Multi-Deck Open Refrigerating Display Case for Frozen Food

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1. Introduction

Demand for frozen food has greatly increased in recent years due to an increase in working women, a general lack of cooking skills, trends toward irregular mealtimes, and remarkable improvements in the quality of frozen food. Once categorized as only a labor saving food, today's frozen food has emerged as major food category.

Because of high gross profit and easy operation, supermarkets put a great deal of effort into frozen foods.

With regard to the recent sale of frozen food, usage has increased of both flat open refrigerating display cases that provide ease in displaying and removing articles, as well as multi-deck open refrigerating display cases that offer high sales efficiency (effective capacity per installation area) and efficient sales of several types of frozen foods.

Because of its low operating temperature, the temperature difference between the inside and outside of multi-deck open refrigerating display cases exceeds 40K.

Advanced technology is required to maintain the inside at a uniform constant temperature suitable for frozen food.

Fig. 1 External view of the multi-deck open refrigerating display case for frozen food

On the other hand, improvements in the display are also necessary.

Fuji Electric has developed the Fresh MAX series of multi-deck open refrigerating display cases having the same display features as multi-deck open refrigerating display case for chilled food (shortened canopy depth, etc.) as well as a structure and specifications for refrigeration efficiency. These features are introduced below.

2. Features

(1) Major external dimensions in accordance with the series standard (canopy depth 995mm)

(2) Stable refrigeration efficiency with a 3-duct circulation structure (an industry's first)

(3) High efficiency defrosting system improved by reversing the middle and outer air curtain fans, and by using heaters

(4) Improved refrigeration prevents from drop in refrigeration efficiency due to frost deposits from the evaporator

(5) Standard equipment with M microcomputer controller

3. Structure and Specifications

3.1 External shape

As shown in Fig. 2, major external dimensions are in accordance with the standard dimensions of the Fresh MAX series multi-deck open refrigerating display cases.

A short canopy depth prevents customers from sensing overhead oppression, but causes a greater non-alignment between the air curtain nozzle and inlet (dimension A in Fig. 2).

Cooled air with high specific gravity has a marked tendency to flow in the direction of gravity. This tendency is particularly strong in the air curtains of multi-deck open refrigerating display cases used for the lowest temperature range. The non-alignment of the nozzles of exhaust and inlets is a serious disadvan-

Fig. 2 Structure of the multi-deck open refrigerating display case for frozen food

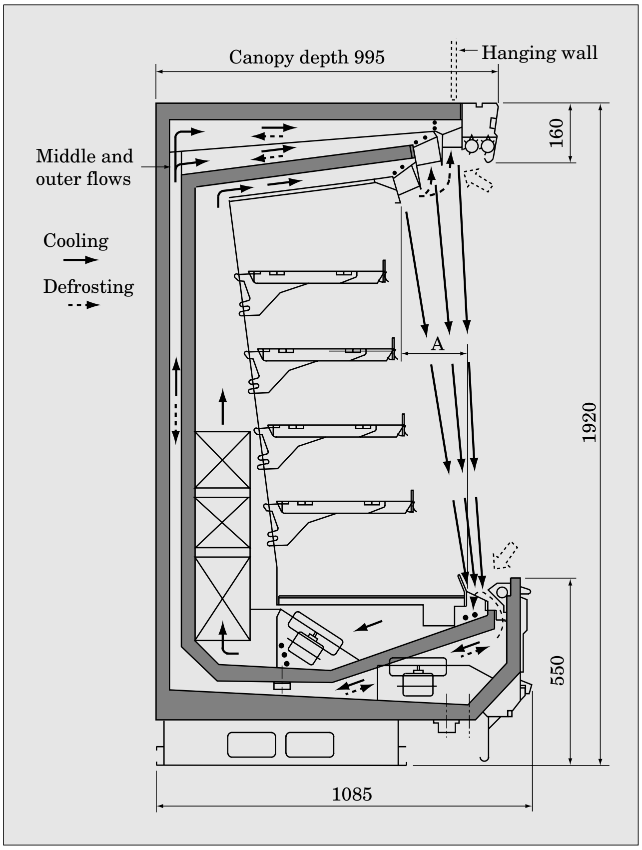
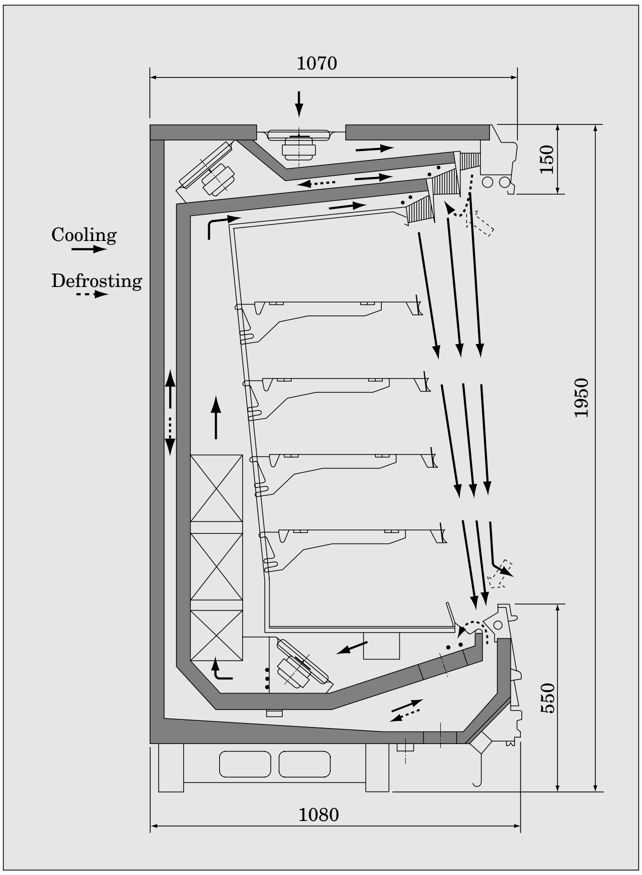


Fig. 3 Structure of the conventional device



tage to refrigeration efficiency.

In spite of this disadvantage inherent in the external shape, the development of the 3-duct air curtain circulation structure has achieved high refrigeration efficiency and has resulted in many other advantages.

3.2 Structure

3.2.1 Duct configuration

Prior systems use 3-duct air curtains consisting of 2-duct circulation and 1-duct downward blowing, but the Fresh MAX series introduced the industry's first 3-duct circulation system.

In the 3-duct circulation system, the outer air curtain duct formerly installed inside the case only for downward blowing is changed because it reduces the display area and effective capacity, and the backside duct is partitioned lengthwise to be shared by outer and inner air curtains. (Patent pending)

At the upper section, the air flow is divided into flows for the outer and inner air curtains. Because the duct is partitioned lengthwise, the divided air flows lack lengthwise uniformity. To make the air flows uniform, static pressure in the duct is raised by tapering the duct from the point of flow division toward the nozzles as shown in Fig. 2. In addition, louvers are provided near the nozzles.

Fans for the middle and outer air curtains, formerly mounted at the top, are now located at the bottom. Each air flow for the middle and outer air curtains is adjusted by the number of fans and duct lengths.

The 3-duct circulation system has the following advantages.

(1) Outer air curtain temperature can be optimized using the inner circulating air flow.
(2) In the summer, hot air near the ceiling does not flow into the air curtain, preventing a drop in refrigeration efficiency.
(3) Decorative walls, hung from the ceiling, can be installed.
(4) Location of fans at the bottom of the unit improves the ability to maintain the fan motors, etc.

3.2.2 Air curtain nozzles

At the air curtain nozzles, an aluminum honeycomb with small cells is used to rectify the blown air. The air velocity distribution over a cross-section of each air curtain is optimized by using slanted trapezoids as the honeycomb cell shape.

Moreover, the air curtain blowing directions intersect each other at optimum angles to form good air curtains.

3.2.3 Air curtain inlets

The air curtain inlets are shaped so as to minimize both the mixing of air curtains from each duct and the deposit of frost on the inlets. The inlets are shaped as shown in Fig. 2. Frost deposited during defrosting does not drain water drops into the case.

3.3 Evaporator

The evaporator is divided into three sections and the fin pitch of each section is experimentally determined to minimize clogging by frost deposits. Because the evaporation temperature is as low as – 40°C, supercooling in the cooling process causes large quantities of frost to be deposited locally, resulting in clogging within a short time.

In this device, the relation between the cooling process and heat transfer area has been selected for strong resistance against frost formation.

3.4 Heater

In addition to the heaters that prevent condensation and frost accumulation on the case surfaces, heaters to prevent frost generation are used in the air passage of the inner air curtain to prevent clogging due to local frost deposits in a short time. The low evaporation temperature sometimes causes what is called air-borne frost in the air flow. Frost production also depends on the duct area, the direction of flow, sudden changes in air velocity, and collision with obstacles. The inner and middle honeycomb heaters shown in Fig. 2 (black spots in the passages) are provided to prevent such frosting. The outer honeycomb heaters are provided mainly to optimize the blow air temperature.

Heaters are equipped also for the inlets and inlet ducts to prevent frost generation and deposits. The inner and middle blow air is nearly saturated. When nearly saturated air at different temperatures is mixed, the water content in the air causes an excess water condition.

Since the air curtain is not static air, it is not considered to be supercooled. However, the fact that mist is generated in the boundary between the inner and middle air curtains in experiments with fuming material suggests the existence of supercooling vapor. The excess water is frozen into ice crystals, i.e. frost, on obstacles such as the inlets and the frost deposits result in clogging.

The heaters for the inlets and ducts are considered very effective.

3.5 Control

3.5.1 Thermostat control

Thermostat control is performed with an M microcomputer controller, standard equipment for all models of the Fresh MAX series. The sensor for this control, installed in the inner air curtain duct, achieves stable thermostat control.

3.5.2 Defrosting control

The defrosting control uses a system which starts at a scheduled time and is reset by temperature. Control is performed with an M microcomputer controller, similar to temperature control.

The defrosting heater capacity is experimentally determined to optimize defrosting efficiency. Inadequate heater capacity unnecessarily prolongs defrosting time, while excessive capacity causes water to refreeze and may form ice banks during extended operation. The heater capacity is determined giving consideration to these points as well as voltage fluctuation.

During defrosting, the fan for outer and middle air curtains is reversed to agitate air in front of the cabinet and introduce outside air. Thus, by positively utilizing the heat of outside air, the defrosting heater capacity can be reduced and defrosting time can be shortened.

Table 1 Specifications of the multi-deck open refrigerating display case for frozen food

Use		Frozen food	
Model		MFA55L3-064A	MFA55L3-084A
Operating temperature (°C)		– 20 to – 18 °C	
Dimensions	Height (mm)	1,920	
	Length (mm)	1,830	2,440
	Canopy depth (mm)	995	
	Front depth (mm)	1,085	
	Front height (mm)	550	
Shelf area (m^2)		3.93	5.25
Capacity (L)		1,095	1,460
Mass (kg)		410	550
Drain bore		40A	
Refrigerating capacity	Required capacity (kW)	2.14	2.79
	Evaporation temperature (°C)	– 40	
	Refrigerant	R-22	
Defrosting system		Reversible outer/middle fans and heaters	
Power consumption	Single-phase 200V, 50/60Hz ( ): Defrosting	1,746/1,753 (1,845/1,852)	2,313/2,318 (2,368/2,373)
	Three-phase 200V, for defrosting heaters	1,620	2,160
Shelf (ft. × pos)		3×2	4×2

4. Conclusion

The features of the Fresh MAX series multi-deck open refrigerating display case have been summarized above.

Fuji Electric will continue to strive to improve air curtains to reduce energy for refrigeration, develop new defrosting systems, and improve display effectiveness.