Babbitted Bearing Inspection Intervals

John K. Whalen
TCE
Why this presentation?

- Our customers are currently looking for 6-7+ years between outages
- They want to know if the bearings are good that long
Outline

- Purpose of this discussion
- Babbitted bearing failure mechanisms
- Condition Monitoring
- Maximizing bearing robustness
- Case study
- Conclusions
Purpose of this discussion

- Users pushing time between outages
- Bearing life a major factor
  - Especially with “clean” service
- What is a reasonable time between bearing inspections?
- How can this time be maximized?
- What can condition monitoring tell us about bearing condition?
Time between outages

- There is continuing pressure to:
  - Keep units running
  - Running efficiently
  - Running safely
  - NO unplanned outages
  - Minimize length of outages
    - Planned and unplanned
Bearing Life

- The components in a machine designed to fail first are the bearings
- “Sacrificial elements”
- Goal is to predict impending failure:
  - Wait until next scheduled outage?
  - Controlled shutdown?
  - WRECK
Bearing Life

- In a perfect world fluid film bearing life is infinite
- None of you live in a perfect world
Babbitt Bearing Failure Mechanisms

- Babbitt fatigue damage.
- Babbitt wiping due to rotor to babbitt contact.
- Babbitt flow due to high temperature.
- Foreign particle damage.
- Varnish build up.
- Electrostatic discharge damage.
Babbitt Bearing Failure Mechanisms

- Electromagnetic discharge damage
- Oil “burn” due to high temperature
- Loss of bond between babbitt and base metal.
- Chemical attack
- Pivot wear in tilting pad bearings.
Babbitt Bearing Failure Mechanisms

- Damage caused by unloaded pad flutter (usually only found in large tilting pad bearings – over 18” thrust over 13” journal)
- Cavitation damage to babbitt
In order to properly assess bearing health, the following is recommended:

- Proximity probes (radial and axial)
  - Monitoring radial vibration AND rotor position
  - Monitoring axial position AND axial vibration
- Oil analysis
- Bearing temperature
- Grounding brush discharge
Examples of Bearing Failures

- Following are examples of failed bearings
Low speed wiping/at speed fatigue due to misalignment
Low speed wiping/at speed fatigue due to misalignment

- Note the “polishing” in the bottom of the bearing (aligned at low speed)
- Note the babbitt damage on one end axially at running position (attitude angle)
- Solved by upgrading to Tilting Pad Journal bearing with Ball & Socket pivots.
Babbitt Fatigue

- BABBITT
- BOND LINE
- STEEL BACKING

- FATIGUE CRACKS APPEAR IN SURFACE OF BEARING

- FATIGUE CRACKS WIDEN & DEEPEN PERPENDICULAR TO BOND LINE

- CLOSE TO THE BOND LINE, THE FATIGUE CRACKS TURN & RUN PARALLEL TO THE BOND LINE, EVENTUALLY JOINING AND CAUSING FLAKING.
Babbitt Fatigue
Fatigue Strength - Effect of Babbitt Thickness

Fatigue Life (hours) vs. Babbitt Thickness (mils)

2000 psi mean load
Fatigue Strength - Effect of Babbitt Temperature

- **Fatigue Life (hours)** vs. **Babbitt Temperature (deg F)**

- **2000 psi mean load**

The graph shows a downward trend indicating that as the Babbitt temperature increases, the fatigue life decreases.
Electrostatic Discharge
Electrostatic vs. Electromagnetic
Babbitted Bearing Failure Analysis

- **Electrostatic Voltage**
  - Static Charge Build Up
  - “Frosted” Appearance
  - Discharges through point of minimum oil film thickness

- **Electromagnetic Currents**
  - Residual magnetism “generates” charge
  - Caused by
    - Rubs
    - Improper welding ground
    - Mag particle inspection
  - Also occurs in improperly insulated electrical machines
  - More severe than electrostatic
  - “Welding” of components possible
Electrostatic Discharge
Electrostatic Discharge
Pivot Wear

- Solved by upgrading to low stress Ball & Socket pivot
- Ball & Socket pivot also allows full axial alignment capability.
- Used successfully for over 35 years
Overloaded Thrust Bearing
Overloaded Thrust Bearing
Hot Thrust Bearing
Oil Coking
Varnish

Figure 6
38M pad back
Varnish

Figure 7
30M pad, retainer and links
Varnish
Too late to tell...
Condition Monitoring

- Of course there is a lot more to condition monitoring including:
  - Infrared Thermography
  - Ultrasonics
  - Motor Current Analysis
  - Machine performance monitoring
Robust bearing design

- Tilting pad journal bearings:
  - Thin babbitt to increase fatigue strength
  - Ball & Socket pivots to:
    - Substantially reduce pivot stress
    - Eliminate common misalignment issues
  - Optimized with Rotordynamic analysis to reduce vibration:
    - Less sensitive to synchronous excitation (unbalance)
    - Increase log dec
Robust bearing design

- Tilting Pad Thrust Bearings
  - Copper alloy/offset pivots to increase load capacity
  - Hardened pivots/links/retainer interface to minimize wear.
  - Ball & Socket pivots to minimize pivot stress and allow full articulation
Case History- Nova chemicals

- Just completing outage of unit #2
- Checked 17 B&S Journal bearings
- Ethylene Plant
  - PGC: Three body + steam turbine driver
  - Propylene + GT (1 bearing) + Helper turbine
  - Ethylene + Steam turbine driver
2K601
North End
9 Years in Service
K201A
South End
9 Years in Service
K601 North
9 years Service
Checked Clearances

- Of the 17 B&S TPJ’s the worst clearance increase was 0.6 mils
- All other were less than 0.5 mils
- Cleaned up and reinstalled all TPJ bearings
They also upgraded to Torlon

- Unit #2 – all compressors upgraded
- Unit #1 – all but the propylene – will upgrade at next outage
- Following photos are after 9 years of running (4+5)
Nova

- Previous outage was after 4 years
- This outage was 5
- Next outage is planned for 6
- Outages of course have been and will be driven by factors other than bearings and seals