Vibration Monitoring of Electric Rope Shovels

Dan Nower, P.E.
Emerson Process Management/Asset Optimization
Machinery Health Management Business Group
Vibration Monitoring of Shovels

• MINExpo 2012: Caterpillar announced the largest Electric Rope Shovel, capable of 120 short tons

• The next day, JoyGlobal (P&H Mining) CAT, introduced a shovel capable of 135 short tons

• **Large Concern:** breakdown (unplanned outages) of one machine will be more disruptive to production

Diagnosing machines is similar to diagnosing people

**Vibration:** The ‘pulse’ of the machine

**Oil:** The ‘life blood’ of the machine

**Thermography:** ‘Taking its temperature’
MHM Throughout the Mine

Critical
Essential
Important
Secondary
Non-Essential

ONLINE MONITORING
MANUAL MONITORING BALANCE OF PLANT

Conveyors
Loaders
Mills

Shovels
Draglines
Trucks
Balance of Plant
Because of global demands, Mine operations cannot afford any of their critical assets to shut down unexpectedly.

Electric Rope Shovels are one of the most critical assets in Open Pit Mining.

Shovels are very large, complex machines with large rolling element bearings and gearboxes.

This machine complexity combined with the tough 24/7 service duty results in too much unplanned shovel downtime.

This unplanned downtime can affect the entire downstream process.
Shovel’s Part in the Mining Pinch

• Due to the machine complexity, Vibration Analysis and PeakVue® tends to be the best technologies to determine the Machine’s Health

• Arguably, shovels are the most difficult to monitor because of their inconsistent, short cycles and variable load operation. [video]

• The Machine Health of most shovels is not monitored in any way

• Progressive mines remove shovels from operation monthly to determine machine health, but there are issues with production and safety
Manual Monitoring of Shovels

- Portable (Manual) Route is ideally scheduled every month
- Requires a 3-6 hour planned outage that is difficult to coordinate
- No other maintenance activity can be performed
- Frequently the task is rescheduled
- Safety issues during manual data collection
- Requires specialized pit technicians
Automate Shovel Monitoring

• The solution is to automate the shovel monitoring
• Utilizing the adaptive monitoring of Emerson’s online monitoring system has proven to capture consistent, repeatable data to accurately determine shovel health
• Emerson’s online monitoring system can continuously monitor the health of the following Shovel Systems
  – Swing
  – Hoist
  – Crowd
  – Propel
Shovel Primary Systems

P&H
4100 XPC

HOIST

CROWD

SWING

PROPEL
Shovel Primary Drive Systems

SHOVEL PLAN VIEW

Machinery Deck Plan

- Rear Machine House I/O Box
- Air Compressor
- Hoist Motor
- Inverter
- Swing Motor and Transmission
- Hoist Drum
- Main Transformer
- Lubrication
- Lubrication System
- Lubrication Reservoir 1270 liters/330 gallons
- 1313 liters/400 gallons
- Air Reservoir 905 liters
- Hose Access Doors
- High and Low Voltage Collectors (deck mounted)
- Swing Motor and Transmission
- 120 VAC Load Center
- Centurion Control Cabinet
- Touch Screen Monitor
- Auxiliaries Load Center
- Motor Control Center
- Electronics Room
System Implementation Challenges

• System Design: Where to install the Sensors
• Installation Time
  • System Cabinet
  • Sensors, Junction Boxes and Cabling
  • Cabinet Acquisition Screen
• Data Collection
• Getting Data out of the Pit
System Design

Typical Shovel – one cabinet
Largest Shovels – two cabinets

Plan View: Shovel Machinery Deck

New addition
Wireless Vibration Monitoring of Cooling Fans
Installation Time: Wiring Harnesses

Cable Assemblies
Installation Time: Plug & Play

Cable Connectors on Cabinet
**Data Acquisition:**

**Typical Operation & Staged Testing**

Test controlled by operator or remote personnel.

### Start Hoist Test
- Begin Test - Crowd out almost to limits and quickly move the hoist up and down.
- Testing underway - Continue hoisting up and down.
- Test Completed - Stop hoisting.

### Start Crowd Test
- Begin Test - Raise dipper until the dipper handles are at perpendicular to the boom and at the inner limits. Set the hoist brake. Move the crowd in and out at maximum speed.
- Testing underway - Continue crowding in and out.
- Test Completed - Stop crowding.

### Start Swing Test
- Begin Test - Raise the bucket to be under the boom end - set the hoist and crowd brakes. Begin swinging to the right at maximum speed.
- Testing underway - Continue Swinging to the right.
- Reverse direction - Swing to the Left.
- Testing underway - Continue Swinging to the right.
- Testing Completed - Stop swinging.
The system was able to trigger and collect data both during staged test and during digging operations:

- High Resolution data was collected each cycle during dipper latching
Data Acquisition: What faults can be found?

**SOLUTION**
- Online continuous vibration monitoring with PeakVue provides earliest possible detection of swing, hoist, and crowd issues ranging from bearing anomalies to gear mesh and impacting.
- Example: Identified a problem in the crowd transmission → planned shutdown.
- Example: Identified a problem with shovel hoist gear wear → planned shutdown.

**CHALLENGE**
- It is difficult to monitor complex gearboxes and non-traditional motors.
- Complexity comes from variable speed + variable load + short duration operations which makes data gathering difficult.

Failed Shovel Hoist Gear
How is the data uploaded?

Customer’s Choice
How is the data uploaded?

- **Manual Wireless Backhaul**
  - Local Analysis

- **Automatic Wireless Backhaul**
  - Local Analysis
  - Remote Analysis

- **Satellite Upload**
  - Remote Analysis
JoyGlobal is the largest manufacturer of mobile mining equipment in the world.

Covers Online Vibration Monitoring on P&H’s Centurion® Controlled Shovels.

Hoist, Crowd and Swing systems are monitored with standard system vibration monitoring system.

Integrated to the JoyGlobal PreVail® Remote Monitoring System to send vibration information to the JoyGlobal HQ.
Enjoy Responsibly
For more Details:

- Emerson Process Experts Blog
  http://www.emersonprocessxperts.com/2011/10/if-it-moves-monitor-it/

- Maintenance World Magazine
  http://palvelut.promaint.net/lehti/maintworld_2_2013.html

- Contact Information
  dan.nower@emerson.com

QUESTIONS?