

Smooth operator

Cranes with brains make life comfortable for one and all

Mikael Holmberg



A 20-year old crane system may appear relatively modern, but technology has advanced so much over this period that improvements in positional accuracy, reduced maintenance and higher reliability can all be achieved. While these productivity improvements add to a system's attractiveness, they are not the direct driving forces behind the purchase of crane systems. In the minds of a company's Executive Committee, the overriding concern is health and safety.

Throughout the world many crane systems are now out of date, something which could compromise the safety of crane drives and factory personnel. As zero accidents are the undisputed target, a modern crane control system needs to carry all the functionality that easily meets this goal.

ABB can help to achieve this. The company is recognized for its experience in designing and developing top quality products for crane applications. The combination of an ABB industrial drive and a newly developed crane control program is designed to meet the safety and performance demands placed upon a crane control system. With this combination, the customer has a system that reacts much better than the one before.

The phrase “trying to please all of the people all of the time” is a tough call for any business. But that is precisely what ABB’s engineers had to consider when designing the latest version of the bespoke crane software for its range of ABB industrial drives **1**. Five very diverse customer types need to be satisfied when designing crane systems: the board of directors; the electrical engineering department; the maintenance department; the crane operator; and finally the factory floor personnel. The one demand each makes upon a control system is “comfort,” yet each has a very different comfort zone with little or no room for compromise.

One of the attractions of the ABB industrial drive is the performance offered by ABB’s motor control platform, known as direct torque control (DTC).

Comfort in the board room

Throughout the world many crane systems are now out of date. As health and safety concerns and the need to meet legal obligations top the list of priorities for most companies, a crane control system is needed that can accurately control the movement of the hoist without endangering the lives of the crane operator and other factory floor personnel. This means the system should be able to handle non-requested movements. In other words irrespective of whether the hook is empty or full, the crane control system must be able to regulate speed and torque to respond to the maximum and minimum speed limits. However, it can cost tens of thousands of dollars to refurbish a large hoist crane, and determining a return on investment purely in terms of productivity improvements can be difficult, if not impossible.

Therefore choosing the right company is imperative. Experience and know-how are essential if the required targets are to be met, and ABB has these in abundance. ABB is recognized for its experience in designing and developing products for crane

applications, using the most modern technology including variable-speed drives and their associated software.

Comfort in the electrical department

Sandwiched between the expectations of the crane operator and that of the board of directors, the electrical engineering department undoubtedly faces the most demands. Not only is it concerned with the health and safety of the factory but it is also charged with maximizing productivity. Using a solution that combines an ABB industrial drive with the newly developed crane control program, the electrical department can easily meet these safety and performance demands.

Turning the old into the new

The modernization of older crane installations begins by looking at the type of motor used to lift the loads. Heavy duty AC slip-ring motors have been widely used in industrial crane drives and are available for currents up to 4,000 A. While effective in harsh environments, these motors do not have the torque and speed versatility¹⁾ of the more modern standard squirrel-cage induction motor **2**. When used with a low-voltage AC variable-speed drive, this induction motor provides

accurate and soft control, which in turn avoids erratic movements of the load. A variable-speed drive, such as the ABB industrial drive, provides a good torque response, which is vital to load control **3**.

ABB’s crane control program, sometimes referred to as the “brains of the system,” is an optional easy-to-use software add-on for industrial drives.

Direct torque control

One of the attractions of the ABB industrial drive is the performance offered by ABB’s motor control platform, known as direct torque control (DTC), and its inherent safety and protection functions. DTC allows accurate control of both speed and torque with or without pulse encoder feedback from the motor shaft. One

Footnote

¹⁾ If the torque of a suspended load is not controlled, the load will swing and this could cause damage through uncontrolled impacts.

1 ABB is recognized for its experience in designing and developing products for crane applications.



Moving ahead

2 Electrical engineers are embracing the torque and speed versatility benefits offered by standard induction motors in crane applications.



significant advantage of DTC is that it can achieve full torque at zero speed without any feedback device. It controls torque with an accuracy of one percent from zero speed through base speed without encoder feedback²⁾.

DTC is ideally suited for use in crane control systems because it is designed for constant torque applications. A typical constant torque application is one where a load is suspended and the torque always remains the same – from zero to maximum speed and vice versa. As the load is lowered, the drive must constantly dissipate energy. A four-quadrant drive is needed to ensure that as a 300-ton load is lowered, energy can be fed back to the grid.

Crane control program

To further enhance crane safety and performance, ABB recently launched its crane control program as an optional, easy-to-use software add-on for ABB industrial drives. Some customers now refer to this program as the “brains of the system.”

While eliminating the need for external programmable logic control (PLC), this flexible and cost-effective software incorporates all the functions commonly required for hoist, trolley and long-travel motions in industrial harbor and tower cranes. A PLC would normally be used within the overriding control system to check the brake setting and the speed of the motor. However, the ABB industrial drive has a built-in PLC function,

thereby eliminating delays or risks, or communication errors.

For electrical engineers, ABB’s crane control program is extremely easy to start up, and this helps to keep total project costs under control. Multiple drives can be synchronized with an internal optical link, thereby reducing the need for separate controllers.

The crane control program supports remote monitoring and diagnostics by means of an intelligent ethernet module which provides access to the drive via the Internet.

Comfort in the maintenance department

In some industries, downtime can cost up to 1,000 euros per minute! Therefore reducing maintenance costs and finding highly reliable solutions are critical. The crane control program supports remote monitoring and diagnostics by means of an intelligent ethernet module which provides access to the drive via the Internet. However, the biggest advantage to the maintenance department of a variable-speed drive solution is a reduction in overall maintenance costs because of less mechanical wear and tear. When drives are installed on cranes, the mechanical wear becomes very small mainly due to their soft-start³⁾ nature.

3 An ABB industrial drive provides a good torque response, which is vital to the control of the load in hostile crane environments, such as steelworks.



ABB has also invested heavily in the research and development of control panels to make the user interface as easy as possible. For maintenance engineers this manifests itself through the control panel, displaying clear text warnings and fault status⁴⁾ so that immediate action can be taken **4**.

Comfort in the cabin

For a crane operator the ergonomics of the actual cabin are of the utmost importance. Clearly the need to sit in one place, often for long durations, demands a new design consisting of: comfortable and ergonomically correct operator seats; easily-cleaned hinged windows; air conditioning; and pneumatic or electric wiper/washer systems through to the temperature control of the cabin. Safety, ergonomics and comfort are essential in ensuring optimum crane operator efficiency, and these are provided by:

- The joystick
- Braking
- Torque memory
- An anti-collision system

Joystick

The interface with the crane control system is mainly via a joystick and

Footnotes

²⁾ However, for additional safety on hoist drives an encoder can be used on the motor shaft to measure the real position of the crane rather than relying totally on the motor model.

³⁾ Soft starters provide smooth and controlled starting and stopping operations. They are used to avoid rough and jerky motor starts, high starting currents and torques, and high current and torque peaks.

this is the lifeblood of a crane operator. The joystick needs to be responsive, accurate and comfortable to use. ABB provides different types of joystick, and one such example is a four-step, potentiometer joystick which features push-button, radio and independent control.

From the moment the power is turned on, the operator expects the system to give an immediate and rapid response. In other words, when the joystick receives a speed reference, it should immediately move the crane hook⁴⁾. ABB reckons the maximum tolerable delay before an operator becomes frustrated is 300 ms.

Braking

The operator must also have confidence in the crane movements he is commanding. When starting the hoist, for example, braking is a must and not an option. A mechanical brake is used to hold the load firmly in place. When the drive starts the motor, there is a need to carefully order the release of the brake. If the brake is released too early, the load will fall uncontrollably. It is therefore essential to achieve maximum torque at zero speed, a role that belongs to the DTC. ABB's crane control program assists in this area by using a function called torque memory.

ABB's industrial drive and its crane control program are combined to meet the safety and performance demands placed upon a crane control system.

Torque memory

The torque memory feature helps to provide safe and reliable mechanical brake control by being part of a system that ensures the hook does not drop during the start-up sequence. To be more specific, the integrated brake control logic utilizes torque memory and premagnetizing to open and close the mechanical brake safely and reli-

ably. The mechanical brake is applied using a spring and is electrically released when the drive system has been started and torque applied to the motor shaft. The software can accommodate different start torque methods, and it also includes a brake monitoring function for start, stop or running sequences. Furthermore, low speed is required at the start of the lifting operation. When the motor is started, full torque is available and this must be controlled at low speed. To ensure precise and accurate movement of the load, the brake is opened and the speed is ramped up.

ABB's crane control program also has an extended run-time feature. When the crane stops, flux remains on the motor (adjustable time). If this flux is not removed (through braking), the time taken to complete the next crane start up is considerably shortened because there is no need for premagnetizing.

Other features of the crane control program include the ability to check the position (open/close) of a mechanical brake. For example, when the line supply fails or is not available or when fuses blow, the brake must close. In other words a brake must operate effectively when no voltage is applied.

Additionally, ABB's industrial drive also features good security measures

to warn the crane driver. If, for example, the mechanical opening or closing of a brake is problematic, a small proximity switch indicates the brake position. The operator receives a warning and is given sufficient time to react by safely lowering the load to the ground. Similar challenges arise when stopping the crane. If the brake is closed too soon, the load jumps. It is essential, therefore, to gradually and softly reduce the speed while maintaining full torque and then to close the brake. Once the brake is applied, the flux can be removed from the machine.

The crane system will automatically do a functionality check before any demands are placed on it. Checks are conducted on all electrical functions to make sure they are in good condition as well as on the mechanical brake to ensure it is operating without slippage.

The crane control program contains a torque memory function that helps to provide safe and reliable mechanical brake control.

Anti-collision system

To avoid collisions, cranes are fitted

⁴ The simple user interface of the drives control panel means maintenance engineers can rapidly respond to warnings or changes in control performance.



Footnote

⁴⁾ This is achieved through an external 24 VDC to the software boards.

Moving ahead

with an anti-collision system with limit switches at the end of the track. Collision prevention is laser controlled and as the drive approaches the end positions, the speed decreases, falling to zero if necessary. High- and low-limit sensors stop the drive at these end positions. The “slow down” safety control function limits the speed to a preset level in critical zones. In emergency situations, a “fast stop” safety control function is used.

A speed monitor function ensures that the crane motor speed remains within safe limits. A speed matching function continuously compares a speed reference and the actual motor-shaft speed to detect any difference. One of these functions will stop the motor immediately should a fault occur.

Operator satisfaction

Installing a new control system can sometimes lead to a psychological game between the crane designer and the operator. In many cases, an operator is able to adapt his technique to compensate for any inefficiencies in a crane system with poor accuracy and responsiveness. The introduction of a new and highly responsive system (even with push buttons and joysticks familiar to the operator) often leads to operator discontentment.

There are two approaches in dealing with this problem. The first involves training operators on a crane fitted with an ABB drive. The second and perhaps the most convincing approach is to change the cockpit entirely. In essence, a new control system changes an operator's feeling for the crane,

giving the impression of operating a different or even a “new” crane. In all likelihood, a new cockpit would speed up an operator's adaption process. According to one customer, this approach “can be more important than the drives. Because the crane operator loses his references and has to get used to a new control system, it can be beneficial to change the physical look and feel of the cab. Otherwise they say the crane is not working well when in reality it is much better.”

Comfort on the factory floor

With large diameter drums – weighing several hundred tons – suspended and moving above the factory floor, personnel need to be assured that the load will not fall or swing violently. This assurance is given by employing variable-speed drives to accurately control the motor. The result is that loads can now accurately align slabs in blocks **5**.

5 The benefits of a drive/motor-software combination from ABB is readily visible for crane operators and factory floor personnel alike.



With each crane revamp, ABB undertakes to provide a system that reacts better than the one before. Even though measurements are taken prior to and after a revamp, it is often the case that these are not needed as the improvements more than speak for themselves.

Perhaps it is possible to please all of the people, all of the time, after all!

Mikael Holmberg
ABB Drives
Helsinki, Finland
mikael.holmberg@fi.abb.com