Development of Laser-guided AGFs for -25°C Freezer

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With its shrinking working-age population resulting from an aging society with a declining birthrate, Japan has a tendency to avoid situations necessitating work in harsh environments, thereby increasing the need for automation and reduction of required manpower. This is especially the case with manned cargo handling in freezer warehouses. The demand for automated facilities in particular will grow, as many of the freezer warehouses currently in operation, which were built in the 1970s to the 1990s, will shortly require renewal. Moreover, the cold chain business is also growing markedly across Asia region against a background of increasing population and economic growth with improved levels of income, raising the demand for temperature control-required goods such as agricultural produce and frozen foods.

Meeting such demand, Mitsubishi Logisnext Co., Ltd. (Logisnext) has developed Japan's first laser-guided automatic-guided forklift (AGF) operable in freezer temperatures up to -25°C, and have made it available commercially since June 2022. This report presents the product.

1. Product features

As is the case with our competitors, we have offered AGFs operable in freezer temperatures up to -25°C using electromagnetic or magnetic induction. However, when a freezer warehouse has heat-insulations under floors, these induction methods tend to be avoided because of the need for floor cutting.

Laser-guided AGFs mounted on the vehicle, on the other hand, are equipped with laser-guided sensors and detect the reflectors attached to the walls to navigate. No floor cutting is therefore required, and the layout can also be changed easily. These are the most advantageous features of this product.

Figure 1 shows an example of a freezer warehouse with stationary racks. There are also cases in which mobile racks are used in a combined manner to improve the storage density.

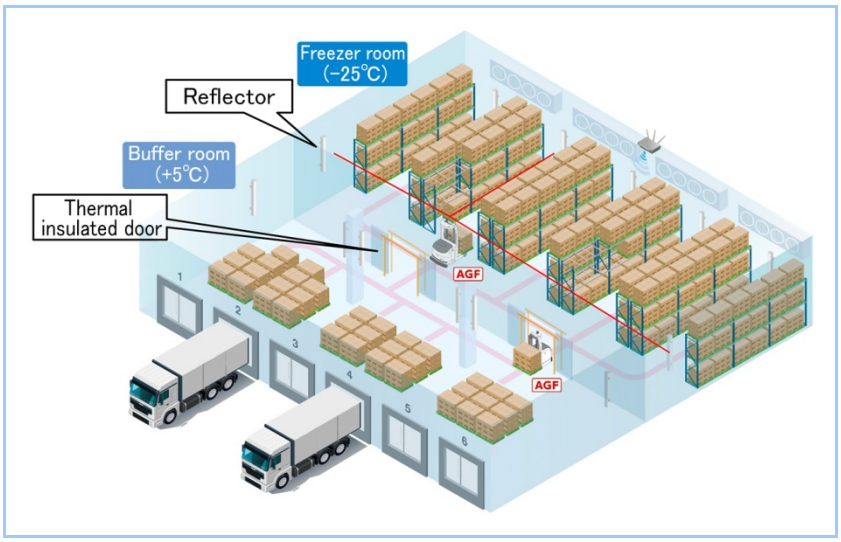

Figure 1 Example of freezer warehouse

2. Product development summary

Described below are the major measures taken for the standard laser-guided AGF to realize stable operation in a cold environment.

2.1 Low temperatures measures

Of the general-purpose sensors employed in our AGFs, some are irreplaceable and yet are unsuitable for use at low temperatures. In order to continue to use them, a rubber heater is installed near these sensors and is turned on before the vehicle enters the freezer room. With this heater control system, the temperature change can be stabilized (patent pending). As shown in **Figure 2**, as long as the location of the vehicle is known at any given time, the heater can be controlled regardless of the vehicle's automatic/manual operation mode or where the vehicle is on the running path. We have thus made it possible to use these sensors despite their unsuitability for cold applications.

Moreover, the hydraulic hoses and oils are those designed for cold applications with a proven record that Logisnext has realized through its development of manned forklifts for freezer warehouses and magnetic induction applications.

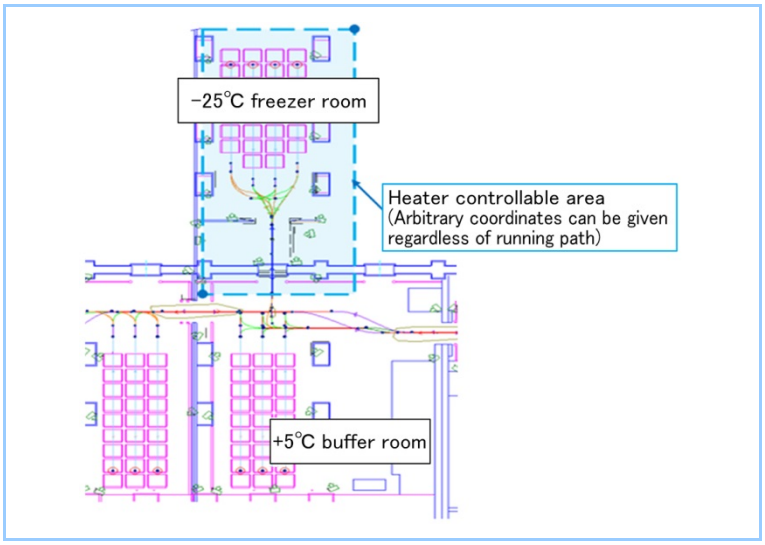

Figure 2 Heater control outline

2.2 Rust-proof and drip-proof measures

A freezer warehouse is generally divided into a freezer room and its adjacent buffer room. The temperature in the freezer room is controlled by opening the thermal insulated door only when the vehicle passes through. However, going back and forth between these two rooms with a temperature difference may cause condensation. For this reason, we have taken rust prevention measures with the effectiveness proven by manned forklifts for freezer warehouses and magnetic induction applications. Firstly, the sheet metal parts are painted with a moisture-proof and rust-proof coating thicker than the standard level. The bolts and nuts in use, which are frequently removed for maintenance and such, are made of stainless steel to maintain the maintainability. Furthermore, oil circulation-type cylinders are used to enhance the degree of rust prevention.

As shown in **Figure 3**, drip-proof structural features include the boxed control panel and the cowl with a flange, which eliminates the gap between the vehicle body and the cowl and prevents water droplets from entering the body.

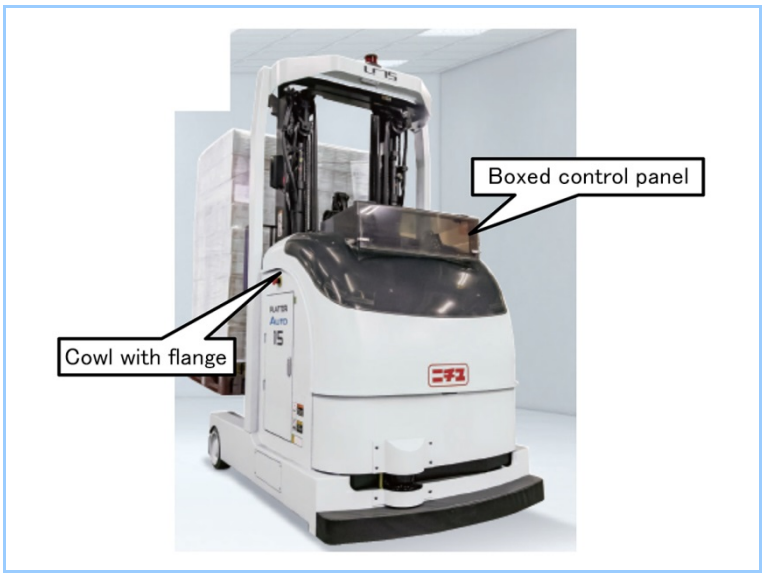

Figure 3 Drip-proof structure overview

2.3 Mist measures

Depending on the buffer room temperature and humidity conditions, mist may form while the thermal insulated door is open as shown in **Figure 4**. Once mist is detected by the laser guide sensor and the obstacle sensor, the vehicle acknowledges the abnormality, which interrupts normal operation. Therefore, the following measures have been implemented.

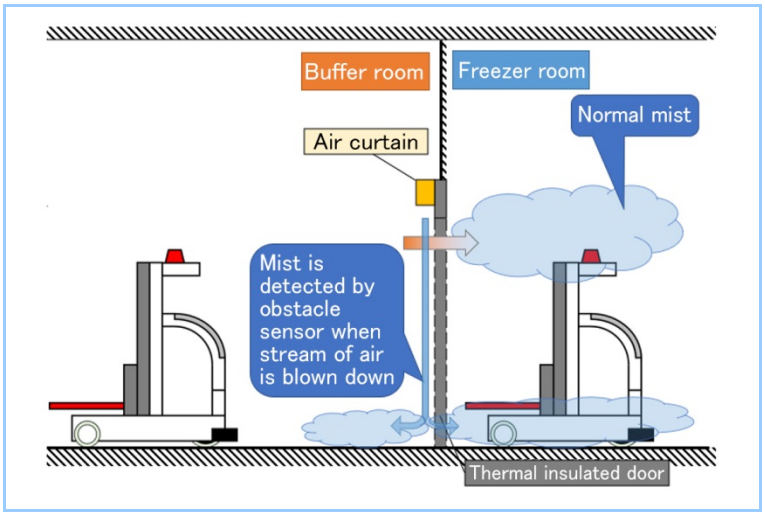

Figure 4 Simplified diagram of mist formation

(1) Blind navigation

Even in an environment where the vehicle temporarily fails to detect a reflector in the vicinity, the use of the function we have added puts the vehicle in the mode in which loss of navigation does not stop the vehicle (i.e., it runs solely by the odometry method). However, in the case of the reflector being detected by the laser guide sensor within the zone of blind navigation, the vehicle corrects its own location information based on the obtained sensor data in a mutually complementary manner.

(2) Use of ultrasonic sensors (patent pending)

Although optical sensors are generally used for obstacle detection, they detect mist as an obstacle. Therefore, ultrasonic sensors are also used to detect obstacles, as their detection remains unaffected in a mist-forming environment despite their disadvantages of lower detection accuracy, less clear detection area, and slower response. As shown in **Figure 5**, the type of sensor is switched over, but only when the vehicle goes through the thermal insulated door.

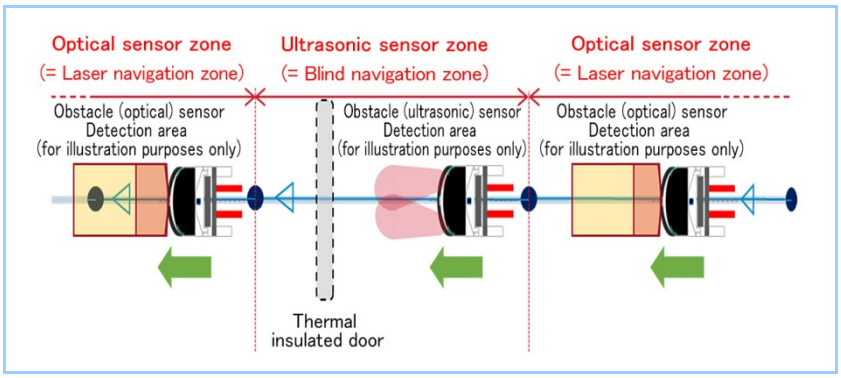

Figure 5 Combined use of optical and ultrasonic sensors

3. Future prospect

The need for automation and reduction of required manpower is growing every year. This is especially the case with work in harsh environments. We will continue to contribute by disseminating products satisfying such needs.