Multi-body simulation at the Deutsche Bahn AG (TZF95)

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Deutsche Bahn AG

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Bonn - Bad Godesberg

T Division

Integrated Systems Rail
Safety  Quality  Environmental Protection

Technology/Procurement (T) ca. 2,500 Employees

Vehicles  Vehicle Spare Parts  Constructio nal Equipment  Electronical Systems, Telecomms., SCCT ¹  Common Purchase, Mechanical Equipment  Information-technology  Strategy Integrated Systems Rail  Management-Services

Engineering-Pool DB System Technology
Activities of TZF 95

TZF 95
Verification and Testing
Fatigue Strength, Simulation

TZF 95.1
Simulation of Structural Mechanics and Running Characteristics
- Evaluation of repair measures
- Evaluation of technical systems
- Accident analysis
- Warranty demands
- Side-wind

TZF 95.2
Operational Loads and Strength
- Operational loads and stresses
- Compression tests
- Shunting tests
- Crash tests

TZF 95.3
Fatigue Strength and Mechanical Function
- Bogie fatigue tests
- Wheel and Shaft tests
- Testing of Side windows
- Testing of hyd Dampers, Springs etc.

Activities of TZF 95

TZF 95.3
Fatigue Strength and Mechanical Function, subject fatigue testing

- **Bogie frames**
  UIC-certification tests and investigation in residual fatigue life of bogie frames and their components

- **Axle and wheel discs**
  UIC-certification tests, product qualifications, manufacture homologations

- **Buffing and draw gears**
  Derivation of load spectra from service tests for application in laboratory

Bogie frame testing
Axle testing
Buffer testing and load spectrum
Activities of TZF 95

TZF 95.3
Fatigue Strength and Mechanical Function, subject mechanical function

• Fatigue and sealing tests of side windows
  Certification according to UIC 566, TSI rolling stock including simulation of rain, dew point testing, residual strength of broken panes.

• Performance tests on axle boxes
  according to EN 12082

• Functional tests on axle boxes
  Investigations in deficiency of grease and axle box failures

• Testing of hydraulic dampers
  Certification testing according to EN 13802, endurance testing, service testing on car

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Activities of TZF 95

TZF 95.2
Operational loads and strength

Measurement under operational conditions:

• Determination and evaluation of load spectra

• Generation of load spectra for fatigue strength test

• Verification of simulation models
Activities of TZF 95

TZF 95.2
Operational loads and strength

Compression test for validation of static strength and stresses of rolling stock

Marshalling hump
- Determination of dynamic strength
- Mechanical testing of components

Shunting tests with incline
Compression test with load frame

Activities of TZF 95

TZF 95.1
Simulation of structural mechanics and running characteristics, subject strength and structural mechanics

- Technical investigation of accidents
- Concepts for repair, specification of maintenance periods
- Evaluation of modified construction

Simulation of crack growth
Optimisation of switch blade
Restoration of bogieframe with extensive corrosion
MBS Tasks

Tasks of multi-body simulation

General research issues
- modelling of an elastic wheelset
- modelling of measuring sections
- simulation of load spectrums

Accident analysis like
- freight waggon accidents

Support of the work of technical boards with basic studies for example
- coupling rod
- longitudinal compressive force in freigh trains

Support of testing and test stand
- calculation of loads for components (spring-damper, bearings, cylinder)
- support for the design of test stands

Sidewind investigations

First example: feasibility study of coupling rods

Task:
- UIC Project
- Feasibility study of different coupling rods for freight waggons in a wagon unit
- Assessment of the running characteristics particular maximum compression forces by simulation

Approach:
- Modelling of freigh vehicles with frame waggons with UIC double link suspension and parabolic spring
- Modelling of the alignment (S-curve with 150m radius, constant curve with 150m and 250m radius)
- Modelling of eight different coupling rods
- Assessment of the criterions according to UIC 530-2 and ORE B55 due to simulation results (uplift of non-guided wheel, lateral force on axle box, deformation of the axle guards, buffer overlap)
modelling of a coupling rod

Technical drawing:

Transmission of force:

- Contact radius: $R=1500$ mm
- Contact area: planar
- Width: 200 mm
- Height: 120 mm
- Displacement to joint: 95 mm

SIMPACT model of coupling rod

Parameter

- Friction in contact area
  - Static friction
  - Dynamic friction

- Masses
  - Rod
  - End plate
  - Joint bolt
  - Spring

Total mass 360 kg

Kinematic of the model

- Suspension in longitudinal direction
- Joint rotation perpendicular to rod
- Rod: 6 dof

Kinematic limitations

- Longitudinal bump stop for joint with pull force
- Contact of the areas with compressive force
Results

Simulation:
- 2 vehicles with a coupling rod
- side buffers on front and back
- curvature: 150 m S-curve
- slow velocity (v \(<\) 10km/h)

Criterion:
- max. of long. compressive force

Result:
- significant influence of coupling rod on compressive force
- different results for S-curve and curve

Second example: derivation of test signals

Task:
- Durability tests of hunting dampers of tilting trains
- Larger operating area of dampers of tilting trains than of dampers of conventional trains
- Verification of different hunting dampers for more than 1,5 Mio. km
- Comparison of 3 different damper types

Approach:
- Line definition (line with tilting operation mode)
- Simulation – calculation of the damper position (length) dependent of radius und uncomp. acc. (aq)
- Classification of the damper position and assignment to radius and aq
- Line analysis – determination of time slices for the damper positions for the line
- Analysis of the measurements for the coach oscillation
- Derivation of the test signal
- Definition of the test stand
Teamwork of our department

TZF 95.1
- Multi-body simulation
- Derive test signal
- Definition of test stand

TZF 95.2
- Apply Test stand
- Perform durability test
- Evaluation of test results

TZF 95.3
- Supply measurement data
- Supply track alignment

Calculations

- Calculation of the damper position dependent of radius und aq
- Calculation with a verified MBS-Model
Classification

- Classification of the damper position
- Determination of time slices for the damper positions for the line München - Berlin

Test signal and test stand

Test signal

Test stand
Conclusions

MBS Simulation at Deutsche Bahn AG mainly used for:
- Test applications and maintenance
- General studies for the formulation of specifications and standards
- Investigations to clarify accident causes
- Investigations of operational concerns like
  - maximum longitudinal forces in train sets
  - clearance gauge calculation
  - speed-limits for specific operational conditions
  - wear of components dependent of different parameters
  - load definition for durability tests and calculations

**Advantage:** Access to current operating data, measurements and vehicles for the validation of the models and results

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Contact

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Thank you!