IEC Standard Compliant Glass Front Vending Machine "Twistar"

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ABSTRACT

To meet the needs for China and ASEAN region, where needs of vending machines are increasing in retail business, Fuji Electric should acquire international certifications and deal with diversity of vending products. In light of this, we have developed the IEC standard compliant glass front vending machine "Twistar." This product utilizes an energy-saving panel housing structure suitable for overseas production and achieves simple control through the integration of the control board and software individually. Furthermore, mounting 4 types of vending module mechanisms can sell all products by one vending machine. We have also developed a soft-handling mechanism for the conveyance elevator to prevent the deformation of products.

1. Introduction

Beverage and food vending machines have currently reached a state of market saturation in Japan, with a total of approximately 2.63 million machines installed. Locations where new vending machines can be installed are limited and demand is focused mainly on replacing existing machines. The Japanese market is entering a period of maturity. The total number of installed beverage vending machines is expected to trend downward due to declining birth rates. As a result, beverage manufacturers, who are the main customers for vending machines, are attempting to reduce investment in vending machines in the form of initial costs, and are deploying energy saving vending machines as a means to reduce running costs in order to make profitability improvements.

Meanwhile, lifestyles are changing in China and Association of Southeast Asian Nations (ASEAN) regions due to economic growth. The light meal and soft drink market has grown by more than 10% over recent years in such countries, and there is a growing need for "vending machine sales" in the retail business. Although there are no official statistics on the total number of installed vending machines, it is estimated that there are approximately 70,000 to 80,000 in China, and roughly 100,000 in ASEAN regions. In terms of product life cycle, vending machines in such countries have entered the introductory period.

2. Development Background

Demand is expected to increase in China and ASEAN regions, focusing on places where people gather, such as factory cafeterias and rest areas, public facilities (airports, train stations and halls) and office buildings.

Fig.1 Glass front vending machine "Twistar"

In order to meet this demand, we have developed the IEC standard compliant glass front vending machine "Twistar" (see Fig. 1).

3. Development Goals and Challenges

There were 3 major issues in developing Twistar. The first issue was to launch production at a new factory in Thailand. The second issue was to obtain international certification in order to expand vending machine sales in ASEAN regions. The final issue was to support a wide variety of products so that vending machines could function as general-purpose machines and sell more types of beverages. Our specific objectives were as follows:

(1) To develop a housing structure suitable for overseas production

Use a panel housing structure that can save energy.

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(2) To achieve simple controls that conform to IEC standards

Obtain international certification for product safety testing by obtaining IEC product safety standards in the form of international certification (CB report).

(3) To increase general versatility

(a) To diversify types of product vending mechanisms

In addition to the 2 types of standard modules, develop new replaceable vending modules for small products and beverage products.

(b) To use soft-handling for product conveyance

Use a product conveyance (soft-handling) system that is gentle on products, to allow products subject to damage to be sold.

4. Features

4.1 Overall structure

Figure 2 shows the internal configuration of Twistar. The heat-insulating layer inside the unit is composed of the body heat-insulating layer surrounding the product storage rack area, and the insulated glass and door heat-insulating layer installed on the door component. Products are stored in the storage rack's spiral component (standard vending module). When a product is sold, the spiral component is rotated and the product is dispensed, whereupon the vertical conveyance elevator sends the product to the product delivery window toward the bottom.

4.2 Panel housing structure

Conventional housings were manufactured on semi-automatic integrated production lines that cover the manufacturing process from bending the sheet metal to welding and painting. This required production lines for welding, cleaning, painting and assembly transport. In response, we developed a new housing that would allow us to begin production quickly in our new Thailand factory. The housing was designed to be assembled on an assembly stand. In addition to combining the painted sheet metal with the heat insulating material into a single unit, the panel was designed so that each wall is an independent piece. In doing so, we have minimized facility installation time and costs (see Fig. 3).

In developing the panel housing structure, we paid consideration to overseas production as well as energy saving. Conventional housings had issues on heat insulation at joints. In response, we heated the inside of the unit using an electric heater, and used a thermal camera to visualize heat distribution with a certain temperature difference kept between the inside and outside of the unit, then evaluated insulation performance (see Fig. 4).

Based on our evaluation, we then investigated how to enhance insulation performance in required locations. Airflow in conventional machines involves a discharge duct located toward the front on the side of the housing and a suction duct located on the rear of the housing. The structure was complicated and there were many components. Figure 5 shows our airflow design and the results of running a simulation. Additionally, the discharge duct and front glass are closely located in order to cool products toward the front glass. Consequently, the blowing temperature is low and the front glass is directly cooled. It was necessary to suppress the amount of heat entering from the front glass, 3 layers of glass were therefore used. Then, we adopted a panel housing structure that features the simplest structure possible. It does not require a suction duct and instead has a front suction and rear discharge. We needed to reduce air volume variation, which causes beverage product temperature fluctuation at each shelf. We ran simulations and de-

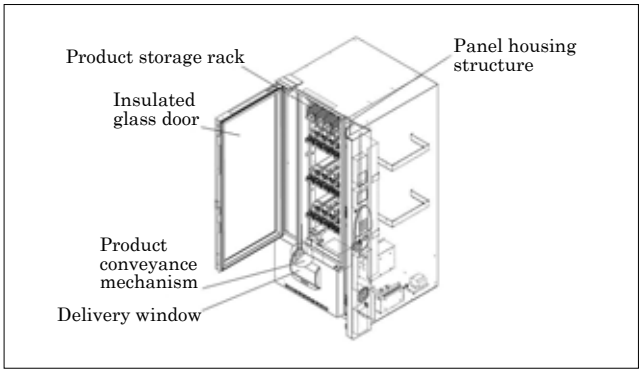

Fig.2 Internal configuration of "Twistar"

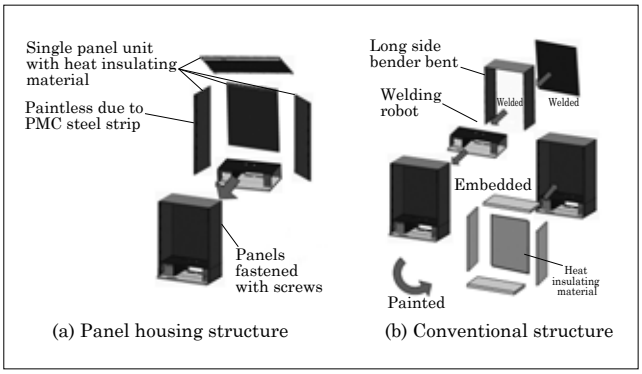

Fig.3 Housing structure

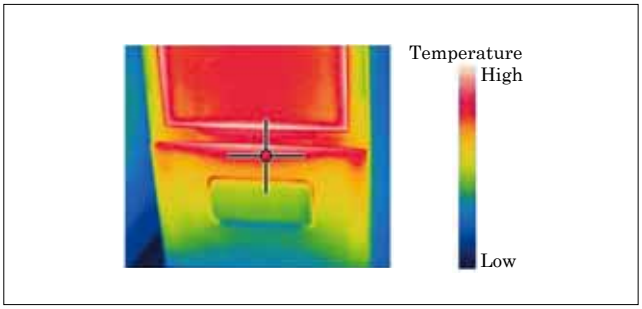

Fig.4 Example of heat distribution at lower front of vending machine

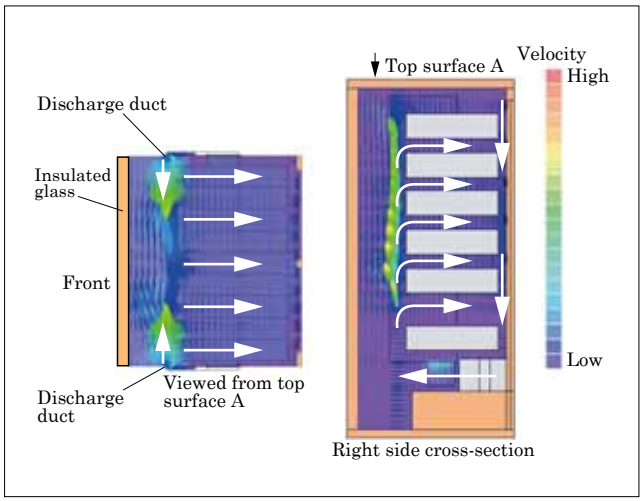

Fig.5 Airflow design and simulation results (conventional structure)

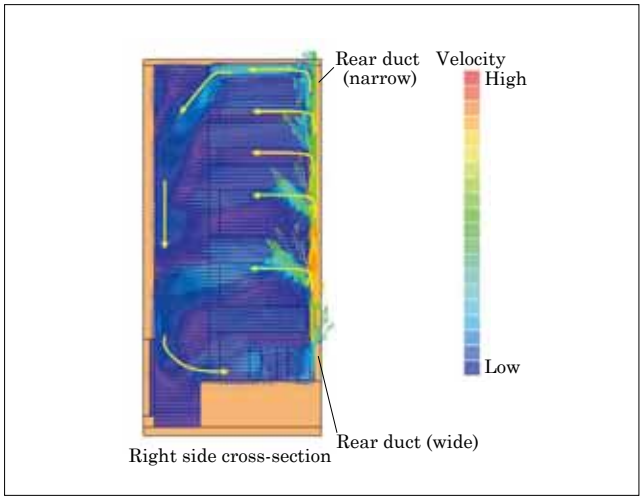

Fig.6 Airflow design and simulation results (panel housing structure)

cided on the ideal airflow design (see Fig. 6). To reduce the airflow concentrated at the top shelf, we changed the dimensions of the rear duct so that the upper portion is narrower than the lower portion. We made a range of improvements such as slowing down airflow around the front glass, reducing the amount of heat entering through the glass by 29% compared with conventional machines even if 2 layers of glass are used instead of 3. Finally, we reduced the temperature fluctuation of subsequent vending products in all columns in the product storage racks to 2.6 K, down from 3.5 K for conventional machines.

4.3 Simple controls

Control functionality for conventional vending machines was performed by a master board and slave board, in consideration of providing the machines with general versatility. However, the new design uses a specialized integrated control board that combines the master board and slave board in a single unit. In order to make the control boards a single unit, we narrowed functionality down to what is essential for vending machines: cooling and vending. The conventional control system contains the master board, dispensing slave board and remote control board, and each equipped with its own software. The new integrated software design uses a simple structure with fewer functions (see Fig. 7).

For money processing, we applied a multi-drop bus (MDB) system, which is generally used overseas, in addition to the conventional vivid transaction system (VTS). We designed the control system to check which system is connected when the vending machine starts up, then communicate using the system that is connected. Magnetic cards, contactless IC cards and POS systems are very region-specific, and compatibility varies from one country to another, creating the need for additional processing such as matching. To allow the vending machine to meet the specifications in each country, we created adapter boxes to share information on the interface. We also prepared equipment for software matching tests to make it possible to conduct tests locally in each region (see Fig. 8).

In order to obtain international certification (CB report) that proves compliance with IEC product safety standards, we developed this product after investigat-

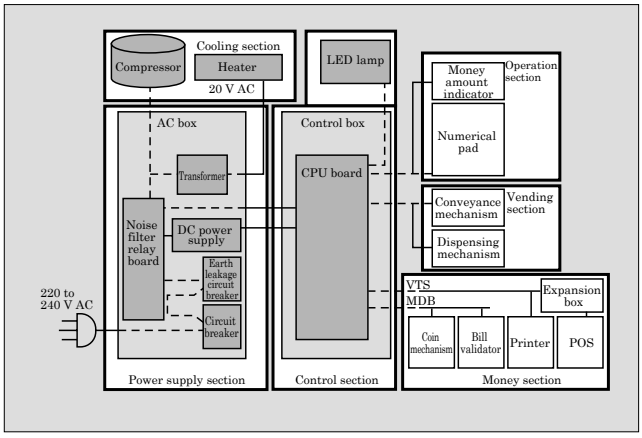

Fig.7 Control system configuration

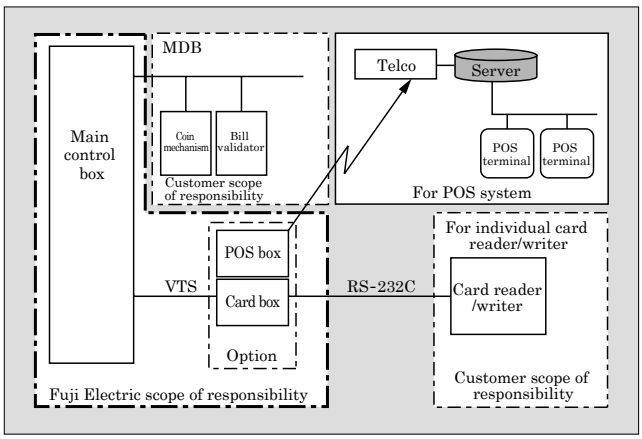

Fig.8 Money processing system configuration

ing differences with the "Electrical Appliances and Materials Safety Act" that vending machines in Japan normally comply with.

We found that we needed to support the radiation emission test (10 m method), which is not stipulated int he "Electrical Appliances and Materials Safety Act." To support this, we made the following improvements to the DC power supply unit, reducing radiation emission (see Fig. 9).

(1) Turn-on time delay

We delayed the turn-on time for the primary side switching circuit. This reduced the high-frequency radiation emitted by pulse components on the differential side (see Fig. 10).

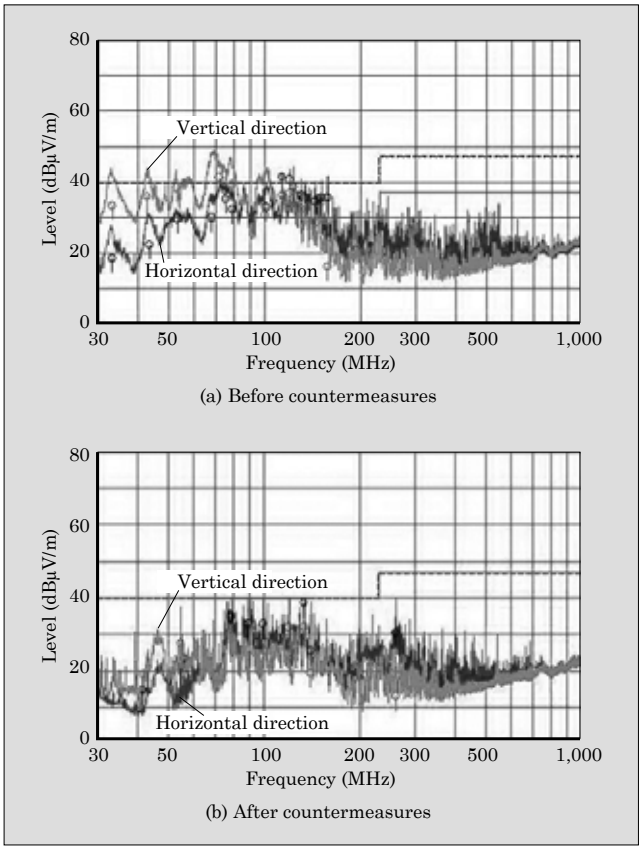

Fig.9 Radiation emission from vending machine

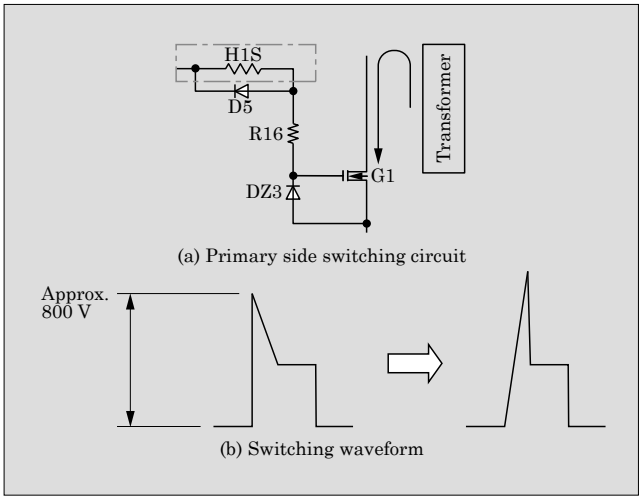

Fig.10 Turn-on time delay

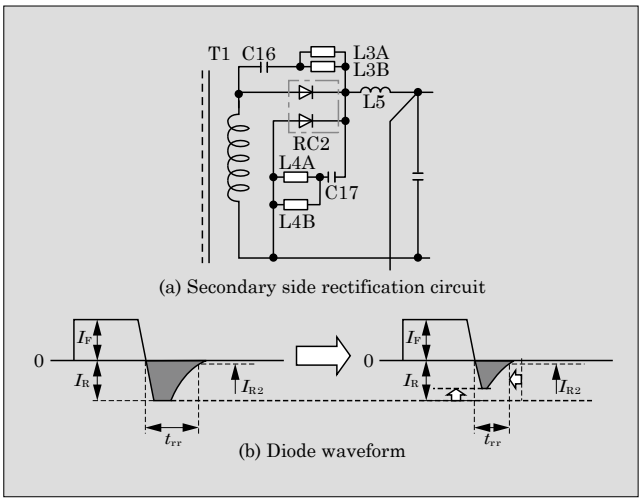

Fig.11 Modification of secondary side rectification circuit

(2) Modification of secondary side rectification circuit

Changing from a fast recovery diode (FRD) to a Schottky barrier diode (SBD) reduced radiation levels by 5 dB (see Fig. 11).

4.4 Increased general versatility

In developing this product, we were required to develop sales specifications, detailing information such as what kinds of products are sold in glass front vending machines in ASEAN regions. We then investigated to identify strong selling products in each country.

After mapping strong selling products in each country by size, we were able to categorize products into 42 sizes. Beverage products with diameters ranging from 43 to 75 mm showed the most sales demand. We learned that there were many products of varying sizes and shapes that are not available in the Japanese market, from snacks with a thickness of 7 mm, to large cup noodle products with diameters of 150 mm. We therefore made it possible to sell all products with

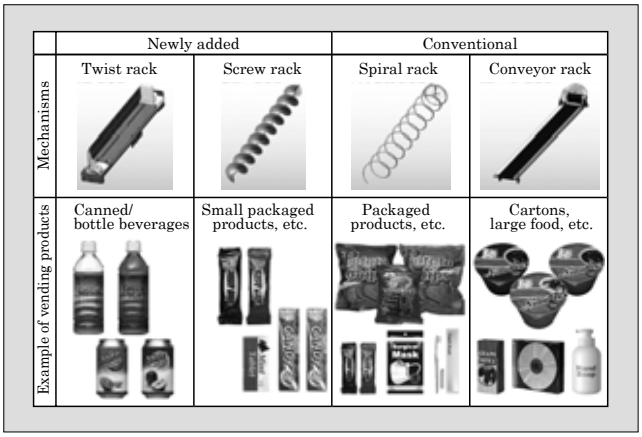

Fig.12 Vending module mechanisms and example of vending products

a single machine, merely by replacing the vending mechanism. In order to accomplish this, we developed 2 types of new vending module mechanisms that offer improved storage density and operability, in addition to the 2 types of conventional vending module mechanisms (see Fig. 12).

When products are passed to the delivery window in conventional machines, the product is passed using the momentum of the conveyance operation after the product is conveyed by the vertical conveyance elevator. During the process in which the product is placed and conveyed, the conveyance base must be lowered to the delivery window while gradually decelerating. In this case, we generally use a control system to pulse drive a stepping motor, which results in a complex control system. To address this problem, we used a DC motor in the vertical axis drive, used encoder pulse signals to control the height of the operation path, and controlled acceleration and deceleration of the motor using pulse width modulation (PWM). As a result, we were able to implement a soft-handling mechanism (see Fig. 13) for product conveyance to lower the conveyance base to the delivery window while decelerating it gradually. This soft-handling mechanism makes it possible to prevent product deformation and damage.

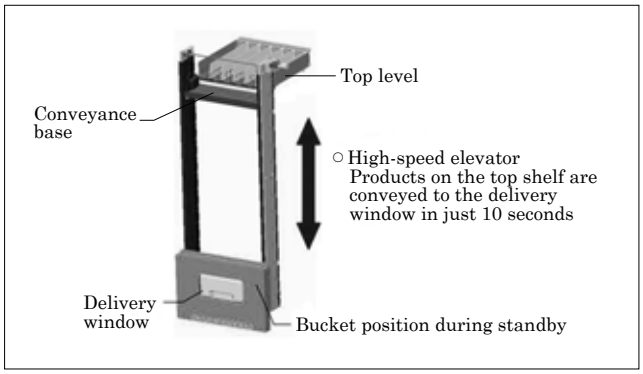

Fig.13 Soft-handling mechanism for product conveyance

5. Postscript

This paper described the IEC standard compliant glass front vending machine "Twistar." Developing this product from a global perspective allowed us to overcome language, culture and custom barriers standing in the way of accomplishing our goals. We will continue to deepen interaction between our mother factory in Mie and our overseas sites, gather detailed information on the needs of our customers and work towards developing strategic products.