Automation of Handling Systems in the Container Terminals of Maritime Ports

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Abstract Automation of handling systems in the container terminals of maritime ports has become one of the most important changes that happened in maritime transport since the first voyage of a container vessel in 1956. Nowadays, new automated terminals are being built in the world. Most of them are located in Europe, then in North America and the Far East. Automated guided vehicles, automated straddle carriers or automated stacking cranes have replaced handling devices that were manipulated and were controlled by port workers in the container terminals. The basic goal of the paper is to focus on the advantages of this progressive system that is based on the increase of the output of the container terminals, the reduction of downtimes or accidents during handling of containers.

Keywords maritime transport, automated container terminals, automated handling devices

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1. Introduction

Container terminals are facilities where containers are loaded, unloaded, handled, and transported by different types of container handling devices between different modes of transport. They are also stored in an open-air storage area for a few days before they are forwarded by sea or land transport to their customers. [1]

The output belongs to the most important indicators of the container terminals. It may be defined as the number of containers that are transhipped by handling devices for the monitoring period. It depends on:

- the dimensions of container vessels that sail into the terminal,
- the types of containers,
- the types of container handling devices,
- the types of container handling systems that are used in the container terminal.

During handling of containers various downtimes that decrease the output of the terminals arise. They follow from the breakdown rate and technical breaks of container handling devices, auxiliary operations that are related to the vessels such as anchoring and inspection of vessels, controls of the documents or containers.

The maritime ports have implemented various ways how to increase their output. One way how to do it is to automate handling systems in the container terminals.

2. Automated container terminals

Automated container terminals are terminals where some container handling devices operate without direct human interaction. Drivers of the cranes have been physically removed, or they have remained in their cabins but they are not needed for the entire duty cycle [2].

These terminals use some automated handling devices (automated guided vehicles, various automated stacking cranes or automated straddle carriers) that:

- transport containers in the water side transfer area from the wharf to the container yard (automated guided vehicles or automated straddle carriers),
- move containers between the water side transfer area and the container yard, the container yard and the land side transfer area and in the blocks of the container yard (various automated stacking cranes, automated straddle carriers),
- transfer containers in the railway terminal (station) located in the land side transfer area between semi-trailers and wagons (rail-mounted gantry cranes).

Automated container terminals differ the level of automation, the type of handling devices and systems. Some of them use only automated handling devices in the container yard. Automated stacking cranes (automated rail-mounted gantry cranes or rubber-tired gantry cranes) move and stack containers into the blocks of the container yard. These cranes can also transfer containers between the water side

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transfer area and the container yard or the container yard and the land side transfer area.

More modern automated container terminals also use automated handling devices that are located in the water and land side transfer area. Automated guided vehicles or straddle carriers that are located in the water side transfer area transport containers between the wharf and the blocks of the container yard. Automated / semi-automated stacking cranes that are located in the railway terminal in the land side transfer area transfer containers between road and railway transport. [3], [4], [5]

3. Automated handling devices

3.1. Automated guided vehicles

Automated guided vehicles (Figure 1) transport containers from the wharf to the blocks of the container yard. Their movements are controlled by the terminal computer system. They follow the reference points (transmitters) located into the floor of the water side transfer area (greed navigation system). They also use the laser navigation system that prevents their mutual accidents.

Automated guided vehicles belong to the group of the passive handling devices. They do not load, unload containers like other handling devices. They only transport containers between cranes and the block of the container yard. They can have diesel or electric engines. They are used into the container terminals due to the reduction of the accident rates, the number of port workers and the staff costs. [3], [4], [5], [6]

Figure 1. Automated guided vehicle in the Container Terminal Altenwerder in the port of Hamburg, source: author

3.2. Automated stacking cranes

In the container terminals two types of automated stacking cranes are being used and they can be located in the container yard or the land side transfer area.

The first type of cranes is used for stacking and movement of containers in the blocks of the container yard that are perpendicular to the wharf (Figure 2). They also tranship container between automated guided vehicles and the blocks of the container yard or between the blocks of the container yard and trucks.

The second type of cranes is used on receipt and delivery operations in the land side transfer area. They usually have large spans and may stack containers up to 6 tiers. They tranship containers between trucks and wagons. [3], [4], [5]

Figure 2. Rail-mounted gantry cranes in the Container Terminal Altenwerder in the port of Hamburg, source: author

3.3. Automated straddle carriers

Straddle carriers have a wheeled frame that lifts and transports containers within its framework. They can stack containers up to 3 tiers.

In the automated container terminals, they are not widespread handling device. In the world only few terminals have used them so far (automated container terminal Patrick in the port of Brisbane, Australia or terminal TraPack in the port of Los Angeles, USA). [3], [4], [5]

4. World Automated Container

4.1. European automated container terminals

In Europe there are the most automated container terminals in the world. Most of them are located in the port of Rotterdam.

The port of Rotterdam is the largest maritime port in Europe. It is the gateway for cargo transported from Asia or America to Europe. It is located on the banks of the New Meuse and the coast of the North Sea. It is also the largest container maritime port in Europe.

The automated container terminals are located in the parts called Maasvlakte 1 and 2. In Maasvlakte 1 there two automated container terminals: ECT Delta and Euromax. The ECT Delta Terminal was the first European automated container terminal. It has been using automated guided vehicles since 1992. It also uses automated stacking cranes in the container yard. The handling system (Figure 3) consists of container gantry cranes, automated guided vehicles, automated rail-mounted gantry cranes, straddle carriers and trucks. Container gantry cranes transship containers between a container ship and automated guided vehicles. These vehicles transport containers from the wharf and to the blocks of the container yard. Each block is equipped with an automated rail-mounted gantry crane that transfers containers between automated guided vehicles and the block. It also manipulates containers within the block. Straddle carriers handle the containers between the block of the container yard and trucks. In the terminal there is also a railway terminal where containers are loaded on the wagons by rail-mounted gantry cranes and are transported to the hinterland by railway transport.

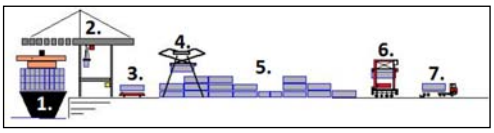

Figure 3. The handling system in the ECT Delta Terminal, source: http://www.ect.nl

The Euromax Terminal Rotterdam is another automated terminal in Maasvlakte 1 that uses automated guided vehicles. The basic difference between ECT Delta and Euromax is that each block of Euromax is equipped with two automated stacking cranes. The first crane transfers containers between automated guided vehicle and the block of the container yard, the second crane transships containers between the block of the container yard and trucks (Figure 4). In the land side transfer area of the terminal there is also the railway terminal (station) where containers are loaded on

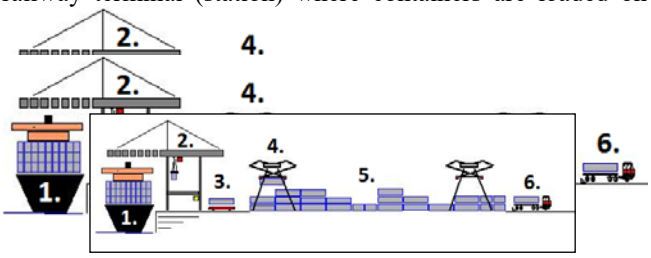

Figure 4. The handling system in the Euromax Terminal Rotterdam, source: http://www.ect.nl

Two new automated container terminals that are located in Maasvlakte II (APM and Rotterdam World Gateway) were opened after 2013. They also use automated guided vehicles and automated stacking cranes for handling of containers. [7], [8]

The port of Hamburg is the third important container port in Europe after the port of Antwerp. It is located on the banks of the Elbe River. In the port there four container terminals, two of them are automated terminals: The Container Terminal Altenwerder (CTA) and the Container Terminal Burchardkai (CTB).

CTA is one of the most modern terminals in the world. It was opened in the operation in 2002. It is located in the southern part of Hamburg. Four Post-Panamax ships can anchor at the wharf. The handling system of CTA is the same as the handling system of Euromax in Rotterdam and consists of gantry container cranes, automated guided vehicles, automated stacking cranes on rails and semitrailers. In the land side transfer area there is also the railway terminal where containers are handled by rail mounted gantry cranes between semitrailers and wagons.

CTB (Figure 4) uses automated handling devices in the container yard. Each block is equipped with three automated rail-mounted gantry cranes (two of them have smaller gauge, one of them has bigger gauge). The first one moves the containers between straddle carriers located in the water side transfer area and the blocks of the container yard. The second one moves the containers within the block of the container yard. The third one moves the containers between the blocks of the container yard and semi-trailers. In the land side transfer area there is also a railway terminal where rail-mounted gantry cranes transfer containers between trucks and wagons. [9]

Figure 4. Container Terminal Burchardkai, source: author

Automated container terminals are also located in the port of Antwerp in Belgium and port of Algeciras in Spain.

4.2. American automated container terminals

In Los Angeles there is an automated container terminal TraPac. The port of Los Angeles that is situated on the coast of the North Pacific is the largest port in the USA. The Terminal TraPac (Figure 5) is the first automated container terminal on the West Coast of the USA. This terminal uses automated handling devices such as automated straddle carriers and automated rail-mounted gantry cranes. The handling system consists of some container gantry cranes, automated straddle carriers, automated rail-mounted gantry cranes, semi-trailers or wagons. Container gantry cranes transfer containers between a vessel and the terminal. Then, fully automated straddle carriers transport containers from the wharf to the container yard. These automated straddle carriers are guided by terminal logistics system that consists of thousands of magnets, laser sensors and GPS for monitoring of container movements. In the container yard electrically powered rail-mounted automated stacking cranes move containers in the blocks. In the land side transfer area these cranes load containers on trucks that transport them to the hinterland. In the terminal 35 per cent of containers are transported by railway transport. [10]

Figure 5. The TraPac Terminal, source: www.youtube.com

Another automated container terminal is in the port of Norfolk that is located on the south bank of the Elizabeth River in Virginia.

4.3. Australian automated container terminal

In Australia there is the only one automated container terminal Patrick that is located in the port of Brisbane. The

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port of Brisbane is the fastest grooving container port in Australia. It is situated in the estuary of the Brisbane River. The terminal Patrick was the first terminal in the world that started using automated straddle carriers in the world. It has got two berths; Post Panamax gantry cranes that transfer containers between a container vessel and the terminal. Automated straddle carriers move containers within the land of the terminal. They do not only stack containers but they also transport and handle with them. Their advantages are their long life cycle and energy saving. [11]

4.4. Asian automated container terminals

In Asia there are some automated container terminals such as the Terminal International in the port of Hong Kong, the Terminal Newport in the port of Busan, the Terminal Evergreen in the port Kaohsiung, the Terminal Tobishima in the port of Nagoya and the Terminal Pasir Panjang in the port of Singapore. These terminals use some automated handling devices (automated rail-mounted gantry cranes) in the container yard.

The Terminal Tobishima uses some automated handling equipment (automated rubber tired gantry cranes and automated guided vehicles.) in other parts of the terminal.

A new automated container terminal was also opened in China in the port of Qingdao. This terminal uses automated handling devices in the water side transfer area and the container yard. This terminal was opened in 2017. [3]

5. Conclusions

World automated container terminals increase the output, they reduce the downtimes of handling devices, times of container vessels in maritime ports and accidents that happen during transshipment of containers. They differ the level of automation, the type of automated handling devices that are used for handling processes and handling systems.

The most modern container terminals are located in Europe. They use automated handling devices in the water side transfer area and the container yard. Automated guided vehicles transport containers between the water side transfer area and the blocks of the container yard. Automated stacking cranes (automated rail-mounted gantry cranes) handle with containers within the blocks of the container yard or between the yard and other parts of the terminal. The port of Rotterdam that is the largest maritime port in Europe has got the most automated container terminals in the world. They are located in new parts of the port - Maasvlakte I and II.

Some world automated container terminals only use automated handling devices in the container yard. Automated stacking cranes (automated rail-mounted gantry cranes handle containers in the blocks of the yard or transship containers between the blocks and trucks / other handling devices (CTB, Hamburg).

Only a few automated container terminals use automated straddle carriers. The first one is the Terminal Patrick in Australia, where these devices carry out all operations with containers within the land of the terminal. The second one is the Terminal TraPac in Los Angeles that uses automated straddle carriers for transport of containers between the water side transfer area and container yard.

In spite of the fact that the costs for the construction are so high, new automated container terminals are being built in maritime port due to their high efficiency.

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