Advanced inspection methods – A new approach to mills and winders

Shawn Crous
Anglo American
Anglo Field Services
South Africa
Order of Presentation

- Mill Inspection history
- Developing mill inspection package
- Benefits of mill inspection package
- Principle of Eddy Currents
- Eddy current uses
- Eddy Current equipment
- Eddy Current signal Response
- Eddy Current Gear Inspection
- Case Study
- Winder Inspection history
- Developing winder inspection package
- Benefits of winder inspection package
- Principles Phased Array Ultrasonic
- Phased Array ultrasonic equipment
- Inspection
- Case Study
- Winder Inspection Package
- Conclusion
- Questions
Mill Inspection History

• Magnetic Particle inspection of gear teeth

• Timely operation due to the cleaning of the lubrication (+/- 12 hours), using a solvent based cleaner.

• Resulted in cleaning agents being trapped in the lubrication, breaking down the viscosity.

• Only the gear inspection could be performed in this time period.

• Labour intensive.
Developing Mill Inspection Package

By introducing an eddy current inspection technique to inspect gear teeth, a number of other inspections can now be performed in the same time frame:

- Thermographic inspection of mill (Performed prior to shut)
- Drive train alignment
- Gear mesh (Lead readings)
- Ultrasonic inspection of mill shell (Wash-away)
- Ultrasonic inspection of all bolting
- Ultrasonic inspection of mill shell welds
- Magnetic particle inspection of pinion shafts
- Ultrasonic inspection of trunnions (Wash-away)
Benefits of mill inspection package

• Benefits of using this advanced inspection method:
  – Reduction of labour
  – No need to clean the gear teeth
  – No more cleaning solvents trapped in the lubrication
  – Reduction of inspection time (Mill gear teeth)
  – Reduction in total inspection cost
  – One report covering total condition of mill
  – One stop shop covering a multiple of inspections
**Eddy Current Principle:**

- Eddy current flow is induced in the test object. Changes in flow caused by the variations in the specimen are reflected into coils, these changes are analyzed by suitable instrumentation.
Eddy Current uses

- Eddy currents can be used for a variety of inspections:
  - Mill gear teeth
  - Aluminium components
  - Vessel welds
  - Aircraft components
  - Conductivity of material
  - Coating thicknesses
  - Winder brake races
• Equipment
  – Differential probes manufactured to fit the gear profile
  – Eddy current instrument
  – Reference Block
  – Frequency is between 8 and 100 kHz
## Eddy Current signal response

<table>
<thead>
<tr>
<th>Localised / circumferential indication</th>
<th>Longitudinal indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impedance Plain (DIFF)</td>
<td>Impedance Plain (DIFF)</td>
</tr>
</tbody>
</table>

![Diagram](image)

- 2mm
- 1mm
- 0.8m
- 0.5mm
- 0.2mm
Eddy Current Gear Inspection

- Eddy current inspection technique was developed as a detection method to locate defects in gear teeth
  - Pitting, spalling, cracking, etc.
- The defective areas are cleaned.
- The defects are then assessed using magnetic particle inspection.
- The size and orientation of the defects are then recorded and reported.
• Signal response from a crack in a gear tooth.
Mill Inspection Package

- Thermographic inspection of mill
  - Bearings
  - Shell
  - gears
Mill Inspection Package (Continue)

- Phased Array ultrasonic inspection of mill gear teeth
Mill Inspection Package (Continue)

- Drive train alignment
  - Tolerance 0.1mm
Mill Inspection Package (Continue)

- Gear mesh
  - Lead readings to measure
  - Root
  - Pressure
  - Backlash
• Ultrasonic inspection of mill shell
  – B-scan
  – Wash-away
- Ultrasonic inspection of all bolting
  - A-scan ultrasonic
  - Mill shell bolts
  - Foundation bolts
  - Coupling bolts
Mill Inspection Package (Continue)

- Ultrasonic inspection of shell welds
  - ToFD
  - Phased Array
• Magnetic particle inspection of pinion shaft
  – Focussing on the keyway
Mill Inspection Package (Continue)

- Ultrasonic inspection of trunnions
  - A-scan ultrasonic
  - Wash - away
Winder inspections are performed to assess the condition of its components for fitness for purpose:

- Sheave wheel groove profile
- Sheave wheel spindles
- Sheave wheel to drum alignment
- Winder brake components
- Winder gearbox teeth, hub and spokes
- Winder drum shaft
- Winder drum alignment
- Winder drum bolts
- Winder foundations bolts
- Winder brake races
• Most of these inspections were performed on separate days mostly on Sundays.

• **Winder brake components:**
  – Brake components are disassembled and cleaned
  – Magnetic particle inspection
  – Ultrasonic inspection
  – Components are then assembled

• Labour intensive

• Risk of components seizing when assembled
Developing Winder Package

• By developing a Phased Array inspection technique to inspect winder brake components (locating pins and tie rod threads), a number of inspections can now be performed in the same time frame:
Benefits of using this advanced inspection method:

- Components do not have to be disassembled for inspection
- This inspection can be performed in a hoist examination
- Reduction of inspection time (Time it takes to disassemble and assemble components)
- Reducing Sunday labour
- Seizing of components is minimised
- Other inspections can be performed in the same time frame
The principles of Phased Array is based on the following:

- Multiplexing of a large number of identical crystals as a single probe
- Control of the focal depth
- Control of the steering angle
- Control of the beam focusing
- Program of the virtual probe aperture (VPA)
- Scan with a large number of A-scans
- All scans can be encoded
- Can display C-scan, B-scan, S-scan and A-scan views.
An array transducer is simply one that contains a number of separate elements in a single housing, and phasing refers to how those elements are sequentially pulsed.
Phased Array ultrasonic equipment

- Equipment
  - Phased array Instrument
  - Phased array transducer (multi-element)
  - Calibration Block
  - Reference blocks
  - Couplant
• 125mm diameter tie rod
• Total number of flaws 13
• POD = Number of flaws detected/total number of flaws
• \( = \frac{13}{12} \)
• \( = 0.923 \)
• \( = 92.3\% \)
• A 2mm flaw went undetected as it was masked by a 4mm flaw.
• Phased Array ultrasonics is used as a detection method:
  – To locate in-service failure of winder brake components (tierods and locating pins) while testing in-situ.
  – Sizing of defects can be performed using normal ultrasonic principles. (6 or 20 db method)
  – Results can be recorded. (Encoded)
  – Interpretation can be performed while scanning the components or the stored data can be analysed after the inspection using tomoview software
Phased inspection of the thread of a typical tie rod
Case Study

- Two phased array images of a threaded tie rod.
  - Image on the left shows no defects
  - Image on the right shows defects at approximately 56 and 75 degrees.
• A 1mm deep crack at a depth of 200mm in a locating pin, detected with phased array at an angle of +/-16 degrees.
• A 1mm, 2mm, 3mm and 4mm flaws detected in the first four threads
Winder Inspection Package

- Time of Flight Diffraction
  - Drum shaft inspection

ILLUSTRATING THE PLACEMENT OF TRANSMITTING AND RECEIVING PROBES INSIDE THE CENTRE HOLE OF THE DRUM SHAFT.
Winder Inspection Package (cont)

- Winder drum alignment
  - Alignment of winder drums
  - Gives an indication of bearing condition
Winder Inspection Package (cont)

- Sheave wheels
  - Sheave wheel spindles
  - Sheave wheel profiles
  - Sheave to drum alignment
  - Magnetic particle inspection of sheave wheels
• Winder bolts
  – Ultrasonic inspection
Winder Inspection Package (cont)

- **Gearbox inspection**
  - Magnetic particle inspection
  - Eddy Current inspection
  - Gear teeth
  - Gear spokes and hub
  - Gear meshing
Conclusion

- Using and developing the latest NDT technology can change the way in which we currently perform inspections:
  - Making it simpler
  - Better or comparable results
  - Saving on time (one stop shop)
  - Permanent records
QUESTIONS