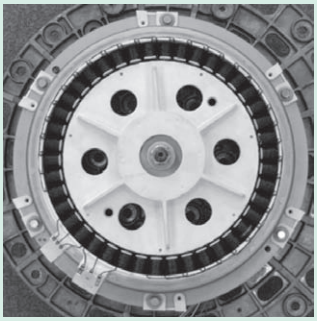


Fig. 3—Washing Machine Tub Drive Motor for Front-loading Washer Dryers.
This motor is a 56-pole, 42-slot permanent magnet motor with concentrated winding.

be made large in the axial direction. For this reason, these types of motors are constructed to have a large diameter and a slim, flat shape.

In addition, a single motor using the direct drive method must work well under different operating conditions, because although low speed and high torque are required during washing, high speed and low torque are required during spin drying. Therefore, to adapt a permanent magnet motor to the high torque required for washing, the permanent magnet’s flux density must be designed to be high during washing, and also so that the flux density inside the motor can be controlled with field-weakening control when removing water to enable a high rotational speed. For this reason, magnetic field analysis is used to calculate the operating states during both washing and spin drying (see Fig. 2), and the shape is optimized based on the motor characteristics of both operating states. In other words, the permanent magnets are arranged in a spoke layout to facilitate increasing the flux density and controlling the field-weakening, while at the same time, the shapes of the periphery of the rotor core and the stator core’s teeth are optimized to reduce the cogging and pulsating torques that cause vibration and noise.

Fig. 3 shows a developed 56-pole, 42-slot permanent magnet motor that uses concentrated winding in the stator’s winding wire to shorten the coil end. A segmented core structure is used in the rotor core from the perspective of inhibiting leakage flux in the permanent magnet, and in the stator core from the perspective of the utilization rate of the materials.

Because motors for home appliances are designed within limitations such as installation space, while at the same time providing the characteristics required for the product, they differ widely depending on the application. Hitachi will continue pushing forward with developing motors for use in high-performance home applications with a focus on market needs.

INVERTER TECHNOLOGY

Inverter Control Technology Supporting New Functions

Inverter control in home appliances is a core technology that determines product performance in fields such as saving energy. It is also a technology that greatly contributes when it comes to implementing new functions that meet a diverse range of consumer needs.

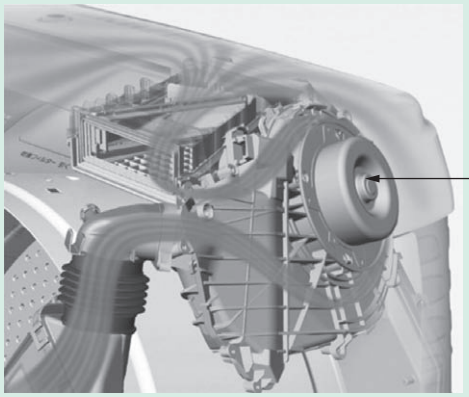


Fig. 4—Turbofan Motor for the "Wind Iron."
This permanent magnet motor is used to create high-speed air flow of approximately 300 kph for use by the "Wind Iron" drying function.

Inverter Control Technology in Front-loading Washer Dryers

Hitachi's front-loading washer dryers use three permanent magnet motors to implement functions that are unique to Hitachi. Each function is controlled by an inverter.

One of the functions of the inverter is to control the motor used to drive the washing machine tub (see Figs. 1 and 3). Vector control for washing machines was developed and adopted for use in implementing three different operating conditions: washing (low speed and high torque), spin drying (high speed and low torque), and braking.

Another is to control the turbofan motor used for drying (see Fig. 4). To enable a maximum motor rotational speed of 14,750 min^{-1} (as of August 2014), the magnetic pole position is estimated with the shunt resistance, which is used for current detection to protect the driver, and control the motor (see Fig. 5).

Water that collects at the bottom of the drum is circulated using a circulation pump motor and control method that can achieve a high washing ability with a low amount of water. This motor can be operated simultaneously with the turbo motor by vector control using single microcomputer.

In addition to motor control in washing machines, Hitachi has also developed unique control methods including induction heating (IH) cooking heaters, and photovoltaic power systems.

Inverter Control Software Development Process

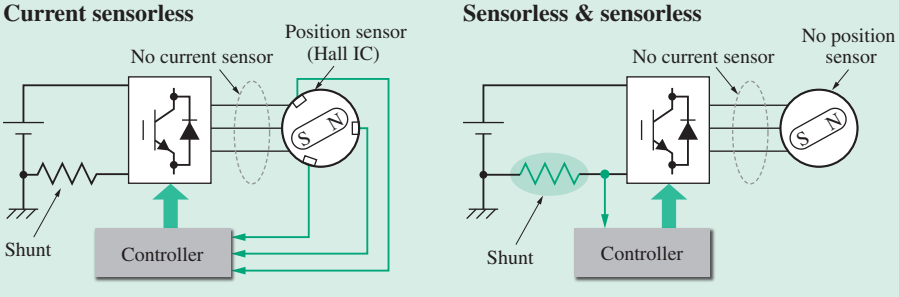
Hitachi uses a control system model-based development environment that incorporates in-house software with commercial tool "MATLAB/Simulink"*1 house in the development of embedded software for inverter control in products released in or after FY2010. This system enables simulation based on designed control models along with automatic source code generation. As a result, not only is human error eliminated during coding, but the readability of the source code is improved as well, leading to increased quality and productivity (see Fig. 6).

Applications are also currently being expanded in fields such as the control of residential photovoltaic power generation systems and induction heating cooking heaters.

CELLULAR MANUFACTURING

"Cellular manufacturing" is a production method that mainly deals with product assembly as a "Monozukuri" technology for home appliances. This production method has dramatically improved productivity.

*1 MATLAB and Simulink are registered trademarks of The MathWorks, Inc.



IC: integrated circuit

Fig. 5—Sensorless & Sensorless Magnetic Pole Position Detection Method Used for Turbofan.
The current sensorless method previously used for magnetic pole detection (left) is compared to the newly adopted sensorless & sensorless method (right).

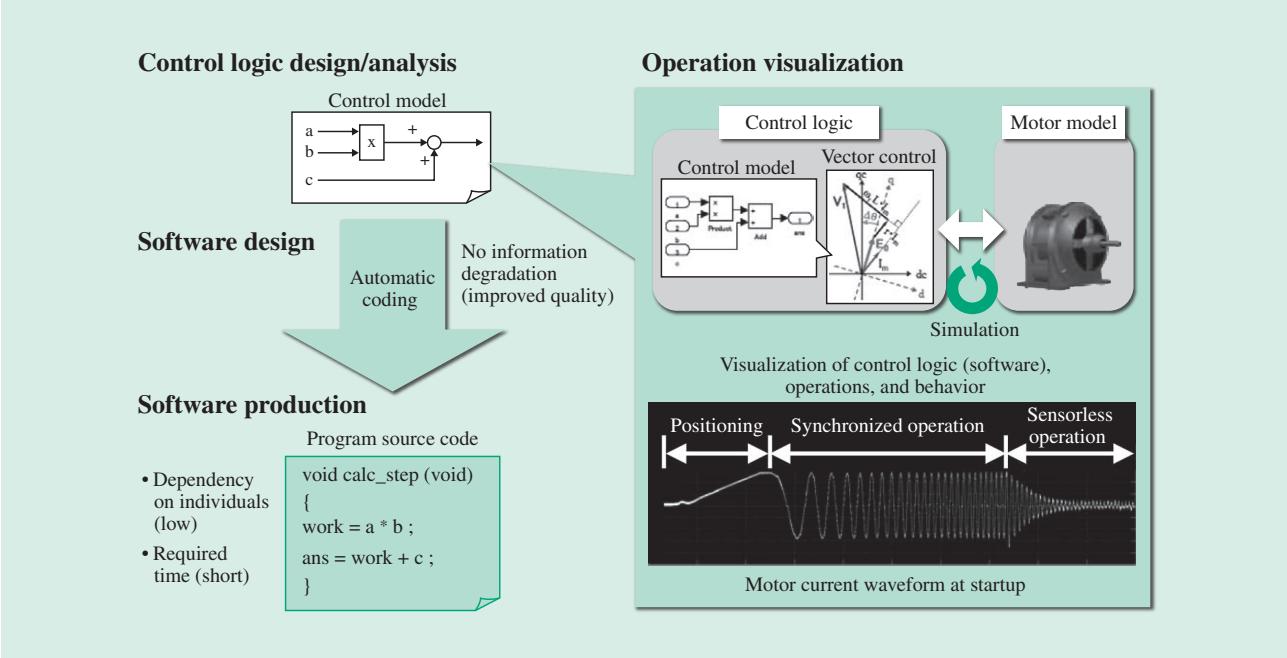


Fig. 6—Development Process Using "MATLAB/Simulink."
Reliability and productivity are improved through an automatic program generation function that works from the control logic, and a simulation function.

"Cellular manufacturing" is a "highly self-contained production method whereby one or several workers are assigned to building the target product or unit assembly all the way until completion," reduces in-progress work between and within processes, eliminates lost time due to switching between production models, and minimizes processing time.

Cellular manufacturing is not limited to a single fixed form, but rather takes a wide range of different forms based on factors such as the product's structure and configuration, the number of parts, the number of production runs, the frequency of model switching, dedicated production and testing facilities, and worker proficiency. Cellular manufacturing can be broadly divided into classifications that include the segmentation cell method, the patrolling cell method, the single person cell method, the inline cell method, and others.

The basic concept is to not have interim works in process based on a fixation with one-by-one production. It is also necessary to eliminate wasted time in everyday work after switching to cellular manufacturing, and important to pursue operational economics based on the traditional industrial engineering approach*2. Cells only generate benefits and become usable after mechanisms and automation are included.

*2 Engineering methods aimed at streamlining integrated systems that include people, materials, facilities, and so on.

Front-loading Washer Dryer Cellular Manufacturing (Cell Segmentation Method)

Due to the structure of washing machines, they contain large parts, and the method for supplying these parts has been problematic. To prevent this from interfering with assembly work, it was decided to supply these parts to workers from above (from the second floor).

Product assembly is split into three blocks that are treated as a single team (consisting of one to three cells), with ten teams comprising one line. A number of meticulous improvements were made to thoroughly synchronize the work balance between individual teams (the cycle time for three cells), including the automation of parts supply, a position optimization mechanism for products, measuring work time, and monitoring formation efficiency of each block and all cells. The dynamic production state management of the production management monitor makes it possible to understand the progress of work and the state of the formation in realtime to enable pre-emptive management and generate a "spiraling up" of improvement, with productivity improved by 44% (see Fig. 7).

Vacuum Cleaner Cellular Manufacturing (Single-person Cell Method)

Vacuum cleaners are assembled one at a time by single workers in a single-person cellular manufacturing

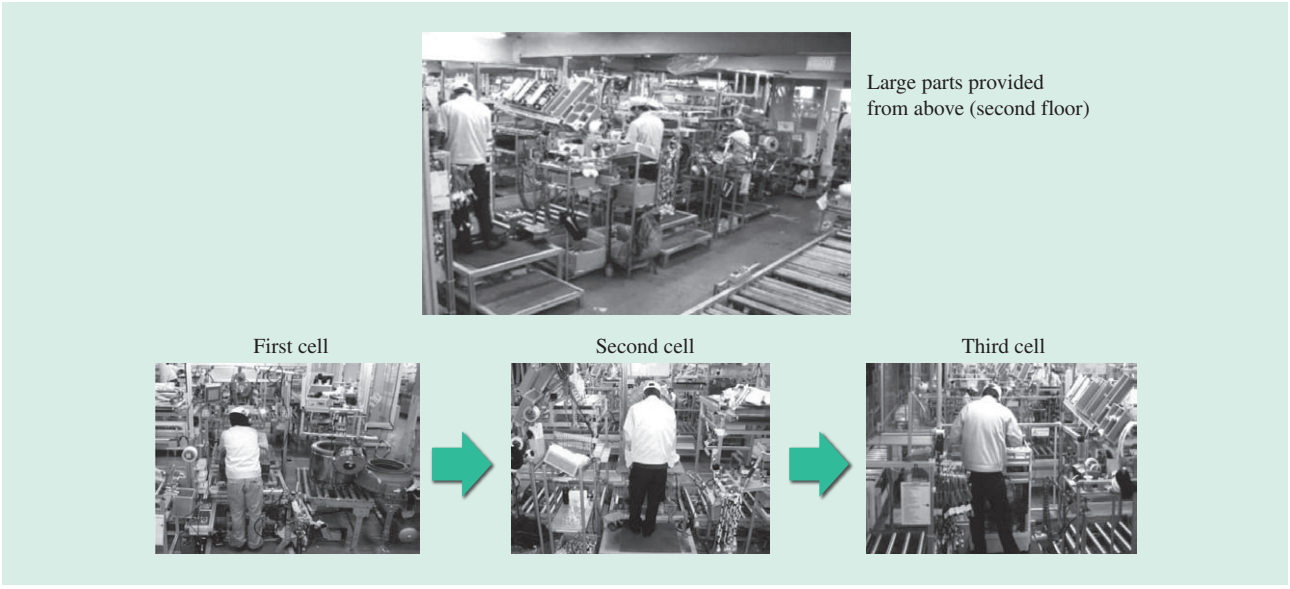


Fig. 7—Front-loading Washer Dryer Assembly Cell.
The three-person group cell segmentation method was used to implement improvements by bringing large parts to hand just in time with an automated mechanism, and by always automatically measuring the assembly takt time.

method. The parts for a single vacuum cleaner are inserted into a special case before they are supplied, and a compact conveyor belt is used to achieve both taking parts in advance and having parts on-hand. The addition of mechanisms such as an automatic removal mechanism for empty parts cases and a mechanism that automatically brings tools to hand (presenting them only when necessary), as well as a device installed to monitor the number of units, all increase the level of completion. To minimize the amount of walking and the number of operations required by parts supply personnel, supplies are consolidated in a single location, and shuttles with part-conveyance mechanisms (two-way dollies with transport mechanisms) travel back and forth between each cell. Efficiency was improved through the adoption of these cellular manufacturing methods, mechanisms, and parts supply improvements, increasing productivity by 40% (see Fig. 8).

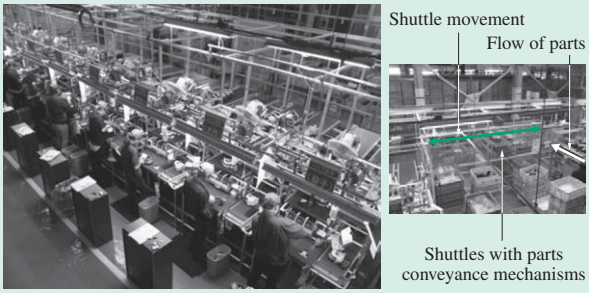


Fig. 8—Vacuum Cleaner Chassis Assembly Cell.
One person per unit completion assembly cells are shown (10 cells). Improvements were implemented by adding mechanisms to cells along with shuttles to supply parts from the back.

MOLD FABRICATION WITH 3D PRINTERS

Internal production of molds through the use of 3D printers in metal optical molding began as part of the development of products for FY2014.

Conventional mold fabrication involves machining parts, assembly, and adjustment, but the introduction of 3D printers has triggered a reformation whereby complicated cooling piping structures can now be fabricated using an “integral molding” method. With this method, metallic powder is hardened using a laser in order to add layers that are 0.05 mm thick, one layer at a time, while gradually forming an intricate 3D mold in a fully automatic fashion (see Fig. 9).

This method reduces the mold fabrication time by approximately 30% over previous methods. Also, a reduction of approximately 20% over previous methods was achieved in the cooling time that occurs during forming by efficient water cooling through a complicated path inside the mold (see Fig. 10).

Progress is also under way in expanding the use of this method to fabricate propeller fan molds for air conditioners, as well as towards application in large air conditioning systems.

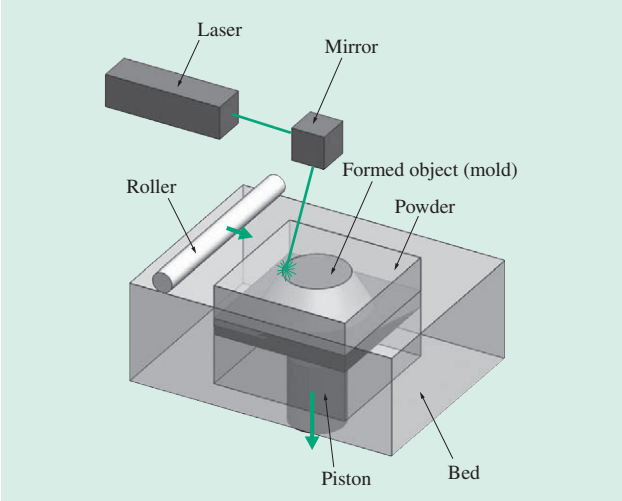


Fig. 9—Processing with 3D Printer.
Uniformly spread metallic powder is sintered into any shape with a laser. Repeated layering is used to enable mold fabrication with an internal structure.

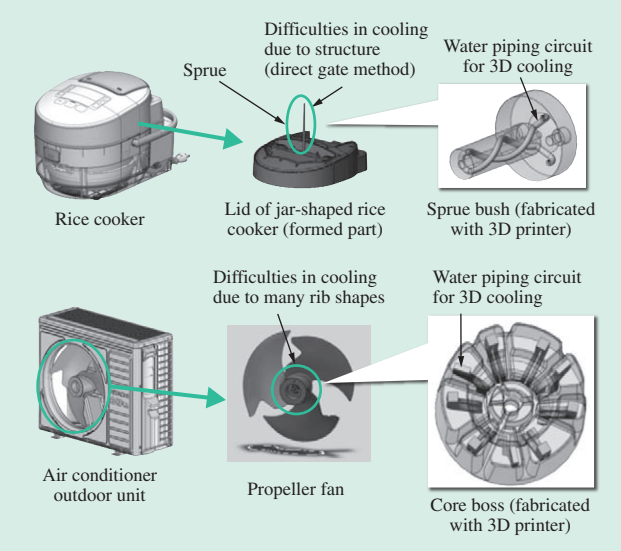


Fig. 10—3D Printer Use Cases.
Cooling time during formation is greatly reduced through the optimal placement of 3D cooling water piping inside the mold part.

CONCLUSIONS

This article introduced “Monozukuri” technologies for supporting and creating a high level of basic performance along with unique functions, including motor technology (washing machine motors), inverter technology (washing machine motor control), cellular manufacturing (front-loading washer dryers and vacuum cleaners), and mold fabrication using 3D printers.

These technologies are being used in the production of other home appliances as well, either in the same manner or with modifications. By developing products while advancing the technologies used to create them on a daily basis at the same time, Hitachi will continue to pursue the “monozukuri” technologies needed to manufacture attractive products.

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Topics

Design Development in Response to the Premium Strategy

OVERVIEW: In response to the premium strategy advocated by Hitachi Appliances, Inc., the Design Division continuously develops its home appliance designs while combining excellent ease-of-use with high-quality exterior design as its everyday tools. This article focuses in on the development of a glass material that has been highly praised in the market, having been launched as an industry-leading design symbolizing this premium strategy.

INTRODUCTION

IN terms of home appliances, the Design Division works with the Simple & Stylish/Usability & Universal/Basic & Belief (SUB) design concept (see Fig. 1) while designing premium products based on consumer lifestyles, combining thoroughly-designed ease-of-use with high-quality exterior appearance to an advanced degree, all while maintaining harmony with the installation location and not being too pretentious.

EASE OF USE AND HIGH-QUALITY EXTERIOR APPEARANCE

The Design Division cooperates with Hitachi Appliances, Inc. by visiting consumer homes to research how home appliances are being used in real life, by continuously conducting lifestyle surveys. With respect to the aforementioned ease-of-use guideline, these surveys are used to discover latent problem areas that the consumer is not generally consciously aware of, so the ideas that are produced can be used in the pursuit of designs that are easy to use. A simple mock-up is created, and the utility of the new idea is repeatedly verified along with the parties relevant to development as an easier-to-use product design is sought (see Fig. 2).

With respect to the high-quality exterior appearance guideline, the Design Division focuses on designs based on Color/Material/Finish (CMF), which is predicated on excellent user-friendliness and cleanability, encourages simple and beautiful forms that achieve a harmony with the increasingly high-quality home interiors of recent years, and strongly expresses the product's appeal in the store. In particular, the Design Division is working to continuously advance cross-sectional projects as an

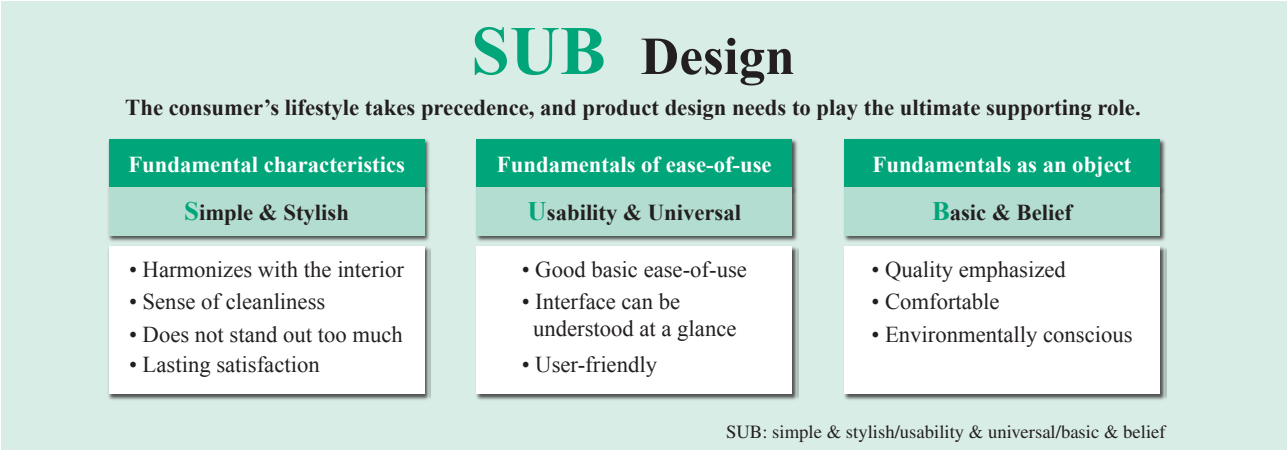

Fig. 1—Simple & Stylish/Usability & Universal/Basic & Belief Design Concept.
Both ease of use and a high-quality exterior appearance are achieved at the same time based on the Simple & Stylish/Usability & Universal/Basic & Belief concept.

Fig. 2—Verification Using Simple Mock-up.
A simple refrigerator mock-up was prepared at full size, and actual usage scenarios were envisioned as ideas were verified.

organization in developing shared elements of CMF, and interface designs.

This article focuses on the development of CMF for achieving attractive product design, and describes the design of a home appliance in response to the premium strategy, centering on the example of a refrigerator.

CMF DOMINANT DESIGN

Not only does CMF strongly appeal to individual tastes, it also makes it easy to execute a unique design strategy that symbolizes a sense of class, like the luster on a piano. Based on information attained from monitor surveys and other sources in the past, CMF tends to be easier to differentiate for people who are not specialists than shapes are. It is for this reason that the Design Division focuses on CMF dominant design.

FOCUSING ON GLASS MATERIAL

Glass is a material that is commonly seen throughout the home, and is characterized by smoothness and a transparent sense of depth. A reinforcing process can be applied to give glass a surface hardness that is three times stronger than normal. Smooth, reinforced glass that has had its surface hardness increased is difficult to scratch during ordinary day-to-day usage and is easy to wipe clean, making it highly functional as a surface material for use in home appliances.

A wide variety of different decorative expressions are possible that take advantage of this transparent sense of depth and smoothness, making glass a design material that can be worked into designs that project a sense of class. Also, when international markets are considered, it is clear that home appliances that use glass have already started to spread.

From this perspective of a material that combines both functionality and designability, and representing the iconic expression of CMF that propels design based on this premium strategy, a premium refrigerator that incorporates reinforced glass was released as a domestic product in 2008 for the first time.

Cleanability and designability were then improved further, with a completely smooth control panel combining capacitance switches and light-emitting diode (LED) display, a function to turn off the control panel and display when not in use, and other innovations (see Fig. 3).

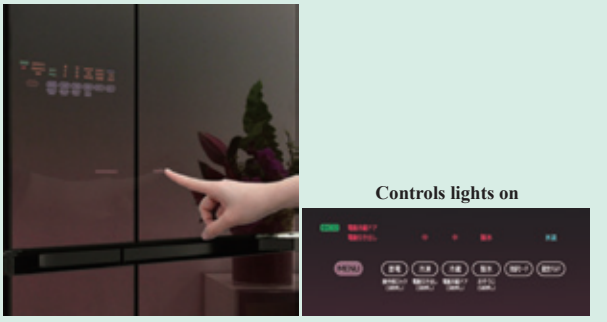

Fig. 3—Smoothing of Control Components.
A combination of capacitance switches and a light-emitting diode (LED) display provide both a simple exterior appearance and cleanability. The controls are hidden when not in use.

Fig. 4—Decorative Refrigerator Expressions.
A mirror-like texture was reproduced through metal deposition (left). Film gravure printing was also used to add gradation (right).

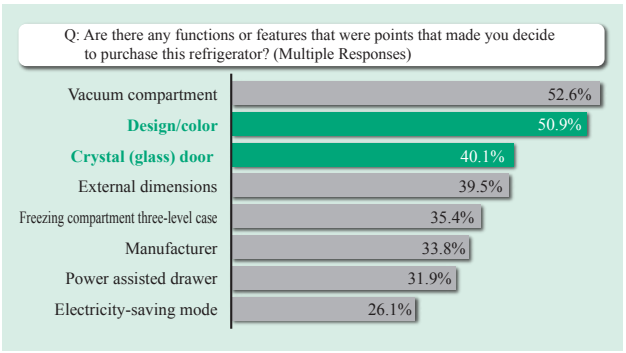

Fig. 5—Deciding Factors when Purchasing a Refrigerator (Multiple Responses) (Hitachi Survey from March 2014: n=350, Purchasers of Hitachi Refrigerators Released in FY2013 [M/G/S Series]).
The design, color, and glass door are appealing points for Hitachi, and are deciding factors that are second only to its unique function of vacuum compartment.

The decorative expression of these refrigerators starts with colors that have been given a sense of depth through reverse silkscreen printing, followed by mirror expressions using metal deposition and gradation expressions using film gravure printing. The sense of quality has been improved with a variety of industry-leading techniques, year after year (see Fig. 4).

Through these efforts, the glass door design of these refrigerators has been mentioned as a reason for purchasing that is second only to the unique Hitachi function of vacuum compartment among Hitachi appeal points (see Fig. 5).

STRATEGIC COLOR PLANNING

To provide consumers with options that suit their preferences when they purchase premium refrigerators with glass doors, first two and then three colors were made available after the 2008 release. Since colors strongly reflect individual preferences, they are often thought to be selected in an arbitrary or sensory fashion. At the Design Division, however, colors are strategically designed based on harmony with the installation environments and with market appeal according to the results of surveys and analyses (see Fig. 6).

As a part of these surveys, the Design Division has been performing fixed-point observations on the interiors of newly constructed condominiums since 2005. Approximately 300 properties in urban areas have been extracted from the Web, categorized by style, and investigated for the differences in materials

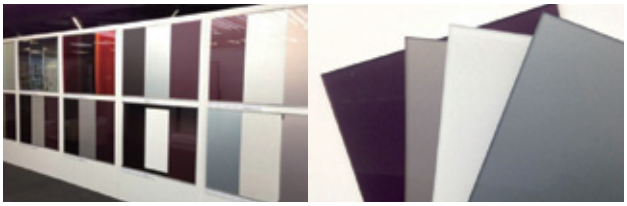

Fig. 6—Color Considerations.
Factors such as trends in interiors and market appeal were considered.

and colors that determine each property's impression. At the same time, based on the fact that printing technology is being used for the decorative material, quantitative trends are also tracked, such as the type of sheet material used in building materials, printed steel sheet patterns, and color component ratios. Furthermore, the analysis of point-of-sale (POS) data are used to verify factors such as the colors that are selling well in the industry (including other companies), and ratio differences based on combinations of color expressions, with the results being used to determine final color variations.

After this analysis, the 2014 model used a champagne color because it harmonizes with the bright oak colors that appear at a high rate as the main construction material for interiors, and both brown and magnolia were added to the lineup as colors that match well with the dark color of walnut materials that appear at the second highest rate (see Fig. 7). In this way, harmony with interiors and appeal in the store were both achieved at the same time.

Fig. 7—Examples of Refrigerator Color Variations Available in FY2014 Models.
Exterior appearances with a champagne color that matches bright oak interiors (top) and a magnolia color that matches dark walnut interiors (bottom) are shown.

CMF PRODUCT DEPLOYMENT

Starting in 2014, the know-how cultivated from refrigerators has been applied to CMF designs based on glass materials in other product genres as well.

First, in the case of the high-end Beat Wash top-loading washer dryer (BW-D10XTV), glass material was used for the lid of the loading opening (see

Fig. 8—Washer Dryer (BW-D10XTV) with Glass Lid.
Along with the improved cleanability, a damper mechanism was also developed based on considerations of user-friendliness when opening and closing the lid (bottom left). A sense of class is also projected through the adoption of a glass lid to which a gradation process has been applied (bottom right).

Fig. 8, top). The lifestyle surveys conducted in 2012 revealed that detergent and other grime that sticks to the area around the lid on the loading opening is a potential point of complaint for consumers. For this reason, the previous plastic lid that folded in two was changed to a single sheet of glass, and the shapes of the hinges supporting that glass and back piece were changed to shapes that make grime less likely to stick while making it easier to wipe any grime off, thereby enabling easier daily cleaning. Since the new glass lid is heavier than the previous plastic lid, Hitachi Research Laboratory and the Design Division of Taga Works cooperated on designing a new damper mechanism that improves the user-friendliness of opening and closing the lid (see Fig. 8, bottom left). The glass is decorated in such a way that the color gradually darkens towards the back in a gradation process, and this gives the high-end model a sense of class (see Fig. 8, bottom right).

The application of glass material is not limited to the domestic Japanese market, however. Hitachi Consumer Products (Thailand) also adopted it for use in its top-loading washing machine (SF-160XTV), which it manufactures for sale in international markets. The transparency of glass is taken advantage of in this model, whereby control buttons and display items that are not often used are covered by the glass lid so the user can usually just look through a small window to see the remaining wash time and other information that is limited to the current operating state. In this way, the necessary information is displayed while control components that tend to be confusing are reorganized into a simple, easy-to-see design (see Fig. 9).

Glass lid when closed

Glass lid when opened

Fig. 9—Washing Machine (SF-160XTV) for the International Market.
The transparency of the glass lid is used to show just the minimal number of buttons and displays on the control/display.

Glass material is also used in the air purifier (EP-KVG900). Air purifiers are kept indoors and clean dirty air all year long, so key design points include ensuring that the device is kept both visually and functionally clean. This model uses a single easy-to-clean glass panel for the front along with capacitance switches, in a design that does not show control buttons or displays when it is not in use. The flat and simple characteristic of the glass is used in a simple design that harmonizes with interiors, while at the same time being easy to clean and maintain on a daily basis (see Fig. 10).

Control lights off

Control lights on

Fig. 10—Global Model Air Purifier (EP-KVG900).
Glass was chosen for use in the front panel. Glass is also used for control and display components that tend to be busy appearance, which in this model are hidden when not in use, providing an interior-friendly feel as well as cleanability.

CONCLUSIONS

Since our glass material was first applied to a premium refrigerator released in FY2008, it has been used in the development of CMF and refined year after year. Its usage was then deepened and used for a wider range of products, and deployed globally as well.

Decorative methods, color deployments, control design, and other features are arranged according to each product's characteristics, but ease of use and high-quality exterior appearance must both be realized regardless of the country, and attractive values are expressed through design.

The Design Division will continue to support Hitachi Appliances in its premium strategy from the perspective of design through the creation of products that thoroughly exhibit ease-of-use as everyday tools, while pursuing technologies to achieve even higher quality decorations and developing highly convenient user interfaces.

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