Improving Reliability and Reducing Steam Leakage in General Purpose Steam Turbines with Floating Brush Seals

Peter Zanini/Presenter
Jongsoo Kim, Jeff Sandridge, Billy Gilmore Jr.
Authors

Peter Zanini – Director Brush Seals
Waukesha Bearings Corporation

Jongsoo Kim, PhD – Chief Engineer
Waukesha Bearings Corporation

Billy Gilmore, Jr. – Rotating Equipment Reliability Analyst
Chevron Pascagoula Refinery

Jeffrey Sandridge - President
RCM Sales & Services, Inc.
Abstract

This case study examines four different applications where brush seals were introduced into the gland boxes of process steam turbines where conventional carbon rings and mechanical seals were previously applied. The resulting observations and data are presented to highlight the impacts to gland box reliability, steam losses, and bearing life.
Presentation Outline

- Overview of Gland Box Sealing
- Case Study I: Refinery in Pascagoula
- Case Study II: Refinery in Texas City
- Case Study III: Petrochemical Plant in Port Neches
- Case Study IV: Petrochemical Plant in Golden Triangle
- Conclusions
Gland Box Sealing

• Conventional: Carbon Rings
  – Conventional practice
  – 4 to 5 rings typical
  – Tight clearance
  – Easy to install
  – Wear easily
• Upgrade: Mechanical Seals
  – Low leakage
  – Alignment sensitive
  – Sensitive to “wet” steam
Case I: Refinery in Pascagoula

- (2) 825HP steam turbines; parallel operation; 24/7 operation
- (6) ring gland box
- Unit 1B – carbon rings; installed January 2011
- Unit 1C – floating brush seal upgrade; installed August 2015
- Exhaust Back Pressure: 150 psig
- Wet steam
Case I: Problem Statement

• Excessive Steam Leakage
  – Gland boxes
  – Carbon ring wear
• Steam Cross-over to Bearing
  – High Oil Temperatures
  – Oil Contamination
• Environmental and Safety Hazard
  – Visible steam cloud
Case I: Root Cause

- Carbon ring wear
- Steam contamination from rust and hard particles
- Wet steam application accelerated carbon ring wear

Rust and Debris Contaminants
Floating Brush Seals

- Densely packed bristles are applied to a carbon ring
- Floating brush seals installed in gland boxes
- Drop-in replacement
- Contacting bristles filter steam contaminants
- Bristles protect downstream carbon rings
Floating Brush Seal Basics

- Rig test comparison
- Carbon clearances based on customer interviews
- Bristle wear rate based on past steam turbine experience
- Brush seal provides a tighter clearance and lower leakage rate

**Operating Conditions:**
- 3” / 76mm Shaft
- 150 psi / 10 bar exhaust
- 3600 RPM
- 750 F / 400 C
Evaluation of FBS performance

- Two identical units selected
- Turbines lacked instrumentation to measure leakage
- Surface temperatures measured on gland boxes and bearing casings
### Temperature comparison

- Temperature gun used
- FBS upgrade showed 20°F drop
- Higher surface temperature on FBS gland boxes supports lower steam flow to pull heat from gland casing.
- Unable to quantify leakage rate.

#### Table

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Gland Box Seal Arrangement (per side)</th>
<th>Seals Installed</th>
<th>Steam Inlet Pressure (psig)</th>
<th>Steam Exhaust Pressure (psig)</th>
<th>Speed</th>
<th>Casing Temp</th>
<th>Last Seal Location</th>
<th>Bearing Cover (Top)</th>
<th>Bearing Oil Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1B</td>
<td>Carbon Rings</td>
<td>1/10/2011</td>
<td>600</td>
<td>150</td>
<td>3709</td>
<td>470</td>
<td>300</td>
<td>210</td>
<td>170</td>
</tr>
<tr>
<td>1C</td>
<td>FBS Upgrade</td>
<td>8/18/2015</td>
<td>600</td>
<td>150</td>
<td>3650</td>
<td>480</td>
<td>410</td>
<td>190</td>
<td>153</td>
</tr>
</tbody>
</table>

#### Graph

- STEAM END GLAND BOX (°F)
- EXHAUST END GLAND BOX (°F)

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Gland Box Seal Arrangement (per side)</th>
<th>Seals Installed</th>
<th>Steam Inlet Pressure (psig)</th>
<th>Steam Exhaust Pressure (psig)</th>
<th>Speed</th>
<th>Casing Temp</th>
<th>Last Seal Location</th>
<th>Bearing Cover (Top)</th>
<th>Bearing Oil Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1B</td>
<td>Carbon Rings</td>
<td>1/10/2011</td>
<td>600</td>
<td>150</td>
<td>3709</td>
<td>470</td>
<td>300</td>
<td>210</td>
<td>170</td>
</tr>
<tr>
<td>1C</td>
<td>FBS Upgrade</td>
<td>8/18/2015</td>
<td>600</td>
<td>150</td>
<td>3650</td>
<td>480</td>
<td>410</td>
<td>190</td>
<td>153</td>
</tr>
</tbody>
</table>
Case II: Refinery in Texas City

- Plant steam study showed gland boxes contributed to 50% of leakage
- 24 month MTBR driven by wet steam and condensate flashing.
- FBS upgrade introduced in 2008
  - MTBR passing 80 months
  - Customer claims 75-80% less leakage
  - Oil temperatures dropped 75-80 °F
Case III: Petrochemical Plant-Port Neches

- 24 month MTBR driven by steam contaminates and condensate flashing
- Customer installed eductors to alleviate steam crossover to bearing oil
- FBS upgrade introduced in 2014
  - Eductors disconnected
  - Bleed off pressure reduced to 5 psig
  - Customer claims annual steam savings of $58,000
Case IV: Petrochemical Plant-Golden Triangle

- Customer upgraded carbon rings to mechanical seals to increase unit reliability
- Customer reported seal failures from condensate flashing.
- FBS introduced in 2013:
  - Withstanding condensate slugs.
  - Easy to install
  - Less expensive alternative
Conclusions

- Operators are seeking to improve gland box reliability
- Steam contaminates and condensate flashing impact carbon ring and mechanical seal performance
- Floating brush seals are an “in-between” alternative which enhance carbon ring performance while offering a more cost effective solution to mechanical seals.
- Upgraded gland boxes with FBS have shown:
  - Increases in MTBR
  - Ability to remove eductors
  - Reduced oil temperatures