Calculation of the momentum drive and travelled distance of freight trains
Multi-body simulation with SIMPACK

SIMPACK User Meeting
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1. Introduction

Activities of T.TVI24

T.TVI 24
Fatigue Strength and Simulation

T.TVI 24(1)
Simulation of Structural Mechanics and Running Characteristics
- Evaluation of repair measures
- Evaluation of technical systems
- Accident analysis
- Warranty demands
- Side-wind

T.TVI 24(2)
Operational Loads and Strength
- Operational loads and stresses
- Compression tests
- Shunting tests
- Crash tests

T.TVI 24(3)
Operational Strength and Mechanical Function
- Bogie fatigue tests
- Wheel and Shaft tests
- Testing of Side windows
- Performance Testing of Axle boxes
- Testing of hydr. Dampers, Springs etc.
1. Introduction

*Multi-body simulation*

- **Maintenance**
- **Engineering and design**
- **Accident analysis**
- **Recertification**

**MBS**

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2. Description of the situation

- New built Port in Duisburg for combined transportation
  - transportation of ISO-Container between train street and sea
  - maximum freight train length 700 m
  - entry speed 40 km/h of electric locomotives
  - no catenary in the area surrounding the cranes for load cargo
  - entrance over two tracks

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**Diagram Details:**

- Entrance tracks
- 700 m straight track for load cargo without catenary
- Driving direction
- Exit track
2. Description of the situation

- Properties of the entrance tracks:
  - eight switches with radius 190 m to 300 m
  - different vertical profiles of the tracks

Distance start track to end of catenary 698 m

Start track 2307

Start track 2302

End of catenary
3. Definition of task

- Wind speed
  - critical wind speed

- Track properties
  - track profile

- Charging
  - unload and load container
  - unload and load wagons

- Train composition
  - different types of wagons
  - number of wagon types

- Travelled distance of the train
4. Simulation with SIMPACK

Simulation model single freight wagons (complex model)

- Two different types of freight wagons:
  - Lgs 580 with double chain link chassis and two wheelsets
  - Sgns 690 with Y25 bogie and four wheelsets
Restrictions for simulation of trains

- long calculation time
- numerical stability

Three mass model

Forces of resistance
- Calculation by expressions
  - with state variables
  - result of single freight wagon
4. Simulation with SIMPACK

**Forces of resistance**

**Roll resistance**

\[ W_{Roll} = m \times g \times \alpha \]

\[ W_{Roll} \]

**Aerodynamic resistance**

\[ W_{Wind} = \left( c_{w \, wagen} \times A_{wagen} + c_{w \, container} \times A_{Container} \right) \times \rho \times \left[ v_{Wind} + v_{Fahrzeug} \right]^2 \times \frac{1}{2} \]

**Acceleration resistance**

\[ W_{arot} = \sum_{i=1}^{n} \frac{J_{yy \, n} \times a_{wagen}}{(r_{n})^2} \]
Curvature resistance is nonlinear and dependent on:

- speed of wagon
- charging
- suspension and chassis
- radius of curvature
- properties of wheel rail contact

Diagram

- comparison of longitudinal friction force between wheel and rail with and without buffer (track 2302) at one wheelset
- rolling resistance included
4. Simulation with SIMPACK

Curvature resistance

Single freight wagon
(complex model)

- Simulation with different boundary conditions for calculation
  - constant speed
  - charging
  - track

- data preparation
4. Simulation with SIMPACK

Curvature resistance

Lgs 580 loaded

Lgs 580 unloaded

Sgns 690 loaded

Sgns 690 unloaded

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4. Simulation with SIMPACK

**Coupler and buffer**

**complex model**
- **coupler**
  - use hysteresis
  - characteristic stiffness curve
- **buffer**
  - use hysteresis
  - characteristic stiffness curve
  - stick-slip contact

**simple model**
- **coupler and buffer**
  - linear stiffness
  - hydraulic damping
Travelled distance of a single wagon

<table>
<thead>
<tr>
<th>Variant</th>
<th>Lgs 580</th>
<th>Sgns 691</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single freight wagon</td>
<td>Three mass model</td>
<td>Difference</td>
</tr>
<tr>
<td>1</td>
<td>474 m</td>
<td>478 m</td>
<td>+0.8 %</td>
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<tr>
<td>2</td>
<td>715 m</td>
<td>719 m</td>
<td>+0.6 %</td>
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<td>3</td>
<td>849 m</td>
<td>860 m</td>
<td>+1.3 %</td>
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<tr>
<td>4</td>
<td>930 m</td>
<td>935 m</td>
<td>+0.5 %</td>
</tr>
</tbody>
</table>
4. Simulation with SIMPACK

*Simulation model of the freight train*

- Properties of freight train models
  - 20 wagon train (ca. $m = 900 \text{ t}$, length 366 m)
  - 35 wagon train (ca. $m = 1500 \text{ t}$, length 634 m)
Simulation of the momentum drive and traveled distance with SIMPACK

Possible to simulate different constellations of trains including aspects of:
- Type of freight wagon
  - Suspension, chassis, mass…
- Track properties
  - Curvature and vertical profiles
- Charging
- Coupling between wagons
  - Properties of buffer and coupler
- External forces
  - Air resistance and wind resistance,…
Thank you!

DB Systemtechnik GmbH
Fatigue Strength and Simulation T.TVI 24
Stephan Behringer
Pionierstraße 10
32423 Minden
Tel.: +49 571 393 1801
E-Mail: Stephan.Behringer@deutschebahn.com