Cranes with brains

Euromax – The modern automatic container terminal

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Containerization has been a catalyst in the growth of global trade. One of the ingredients of its success is that it has driven down transportation costs significantly – to the point that shipping accounts for only a small part of the product's price-tag. To further raise productivity, the ports of the world are seeking to automate handling.

In a modern container terminal more than 10,000 boxes are moved every day. Every one of these moves is unique – it has to be performed quickly and to the right destination without interfering with other containers, cranes or vehicles. These moves were previously performed using manually operated equipment – but technology from ABB now facilitates the full automation of these operations.

The shipping container – which was introduced during the 1960ies – has revolutionized shipping and port operations. During 2006, the world's ports will handle approximately 300 million containers, shipping an innumerable variety of products. With the push for increased productivity and enhanced efficiency, the automated handling of cargo is becoming a necessity.

The introduction of the shipping container has reduced costs and significantly increased the volume of goods that is being transported by ship. Sea containers are 8 feet wide and 8,5 or 9,5 feet high. The most common container lengths are 20 feet long – defined as one TEU (twenty feet equivalent unit) and 40 feet (2 TEU). Before the container was introduced, the on and off-loading process was so slow that ships had to remain in port for weeks at a time. Today, a large container ship carrying a total of 6000–9000 TEUs can typically exchange 4000 to 5000 TEUs (up to 50,000 tons) in less than 24 hours.

This breakthrough in efficiency has been an important factor in the rapid globalization of world trade and manufacturing. Transport costs now make up a very small part of the product's price-tag.

In recent years, automation has revolutionized many industries. Port operators have been slower to take advantage of automation. The size of the containers, cranes and terminals as well as around the clock operation in

all kinds of weather conditions, present substantial challenges. This has called for development of dedicated equipment and control concepts.

Today proven automation technology is available to reliably handle the machines and conditions required for efficient and economical operation . . .

ABB takes the lead

ABB is leading the way in the automation of the container port industry, resulting in better utilization of resources and reduced costs for the ship owner, the port operator and, ultimately, the consumer. ABB has delivered automation and electrical systems to a large number of automatic yard cranes and ship-to-shore cranes all over the world – thereby becoming the market leader in this segment. ABB played the leading role in supplying 52 fully automated yard-cranes to Container Terminal Altenwerder (CTA) in Hamburg (title picture) – the most advanced container terminal in the world – operation of which started in 2002.

This year, automation systems for six yard cranes in the port of Kaohsiung, Taiwan have been put into service, and deliveries to the large Euromax project in the Dutch port of Rotterdam have begun.

Euromax

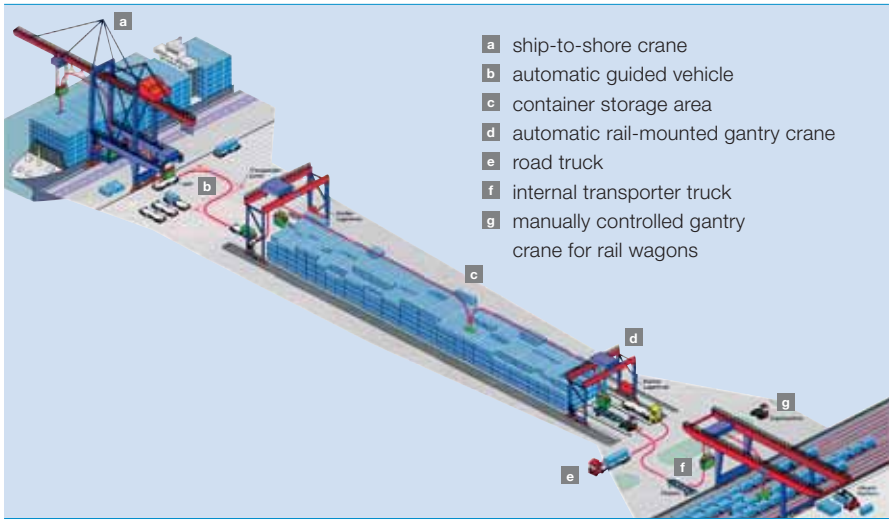
The Euromax shipping terminal is a joint venture by Hutchinson-Whampoa of Hong-Kong, and AP Möller of Denmark – two of the largest terminal operators in the world. Their objective is to design, build and operate a new terminal in Rotterdam, utilizing advanced technology in order to keep ship berthing times short and cost per handled container low.

During 2005, potential suppliers for the automatic terminal were evaluated. ABB won the order for electrical and automation equipment, with Zhenhua Port Machinery Company (ZPMC) of Shanghai, China, being chosen for the mechanical part of the cranes.

Process flow in Euromax

The process flow 1 and the types of cranes used, will be basically the same as what is used in CTA. Containers are unloaded/loaded from the vessel by means of a ship-to-shore crane (STS) 1a 2. Such a crane typically weighs 1500–2200 tons and makes 35 to 50 moves per hour. In each move one to four containers are trans-

1 Container handling within an automatic terminal



2 With modern ship-to-shore cranes a ship with 4000-5000 TEU (twenty feet equivalent) to unload/load can be handled in less than 24 hours

Euromax at a glance

Phase I of the terminal, built for 2,100,000 TEU/y, will be taken into commercial operation in 2007 and will require the following handling equipment:

- 12 large ship-to-shore cranes
- 4 barge cranes
- 58 automatic RMGs (rail-mounted gantry cranes)
- 2 manual RMGs for rail wagons

The ABB integrated crane control system includes:

- Over 300 ACS 800 crane drives
- 1600 AC motors from 10 to 700 kW
- Medium voltage switchgear and transformers
- Low voltage crane distribution
- AC 800 crane control systems
- Advanced sensors
- Terminal wide maintenance and monitoring
- Cameras and remote operating equipment

The crane equipment is fitted to the cranes at the crane manufacturer's site and is commissioned at the Euromax terminal.

ported between the ship and the dock. STSs are operated semi-automatic with a driver located in a cabin on the trolley about 50m above the quay. The container is automatically loaded on an AGV (automatic guided vehicle) 1b 3 which takes the container to a storage area 1c. This area is divided into blocks, each covered by two automatic rail-mounted gantry cranes (ARMG) 1d 3. The container is picked up by one of these and moved to the desired position in the block – this operation is performed fully automatically.

The location of the container in the storage area is chosen by the Terminal Operating System (TOS) – an advanced process control system from which the ARMGs receive their work-orders.

Containers to be forwarded by land are loaded onto road trucks 1e or onto internal trucks 1f for transport to a railway loading point 1g inside the terminal area. All operations of the ARMGs are fully automatic except the handling of road trucks at the land-side interface, where manual supervision of the movement is a safety requirement due to interaction with the truck driver. From when the load reaches a limit a few meters above a road truck, until it clears the same level on the way back to the container stack, the motion is controlled by an operator in a remote office 4 (one supervisor for eight to twelve ARMGs) using four to six compact cameras located on the crane.

Port operations

The key performance indicators for a container port are:

- Berth productivity – how fast is a vessel unloaded and re-loaded.
- Yard-crane productivity
- Number of containers handled per yard area
- Service time for road trucks
- Energy cost per TEU
- Labour productivity – how many containers per man-year

In order to meet these targets, several technical issues had to be resolved:

- Design of equipment for the harsh crane environment, enabling reliable operation with minimum maintenance
- Handling of large flexible crane structures
- Fast and accurate automatic operation
- Handling of ground/rail conditions allowing cost efficient civil engineering concepts
- Flexibility – handling of various container as well vehicle types
- Safe interfacing to manned equipment

3 Automated handling of containers using automatic guided vehicles and automatic rail mounted gantry cranes

During 2006, the world's ports will handle approximately 300 million containers.

ABB automation technology

The ABB standardized ARMG and STS crane automation packages are based on fast and accurate measurement of

- Load position
- Target position
- Obstacles positions

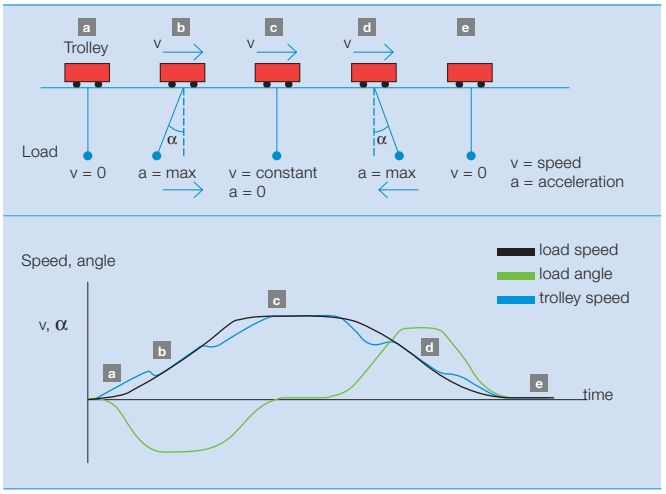
combined with advanced load control

4 Supervision of automated rail-mounted gantry cranes at CTA Hamburg

Load position measurement

The Load Positioning System (LPS) 5 consists of a camera equipped with a video processor and an infrared transmitter box mounted on the spreader. The transmitter includes a number of infrared markers, each of which the camera identifies to an accuracy of better then a millimeter.

5 The load positioning system uses infrared sensors to identify the precise load position



The control system then uses the positions of the markers to calculate the position and orientation of the load relative to the trolley. This information is used as feedback into the position and motion controllers to ensure maximum precision.

Target and obstacle position measurement

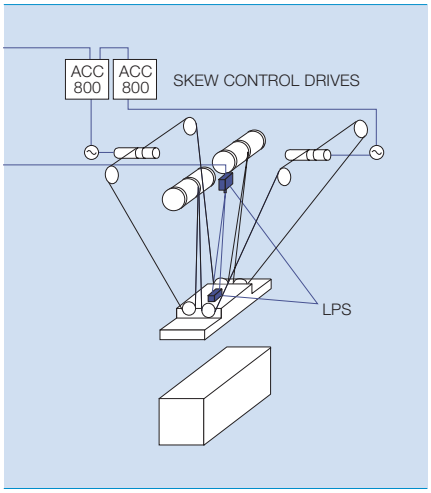
The TPS (Target Positioning System) uses a high precision laser beam that is directed by a series of controlled mirrors to enable three-dimensional scanning 6. In ARMG appli-

cations, one or two of these scanners are mounted on the trolley and used for a number of tasks within the automatic sequences. During automatic operations within the stack, the TPS is used to locate the exact position and size of the target container, check the clearance to adjacent stacks and verify the positions of the containers as they are stacked.

The TPS is also used to generate correction references when operating containers in transfer areas with both automatic and manually driven vehicles. Additionally, the TPS is used to identify positions of obstacles which can influence the path of the hanging load.

The LPS and TPS jointly enable the ABB yard cranes to swiftly and with a high reproducibility build stacks of loaded containers of up to 25m in height with a tolerance of just a few cm.

6 The target positioning system uses a precision laser and mirrors to identify with great precision the box to be grabbed



The Target Positioning System is used to locate the exact position and size of the target container, check the clearance to adjacent stacks and verify the positions of the containers as they are stacked.

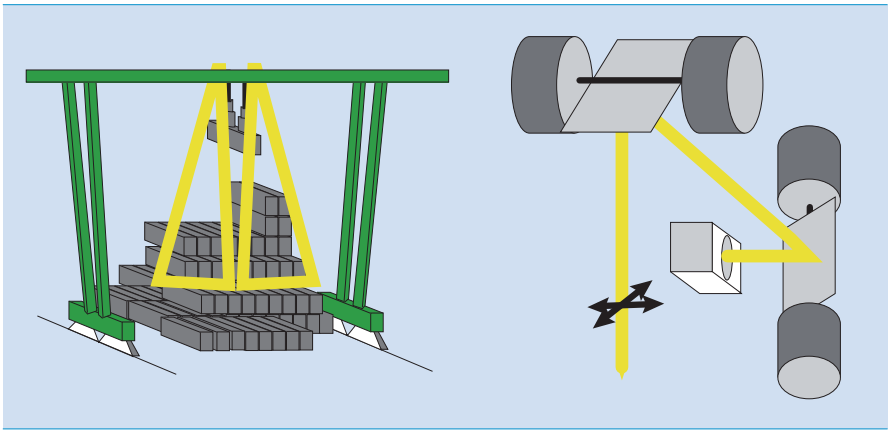
Load control

The ABB load control is based on a software model of the physics of the hanging load. This include algorithms to control the pendulum movements in trolley, gantry and skew (rotation around the plumb line) directions, which ensue every time a container is lifted and transported 7.

With the position feedback from the load position sensor external influences such as wind and asymmetrical loading can also taken into account. Optimum productivity is reached based on:

- Short but safe load path
  By traveling the shortest route, over the landscape of containers, substantial time is saved. The path is calculated based on measurements by the TPS.
- Fast approach to target
  The model based load sway and position control calculates the optimum approach for the load, with rope lengths of 3–50 meters and with trolley and hoist speeds of 300 m/min and 200 m/min respectively.
- Positioning without final adjustments
  The TPS provides continuous measurements of the target position enabling the load control to aim directly for the actual target position.

7 The automated movement of the trolley must take into account the sway of the container



Integration of information

Automatic cranes receive orders from the Terminal Operating System (TOS). The TOS optimizes the yard utilization, while the crane control system find the optimal transport path and is responsible for collision avoidance.

The crane control system manages the interaction with and deployment of remote crane operators. It also controls safe access for vehicles and staff into the automated area.

Large fleets of cranes makes it necessary to integrate the terminal wide maintenance and monitoring functions with the logistic and operations information. This provides operations as well as maintenance staff with a complete overview and control of the terminal as well as decision making support.

ABB and ports

ABB has developed an automation concept for container cranes enabling automation to be combined with efficient crane and terminal designs. Modern control theory ensures fast handling. Innovative sensors provide the flexibility needed in practical operation.

By providing standardized integrated systems including electrical and drive equipment and automation and terminal wide information management, ABB enables the rapid introduction of automation in new as well as existing terminals.

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