Improving the Safety, Reliability and Productivity of Coke Handling Bucket Cranes

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Coking.com Safety Seminar
May 7-10, 2007 - League City, TX

Improving Safety, Reliability and Productivity of Coke Handling Bucket Cranes.

Safety, reliability and productivity are all prime concerns for coker operators using bucket cranes for moving coke. A principal obstacle to this is the minimal time available for weekly maintenance, and infrequent outages for major repairs. To help avoid down-time, Konecranes' approach to Coker Cranes is to include features that reduce the need for maintenance, and to make things easier to repair when maintenance is required.

This presentation outlines the many maintenance-reducing features that Konecranes has incorporated into the design of coker cranes, based on years of working with our customers. By comparing our experience to theirs, we are continually making improvements in safety, reliability and productivity.

- Don Paulino
This is a list of projects with Konecranes. It shows the crane and coke bucket sizes.

Noteworthy is the recent progression towards ever larger buckets and cranes.

When Konecranes supplied its first coker crane about 10 years ago, the average bucket size was under 17 cubic yards. Most recently the bucket sizes are above 20 cubic yards and some approaching 30 yards. The biggest crane and bucket on this list is the 25 cubic meter (33 cubic yard) bucket on a 44 metric ton (48 short tons) single leg gantry for Indian Oil Company Ltd.
Lessons learned from industry feedback via interviews with refinery personnel, have triggered R & D efforts to adapt new technologies to address the issues. Operator safety has been addressed in this process and some of the key safety features are listed.

The cab is pressurized with a particulate filter (last stage is a HEPA filter) for the make-up air. Purafil chemical filters are used for more severe environments.

The controls are installed inside and a pressurized control room with climate control.
Feedback from our refinery customers has increased awareness of the limited crane maintenance windows. This awareness drives our crane designs to lower or extend the maintenance requirements and to find ways to speed the maintenance events. This slide lists some of the features that improve the crane's maintainability.

This is accomplished by making parts last longer and by making them easier to change. Built-in diagnostics systems reduce the trouble shooting down time.
Reliability Improvements are also related to maintainability. The items listed increase both the reliability as well as the lifetime of the crane parts.

Rope Over-wrap Prevention Device consists of rope retention rollers that are mounted near the hoist drums and they detect a harmful over-wrap condition and stop the drum rotation before the rope is damaged.

Generous storage space is provided on the closing line drum for re-reeving the bucket. This saves maintenance time and lowers wire rope consumption costs.

Load cells are used to prevent harmful mechanical overloads.

Increasing the hoist drum and bucket sheave diameters to a value 30 times greater than the rope diameter extends rope lifetimes as well as the lifetimes of the drums and sheaves.
For highest reliability, all Konecranes coker cranes are fitted with PLC based controls technology.

This system architecture allows multi-level access for data analysis and trouble shooting. Provides instant access to critical data about the crane condition.

There is an operator's display panel in the cab that is used to communicate with the crane operator. The panel displays the crane operating condition, faults, alarms, etc. The crane operator has access to all of the critical crane condition data.

All of the VF controls are connected with a Profibus communications link so that critical data is centralized. This facilitates maintenance diagnostics.

This technology enhances crane safety as well.
**DynAGrab Hoist Control**

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<td>Reduced Operator Train-up Time</td>
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<td>Difficult to Learn</td>
<td>More Effective Load Handling</td>
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<td>Long Training Time Needed</td>
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<td>Inefficient Handling, Spillage</td>
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<td>Uneven Load Sharing Between Hoists</td>
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**DynAGrab** hoist control has a positive impact on the cranes maintainability and safety as well as its productivity.

This control is a proprietary PLC software that automates the most difficult aspects of operating a four rope mechanical bucket. This control lowers the operator skill set needed for effective material handling. This automation technology makes crane operation an easier task.

**DynAGrab** - The system drastically reduces slack rope condition that is harmful to hoist machinery as well as to rope life.
**Hoist Control**
**DynAGrab Synchronization Controller**

**Features:**
- Load Balancing
- Automatic Sinking & Filling
- Field Weakening
- Fast Stop / Slack Rope Control
- Drum Rotation Synchronization
- Fault Detection
- Jammed Grab Detection
- SAFETY: Overload Protection
- Less Demanding of Operator
- Higher Coke Handling Thru-put

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**DynAGrab** hoist control measures the rotational position of the two hoist drums relative to each other and automatically and without operator input, synchronizes that relative position during any combination of open/close or raise/lower movements so that the bucket is doing exactly what the operator intends. Coke spillage due to accidental loss of synchronization seen on most manual cranes, is eliminated.

The automatic sinking and filling feature allows the operator to precisely set the digging depth and bucket filling according to the coke density and consistency. This reduces overloads and optimizes the bucket filling on each cycle. The result is a productivity improvement.

If the bucket jams on some foreign object, the system detects the condition and reports it to the crane operator.

**DynAGrab** control can be tuned to the optimum bucket load for the coke density and with it’s overload sensing will prevent operators from handling more than that defined optimum load.

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DynAPilot Sway control is a patented technology that harnesses load swing in a way that enhances productivity.

The system helps prevent impacts with obstacles inside the crane operating space.

With DynAPilot switched on, the natural load swing caused by acceleration/deceleration of either the bridge or trolley movements is dampened so that it has no impact on the cycle time. The uncontrolled load swing is eliminated and shorter cycle times is the result.

Safety is enhanced with less opportunity for the operator to swing the bucket into an obstacle.
Introduction:

Konecranes has labeled its proprietary version of Regenerative variable frequency control as "DynAReg".

First used almost 10 years ago on high-value STS container cranes, DynAReg is today being adapted to other types of process cranes. Introduced to coker crane customers mid-2005, it is the Konecranes standard solution and is fast becoming the preferred technology for all new coker cranes.
DynAReg - This slide compares the Regenerative type energy flow schematic on the right side with that of the non-regen control type on the left.

The Regen system illustrates that the energy produced by decelerating motors is returned to the common supply line (common DC bus) where it can be used by other motors that are working in non-decel mode. Excess braking energy not consumed by operating motors is returned thru the Network Braking Unit into the power supply line as clean power.
This slide highlights advantages/benefits of modular design.

Maintenance personnel deal with smaller, easier to handle modules instead of complete VF drive units as on the previous generation VF drives.

Hardware pieces are interchangeable among the motor drive units and the AFE units.

Spare parts inventories and investments are much smaller.
In addition, the customer can connect to the internet for access to Konecranes Remote Monitoring and RemoteExpert assistance for emergency trouble shooting...the fastest way to get an expert’s eyes on the problem.

The expert can access all crane data (structural drawings, electrical drawings, material lists, Operation and Maintenance Manuals, etc. which are stored digitally on the CMS hard drive.
DynAMonitor is a PLC resident software that monitors about 400 data points on the crane and reports them through two display panels. One in the operator's cab and one in the control house. The software maintains a 2000 event rolling archive of the measured points and error messages.

When connected to a LAN, it provides current time data monitoring and has some limited reporting capability for written reports.
CMS is an industrial PC with proprietary software. The unit is installed inside the pressurized control house and it provides a data collection and archiving system capable capturing and holding up to four years of crane data.

The system software has analysis and reporting modules to enhance the maintenance experience.

The system has provision for remote data access via wireless LAN.

This implements the RemoteExpert feature which makes available the best Konecranes controls trouble shooting engineers to assist in problem solving traveling to the job site.

This capability is expected to lead to significant reliability and up-time improvements.
Runway Structure Issues

Structure Problems:
- Skewing of Bridge Effects
- Rail Alignment
- Damage to Rail Attachments
- Misalignment of Beams and Columns
- Wheel and Rail Wear
- Stress on Wheel Bearings and Crane Structure

Konecranes Auto-Steering Control:
- Harmful Lateral Loads Virtually Eliminated
- Dramatic Reduction in Wheel/Rail Wear
- Reduced Stress on Wheel Bearings
- Reduced Stress to Crane Structure
- Alignment of Runway Preserved
- Improves Safety by Limiting Structural Overloads

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Feedback from users of long span bridge type coker cranes (vs. gantry type) indicates tracking on the crane structure can be a problem. The patented DynATrak control automatically steers the crane along the runway to a centered position of the bridge wheels relative to the rail centerlines. The system minimizes or eliminates contact between the wheel flanges and the sides of the rail which reduces wear of the both components.

In addition, eliminating the wheel flange to rail contact drastically reduces the lateral loads to the crane structure extending the lifetime of all affected components. Such as rail, rail clips, runway girders, girder connections, wheels, wheel bearings, etc.
The patented DynATrak Auto Steering system uses laser sensors to measure the distance to the rail head at two points along the end trucks on one rail. The sensor inputs are used to determine the amount of the offset between the rail and wheel centerlines. This information is converted into drive instructions for the two VF drives that operate the bridge drive motors. Each VF drive controls all the motors on one rail side. The speed differential between the two drives causes the bridge to "steer" back into alignment.
Environmental Issues

Corrosive Coke Pit Environment:
- Moisture / Steam
- Corrosive Fumes
- Ignitable Fumes
- Conductive Dust
- Exposed to Rain, Ice, Weather
- Abrasive Coke Dust
- Hazards for Operators

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<table>
<thead>
<tr>
<th>Environmental Issues</th>
<th>Konecranes Solutions</th>
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<tr>
<td><strong>Corrosive Coke Pit Environment:</strong></td>
<td><strong>Fully Enclosed Control House:</strong></td>
</tr>
<tr>
<td>• Moisture / Steam</td>
<td>• Temperature &amp; Humidity Controlled</td>
</tr>
<tr>
<td>• Corrosive Fumes</td>
<td>• Dust Kept from Controls &amp; Electronics</td>
</tr>
<tr>
<td>• Ignitable Fumes</td>
<td>• Weather Protected Environment for Maintenance</td>
</tr>
<tr>
<td>• Conductive Dust</td>
<td>• Clean, Safe, Lighted Work Area</td>
</tr>
<tr>
<td>• Exposed to Rain, Ice, Weather</td>
<td>• Pressurizing Filtration</td>
</tr>
<tr>
<td>• Abrasive Coke Dust</td>
<td>• Redundant A/C Available</td>
</tr>
<tr>
<td>• Hazards for Operators</td>
<td>• Stainless Steel Exterior Available</td>
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<tr>
<td></td>
<td>• Chemical Filtration Available</td>
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</tbody>
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The pressurized, environmentally controlled house has been an important contributor to reliability of the crane electrical systems. It is a contributor to crane safety as well in that maintenance personnel can work on the crane controls inside a clean room instead of in the open air which can be hazardous in wet weather conditions.

As an option, the control house exterior can be clad in stainless steel for corrosion resistance.

A/C systems and pressurized filtration systems are used to control the room environment providing a safe haven for controls maintenance and extending lifetime of the electrical components inside.
## Environmental Issues

### Konecranes Solutions

<table>
<thead>
<tr>
<th>Hazardous Coke Pit Environment:</th>
<th>Fully Enclosed Operator’s Cab:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Moisture / Steam</td>
<td>• Temperature &amp; Humidity Controlled</td>
</tr>
<tr>
<td>• Corrosive Fumes</td>
<td>• Protected Environment for Operator</td>
</tr>
<tr>
<td>• Ignitable Fumes</td>
<td>• Ergonomic Chair and Controls</td>
</tr>
<tr>
<td>• Exposed to Rain, Ice, Weather</td>
<td>• Windows Arranged for Maximum Visibility</td>
</tr>
<tr>
<td>• Abrasive Coke Dust</td>
<td>• Safe, Comfortable Work Area</td>
</tr>
<tr>
<td>• Hazards for Operators</td>
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Environmentally controlled cab space.
A/C and pressurization with a multistage filtration/pressurization unit. HEPA filter in last stage.
Purafil chemical filters available as price option when warranted by specific environment.
### Control Issues

<table>
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<th>Konecranes Solutions</th>
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<tbody>
<tr>
<td><strong>Large Control Components:</strong></td>
</tr>
<tr>
<td>- Significant time and effort to change out a failed inverter</td>
</tr>
<tr>
<td>- Rewiring necessary</td>
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<tr>
<td>- Large, heavy components</td>
</tr>
<tr>
<td>- Crane down during change-outs</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Wired-In Spare Inverters:</th>
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<tbody>
<tr>
<td>- Increase Crane Reliability Proposition</td>
</tr>
<tr>
<td>- Quick switch over from problem VF Drive Unit to Stand-by</td>
</tr>
<tr>
<td>- Allows “Off Line” repair when time available</td>
</tr>
<tr>
<td>- Prolongs lifetime of Spare Drives with Energized Environment</td>
</tr>
<tr>
<td>- Significant savings in unplanned down time</td>
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</tbody>
</table>

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A recent technical innovation is the addition of spare VF drive units, pre-wired inside the control house. These spare units, one each for the hoist, trolley and bridge are pre-wired so that they can be switched over in a short time.

This allows the crane operation to continue with minimum interruption until there is a time window to service the problem drive.

This feature provides a major benefit to crane up-time.
Gearing Issues

<table>
<thead>
<tr>
<th>Low Quality Gearing:</th>
<th>High-Quality Gearing:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Long Lead / Expensive Spares</td>
<td>• All gearing 58 HRC, carburized, finish ground</td>
</tr>
<tr>
<td>• Must open gearbox to remove drum</td>
<td>• AGMA Class 11 minimum</td>
</tr>
<tr>
<td>• Hoist gear quality traditionally low, AGMA 4 to 6</td>
<td>• Moment isolation mounting preserves alignment</td>
</tr>
<tr>
<td>• Failures can be catastrophic, damaging hoist machinery</td>
<td>• 50,000 hrs Bearing Life exceeds CMAA Class F</td>
</tr>
</tbody>
</table>

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The industry standard has been CMAA Class E cranes with lower classes of gearing, AGMA 4 to 6 Class. Supplying cranes with higher quality gearing (**AGMA Class 11**) sized for the work load in addition to the torque load results in much longer lifetime and lower maintenance costs. Properly designed and maintained gearing should last the lifetime of the crane.

Replacement of hoist gearboxes is a costly event that takes the crane out of service for at least a day.
### Mechanical Issues

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<th>Reported Problems:</th>
<th>Konecranes Solutions</th>
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<tr>
<td>Hoist Machinery Problems:</td>
<td>Konecranes Moment Isolating Machinery Mounting:</td>
</tr>
<tr>
<td>- Cracked Drum Welds</td>
<td>- Eliminates Drum Gear Misalignment</td>
</tr>
<tr>
<td>- Leaking Oil Seals</td>
<td>- Eliminates Cracking of Drum Welds</td>
</tr>
<tr>
<td>- Drum Gear Misalignment</td>
<td>- Drum Removable Without Opening Gear Box</td>
</tr>
<tr>
<td>- Complicated Disassembly</td>
<td>- No Fatigue on Non-Rotating Drum Shaft</td>
</tr>
<tr>
<td>- Fatigue in Drum Shaft</td>
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</tr>
</tbody>
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Moment Isolation Machinery Mounting is a unique design that eliminates the harmful stress concentrations in the drum shaft and drum to gearbox connection. This area has been reported as a common failure zone on older coker cranes with the traditional mounting methods.

This failure mode does not exist on the Moment Isolation Design that eliminates the stress concentrations.

This design has an additional maintenance benefit in that it allows replacement of the hoist drums without the need to open the gearbox avoiding the time consuming re-alignment of the drum gear.
Conventional design showing gearbox, drum shaft, drum and tail bearing. Deflection of the drum under load generates stress concentrations at the shaft transition into the rigidly mounted gearbox. The shaft bending/deflection alters the loading pattern on the drum gear, accelerating wear.

Replacement of the drum, shaft or the drum gear requires opening the gearbox and then realigning the drum gear mesh by shimming the tail bearing support. This alignment procedure can take most of a day under good conditions.
The Moment Isolation Design separates the gearbox from the hoist with a drum hub that is machined to interlock with and match the drum flange. There is no need for realignment of the drum gear or even to open the gearbox when changing the drum. The machined interface between the drum hub and the drum assures precise alignment when the drum flange is bolted to the hub. There is a self aligning bearing at the tail end that accommodates the shaft bending without over stressing. Changing the drum with this design is much faster and a lot less work.
Buyer-Seller Partnership

Crane Buyer
- Process Knowledge
- Equipment Knowledge
- Operational Experience
- Maintenance History
- Lessons Learned

Crane Vendor
- Proven Applications
- R&D Efforts
- Economies of Scale
- Crane Expertise
- Global Perspective
- Experience in Other Industries/Regions

Partnership
Best fit of Product to Project

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