Wheel Profile and Track Geometry Threshold Optimization in an Australian Mining Railroad using VAMPIRE®

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Overview

• Roy Hill Background and the Mining Operation
• Unique Overall Solution Need
• Wheel/Rail Contact Analysis
• Track Geometry Threshold and Speed Restriction Determination
ROY HILL BACKGROUND AND THE MINING OPERATION
Where is Roy Hill?

- Mining operation project in Western Australia in the East Pilbara
Mining Operations

- Open cut mine operating multiple pits & 55 Mtpa wet processing plant
- Maximum operating axle load of 42.8t
- 344km Heavy Haul Railway
- 5 loaded movements per day
Track Schematic

Features
- 136 lb - RE
- 1000m curves in mainline
- 450m curve in loading/unloading loops
- Standard track gage
- 1:40 rail cant
The Ore Wagon

CRRC Design and Build
• 1196 Ore Cars in tandem pairs

Standard Features
• 21.6t Tare
• 160t Gross
• ECP Brakes
• Auto Park Brake
• Amsted SSRM Bogie
Truck Design Details

- 125-ton NA design with modifications
- 40 ton axle
- 38” wheels

Variable Damping

Stucki Side Bearing

Low Friction Centre Bowl

Amsted SSRM Bogie
Track Measurement Vehicle

- Track Geometry
- Rail Profile
- Corrugation
- Ultrasonic Rail Flaw
- Ground Penetrating Radar
- Track Bed Imaging
- Rail Surface Imaging
- Ballast/Formation Profile
- Right Of Way Video
NEED TO TIE EVERYTHING TOGETHER !!!!
Rail Track Conditioning Monitoring (RTCM)

- Inspector Entries
- Automated Inspection Systems
- In Motion Weighbridge Tonnage

Rail Track Condition Monitoring System (RTCM)

- Digital Track Notebook (DTN)
- TrackIT
- Automated Maintenance Advisor (AMA)

- Regulatory Reporting
- Specialised Reports

SAP

GIS

Work Orders
Overview of Process

• Pieces of the Big Puzzle
• Once the thresholds are determined track measurements will be used to flag locations of concern

Optimize wheel profiles to provide good baseline operating conditions

Develop Optimized Track Geometry Thresholds for Safe Vehicle Operations

Use Track Geometry Thresholds in the RTCM Process
WHEEL PROFILE ANALYSIS
Review of Wheel Profile

- Developed to match the Roy Hill rail design - AREMA 136 lb RE-10 inch
- Wide Flange Profile - 34mm width
- High conicity near the flange – 1:10
- Taper at the taping line 1:40
- Concerns with high stresses on the gauge corner based on high conicity and observations on other track in the Pilbara.
Optimized Wheel Profile

- WP2 profile based on the modified wide flange wheel.
- Flange and flange root were altered to a shape similar to that of the AAR-1B-WF, with a constant tread taper carrying to the flange root.
- Several criteria analyzed including Nadal Limit, Base/Height (B/H) Ratio, Equivalent Conicity, and Hertzian Contact Stress.
Parameters Analyzed

- Hertzian contact force and stress
- Equivalent conicity to ensure stability
- General contact conditions with a change in lateral shift
- Nadal limit for potential wheel climb
- B/H ratio for rail roll over evaluation
Results of Wheel Profile Analysis

- In general track does not have sharp curves so it allowed us to tailor it more towards lower RCF potential
- Lowered contact stress to provide reduced wear and fuel consumption
- Lowered equivalent conicity to provide higher stability
- Wheel wear – Roy Hill expects to achieve 400,000km between turns on the ore car fleet
- Truing will remove approximately 5mm every two years
TRACK GEOMETRY THRESHOLD OPTIMIZATION
Need for Track Geometry Thresholds

• Operation is very complex with large wheel/rail forces
• Captive fleet with a specific design of the ore wagons
• Need to understand the limits for track deterioration and speed restrictions
• Gets used in the RTCM process as baseline and then continuous monitoring using near real-time VAMPIRE module
Threshold and Speed Limitation Determination Process

Inputs for Simulations
- Track design
- Vehicle design
- Contact conditions
- Operating conditions

Track Geometry Thresholds and Speed Restrictions

Track Measurements and Exceptions
**Analytical Process**

**Rolling Stock Modelling:**
- Build ore wagon models in VAMPIRE;
- Modify vehicle models to reflect worn conditions.

**Infrastructure Modelling:**
- Build baseline track models from Roy Hill geometry setout tables;
- Incorporate geometry defects into baseline models.

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**VAMPIRE Dynamic Simulations**

**Dynamic Response Result**
- Dynamic output includes: wheel/rail contact force, carbody acceleration...
- Output data were sampled at 500Hz.

**Geometry Defect Threshold**
For each design speed track, the threshold for each type of geometry defect at each operation speed was defined.

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**9 criteria values of each dynamic simulation**
- The criteria values were calculated from output data;
- The criteria limits were defined from AAR chapter XI.

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**Threshold Determination Algorithm**
Simulation Details

Vehicle models constructed
- Empty.loaded
- CG biased/unbiased
- Wedge rise /No wedge rise
- 32 different vehicle configurations

Track modeling
- 16 design track models
- 8 perturbation types
- Magnitude variations
- Speed were varied in 4 steps

Wheel rail modeling
- New/worn wheel
- New/worn rail
<table>
<thead>
<tr>
<th>Type of Perturbation</th>
<th>Wavelength(m)</th>
<th>Shape</th>
<th>Speed(km/h)</th>
<th>Magnitude(mm)</th>
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</thead>
<tbody>
<tr>
<td>Track Lateral</td>
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<tr>
<td>Narrow gauge</td>
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<td>Versine</td>
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<td>30 to 100</td>
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</table>
Example of Threshold Determination
Example of Threshold Determination

- Conduct simulations for all scenarios including varying vehicle, track and speed conditions
- For the example of twist long chord of 14.47m a threshold of 60mm was determined for 80 kmph design speeds
- Furthermore, thresholds were then obtained for the same 80 kmph design track for speed restrictions – Larger perturbations -> slower speeds !!!!
- The same process was followed for tracks with design speeds of 60 kmph and 40 kmph
## Lateral Perturbation Thresholds

<table>
<thead>
<tr>
<th>Perturbation (wavelength)</th>
<th>Simulation Speed (km/h)</th>
<th>RH Initial (mm)</th>
<th>FRA Standard (mm)</th>
<th>AUS Standard (mm)</th>
<th>Recommended Threshold (mm)</th>
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<tr>
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<th>RH Initial (mm)</th>
<th>FRA Standard (mm)</th>
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Summary and Conclusions

• Custom thresholds are in place on the TMV
• Highly monitored captive fleet system
• Performance assessments are routine and aggressive
• Unique opportunity to allow constant improvement