On estimating the risk of wheel damage for wagons with paper rolls considering various dynamic conditions

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Agenda

1. Background
2. Method
   - Track
   - Vehicle
   - Load
   - Simulation setup
   - Modelling
   - RCF
3. Results
4. Conclusions
5. Further work...
Background
Background

- Y25 bogie wagons leased from Ahaus Alstätter Eisenbahn
- Maintenance of the running gear is on AAE
- Maintenance of the wheelsets is on HR

- Damage: Surface initiated RCF
Background

Objective

Prediction of surface initiated surface initiated RCF and analyse the influence of operational parameters using Rail Vehicle Dynamics
## Track Sections

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<th>Section 2</th>
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<td>Umeå (Uå) – Vännäs (Vns):</td>
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<td>Vännäs (Vns) – Mellansel (Msl):</td>
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<td>Mellansel (Msl) – Långsele (Lsl):</td>
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<td>Ramsjö (Rsö) – Ljusdal (Ls):</td>
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<td>Västerås Norra (Vån) – Kolbäck (Kbä):</td>
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<td>Kolbäck (Kbä) – Jädersbruk (Jbk):</td>
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<td>Jädersbruk (Jbk) – Frövi (Fv):</td>
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<td>Östansjö (Öj) – Laxå (Lå):</td>
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<td>Laxå (Lå) – Falköping C (F):</td>
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</table>

**Standard gauge:** 1435mm  
**UIC60 rails**
## Track

### Irregularities and Quality

<table>
<thead>
<tr>
<th>Permissible local speed in km/h</th>
<th>Alignment</th>
<th>Longitudinal level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Values of quality level in mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>QN1</td>
<td>QN2</td>
</tr>
<tr>
<td>QN1 Standard deviation $\Delta y^0_\sigma$ and $\Delta z^0_\sigma$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V \leq 80$</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>$80 &lt; V \leq 120$</td>
<td>1.2</td>
<td>1.5</td>
</tr>
<tr>
<td>$120 &lt; V \leq 160$</td>
<td>1.0</td>
<td>1.3</td>
</tr>
<tr>
<td>$160 &lt; V \leq 200$</td>
<td>0.8</td>
<td>1.1</td>
</tr>
<tr>
<td>$200 &lt; V \leq 300$</td>
<td>0.7</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Good quality:** $\geq 55\%$ of track geometry quality belongs to QN1

**Intermediate quality:** $55 - 45\%$ of track geometry quality belongs to QN1

**Bad quality:** $\leq 45\%$ of track geometry quality belongs to QN1.

Sections with bad quality: 129 (Vännäs-Mellansel), 216 (Ramsjö-Ljusdal) and 351 (Jädersbruk-Frövi)
Vehicle

Wheel profile: S1002
Wagon frame: SGNSS

Source: http://www.kockumsindustrier.se/

Load

a

b

c
Simulation setup

Load collective method

- Bundles divided into curve cases.
- Average of each curve case chosen.
- Speed calculated according to standards for freight vehicles (maximum 100km/h)
- Track quality of each curve case evaluated separately.
- Simulation carried out for each bundle and each curve case.
- Results from each curve case added to the according bundle.

### Example of bundle between Vännäs and Mellansel

<table>
<thead>
<tr>
<th>Curve radius, [m]</th>
<th>Curve radius, [m]</th>
<th>Cant, [mm]</th>
<th>Constant curve length, [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;400</td>
<td>344</td>
<td>115</td>
<td>241</td>
</tr>
<tr>
<td>400-600</td>
<td>574</td>
<td>94</td>
<td>611</td>
</tr>
<tr>
<td>600-800</td>
<td>700</td>
<td>60</td>
<td>221</td>
</tr>
<tr>
<td>800-1000</td>
<td>955</td>
<td>42</td>
<td>329</td>
</tr>
<tr>
<td>1000-1500</td>
<td>1047</td>
<td>33</td>
<td>347</td>
</tr>
<tr>
<td>1500-2000</td>
<td>1535</td>
<td>15</td>
<td>242</td>
</tr>
<tr>
<td>2000-3000</td>
<td>2340</td>
<td>8</td>
<td>272</td>
</tr>
<tr>
<td>3000-5000</td>
<td>4365</td>
<td>4</td>
<td>215</td>
</tr>
<tr>
<td>5000-10000</td>
<td>5275</td>
<td>2</td>
<td>407</td>
</tr>
</tbody>
</table>

Load

- a) Standing rolls
- b) Lying roll
- c) Recycle paper

Friction coefficient

- i. .35
- ii. .45
- iii. .55

[Friction coefficient graph]
Modelling

MBS: GEN SYS

• Track
• Wheelset
• Bogie
• Wagon frame
• Carbody

• Y25 bogie validated and benchmarked in SUSTRAIL EU project

What is RCF?
- Repeated action of creep forces.
- Creep forces are functions of wheel-rail geometry, material, normal forces and creepage.
- Usually appear perpendicular to the resultant creep force. (Surface initiated)
Different zones of RCF
- Zone 1: Inner wheel when curving
- Zone 2: Outer wheel when curving
- Zone 3: Longitudinal creep forces
- Zone 4: Lateral creep forces

Source: Bombardier

Worn down by wear
RCF - $F_{i_{surf}}$

$\Rightarrow$ Indication of RCF if $F_{i_{surf}} > 0$

RCF - $F_{\text{surf}}$

Working points for different loads. Rad: 600m, Fric. coeff.: 0.45

Ideal track
RCF – Considering wear

- RCF correction factor (Energy dissipation)

- Archard’s wear model

\[
E_2 = 175 \text{J/m}
\]

RCF – Considering wear

- RCF correction factor - 400m curve
- RCF correction factor - 1000m curve
- RCF correction factor - 1500m curve
- Archard - 400m curve
- Archard - 1000m curve
- Archard - 1500m curve
Results

Friction & track quality vs curve radii

Friction coeff. 0.55 - Standing (Right wheel)

Friction coeff. 0.35 - Standing (Right wheel)

- Graphs showing the relationship between friction coefficient and curve radii for different track conditions.
Results

Different speeds

RCF for different speeds on a 1000m radius curve (Right wheel)
Results

Different qualities

BDL 129 (Vännäs-Mellansel), Right Wheel

Track
• Good quality
× Bad quality
Results
Wheel position of RCF
Results

Density

Most frequent case of RCF:
Standing load case, 800-1000m curve, 0.1-0.2 RCF value
Results

Different loads

RCF - Different loads - 600m radius curve (Right wheel - no consideration for wear)

RCF - Different loads - 600m radius curve (Right wheel)
Results

Density

- 800-1000
- 800-1000
- 600-800
- 800-1000

Load cases

- Lying 36%
- Return 35%
- Stand 29%
Conclusions

• Track quality affects RCF – Consult with Trafikverket
• Speed affects RCF – Addapt the speed profile to the most problematic curves (800-1000m)
• Load cases don’t have big relative differences
Further work

• Validations of RCF position on wheel with real case RCF
• Optimizing different ways of loading the rolls (Change centre of gravity, interias…) What effect does it have on RCF?

• Simulation of paper rolls load shift
• Simulation of SUSTRAIL vehicles
Thank you for your attention!

Questions?