

Special Feature 1

Toyota Industries' Container Transport AGV System Contributing to Evolution of Port Logistics



Toyota Industries' Container Transport AGV Specifications

- Length: 14.3 meters
- Width: 2.8 meters
- Height: 1.8 meters
- Weight: 23.5 tons
- Allowable load: 30.5 tons
- Maximum speed: 25.0 km/h (20.0 km/h when loaded)
- Drive system: Diesel-electric system

The globalization of economic activities and a subsequent rise in cross-border commodity flows have led to a greater volume of containers handled at seaports. Maritime container terminals, which play a major role in supporting growing container traffic, are now required to evolve in many ways to achieve higher efficiency in their container transport operations and improve the work environment. As such, one of the most significant issues is automation. Toyota Industries is making a substantial contribution to the automation of container terminals by leveraging its years of experience in developing automatic guided vehicles (AGVs). This section highlights our container terminal automation system, a unique project originating from Japan, based on an interview with some key project members.

Positions and departments of the four Toyota Industries employees featured in this section are as of March 31, 2013.



Tobishima Container Berth

Necessity of Automation at Container Terminals

Higher Efficiency Essential in Enhancing Ports' Competitiveness

Increasingly globalized economic activities have been generating a greater flow of commodities between countries. Accordingly, maritime transport, which serves the crucial role of moving commodities around the world, has been handling an increasing volume of shipping containers, with the world's maritime container traffic in 2010 reaching more than five times the volume in 1990*.

Amid this environment, maritime container terminals not only in Japan but also all over the world have been pressed to reduce the time needed for the loading and unloading of cargo on and off container vessels and increase the efficiency of operations in terminal yards.

* Statistics by the Ministry of Land, Infrastructure, Transport and Tourism

Seeking to Improve the Work Environment

In many container terminals, cranes that hoist containers have cabins 40 meters high from the ground, forcing operators to work in a tough environment. They are constantly exposed to ocean winds, intense heat during summer and severe cold in winter and often work late at night. Loading containers onto a trailer truck is also a difficult task, as it requires both the crane and trailer truck to be stationed precisely at specified locations. Both the crane operator and trailer truck driver thus need to have a high level of skills, experience and sometimes a "feel" to perform their respective jobs. Many have been voicing the need for improving their work environment.

In order to achieve higher efficiency and a better work environment, Tobishima Container Berth Co., Ltd. (TCB), the operator of a container terminal within the Port of Nagoya in Aichi Prefecture in Japan, decided to introduce large-sized container transport AGVs to automate operations within maritime container terminals. "The entire team worked toward one goal," says project leader Kazuhiro Suzuki, Assistant General Manager of the Trans System Engineering Office. Looking back on their enthusiasm at that time, he adds, "We channeled our accumulated AGV system technologies and logistics know-how into this project with the determination to contribute to the development and growth of the seaport."



Kazuhiro Suzuki
Assistant General Manager,
Trans System Engineering Office,
Engineering Department,
TOYOTA Material Handling Company

Contributing to Growth by Leveraging Toyota Industries' Strengths

Efforts in the Area of Software Development

Building a Total System Covering the Entire Terminal

To raise the competitiveness of the seaport, we leveraged our know-how in the field of commodity flow optimization, which we have cultivated through the development of transport and storage systems for more than 30 years, and our experience in developing AGVs, thereby contributing to greater overall operational efficiency at terminals.

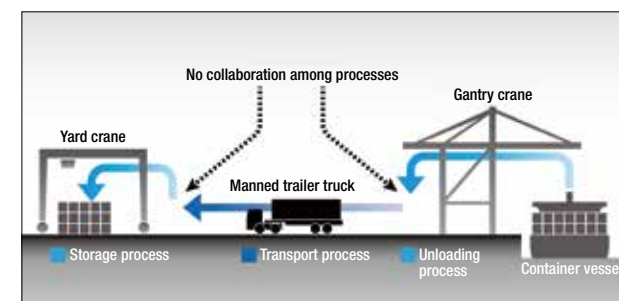
For instance, our container transport AGV system controls the scheduling of AGVs in a Just-In-Time (JIT) manner by working in conjunction with other components of the terminal, such as gantry cranes that transfer containers from a vessel to a transport AGV. At an intersection within the yard, the non-stop control program prevents multiple AGVs from entering the intersection at the same time, saving fuel by eliminating the need to slow down, stop and accelerate again at the intersection, as well as providing better transport performance. After being



Hiromi Mitoh
General Manager,
Seaport Business Development Group,
Logistics Solutions Project,
TOYOTA Material Handling Company

loaded with containers, our AGVs are capable of selecting the optimum route to the storage yard on their own. Hiromi Mitoh, General Manager of the Logistics Solutions Project, emphasizes the significance of the Tobishima project, noting: "Our AGVs operate in coordination with cargo handling equipment and the management system of the entire terminal, enabling JIT operations. This was the world's first initiative of its kind that attempted to realize higher work efficiency."

By systematizing the operation of the entire terminal, we were



Notional Diagram of Conventional Container Terminal

In a conventional terminal, container handling and transport operations are undertaken individually by gantry cranes, manned trailer trucks and yard cranes.

able to contribute to not only increasing its logistics efficiency but also considerably improving the challenging work environment.



Efforts in the Area of Hardware Development

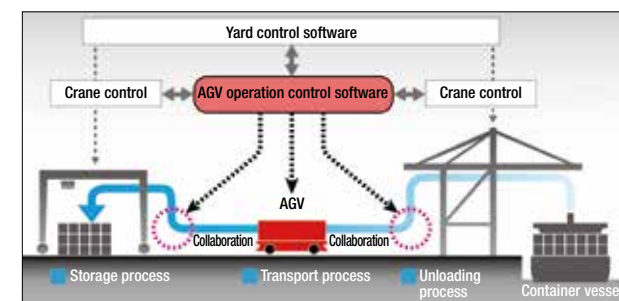
Superior Functionality Based on AGV System Technologies and Know-How

In addition to the software aspect of how to control the entire terminal operation, another important factor of the container transport AGV system is its hardware, namely, the performance of AGVs that actually carry containers. We integrated our various technologies into these AGVs to ensure durability, energy-saving performance and safety in a tough operating environment.

Our AGV is about 14 meters long and weighs more than 50 tons when loaded with a 30-ton container. This huge vehicle is capable of autonomously driving at the maximum speed of 20 kilometers per hour and parking at a designated location with a margin of error of within 2 centimeters. This outstanding level of accuracy was the major enabler of automatic transfer of



Shinji Katsuda
Group Manager,
Trans System Engineering Office,
Engineering Department,
TOYOTA Material Handling Company



Notional Diagram of Automated Container Terminal

The system is controlled by AGV operation control software and other programs, which optimize the collaboration between AGVs and cranes and improve the container terminal's overall logistics efficiency.

containers between our AGVs and yard cranes, which helped us make a significant contribution in improving the work environment.

"In addition to ensuring durability against high temperatures in summer, low temperatures in winter, driving rain and gusty sea breezes, we worked to provide better resistance against the impact of a fully loaded container landing on the vehicle, which can exceed 30 G, as well as a high level of safety," says Shinji Katsuda, Group Manager of the Trans System Engineering Office. He recalls, "We also made efforts to respond to the requests of the customer for better energy-saving performance and easier maintenance."

Yasushi Saito of the Trans System Engineering Office also emphasizes their ingenuity in its structure. "A precision computer for controlling the AGV is installed in the middle portion of the vehicle body," he explains. "To install other control devices around this computer, we had to create space by making devices more compact. The designing process involved the continuous fine-tuning of the overall vehicle balance."



Yasushi Saito
Trans System Engineering Office,
Engineering Department,
TOYOTA Material Handling Company

Excellent Environmental Performance

Our container transport AGV is driven by a diesel-electric system, in which an electric motor operates the vehicle using the power generated by the diesel engine. The vehicle is also equipped with a fuel-saving mode that efficiently uses energy by prioritizing when to use and save power depending on the operating status. "We reduced the weight of the vehicle itself and modified its operation system. The result was higher fuel efficiency and less CO₂ and nitrogen oxide (NOx) emissions," says Katsuda proudly.

Multi-Layered Safety Features

We paid particular attention to addressing the customer's concern regarding safe operation of our container transport AGVs at the automated terminal.

Our AGV system provides multi-layered safety features for potential risks. Each AGV is fitted with a laser radar device to detect an obstacle in its moving direction. Its contact-sensing bumper is capable of sensing unexpected falling objects on its path to avert even minimal contact. In addition, the AGV's operation control software program prevents interference with other AGVs in the vicinity by controlling the direction of the AGV's movement as well as links to the crossing gate control that contributes to the prevention of a collision between a trailer truck and an AGV.



Receiving 2012 Good Design Gold Award*

As described previously, Toyota Industries' container transport AGV system effectively combines software (control system) and hardware (AGV itself) to ensure highly efficient container transport operations, excellent environmental performance and safety. In this way, our AGV system assists the entire container terminal, including gantry cranes and trailer trucks, in achieving higher operational efficiency.

These superior features have earned high acclaim, and our AGV system received a 2012 Good Design Gold Award. As one judge noted, it "really is a fusion of product design and social system design, and provides Japan's maritime transport industry with a new, promising means of implementing its growth strategy." Receiving such high praise from a third party gives us a huge boost in confidence, and we are more determined than ever to contribute to customers' businesses in every possible way.

* Highest prize given to a group of 2012 Good Design Award winners, exclusively selected by a panel of judges as having particularly outstanding design



Launching AGV System Meticulously Tailored to Customer's Requests

The designing of the vehicle itself involved a number of challenges. We had to achieve a level of durability able to withstand the shock of a container landing on the vehicle while protecting a precision-computer mounted on the body. The vehicle, weighing more than 50 tons, has to run safely at the maximum speed of 20 kilometers per hour and park at a designated location with a margin of error of



within 2 centimeters. We also developed numerous software programs to ensure safe and efficient automated operation of multiple AGVs and cranes.

Most importantly, however, was conducting careful *genchi genbutsu* (go and see for yourself) checks to verify that both hardware and software function properly in every possible circumstance, the same as in theoretical simulations. “We conducted feasibility tests mainly at night so as not to interfere with TCB’s terminal operations,” says Mitoh. “We made improvements again and again to increase operational accuracy. Looking back, it was a daunting, time-consuming task. But we worked as one team and were eager to meet the customer’s, and ultimately, end users’ needs.”

With unwavering enthusiasm, Suzuki adds: “A collaborative relationship with TCB and other companies engaging in terminal operations was particularly important. We paid meticulous attention to the customer’s requests, finding solutions to issues and building technically feasible measures through in-depth discussions. All project members, including those engaging in manufacturing, banded together as one strong team to develop an operational structure truly needed by the customer from the perspective of a total system that encompasses both hardware and software. Toyota Industries is perhaps the only company that can make this project possible, and this makes me very proud.”

■ Expected Growth in Needs and Future Approach

Customers’ needs for higher efficiency in seaport logistics operations are expected to steadily increase.

To respond to these needs, we will develop container transport AGV systems that create new values. That will involve combining “human meticulous attention to detail and flexibility” and “precision and stability of machinery” and delivering these systems to customers together with our logistics know-how.

We aim to improve the performance of AGVs themselves and at the same time pursue a coordinated and collaborative approach to enhancing overall system capability. We will continue to dedicate considerable efforts toward this goal in hope that our container transport AGV systems will contribute to better seaport logistics efficiency, and in the end, improve people’s lives.



Customer Voice

Masato Kato

President,
Tobishima Container Berth Co., Ltd.

Tobishima Container Berth Co., Ltd. (TCB) is the operator of a new container terminal opened at the end of 2005 as model terminal for a Super Hub Port of the Port of Nagoya. TCB is a joint venture of 10 companies providing maritime, harbor and land transportation services. Its mission is to contribute to the country’s economic growth by achieving greater convenience and efficiency and to seek ways to become a win-win terminal for everyone involved.

Our terminal is among the few in the world and the only one in Asia to fully automate its container transport operations. We asked Toyota Industries to develop and install container transport AGVs. The company delivered to us exactly what we have envisioned, that is, AGVs that are not only automated but also capable of working on their own with a human touch. Since their introduction in February 2009, these AGVs have not had any accidents and have gained high acclaim among the companies involved in terminal operations for improving the work environment and the safety of operators working within the terminal.

The process of developing, installing and launching these AGVs entailed a myriad of issues to overcome and involved a great deal of effort on the part of Toyota Industries staff. As an individual involved in this project, I witnessed their incredible commitment and hard work. I still remember each one of them, and they have earned our deepest respect and appreciation.

In order to fulfill our aforementioned mission, we have rolled out an initiative to gain an unparalleled level of competitiveness. For us, automation does not end with its introduction into the terminal but marks the beginning of constant efforts for improvement. By defining the meaning and indicators of competitiveness for a seaport, we are working under the belief that to get better we have to change now while carrying out improvement activities on a daily basis. More than a year has passed since we began this initiative, but we still see a lot of seeds for improvement. As the saying goes, “We have to renovate ourselves from day to day.” Toyota Industries’ team is also providing their support, and we have high expectations for their technological superiority and fully appreciate their willingness to take on any challenge.

We are committed to increasing our competitiveness and evolving into a seaport that makes our customers happy.