Embracing automation

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In the production plants of various industries, the chain from raw material to final product has been efficiently optimised to ensure uninterrupted production and maximum profitability. In this development, automation has played a key role. The same is now happening in container handling, where automation is expanding in the number of cranes and terminals but also in the level of functionality being delivered. Container terminals are becoming factories without roofs.

Automation is taking a major leap in many parts of the world. More and more container terminals are adopting automated solutions to meet the challenge of larger ships, taller cranes and bigger call sizes. This evolution changes the role of humans in the container handling process, from ship to gate. When automated systems are used, people are no longer continuously controlling the processes; instead they monitor, handle exceptions, and manage automated resources.

The container terminal's challenge

More 16,000-19,000 twenty-foot unit (TEU) ships are introduced in the Asia-Europe trade every month. Within the next two years, the average ship size in this trade will reach 14,000 TEU. In addition, cascading of ships together with a lot of new 9,000 TEU ships will result in a doubling of the average ship size used in all other major trades within a few years time. Even if the trade volumes are expected to slowly increase, the number of loops and the number of port calls will decrease due to the increased vessel size. There were 35 vessels coming from Asia to Northern Europe in 2007 every week - this number is now down to 21 and is anticipated to continue to decrease. The challenge for the container terminals now is to handle fewer but very large calls. Shipping lines will not accept lower service levels or longer times at berths. Handling 20,000 TEU calls in 48 hours realistically requires a capacity of about 500 TEU/hour.

And along with larger container ships comes a need for larger cranes to be able to load and discharge larger ships, and to do that efficiently. The question is how to handle the operation of the giant cranes with lifting heights of 50 metres and more. And it does not stop here. Like many other industries with harsh working environments, the container handling industry needs to figure out how to remain an attractive work place for the future generations of port staff. Today all the industries are also seeking ways to increase energy efficiency to lower their environmental impact, and container terminals can do a great deal to improve their energy efficiency.

Automation as the response

The good news is that container terminals can meet the challenge by deploying advanced equipment and systems already available today. Crane and terminal automation is key to meeting the challenges the terminals are facing. It enables:

- an improved working environment
- safety for staff and cargo
- a lower environmental impact
- efficient land utilisation
- higher average and peak productivity
- reduced maintenance
- flexibility in handling varying volumes.

ABB has a long history of working with automated systems for cranes and terminals. More and more automation functions have been introduced over the years, which have allowed cranes to be partly or fully automated. Intelligent automation now enables the cranes to automatically adapt to changing circumstances optimising performance and output. In the case of automated stacking cranes, gates and crane OCR, the remote operation is exception handling only. When it comes to intermodal cranes, and especially ship-to-shore (STS) crane operation, the operator action is required for tasks within manned areas.

When it comes to lowering environmental impact, automation and energy efficiency go hand in hand. Automated cranes and increasingly also vehicles are electrically powered. This enables regeneration of power and optimisation of terminal power consumption over time. Automated equipment is operated following the most efficient paths and without unnecessary accelerations /decelerations, and huge savings can be made by reducing/ eliminating lighting in the terminals.

Magnificent view: The impressive fleet of fully automatic stacking cranes at Busan Newport 1-2 Terminal in Korea has been taking care of the yard operations since 2009. The terminal's latest extension opened for operation in 2012.

The quay operations

The STS cranes set the pace for the whole terminal. This means that the productivity of the fleet of STS cranes is extremely important for the commercial success of a container terminal. STS crane automation and remote control of STS cranes are currently two major trends that are profoundly reshaping crane operations. The main driver behind these trends is the need for cranes that have a lifting height of more than 50 metres. The need for such lifting heights is due to the larger ships, like the 18,000 TEU triple E class ships, being put into service. With ships of this size, the travel distance of the trolley also increases and this requires the cranes to be run faster to maintain the productivity level. Moving the human operator from the crane cabin and having him operate the crane by remote control and automation allows the full capacity of the cranes to be continuously utilised. It also opens up the possibility for the use of cranes with even higher speeds and accelerations yet to be built.

Automation for STS cranes consists of the following functions:

- continuous load sway and skew control
- ship profiling and optimum path control
- OCR identification of containers and vehicles
- measurement of vehicle position and guiding of vehicles
- automatic container landing on platforms, ground and vehicles
- single interfacing with terminal operating systems (TOS) for work orders, bay layouts, container and vehicle information.

Today, these functions are available for all types of STS cranes including double trolley and/or double hoist/tandem spreader cranes.

Top: Fast and safe: APS Technology Group's gate automation system at Port of Houston; Below: Control with comfort. ABB's new Remote Control Station for remote monitoring of automatic cranes and handling exceptions.

There is a clear market trend towards cranes that can handle multiple containers. For instance, in 2013-2015, ABB has and will deliver automation systems, including automatic landing on the quay side, for 33 cranes with double trolley and 46 cranes with double hoist or tandem operation.

To date, the largest cranes have double trolley and double hoist and a lifting capacity of 130 tonnes under spreader. The automation makes these complex machines manageable for operators and terminal logistic systems, ensuring uninterrupted production with high productivity.

Production records verify that automation improves productivity and is also 'machine-friendly' since it runs the operation smoother than a human operator and leads to less damage to the equipment. This also reduces maintenance costs for machinery such as spreaders. In a simulated environment exact comparisons can be made running the same scenario with and without automation functions. Simulations verify that a really inexperienced operator using automation reaches a higher productivity than an experience operator working in manual.

The yard operation

When the speed is geared up at the quay, a fleet of coordinated automatic stacking cranes becomes a necessity. The yard must be able to fully support the quay operation and deliver good service to landside transportation. During the last decade, many terminals have implemented highly-automated stacking cranes. In fact, the number of automatic stacking cranes delivered and equipped with ABB's automation system will exceed 500 this year.

Also, stacking cranes are continuously becoming larger and more advanced. Today, end-loading cranes are able to stack 5/6 tiers high and 10 wide, while the cantilever cranes typically stack 6 high and 10-14 wide. The handover to all types of vehicles can be automated when proper safety arrangements are implemented. In order to save time, the cranes operate using optimum path overlapping horizontal and vertical motion, and multiple cranes in a block are coordinated to avoid waiting times.

Stacking cranes equipped with intelligent automation are able to respond to varying seaside and landside volumes and ensure timely delivery of containers for quay and rail terminal processes. The scheduling function allows the cranes to optimise the use of the cranes within the block based on all known work orders and time constraints. This improves productivity and reduces empty travel, and through that, energy consumption.

From ship to gate

The large cargo quantities to be handled in a short period of time are a challenge for the whole chain from ship to gate. Advanced on-dock rail and intermodal facilities can be used to strengthen the chain. Intermodal cranes can be automated to the same level as stacking cranes and STS cranes. Using automated cranes and AGVs, it is possible to move a container from the ship via the stack to a rail wagon without using any manned machine in the process.

In a fully automated terminal, accurate information about container identity and location is of the utmost importance. It is important to eliminate inefficient and risky processes throughout the chain, for example, manual handling of truck, container and driver information at the gate. Also, for the STS cranes, manual handling of container and vehicle identification creates unsafe and inefficient hand-off processes.

By automating these transfer points with gate, rail and crane OCR solutions, the time spent on handling the containers is significantly reduced, greater inventory transaction accuracy is achieved, truck turn times within the terminal are reduced, and the safety is increased. In the Group Maritim TCB terminal in Buenaventura Columbia (TCBuen), where such a

solution was delivered by APS Technology Group, a member of the ABB group, STS crane productivity also increased by three moves per hour thanks to faster hand-off of the containers.

Remote operations from a control room

Today, remote operation and exception handling are an integral part of automation that enables humans to be separated from machines and moved from a dangerous and harsh working environment to the safety and comfort of a control room. The remote operation also creates an attractive working environment for the next generation of port staff, increasing productivity and ensures that the operators do not develop health problems due to poor working environment.

ABB has developed new, ergonomically designed remote control stations for operators monitoring and supervising the automatic cranes and for handling exceptions. The layout of the joysticks and controls in the remote control station is the result of careful ergonomic analysis of operators' work flow and cooperation with crane operators. The controls are positioned in a way that supports the operator's natural work flow.

In addition to a clearly improved working environment, remote operation increases productivity, improves safety, and reduces energy consumption:

- on-board cameras provide better views than what is possible from the cabin in situations like landing containers on a ship/vehicle or handling hatch covers close to ground
- remote operation supports seamless operation without any loss of time at shift changes/breaks
- remote operation eliminates time and cost for transportation of staff to cranes
- with remote operation, all cranes are immediately available. For example, moving four containers from a feeder vessel takes a few minutes instead of up to an hour when you do not have to move the operator to/from/between crane(s).
- no need to change to special clothes and gear.

The team

There is one additional benefit with operations from a control room that deserves to be highlighted in this context. Remote operation means that the team comes together in one location. The terminals are run by a team of motion, logistics and maintenance specialists who handle the planning and manage exceptions together. This results in a new level of collaboration and team spirit since everyone easily interacts and shares the same view. Systems like the ABB Terminal View provide an overview of the entire terminal. This enables a multidisciplinary group to identify bottlenecks, which optimises processes and sets priorities to increase terminal productivity.

Outside the box

In 2012, the container handling industry made history. Terminal operators at three greenfield terminals placed the first volume orders for remote controlled STS cranes. The projects now being completed are all based on ABB's pioneering remote controlled STS installation in Panama, which has been in operation since 2010.

The 43 remote-controlled cranes ordered for these terminals corresponded to some 20 percent of all STS cranes in the world ordered that year. Almost all of these cranes have 50 metres or more lifting height and will all utilise automatic functions to a maximum extent. This is especially true in the case of the two Maasvlakte II terminals, where double trolley cranes are employed and enable full automation on the landside. Some of the cranes will be delivered without the driver's cabin, which makes the trolley lighter and eliminates the cost of the cabin, cabin equipment, air-conditioning and cabling.

Examination of the cranes and other equipment terminals have ordered recently shows that the industry is moving towards more advanced equipment, integrated systems and automation, involving the whole chain from ship to gate. Automated horizontal transport is being delivered to several terminals. The automatic stacking cranes are the forerunners of automation and are now moving the automation frontier to new regions like Central America with projects in Mexico and Panama. For example, the Manzanillo Terminal in Panama is strengthening its yard crane fleet with six automated cantilever stacking cranes, which will operate alongside the existing RTGs, significantly increasing the container handling capacity of the terminal.

The changes that we now see in the industry are based on urgent needs and the availability of suitable technologies. This means that we will see a fast transformation of our industry within the next few years.

About the author

After graduation from the Chalmers University of Technology in Gothenburg, Sweden with a Master of Science degree in electrical engineering, Uno Bryfors joined ASEA (ABB) in 1981 as a development engineer. Prior to his current position as vice president of Crane Systems ABB AB, Uno Bryfors was the manager of the R&D department at crane systems and responsible for the introduction of automation and un-manned operation of harbor cranes.

About the organisation

ABB Crane and Harbor serves customers in container and bulk cargo handling. Based on its in-depth experience on terminal operator's processes and operations the unit provides complete automation and electrification systems for new installations, upgrades as well as modernization of existing systems. ABB's automation and electrification solutions increase the terminals' productivity allowing short turnaround times for even for the biggest vessels.

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