Freight Wagon Running Gears with Leaf Spring and Ring Suspension

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Common Freight Wagon Running Gears in UIC-Area

Y25-Bogie

- Helical Springs in vertical direction
- Friction Damping (Lenoir-Damper)
- stiff Axle Guiding

Axle Guiding of Y25-Bogie with Lenoir-Damper
Bogies with Leaf Spring and Ring (Chain Link) Suspension

- Leaf Spring or Parabolic Spring in vertical direction
- Friction Damping between the single Leaves of the Spring
- “Soft” Axle Guiding

Different kinds of Chain Links
Single Axle Running Gear with Ring Suspension

- Parabolic Spring in vertical direction
- Double Chain Link Suspension in lateral and longitudinal direction
Assembly of Chain Link Suspension

- Chain Link
- Chain Link Stone
- Bolt
- Parabolic Spring

Friction between

- **Longitudinal direction:**
  - Bolt and Chain Link Stone / Parabolic Spring

- **Lateral direction:**
  - Chain Link and Chain Link Stone
Characteristics of Freight Wagon Running Gears

- simple mechanical Design
- no hydraulic Dampers
- significant Hysteresis in Force Characteristics of Suspension Elements

Requirements for dynamic Calculations

- Parameters determining the Characteristic of the Chain Link Suspension have to be known
- Force-Routines for the Calculation of the Friction dependent Characteristics have to be developed

Measurement of Suspension Characteristics is necessary for dynamic Calculations.
Measurement of Suspension Characteristics

Test Rig for complete Ring Suspension System

- Measurement of vertical Suspension Characteristics
- Measurement of longitudinal and lateral Suspension Characteristics depending on the vertical Load

Hysteresis caused by Friction

“Static Hysteresis”

Force Characteristics mainly depends on Amplitude of Excitation and not on Velocity/Frequency!
Characteristics of Leaf Spring and Chain Link Support

Vertical Characteristic
Parabolic Spring

<table>
<thead>
<tr>
<th>Force [N]</th>
<th>Displacement [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>20000</td>
<td>0.020</td>
</tr>
<tr>
<td>40000</td>
<td>0.040</td>
</tr>
<tr>
<td>60000</td>
<td>0.060</td>
</tr>
<tr>
<td>80000</td>
<td></td>
</tr>
<tr>
<td>100000</td>
<td></td>
</tr>
</tbody>
</table>

Longitudinal Characteristic
Chain Link Suspension

<table>
<thead>
<tr>
<th>Force [N]</th>
<th>Vertical Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>25kN</td>
<td></td>
</tr>
<tr>
<td>50kN</td>
<td></td>
</tr>
<tr>
<td>100kN</td>
<td></td>
</tr>
</tbody>
</table>

Displacement [m]:
-20000, -15000, -10000, -5000, 0, 5000, 10000, 15000

Force [N]:
20000, 40000, 60000, 80000, 100000, 150000, 200000

Measurement of Suspension Characteristics
Calculation Model for longitudinal direction

- Variation of:
  - Friction Coefficient $\mu$
  - $\Delta R$ Bolt / Chain Link

- Comparison to Measurement

Excitation used for Calculation

Deflection [mm] vs. time [s]
Calculation Results of Parameter Variation

Friction Coefficient $\mu$

Radius Difference $\Delta R$

- Force [N]
- Displacement [m]
- Displacement [m]

- 0.2
- 0.4
- 0.6

- 1.0mm
- 0.5mm
- 0.1mm

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Calculation of Chain Link Characteristics

Force Element for Use in Vehicle dynamic Calculations

- User-Routine as Component Force Element (Cmp)
- Two Friction Elements to calculate vertical Characteristic of Leaf Spring
- For calculating longitudinal and lateral Characteristics of Chain Link Suspension: Three Friction Elements in each case
- Parameters for Chain Link Suspension depend on vertical load

Parameters for the User-Routine are automatically calculated from Measurements (Matlab-Algorithm)
Calculation of Chain Link Characteristics

Comparison Measurement / Calculation / User-Routine

Longitudinal Characteristics of Chain Link Suspension

- Displacement [m]
- Force [N]

- Measurement
- Simpack-Model
- User-Routine
Vehicle Description

- Short Distance between Bogie Pivots
  \[ 2a^* = 7\text{m} \]
- Bogies of Type “LHB82”
- Parabolic Spring and short Chain Link Suspension
- Used for Transportation of Coils
Coil Transportation Wagon
Type Shimms

Vehicle Modell

- 2 Bogies of Type LHB82 are modelled
- Parabolic Spring with Short Chain Link Suspension
- Pivot Bearing and Sprung Side Bearers between Carbody and Bogie-Frame
- Force Element acting on the Carbody to reduce vehicle speed
Stability Analysis, non-linear (limit cycle)
Excitation: Vehicle leaving curve with $v = 150\text{km/h}$

Vehicle Speed

Lateral Displacement WS1

longitudinal Characteristic
Chain Link Suspension
Double-Deck Car-Carrier
Type Hcceeerrs 330

Vehicle Description

- 4 Cars with Single Axle Running Gears
- Tight Couplings with special Bumpers between the Cars
- Used for Transportation of Mercedes E and S Class
- Safest Way to move a Mercedes S Class!!
Double-Deck Car-Carrier
Type Hcceerrs 330

Vehicle Modell

- First half - 2 Cars - of the Wagon are modelled
- 4 Single Axle Running Gears with Double Chain Link Suspension
- Dummy Cars for the leading Wagon/Locomotive in front and for the third Car of the Hcceerrs
- Coupling and Bumpers between all Cars are modelled including Contact with Friction
Vehicle passing S-shaped Curve

- Radius $R = 300m$
- Rail Cant $u = 100mm$
- Cant Deficiency $u_f = 130mm$
- Track-Excitation (ORE B176)

"Steering Effect" of Wheelset
Double-Deck Car-Carrier
Type Hcceerrs 330

Simulation Run for track length of 70km

Hcceerrs 330, Calculations UIC 518

- $Y_{qst, RS1 li}$ [kN]
- $Y_{qst, RS1 re}$ [kN]
- Sum $Y_{RS1}$ [kN]
- $a_{TP 0.4Hz}$ [m/s²]
- $v_{ist}$ [km/h]
- $v_{soll}$ [km/h]
Double-Deck Car-Carrier
Type Hccceerrs 330

Simulation Run for track length of 70km

Statistics according to UIC 518

Fahrsicherheit

400<R<600m
N1: 37
N2: 27
Ngges: 38
k=3
P=99.85%
2m-Werte nach UIC518

R>600m
N1: 43
N2: 14
Ngges: 71
k=3
P=99.85%
2m-Werte nach UIC518

Summe Y RS1 [kN]

uf [m]
Problem: Freight Wagon Running Gears show a significant Hysteresis in nearly all Suspension Elements

Solution:
- Measurement of Hysteresis Characteristics
- Calculation of Characteristic to determine Influence of mechanical Parameters
- Development of an analogue Model for Vehicle dynamic Calculation

Method can be transferred on several Types of Spring Elements
- Annular Springs / Disc Springs in Buffers
- Some types of Rubber Springs
- ...