Simulation and Validation of Derailment Experiments with Simpack

2016 SIMULIA European Multibody Simulation User Group Meeting
Agenda

• Motivation

• Test rig

• Simulation and Validation results

• Process and Tools

• Conclusions
Motivation

The Siemens Mobility Division offers automated metros for driverless train operation.

• Derailment detection system because of safety reasons

• Implementation of algorithms need bogie specific parameters

• Parameters are determinded by real experiments with a bogie

Is it possible to simulate the derailment experiments with Simpack on a virtual test rig?
Test Rig

- One single bogie with an equivalent mass
- Equipped with an extensive measuring system
  - Accelerations at each suspension level
  - Relative distances in primary suspension
  - Speed
  - Angle of attack
Test Rig – Modelling in Simpack

- Steelplate on left side
- Additional bushing elements
- Lift lock
- Emergency Spring with friction
- Torsional stiffness of bogie frame
Focus of this Work

Derailment safety – design of bogie
Ensure that wheel climb does not happen

Process of derailment itself, by derailing over the wheel flange to the outer side

Not Focus of this work

Focus of this work
Validation – relative distance in primary suspension of derailing wheel

Focus of Validation

Wheelset starts to slip down rail
Lift stop takes effect
Wheel hits ground

leading wheelset right

relative distance [m]
Validation – relative distance in primary suspension in each wheel

- Leading wheelset left
  - Relative distance [m]
  - Time [sec]
  - Experiment (blue)
  - Simulation (red)

- Leading wheelset right
  - Relative distance [m]
  - Time [sec]
  - Experiment (blue)
  - Simulation (red)

- Trailing wheelset left
  - Relative distance [m]
  - Time [sec]
  - Experiment (blue)
  - Simulation (red)

- Trailing wheelset right
  - Relative distance [m]
  - Time [sec]
  - Experiment (blue)
  - Simulation (red)
Validation – acceleration at axlebox

Wheelset starts to slip down rail
Lift stop takes effect
Wheelset hits ground

Interpretation of accelerations difficult
Validation – acceleration at axlebox

\[ s = \int v(t) \cdot dt \]

\[ v = \int a(t) \cdot dt \]
Scenarios of validation

Derailment to outer side

qualitatively and quantitatively good

Derailment to inner side

qualitatively good quantitatively okay Δ~25%

Derailment to outer side with twist

qualitatively okay quantitatively good

Time Integration interrupted

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Uncertainty of Friction

- Friction has high influence on results
- Differences in results
- Rust on rail
- Traces on steelplate (plastification cannot be modelled)
- Further investigations have to be done

Friction?
Incorrect modelling of force element?
Process and Tools

1. **Measurement data**
2. **Analyze measurements**
3. **Generate steering file**
4. **Run simulation**
5. **Synchronize data**
6. **Compare results**
7. **Model does well?**
   - **Yes**: **Validated model**
   - **No**: **Adapt model**

The process involves the following steps:

- **Analyze measurements**:
- **Generate steering file**:
- **Run simulation**:
- **Synchronize data**:
- **Compare results**:
- **Model does well?**
- **Adapt model**
- **Validated model**
Conclusions and Future Work

- Validated model allows better understanding of the derailment process
- Validated model can be used as a starting point for more complex models
- Extended DoEs with different parameters

Real tests with another bogie
- With even more streamed signals
- Friction modifier
- Kalkers Contact in Simpack9
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