Fuel Efficient Bearing Systems

Presented by
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Synopsis

- Summarize resistive forces that exist in freight rail cars
- Narrow our focus to an evaluation of rolling resistance in loaded journal bearings
- Share our analysis of these findings to then identify the key features in selecting fuel efficient bearing systems
Train Energy

• Locomotive power provides the pulling (pushing) force for the railcars.

• As the train moves much of the generated power is dissipated by the various parts of this complex mechanical system.

• Engine power is lost in:
  – transmission
  – vehicle slip
  – overcoming motion resistance
Contributors to Loss of Motive Force

- **No control exists over some resistive forces:**
  - wind speed or direction
  - the established track grade
  - physical effects due to outside temperature.

- **Operating requirements or practices set others:**
  - rate of acceleration
  - use of rail lubrication
  - braking forces.

- **Equipment design features establish a third group:**
  - engine operating efficiencies
  - the equipment's aerodynamic features
  - achieved traction versus undesired drag.
AAR Train Energy Model (TEM)

• TEM model evaluated the vehicle's resistance under various standard operational scenarios.

Vehicle Resistive Forces Comparison
(Loaded Aluminum Coal Hopper Running at 50 mph on Level Tangent Track)

- Wheel Rolling Resistance: 56%
- Bearing Resistance: 16%
- Aerodynamic Resistance: 28%

Vehicle Resistive Forces Comparison
(Unloaded Aluminum Coal Hopper Running at 50 mph on Level Tangent Track)

- Wheel Rolling Resistance: 60%
- Bearing Resistance: 22%
- Aerodynamic Resistance: 18%
Bearing Rolling Resistance

• The sources of tapered roller bearing turning resistance are generated in three areas:
  – rolling/sliding contact including cage interactions
  – lubricant effects such as churning and viscous drag
  – seal drag
Temperature vs. Start-Up Torque

- Full Bearing Assembly
- Assembly Void of Grease
- Grease and Seals Removed

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Rail Sciences Loaded Bearing Test
Evaluation by an Independent Test Laboratory
Test Procedure

• Test at three loads.
  – 1,200 lb per bearing (low load)
  – 5,200 lb per bearing (empty car)
  – 35,700 lb per bearing (286,000lb car)

• Test from 5 mph to 80 mph
  – (36-inch diameter wheel)

• Initial bearing run-in 15,000 miles
Test Procedure (continued)

• Beginning of Test
  – 5 mph
    • Run for 5 minutes
    • Check average bearing temperature
      – Check for temperature increase of less than 0.07°F/min
      – Data is collected at 2 Hz for 2 minutes
      – Results averaged 120 samples
    – Speed increased by 5 mph and procedure repeated

• Entire 5 to 80 mph test is repeated on same bearings with seals removed.
Observations

• Under these conditions,
  – Torque increases with:
    • Increasing load
    • Increasing speed
    • Decreasing temperature

• Bearings were allowed to reach ‘their own’ steady-state temperature.
  – Simple example of what happens when a bearing hunts for its steady state temperature.
    • Torque -> heat -> lower torque -> lower heat -> higher torque -> etc.
Typical Bearing Data

![Graph showing the relationship between speed (MPH), average temperature (F), and torque per bearing (ft-lbs). The graph includes data points for Bearing, Ambient, and Torque.]

Speed (MPH)

Torque per bearing (ft-lbs)

Average Temperature (F)
Typical Torque versus Temperature
RSI General Test Conclusions

• The bearing test rig has repeatability and reproducibility in measuring the rotational resistance of the test bearings.

• The greatest controlled variable to rotational resistance is load applied on the bearing.

• The largest influence on rotational resistance is temperature of the bearings.

• Contribution to rotational resistance from the seals is approximately constant with respect to rotational speed at a given load.

• The [percentage] contribution of rotational resistance due to seals decreases with an increase in load.
RSI Torque & Temperature Findings

- The Brenco Class F bearings with labyrinth seals on average stabilized at a significantly lower temperature than the Brenco Class F bearings with either optimized/no garter spring (11°F) or standard (22°F) radial lip seals.
- The Brenco Class F labyrinth seals averaged 1.0 lb.ft. less torque per bearing than the Brenco Class F with optimized/no garter spring seals and 2 ft.lbs. less torque per bearing than the standard radial lip seals at equivalent temperatures.
- Overall, the Brenco Class K labyrinth seals require 1.4 lb.ft. less torque per bearing than the Brenco Class K optimized radial lip seals.
Fuel Consumed and Operating Cost Comparison for Available Class K Seals

<table>
<thead>
<tr>
<th>Bearing and Seal Type</th>
<th>RSI Bearing Testing</th>
<th>Fuel Consumption</th>
<th>Operating Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seal Torque (ft-lb/set)</td>
<td>Seal Temp (°F)</td>
<td>Fuel/Mile (Gal/mile)</td>
</tr>
<tr>
<td>Competitor A - Premium Class K</td>
<td>3.2</td>
<td>13.7</td>
<td>3.04E-4</td>
</tr>
<tr>
<td>Competitor A - Standard Class K</td>
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<td>23.4</td>
<td>4.465E-4</td>
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<tr>
<td>Competitor B - Premium Class K</td>
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<td>39.35</td>
<td>5.60E-4</td>
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<tr>
<td>Competitor C - Premium Class K</td>
<td>3.45</td>
<td>28.8</td>
<td>3.278E-4</td>
</tr>
</tbody>
</table>

- **46% savings** in fuel due to seal drag from lowest to highest torque design
- Equates to $50 savings per bearing per year at fuel cost of $2.00 per gallon
Findings from TEM Simulation

• Western coal route simulation results
• Low torque labyrinth vs. standard established for radial lip seal equipment
  • 1.6% TEM calculated fuel savings
  • 0.4 gallons per 1000 miles per bearing
Areas Identified for Improvement

• Roller bearings have a direct effect on the operating efficiency of a train

• The three most critical items to achieve more fuel efficient bearings are:
  – high reliability bearing components to eliminate unscheduled train stops
  – grease selection for cold climates
  – seal selection for high utilization services
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