Retrofits:
New life for an old crane

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Sooner or later, the owners of port cargo handling equipment are going to face a number of technical and organizational questions about the future. After 15-20 years of operation, the steel structure and mechanical components of most port lifting machines still function well. However, these cranes often become obsolete for several reasons:

1. Lack of spare parts and technical support for discontinued components. The next generation of electronics and computerized parts becomes available every 5-7 years.
2. More stringent safety requirements. Regulations for the safety of personnel, cargo and lifting equipment are tighter when compared with the rules of 15-20 years ago.
3. Improvements in ergonomic and operational design. Technological developments have given modern lifting machines a range of features that make the work of operators easier.
4. Environmental concerns. Modern companies and their customers want to reduce carbon emissions (such as those produced by cranes with a diesel genset) and use environmentally friendly materials in the manufacture of their equipment.

There is a need to bring old cranes into line with current requirements. In essence, crane owners at ports tell crane manufacturers that "we want our old cranes to have the same systems and features as new cranes, and it should not be expensive." An existing crane can have new technology added to it through a retrofit or a modernization. The main difference between the two methods is that the retrofit has a higher level of standardization, usually around 70-95%. In other words, a retrofit is mostly a ready-made standard product which is applicable to a specific model, make, or type of crane – sometimes even all the cranes in a terminal or company fleet. To install this product on a specific crane, it takes about 5-30% of the engineering work of a modernization. By contrast, a modernization is a unique product, designed for one crane only. The retrofit is a mass product.

If the retrofit can be applied to several cranes in a fleet, it only needs to be designed once, which provides significant savings, lowering the overall price, and making it a more competitive option.

The four reasons that cause cranes to become obsolete has guided development of the four main types of retrofits:

1. Drive and control system retrofits;
2. Safety-assisting retrofits;
3. Automation and operator-assisting retrofits;
4. Power supply system retrofits.

Each of these types of retrofits can be installed separately or in combination with other types of retrofits. For a deeper understanding of the retrofit concept, let's consider each type separately.

Drive and control system retrofits

Most of the old crane control systems which rely on technology such as contactors, relays, thyristor DC drives, and some frequency converter AC drives, are technically and physically outdated. Manufacturers no longer provide spare parts and technical support for obsolete components. Repair work for old electric and electronic components is quite expensive and sometimes not even possible. All this leads to crane downtime.

Owners with several identical cranes sometimes use one of them for spare parts. However, this cannibalizing can only ever be a temporary solution. When they have both old and new cranes in their fleet, owners quickly realize that the modern diagnostic systems on new cranes help identify faults faster, improving crane reliability and uptime. Even so, their old cranes are still in good condition and do not yet need to be replaced.

The question is: "How is it possible to keep the old crane reliable and improve its functionality on a budget?" The answer is: "Retrofits."
Konecranes has been adding retrofits to port cranes since 2013. Over the five-year period 2013-2018, the drive and control system retrofit was installed on 75 rubber tired gantry (RTG) cranes worldwide. The retrofit concept and scope were defined to maximize standardization in modular design and the specification of components. A standard drive and control system retrofit includes:

- New electrical control panels (including frequency converters) in the crane electrical room;
- New crane management system (CMS);
- New touch panels to replace obsolete operator displays
- Upgraded programmable logic controller (PLC) components to support Ethernet, Profinet and Profibus protocols;
- Updated PLC software;
- New 3G/4G modem for remote diagnostic and monitoring functions.

Figure 1 – RTG electrical room before (left) and after (right) a drive and control system retrofit

Optional extras in the drive and control system retrofit are:

- New braking resistors for frequence converters;
- New trolley cable (or festoon);
- New operator control devices (e.g. change analog joysticks to digital).

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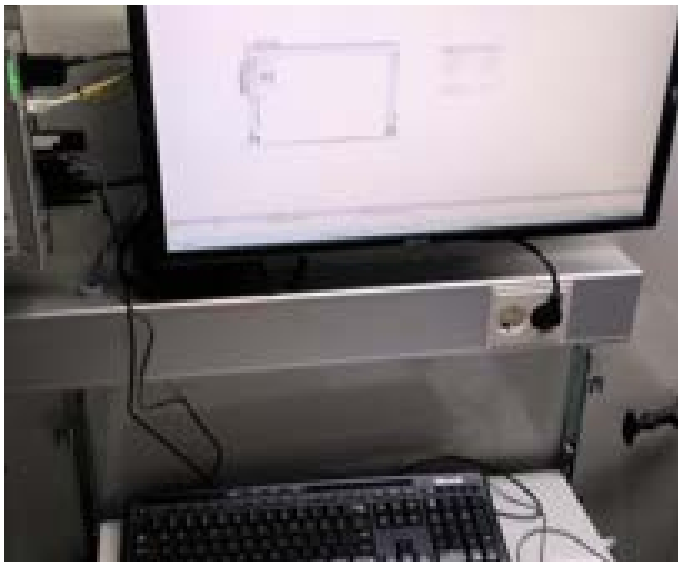

Figure 2 – Obsolete diagnostic display (left) and new CMS (right)

Other retrofits, such as safety, automation and power supply systems, can function as additional options for the drive and control system retrofit. The modular design of these retrofits make them easy to integrate into the general crane control and diagnostic system.

Konecranes assembles and tests all retrofit components at the company factory in southern Finland. All testing is done before shipping to reduce equipment downtime. Depending on the options, a retrofit will keep the crane out of service for an average of 7-10 days during installation and commissioning.

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A drive and control system retrofit is an efficient and economical solution. At only 15-30% of the price of a new crane (depending on the options), a customer gets a crane with new, modern control and diagnostic systems, remote monitoring functions and full spare parts support from Konecranes. It uses high-speed standard data transfer via Ethernet and Profinet, and a modular PLC software structure allows smooth integration with other systems. For example, a crane could be connected via Ethernet with the terminal operating sys-tem (TOS). This lets the TOS exchange data with the crane, which is the first step towards terminal automation.

Figure 3 – Electrical panels on testing stands at the Konecranes factory

Safety-assisting retrofits

Modern crane safety systems are not limited to overload protection and limit switches, like it was 20 or 30 years ago. Today, laser scanners, GPS sensors, video systems, machine vision, and other smart technology is available. Computer-based safety systems allow operators to monitor the area around the crane in real-time, identify potentially unsafe situations early and even intervene in the crane control system to prevent potential accidents.

The safety systems currently used on the new Konecranes STS/RTG/RMG cranes can be easily retrofitted onto older cranes. For example, Gantry Collision Prevention uses laser sensors installed on the crane's bogies to scan the surrounding area and the travelling path of the crane to help operators avoid potential collisions with other objects such as trucks, container stacks and other cranes. The control system of the crane receives data about nearby objects – position, size and distance away – from the scanners, and slows or stops the crane based on that data and its own gantry speed. Compared to the old systems based on linear beam infrared sensors or limit switches, the laser sensors are far more accurate.

Gantry Collision Prevention can be integrated into any brand of crane with any control system based on a PLC or even contactors. If the crane uses contactor-based controls, the laser sensors can be connected to the crane's electrics in the same way as a limit switch.

Another example of a safety-assisting retrofit based on laser scanners is Stack Collision Prevention, which prevents the spreader (or a container attached to it) from colliding with the container stack under the crane. Laser sensors scan the stack under the crane so the control system can slow or stop crane movement that might hit the stack.

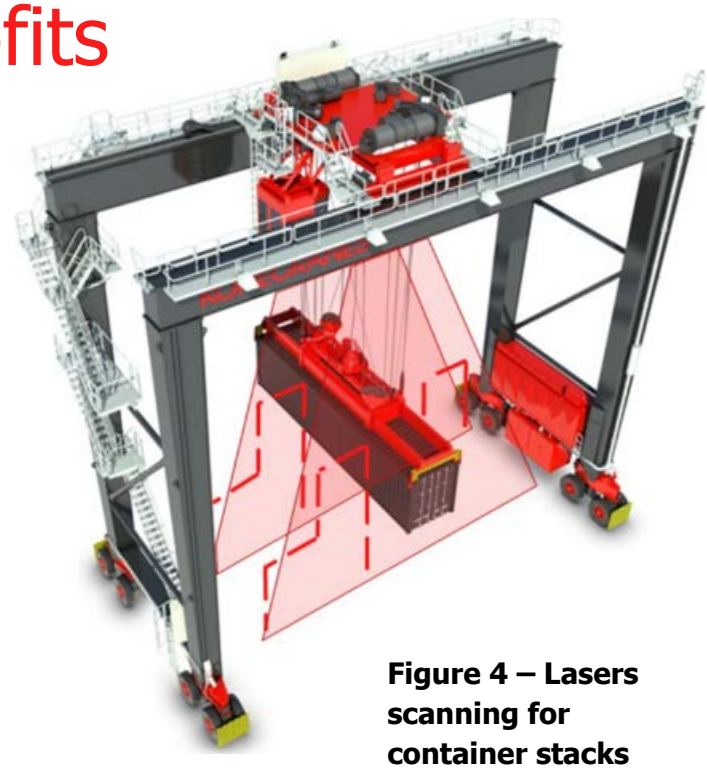

Figure 4 – Lasers scanning for container stacks under an RTG crane

A single collision can be very expensive: one fallen stack has the potential to injure personnel, damage goods, and lower the reputation of the business. Stack Collision Prevention is a wise investment to help ensure the safety and security of a busy yard.

Figure 5 – Possible consequences of a spreader colliding with a container stack

Crane automation and operator-assisting retrofits

Each crane operator is responsible for one cargo handling machine during its manually controlled operations. A huge number of factors, both external (surrounding the crane) and internal (control features and crane "behavior"), must be taken into account. So an ergonomic cabin with a comfortable driver's seat, easy-to-use controls, and good lines of sight are essential. This is why even something as simple as a seat replacement could be considered an operator-assisting retrofit.

In many cases, it is impossible for the operator to see the whole working area. Depending on the movement required, the steel structure of the crane, its load and surrounding objects can obscure the view from the cabin. The operator can be a significant distance from the load, but still needs to see it clearly for positioning. So a camera system on the crane can be very useful.

Careful planning ensures the right kind of camera for image resolution (clarity of picture), light sensitivity (day and night use), resistance to environmental hazards (vibration, moisture, dust, etc.); the optimal number of cameras; and the best installation positions on the crane structure to provide the operator with enough visual information to assist in crane control and improve safety. Displays installed in the cabin must be big enough and clear enough to provide a high-quality picture. A camera system retrofit can be applied to any type of crane. It is not connected to the crane's control system and integration is quite easy.

Auto-Steering for RTGs could be thought of as both an operator-assisting retrofit and an automation system. Without automatic steering, the crane operator must maneuver the gantry manually to prevent skew. Poor steering may lead to collision with a container stack (if collision prevention has not been installed). Auto-Steering is based on the Global Positioning System (GPS), with a position detection accuracy of ±2cm.

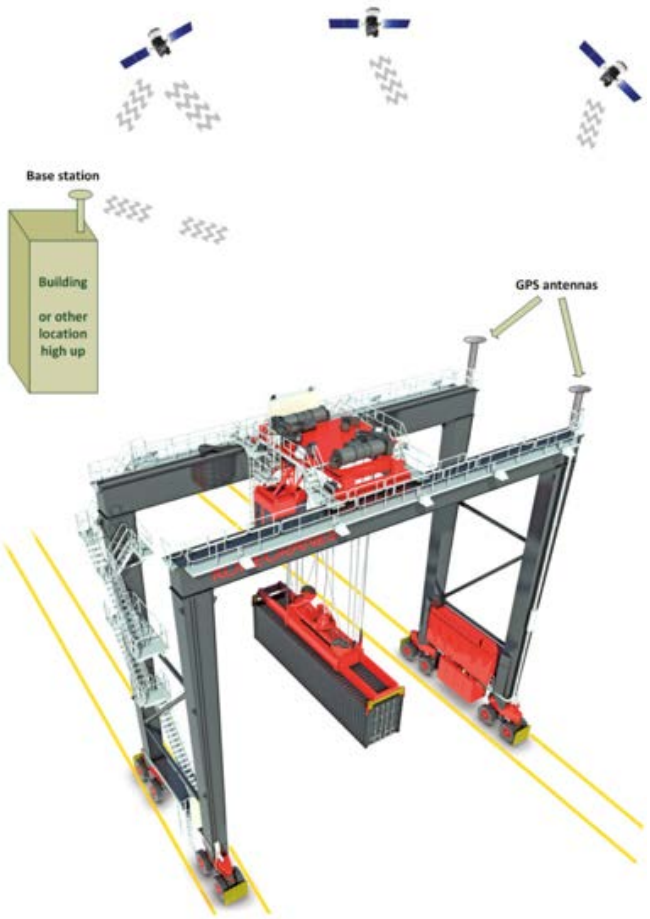

Figure 6 – Auto-Steering is based on GPS

Auto-Steering uses a base station with a GPS antenna located at the highest point of the container terminal (on the roof of the building or on a light mast). The base station is an unmovable, zero-point reference used to determine the coordinates of cranes, containers, and other obstacles. Each RTG is equipped with two GPS antennas located on the ends of the main girders on the same side of the gantry. Placed so that the line between them is always parallel to the crane's path, both antennas connect to the on-board computer through GPS receivers. The computer knows the coordinates of all possible paths of all mobile cranes at the terminal. By comparing the real-time coordinates of both antennas with its programmed path, the computer corrects the direction of the crane if it deviates from its planned route by more than 10 centimeters. The control system slows down one side of the gantry, keeping the crane aligned on its programmed path. Auto-Steering works so smoothly, the crane operator does not feel it, and can concentrate instead on the load. The retrofit can be installed on any RTG equipped with a PLC and either digital or analog electric drives.

Other automatic steering systems are based on lasers, video cameras, and so on. However, GPS opens the crane to higher-level automation. The next step is Auto-TOS-Reporting, which uses the TOS to exchange data with the crane about container location, employs the same components as the GPS steering system, and only needs some additional software. Following that is Auto-Positioning, which receives the exact coordinates from the TOS to find the location to place a container or pick one up. A simple touch control moves the gantry and its trolley to the required position in the stack. Automation then progresses through remotely operated crane to semi-automated crane and, finally, to the fully automated crane.

Power supply retrofits

As environmental regulations around the world have become stricter, the demand for power retrofits has grown. Reducing carbon emissions is the main goal of lower-emission diesel engines, hybrid systems (with batteries or supercapacitors for storage), or full electrification.

Full electrification of the crane, equipped with a diesel-electric power supply, is the most expensive but also the most environmentally friendly option. The high cost is due to the mechanical and electrical alterations to the crane coupled with adjustments to the yard infra-structure, including cabling, new transformers, crane feeding, and so on.

Cranes have not been using hybrid power systems for long, although the automotive industry has been installing them on cars for over 10 years. It uses a diesel-electric set with lower power, compensating for power consumption peaks with energy from storage. While the crane idles, the generator builds up the energy storage. A hybrid system saves fuel and causes lower emissions compared to conventional diesel-electric power.

However, hybrid power must utilize high-capacity energy storage to be efficient. Lithiumion batteries and supercapacitors are costly and have a limited lifetime. Sometimes, investment in a hybrid system never pays back because fuel savings are less than the price of the system. To mitigate this problem, some countries (such as the USA) provide funding for retrofits that reduce emissions. Owners of diesel electric cranes are very willing to retrofit their equipment to run on hybrid or fully electric power if the government will support them in the change.

The busbar and cable reel retrofits are the two main ways to convert an RTG crane to fully electric operation. A busbar retrofit needs a lot of yard modifications, including an electrified fence down the side of the yard, feeding points and other technical changes. For this reason, it is recommended for large terminals with a lot of cranes. On the other hand, most of a cable reel retrofit is attached to the side of each crane. The cable reel retrofit is recommended for small terminals.

Figure 7 – Electric RTG (e-RTG) with busbar

Conclusion

The main benefits of retrofits, when compared with conventional modernizations, are:

- Modularity – more standardized solutions with less custom design leads to cost savings and a lower price for the end customer;
- Integration – the same retrofit concept can be integrated into different crane types and brands;
- Succession – one retrofit opens the way to more retrofits, building on a long-term investment in automation and reliability.

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