Frequency control of crane hoist speed.

Using the frequency of the rotor voltage to determine the speed of hoisting or lowering crane rather than vulnerable tachometers is increasingly employed for heavy duty cranes where encoders are not desired, and for retrofitting all kinds of cranes with slip-ring motors.

Drive systems based on slip-ring AC motors and ASTAT speed control from ABB are widely used in industrial cranes.

The voltage of the stator is usually controlled with thyristors. To ensure stable control of the load, the control system requires information about the motor speed. Up to now, tachometers or encoders have been used to measure the motor speed, however, tachometers, with their associated equipment, tend to be mechanically sensitive and are often difficult to install, due to space constraints. The new control concept overcomes the sensitiveness and other constraints by using the frequency of the rotor voltage to determine the speed. It is expected to be widely used for heavy-duty new cranes where encoders are not desired and for retrofitting all kinds of cranes with slip-ring motors.

ABB has developed and patented a new concept for determining the speed of slip-ring motors that overcomes the shortcomings of previous methods. The new concept is based on measurement of the rotor voltage. The voltage input signal is used to determine the frequency of the rotor voltage. It is then possible to calculate the slip and, from this, the rotor speed.

The concept includes a digital signal processor to suppress noise and power semiconductor harmonics in the measured voltage signal prior to making the calculations. It also transforms and filters the analogue signal input. In addition, the signal processor includes an A/D converter to give a digital signal output. A mathematical algorithm is used to determine the voltage frequency, slip and rotor speed. A microprocessor carries out the calculation and other functions, which gives a very robust design with no additional movable parts.

As the concept is based on real measurement and is not dependant of any motor construction parameter it is suitable for any slip-ring AC motors. It is especially suitable for crane motion drives as the speed signal is updated every 3ms when around zero speed and every 10ms for two-thirds of the motors nominal speed. In the highest speed range, open control is enabled.

ASTAT: -- crane motion controllers. (Control).

A new generation of digital crane controllers for slip ring motors which provide remote motion control, lower maintenance, networked diagnostics and are designed to work in harsh and hot industrial environments with little auxiliary equipment, such as cooling, is finding increasing application for new and revamped cranes.

ABB has been supplying ASTAT[R] control systems for slip-ring motors used in the drives for cranes and heavy-duty materials handling systems for 35 years. Employing the comprehensive experiences accumulated from over 6000 crane drives fitted with ASTAT control systems, and drawing on the latest developments in electronics and computer technology, ABB is now introducing the ASTAT Crane Motion Controller. This is available for current ratings of 25 to 2200A and supply voltages from 380 to 600V, 50/60Hz, AC.

ASTAT is not merely a system for controlling crane motors, but it is a Crane Motion Controller specially developed to meet the stringent demands of crane users in harsh environments such as those of steel mills. This is why it functions even when the temperature is as high as 70 [degrees]

C. The controller is already in a `naked' version designed for dusty environment with isolation EN 60664, pollution degree 4, which is better than the normal drive equipment.

Operation is also possible at down to 70% of the nominal voltage. ASTAT is consequently highly suited for crane drives in areas with a weak power supply. To enable economic system design in local diesel motor driven electrical generator (DG) systems, the line frequency allowed has a band of 20Hz, nominal +/- 10Hz.

Low energy & heat

The controller has a very favourable energy balance with well-balanced power losses compared to other concepts. Losses from the controller, cables and other equipment are very low. For this reason, together with the inherent ability to operate at elevated temperatures, the capacity of electrical room air conditioning is reduced or not required, with a consequential cost saving. ASTAT uses secondary resistors which can be short-circuited for normal speed operation, giving no contribution to loses. Energy is generated and returned to the grid when lowering the load at a speed slightly faster than the synchronous speed of the motor. The motor is in principle a Direct on line (DOL) in which the motor acts as if was classically connected to the supply without electronic control with short circuited (ie unused) secondary resistor.

Crane automation

In the process end, ASTAT is a standard fit with Pulse Encoder and Serial channel inputs for measurement. Beside that a number of digital in/out and analogue in/out (DI, DO, AI and AO) are fitted as the interface. Dual motion control such as Common Reference, Grab Duty, Electrical Shaft and (Redundant drive) Load Sharing, are achieved without additional hardware. Positioning, which is similar to an Electrical Shaft with fixed master, is supported by closing the position loop in ASTAT.

Each motion can be controlled from ground level by interfacing each ASTAT with an IP-address holder on the crane, connected over a Radio-LAN, each being a member of a control network.

Simpler maintenance

Advanced diagnostics provide more than 50 different fault messages per ASTAT. The controller's high heat tolerance, the use of plug-in components and improved motion control, all help to simplify and reduce maintenance of the crane motion control system and its associated slip-ring motor. This can be limited to the periodic checking of the motor brushes and inspection of the fan in the controller.

By keeping traditional line frequency switching, ASTAT avoids causing currents in bearings or the cracking of motor isolation. ABB's concept of using slip-ring motors has a proven life of over 25 years, so this new generation ASTAT will make down -- time even shorter than before.

For troubleshooting and evaluation of possible problems, a PC-based Commissioning and Maintenance Tool program (CMT) is available as freeware. It can be run simply as a point-to-point PC-ASTAT using a simple cable, or it can be installed on a network from the computer to all the ASTATs on the crane. Today the trend is to move the access of information away from the crane into the electrical maintenance engineer's office. The CMT contains functions for Parameterisation, Signal view, Trend curves, Fault signals etc.

Crane revamps

Slip-ring motors are used today in most cranes operating in Asia, Europe and North America. The ASTAT Crane Motion Controller is consequently an ideal solution when the time comes to upgrade the crane drive control system in conjunction with, for example, raising the level of

automation. In such cases the crane user can then retain the original motor. Shielded cables are not required meaning that existing cabling can be reused if its quality remains acceptable.

Fully digital system

ASTAT is a modular system with a high computing and communication capacity. A complete system comprises a thyristor module, control system module, rotor feedback module, optical fibre cables, cabin I/O module and over voltage protection. In many cases only the thyristor module and control system module are needed, and for sizes below 200A, the modules are mounted together. The same hardware can be used for both single and system drives.

Advanced microprocessor technology and digital signal processing are used to determine the actual shaft torque thereby making the control of the slip-ring motor even more effective. The motor speed is determined digitally by monitoring and advanced filtering, of the rotor voltage. In most cases it is no longer necessary to include a mechanically sensitive pulse transmitter for this purpose. The resolution of the estimation of speed is [10.sup.-4] around zero speed, but lower for speeds close to the synchronous value. For this reason, speeds higher than 85% of synchronous are made as bump-less switching to direct on-line (DOL) with the thyristors acting as Forward and Reverse contactors. To-date, no single drive industrial crane motions have been seen by ABB engineers where this 85% speed restriction is unsuitable.

Fast installation

The modular design of ASTAT makes for fast, trouble-free installation and commissioning. Due to its compact design, the hardware takes up less space in the crane girder or cabinet and is lighter than other control systems. The requirements for ancillary equipment are also reduced. This applies in particular to air conditioning equipment which can frequently be dispensed with. Also, no special power cables are needed.

ASTAT can be fed from a normal sliding contact system with horizontal or vertical bus bars without generating harmful emission to interfere with other electronic equipment in the mill.

The same PC-based tool is used for the design and engineering work as well as for commissioning. The PC spreadsheet technique used in the tool is also a great help, not only for installation and commissioning, but also for maintenance.

Operational experience

The first ASTAT motion control system has been in service for over a year. The experience is that all revamping jobs should be carried out as a joint electrical and mechanical project. A more advanced crane control system can reveal shortcomings in gearboxes and brakes that were not evident with traditional contactor control. Crane drivers adapt themselves during 25 years of continuous degeneration of the drive gear, and often do not report the deteriorating condition of the equipment prior to the replacement of the electrical control system. New installations do not face this kind of problem.

A special case that caused much headache was a crane travel motion fitted with what was thought to be two identical motors on the right and left sides. After careful washing of rating plates it was seen that one motor was star- connected and the other delta-connected-to the stator.

A general impression is the surprisingly good condition of many of the 20 to 30 year old slip ring motors that are seen in revamping projects.