Development of Compact All-Directional Type Automatic Guided Vehicle (AGV) (3MC-M2.5)

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Keywords AGV, Platform type, SLAM, Self-navigation

Abstract

We have developed an Automatic Guided Vehicle (AGV) 3MC-M2.5 that runs in all directions. We unified the control system for the 3MC series as a successor model to the conventional model ACBM2.5.

It is equipped with multi-sensing functions [magnet guidance, laser distance measurement, and autonomous travel system using Simultaneous Localization and Mapping (SLAM) technology] that was not available in the conventional model. Compared to the conventional model, the drive system has been changed, wiring has been reduced, the mass of the main body has been reduced by 21%, and the dimensions of the main body have been reduced by 35%. In addition, maintainability has been improved by adopting a brushless motor. Furthermore, it has been reduced life cycle of CO_2 emissions and by our standard, has been certified as a "green product".

1 Preface

We started selling Automatic Guided Vehicles (AGVs) in 1983, and commercialized the standard platform type as the ACB series in 1987. After, in 2000, we developed an all directional type ACBM series, and in 2010, we developed the 3MC series with improved functions and operability, responding to customer requests. In recent years, instead of the magnet guidance that runs while detecting magnetic tape laid on the floor, the autonomous travel system that uses Simultaneous Localization and Mapping (SLAM) technology has been attracting attention.

We are applying the autonomous travel system to our heavy-duty AGVs that can carry from 1 to 6 tons, but the demand for small items transport is also increasing. This time, we have developed a compact AGV 3MC-M2.5 that can run in all directions using an autonomous travel system and can be operated on complicated routes and narrow passages. This paper introduces the specifications and features of the 3MC-M2.5.

2 Specifications

Fig. 1 shows the names of each part of 3MC-M2.5, Fig. 2 shows the outline drawing, and Table 1 shows a list of specifications. The appearance of the 3MC-M2.5 is rounded at the four corners of the frame, and the platform is fully flat to increase the degree of freedom for mounting the transfer equipment. The external dimensions are W704 × H340 × L1184 mm, which is smaller and lighter than the conventional model. The rated capacity is 400 kg assuming 150 kg for the transfer equipment, and 250 kg for the payload. The 3MC-M2.5 is a platform-type AGV, and transfer equipment such as a belt conveyor or a collaborative robot are mounted on the platform. It is possible, for example, to build a

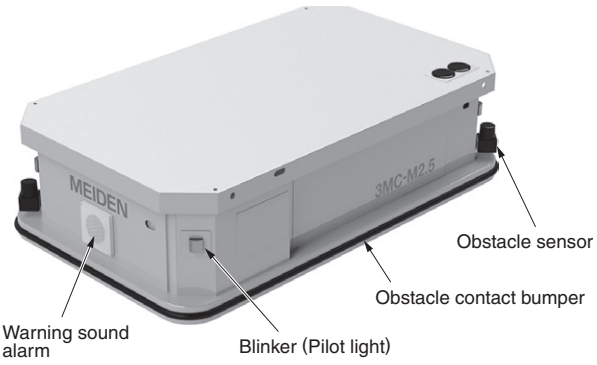

Fig. 1 Names of Each Part of 3MC-M2.5

Obstacle sensors for safety device, obstacle contact bumper, warning sound alarm, and blinker (pilot light) are accommodated.

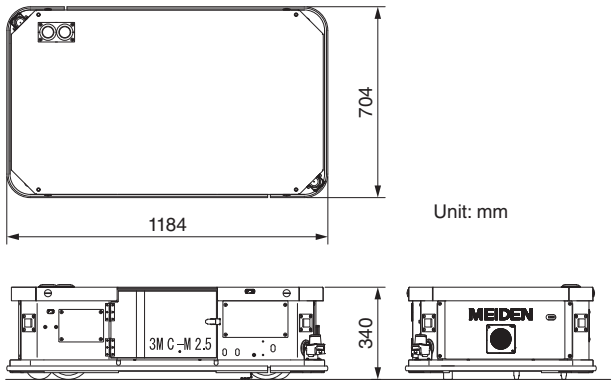

Fig. 2 Outline Drawing of 3MC-M2.5

The vehicle size is W704 × H340 × L1184 mm. This is a compact model compared with the conventional model.

Table 1 List of Specifications

A list of specifications for the 3MC-M2.5 and a conventional model ACBM2.5 are shown.

Item		3MC-M2.5 (New product)	ACBM2.5 (Conventional product)
Major dimensions	Body length (mm)	1184	1600
	Body width (mm)	704	756
	Body height (mm)	340	360
	Tare mass (kg)	230	290
Performance	Guidance system	Magnet guidance, laser distance measurement, SLAM using laser (Multi-sensing functions)	Magnet guidance, laser distance measurement
	Traveling direction	Multidirectional spin turn	Multidirectional spin turn
	Rated capacity (kg)	400 (Including transfer machine 150 kg)	400 (Including transfer machine 150 kg)
	Maximum speed (m/min)	60	60
	Minimum turning radius (mm)	850 (180° turn)	1000 (180° turn)
	Stopping accuracy (mm)	±10 (Magnet guidance, laser distance measurement) ±50 (SLAM using laser)	±10 (Magnet guidance, laser distance measurement)
	Gradability (%)	2 (Continuous 5 m)	2 (Continuous 5 m)

system that automatically loads and unloads the carrying items to the conveyor of the manufacturing equipment. Although the transfer equipment is standardized, it can be designed according to the carrying items of the customer. In addition, it can run in all directions such as forward, backward, sideways, slantwise, spin turn, and can approach manufacturing equipment behind the aisle and run within a narrow aisle. As a result, optimal and efficient operation can be performed according to the layout of the site.

3 Features

3.1 Multi-Sensing Function

The 3MC-M2.5 has a multi-sensing function that can handle multiple guidance systems. There are three systems: (1) a magnet guidance, (2) a laser distance measurement, and (3) the SLAM using a laser. The AGV can run while switching the guidance system, and the customer can select the guidance system suitable for the site situation.

(1) Magnet guidance

A magnetic sensor is attached to the AGV, a guidepath is laid on the floor with magnetic tape or magnetic rod, and it runs on it. This is the most proven guidance system, but it requires guidance line laying work.

(2) Laser distance measurement

The laser distance measurement AGV is equipped with a laser range finder that measures the distance and angle of the reflector attached to a wall or pillar with its laser light to calculate the AGV's own position. The AGV travels on a preset travel path while calculating its own position. Since the position of the reflector and the travel route are set on the layout drawing created by the CAD, the travel route can be changed on the PC even in the event that the layout of the site is changed.

(3) SLAM using laser

The SLAM generates an AGV driving environment map in advance with a laser range finder and set the driving route on the map. In automatic driving mode, the self-position is estimated from the distance information from the laser range finder and the values of the wheel rotation sensor. The AGV then autonomously runs the route designated by the digital map. If the layout of the site is changed, the self-position can be estimated by recreating a new digital map by the above procedure, and the AGV automatically runs. It does not require guide wire work or reflector installation work.

3.2 Safety Device

Since AGVs may travel on complicated tracks and places where many people walk, safety equipment suitable for the driving site is required. The 3MC-M2.5 is equipped with the following functions

and devices to ensure safety against accidental bump/contact with the people.

(1) Obstacle sensor

A non-contact obstacle sensor is installed at the front and rear corners of the vehicle body to monitor all directions of the AGV. When a person or obstacle approaches the AGV in its traveling direction, the vehicle slows down to where it does not pose a danger, or it stops before contact. The detection area of the sensor can be set freely, and the detection area can be changed according to the passage conditions.

(2) Obstacle contact bumper

A contact type bumper is attached to the entire circumference of the lower part of the vehicle body frame, and safety measures are taken for contact/collision detection. With the obstacle sensor, it assumes that the AGV will decelerate and stop, but if a person suddenly jumps out, it will make an emergency stop of the AGV by the contact type bumper.

(3) Miscellaneous

In addition, the AGV is equipped with a warning sound alarm and a blinker (pilot light) to call attention to the surroundings and display the driving direction for safe travel.

3.3 Options

(1) Automatic battery charger

An automatic battery charging contact is attached to the front right of the vehicle body and an automatic battery charger is installed on the ground. It is possible to build a system that operates continuously for 24 hours without replacing the battery.

Fig. 3 shows the automatic battery charger. It consists of an automatic battery charging control device and an automatic battery charging terminal. Charging is a current-limited constant voltage method that monitors the battery voltage and performs optimal charging in a short time. When the AGV arrives at the charging station, the charging contact on the ground moves with the electric actuator and contacts the charging contact on the AGV side to start charging. During charging, the interlock prevents the AGV from accidentally starting. The AGV starts running after confirming that the charging has stopped and the charging actuator on the ground has returned.

(2) Wireless Local Area Network (LAN) unit

Fig. 4 shows the external appearance of the wireless LAN unit. By mounting a wireless LAN unit on an AGV, multiple AGV transfer systems can be constructed and operated efficiently while communicating with the system control panel on the ground. The system control panel manages the AGV in an integrated manner, and performs destination instructions, standby control that prevents AGVs from colliding at intersections, and external standby control that works with automatic shutters. In addition, since the AGV status can be monitored in real time, the status and position of the AGV can be grasped instantly, and recovery work can be performed in the event of an abnormality.

(a) Automatic battery charging control device

(b) Automatic battery charging terminal

Fig. 3 Automatic Battery Charger

External appearances of the automatic battery charging control device and automatic battery charging terminal are shown. A contact type automatic battery charging system can be established.

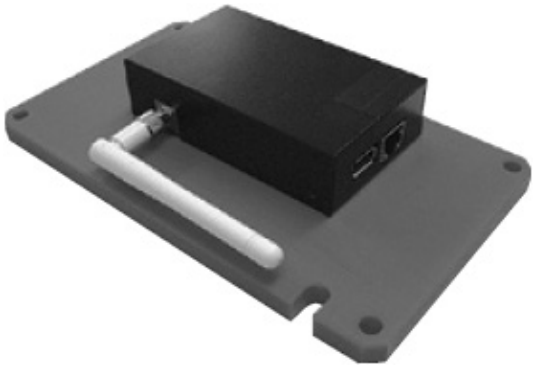

Fig. 4 Wireless LAN Unit

An external appearance of the wireless LAN unit is shown. This unit is installed on the AGV so that wireless communication can be carried out with the system control panel on the ground. A conveyance system can be established for multiple AGVs.

4 Postscript

We introduced the 3MC-M2.5, which is the

successor model to the conventional model ACBM2.5. In the future, we will not only build the transportation system using 3MC-M2.5, but also improve it with a view to supplying it to system engineering manufacturers. In addition, we intend to further improve the performance and accuracy of autonomous guidance map generation and self-estimation of its position to provide better AGVs to our customers.