

In Food Distribution, Technologies to Improve Convenience and Save Labor and Energy: Current Status and Future Outlook

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1. Introduction

In Japan, the population is aging and the workforce is declining. Furthermore, in the retail and distribution industry, human resource shortages are accelerating and competition to acquire labor is intensifying. The increase in overseas workers has brought about the need for more user-friendly products and worker-friendly environments. On the other hand, consumer demand is diversifying, and there is increasing demand for high-quality goods and services in the food and beverage distribution industry.

In overseas markets, income levels have been improving due to economic growth, especially in Southeast Asia, and this has caused a transition in consumption from daily necessities to durable goods such as automobiles and home appliances, as well as dining out, leisure and luxury goods and services. In this respect, the market for products in the food and beverage distribution industry, such as coffee machines and vending machines, is expected to expand in the future.

In order to respond to these market changes, Fuji Electric is working on research and development of applicable technologies based on the three keywords “Enhanced Convenience,” “Labor Savings” and “Energy Savings” in the food and beverage distribution sector. In this paper, we will describe these new technologies.

2. Enhancing Convenience and Supporting Diversification

In the soft drink industry, more than 1,000 new products are marketed and sold each year. Among these new products, only a few survive the increas-

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ingly intense competition of the industry. Fuji Electric is seeking to promote the consumption of products by effectively making use of the features of vending machines.

2.1 Vending machine that can sell -5°C beverages

One of the features of vending machines is the ability to precisely manage the temperature of products. In particular, in recent years, it has been necessary to adjust temperature ranges based on the preference of consumers, while also maintaining the appropriate temperature for each product.

It is against this backdrop that we recently developed a vending machine in partnership with Asahi Soft Drinks Co., Ltd. that cools carbonated beverages to -5°C , the temperature just before freezing. When consumers open the cap, the beverage immediately starts freezing in a form similar to sherbet.

This phenomenon makes use of supercooling phenomenon^{*1}, which requires that the beverage be cooled in an undisturbed state for a certain period of time. Utilizing the temperature control function of this vending machine can achieve this type of environment.

In order to prepare this undisturbed cooling environment for beverages, we have made use of a defrosting system based on a hot gas defrosting method that utilizes the refrigerant’s condensation heat. By combining this system with cooling control to minimize temperature variation inside the vending machine, we have achieved temperature control of separated three zones inside the vending machine: a sub-freezing temperature zone (for the next product to be sold), preliminary cooling zone and replenished product cooling zone. As a result, the vending machine is able to maintain a sub-freezing temperature zone for the product when it is sold (see Fig. 1).

This technology is expected to enhance custom-

*1: Supercooling phenomenon

This is a phenomenon in which a liquid does not solidify and maintains its liquid

state even at temperatures below the freezing point. It is achieved by slowly cooling at a uniform temperature. If shock or impact is

applied in this state, the liquid immediately solidifies.

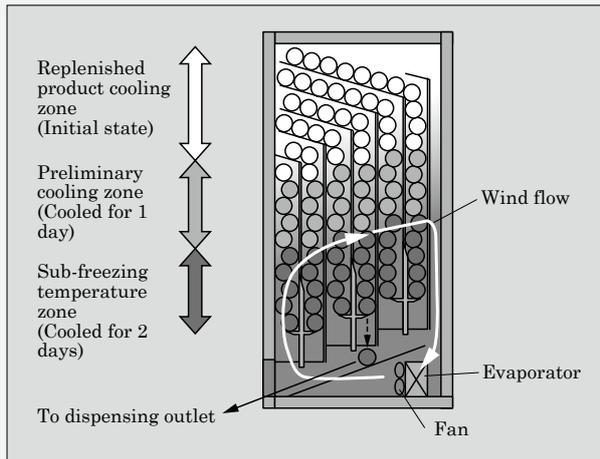


Fig.1 Zone operation system

ers' brand power by enabling sales to go beyond simply selling things, because consumption is encouraged as a result of the fun-factor of seeing a product freeze in front of one's eye and enjoying snow-cone like texture in one's mouth. We believe that the evolving performance and functions of vending machines will revitalize the vending machine market and contribute to increasing customer sales (Refer to "Vending Machine That Can Sell -5°C Beverages" on page 10).

2.2 Cloud-based vending machines quickly responding to market needs

The advancement of information and communication technologies (ICT) has made it easier for people to exchange large amounts of information, and this, in turn, has had a significant impact on how industries do business. Furthermore, innovative business models are just beginning to be created worldwide where multiple number of companies utilize their strong points and develop products quickly and cost efficiently by removing barriers between companies and industries. In order to respond to the proliferation of vending machines throughout the world, we have been developing an environment that enables customers to freely add or remove functionality based on local needs, while simultaneously constructing a framework that supports new entrants to the vending machine business. Furthermore, we have redesigned conventional control systems in order to respond to various specifications in short lead times required by customers and to accelerate collaboration with various different industries.

*2: Real-time OS and general-purpose OS

Conventionally, a real-time OS has been used to achieve real-time features. Dedicated facilities and environments are

needed to develop applications that run on the real-time OS. By separating a general-purpose part that do not require real-time features from a real-time part, this machine uses a general purpose OS such as Linux

for the former. Using a general purpose OS allows other companies, such as vending machine operators, to facilitate the development and addition of the applications they need.

By layering and modularizing the software of vending machines, the cloud-based vending machine separates opened and closed (black-boxed) components, thereby enabling other companies to freely add functionality, reduce their software sizes and improve development efficiency while maintaining a high level of security. Moreover, it facilitates the addition of functionality developed by other companies by providing an operating environment that consists of an embedded real-time OS*2 and internationally standardized general-purpose OS*2 (Linux<Note 1>, Android<Note 2>). We are offering this model to markets other than Japan and aims to accelerate the spread of vending machines worldwide (Refer to "Cloud-Based Vending Machines Quickly Responding to Market Needs" on page 15).

2.3 Vending machine business processes enhanced with ICT solutions

The development of communication technologies and sensors has been enriching life by connecting things throughout the world through all types of devices, not limited to computers and smartphones, but also conventionally unimaginable ones including home appliances, automobiles and manufacturing equipment. By 2020, it is said that approximately 40 billion products will be connected to the Internet to provide various types of services⁽¹⁾.

It is expected by all quarters that even in the distribution sector, which includes vending machines and retail stores, various services will be deployed using the Internet of Things (IoT).

For example, grasping the state of actual inventory, which changes day to day, in real time and predicting daily consumption (demand) will encourage distribution process from primary industries to retailers to change and optimize distribution quantity and frequency. This enhancement leads to the solution of social challenges, such as promoting efficient distribution.

By developing ICT for vending machines and store appliances, which have conventionally been deployed on a device-by-device basis, we believe that the deployment of services will spread, thereby making it necessary to cooperate with different industries. Figure 2 shows a system for providing

<Note 1> Linux is a trademark or registered trademark of Linus Torvalds in Japan and other countries

<Note 2> Android is a trademark or registered trademark of Google LLC

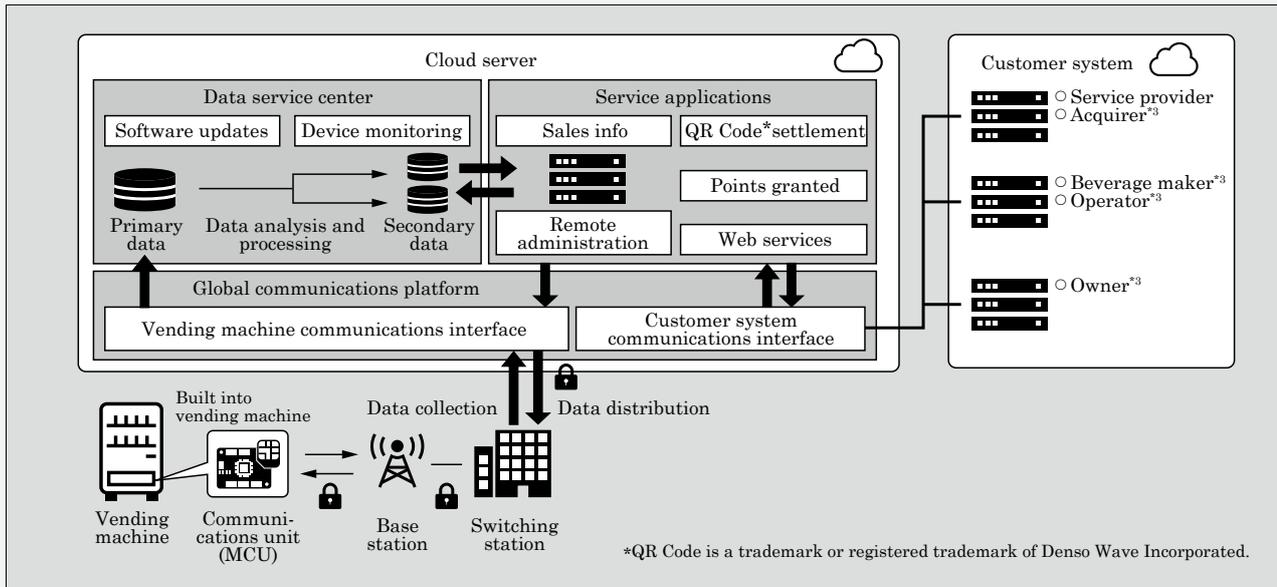


Fig.2 Services that use general-purpose cloud systems

services that improve business processes (Refer to “Vending Machine Business Processes Enhanced with ICT Solutions” on page 19).

3. Facilitating Labor Savings

3.1 Showcase using HFO refrigerant*4 with built-in cooling unit to render installation work unnecessary

Convenience store companies that want to expand their businesses have been eagerly awaiting the development of showcases that take into consideration the construction restrictions imposed on stores located inside buildings when opening new stores. It is against this backdrop that we have developed a showcase equipped with a built-in cooling unit that utilizes an HFO refrigerant^{<Note 3>}(see Fig. 3).

In this regard, we have developed a new type of air curtain that uses ducts below the shelves to di-



Fig.3 HFO refrigerant showcase

rect cooling air from the back to the front in combination with air that flows from above. This system reduces the amount of outside invading heat and meets the cooling performance requirements using a small-capacity cooling unit. Placing the cooling unit on top of the case allows the showcase to lower the bottom shelf and increase the number of shelves, expanding product display area. Furthermore,

<Note 3> The “Showcase with Built-In HFO Refrigerant Cooling Unit” was awarded the Outstanding Performance Award of the “21st Ozone Layer Protection and Global Warming Prevention Awards” sponsored by Nikkan Kogyo Shimbun Ltd. <https://biz.nikkan.co.jp/sanken/ozon/number21.html>.

*3: Acquirer, beverage maker, operator, owner

Acquirer

The acquirer is a company that acquires and manages affiliated merchants on cashless payment services. It supplies payment to merchants for goods sold by the merchant on credit to users and provides the system that enables merchants to setup payment infra-

structure.

Beverage maker

The beverage maker is a manufacturer and distributor of beverages.

Operator

The operator is a company that installs, manages and maintains vending machines. It also replenishes goods and handles sales collection.

Owner

The owner is a company or individual who owns vending machines.

*4: HFO refrigerant

HFO is an abbreviation for hydrofluoroolefin. HFO refrigerants are characterized by a low global warming potential and an ozone layer depletion coefficient of zero.

incorporating the cooling unit into the showcase eliminates the need for on-site cooling system piping work required for separate-type showcases. We utilized the heating and cooling technology that we cultivated in our vending machines (PWM type*⁵ electronic expansion valve, high-efficiency all-aluminum heat exchanger) in the showcase to achieve compressor size reduction and cooling unit integration that helped to significantly reduce the amount of refrigerant filling (83% reduction). The showcase uses low GWP*⁶ refrigerant HFO-1234yf for the first time in the industry. Moreover, we have developed an evaporating system that utilizes the exhaust heat created when condensing the refrigerant in the cooling unit to evaporate the drain water inside the cooling unit so that buried piping work is simplified (Refer to “Showcase Using HFO Refrigerant with Built-In Cooling Unit to Render Installation Work Unnecessary” on page 23).

3.2 Labor-saving showcase reducing operational workload

Labor shortages in the convenience store industry have become a challenge. As a result, there is increased demand for labor savings and energy savings through automation and simplified operations that can help to reduce workloads.

We have developed the following labor-saving items that aim to reduce the amount of labor-intensive tasks performed by store employees:

- (a) Slide shelf with tilting mechanism that makes it easy to pull out showcase shelves and streamlines product replenishment by switching between inclined and level states.
- (b) Filter simple access mechanism that allows the filter to be removed directly from the front of the showcase and makes it easy to check the state of the filter.
- (c) Movable shelves that can be mounted for carry heavy loads on walk-in showcase racks to streamline product replenishment for achieving labor savings (Refer to “Labor-Saving Showcase Reducing Operational Workload” on page 28).

3.3 Drip coffee extraction technology for coffee machines

In recent years, the coffee market throughout the world has been changing rapidly. In particular, a type of specialty coffee, referred to as third wave coffee, has been popular in the United States and has increased the demand for real drip coffee. Furthermore, the demand for coffee beverages has been increasing in Asian countries due to improved income levels, and in particular, the Chinese market for coffee has been growing rapidly. It is against this backdrop that we have developed the following technologies:

- (a) Mesh filter that extracts high-quality coffee as close to paper drip as possible and can be used in coffee machines and cup vending machines in overseas markets where it is difficult to obtain paper filters.
- (b) New type of coffee extraction device for third wave coffee that delicately controls flavor by strictly adhering to the taste of freshly brewed hand drip coffee.
- (c) New type of mill, based on research on electrostatic charging mechanisms, that provides delicious coffee by preventing malfunction and extraction quality deterioration caused by clogging due to the abnormal adherence of roasted beans in the outlet (Refer to “Drip Coffee Extraction Technology for Coffee Machines” on page 39).

3.4 “ECS-777” automatic change dispenser that meets the needs of the markets

As mentioned previously, the retail and distribution industry, typified by supermarkets and convenience stores, is having a harder time securing a workforce of temporary and part-time employees. Moreover, it is becoming increasingly necessary to outsource check-out duties. As a result, self-checkout and semi self-checkout systems*⁷ are being used in earnest to streamline the checkout process and reduce labor costs and checkout waiting times.

Since these systems are operated by consumers rather than store employees, the change dispensers used with these systems need to achieve a higher level of user-friendliness, resistance to bill and coin

*5: PWM method

PWM stands for pulse width modulation and is a power control method. It uses a semiconductor to create a constant cycle for the ON/OFF state of the pulse train and supports arbitrary voltage output proportional to the ON-state pulse width. It is characterized by excellent controllability and high efficiency and is widely used in inverter circuits.

*6: GWP

GWP stands for global warming potential. Greenhouse gases absorb some of the infrared radiation emitted from the surface of the earth and cause the greenhouse effect. The influence of the greenhouse effect is indicated with CO₂ as the basis (=1.0). The smaller the number, the lower the greenhouse effect.

*7: Self-checkout and semi self-checkout

Self-checkout refers to the purchaser scanning the product barcodes and paying for the products by himself/herself. Semi self-checkout refers to a store employee scanning the product barcodes and the purchaser paying for the products at a checkout machine installed near the cash registers.



Fig.4 “ECS-777” automatic change dispenser

jamming and safety than conventional change dispensers. In order to respond to these market needs, we have developed the automatic change dispenser shown in Fig. 4, as well as a slim coin roll storage that can be easily mounted to self-checkout systems (Refer to “ECS-777 Automatic Change Dispenser That Meets the Needs of the Markets” on page 44).

4. Responding to Energy Savings and Environmental Needs

4.1 Store air conditioning solution to save storewide labor and energy

In the convenience store industry, there is increasing demand for energy-saving solutions that are measures for enhancing environmental friendliness and suppressing rising labor costs. Conventionally, store power consumption has been reduced by achieving energy savings in each piece of equipment such as air conditioner and showcase.

Fuji Electric has been operating an actual retail store in its factories for several years, and has verified the movement of heat at this store and has sought new ways to attain further energy savings. Based on our studies, we have developed an in-store heat balance analysis tool for analyzing the heat balance of the entire store. This tool makes it possible to visualize the heat load of each piece of equipment by connecting with heat and airflow analysis software that makes estimates in consideration of the in-store layout. This tool has dramatically sped up the time required to implement new ideas.

As a result of using this tool to analyze heat balances, we have developed a positive pressure control system for suppressing heat loads caused by the invasion of outside air that enters from the automatic door of the store. Furthermore, by taking into consideration the in-store layout of equipment and ventilation, the tool helps to achieve cost and energy savings, while also improving store cleanliness by suppressing the amount of dirt and dust that enters the store from the outside (Refer to “Store Air Conditioning Solution to Save Storewide Labor and Energy” on page 33).



Fig.5 Counter fixture

4.2 Freshness-keeping technology with ambient humidity control

In Japan, discarded food occupies about 30% of total food consumption. Among them, food loss, resulting from the discarding of edible food, currently accounts for more than 6 million tons of food. This has become a serious social problem that also suppresses the profitability of the retail and distribution industry, especially supermarkets and convenience stores.

The hot snacks sold next to the cash registers in convenience stores are disposed of within a few hours due to their texture losing freshness and moisture during heating. As a result, there is a demand for food fixtures that control ambient humidity during heating to keep food fresher for longer.

Therefore, we have applied our polymer-electrolyte fuel cell technology in the development of a humidity control component that optimizes the electrolyte membrane and catalytic composition without the use of liquid water. Compared with humidity control methods that use liquid water, this humidity control component can be applied to counter fixtures (see Fig. 5) to significantly reduce the risk of fungal and bacterial growth and keep food at its required ambient humidity. By suppressing excessive dryness and moisture in food and maintaining the value of the food products, this technology can increase sales opportunities and reduce the loss of the retail and distribution industry caused by discarded food (Refer to “Freshness-Keeping Technology with Ambient Humidity Control” on page 49).

5. Postscript

It is expected that the needs of the food and beverage distribution industry will continue to diversify, and in this regard, Fuji Electric must be prepared to respond quickly. We plan to continue to research and develop our core technologies related

to cooling and heating, mechatronics, sensors and communications in support of customer business environments so that we can offer unique products that meet the latent needs of the market.

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- (1) “Key Points of the 2018 White Paper on Information and Communications in Japan”. The Ministry of





* All brand names and product names in this journal might be trademarks or registered trademarks of their respective companies.