TECOSIM
best partner for simulation

Test verification techniques in LS-Dyna

6. LS-Dyna Forum 2007, 11. - 12. Oktober 2007, Frankenthal

Dr.-Ing. Martin Müller-Bechtel
Dipl.-Ing. Udo Jankowski
Dipl.-Ing. José Martínez

TECOSIM
best partner for simulation

TECOSIM

Solutions

TEC|BENCH
Project overview
Hardware analysis
Simulation

Contents

- TECOSIM
- TEC|BENCH™
- Project overview
- Hardware analysis
  - Body in white crash
  - Benchmarking – Scanning – Reverse engineering
  - Material analysis
- Simulation
  - Model setup
  - Verification process
  - Robustness study
  - Parameter identification
  - Structural result

TECOSIM
best partner for simulation

TECOSIM
- Company
- Solutions

TECOSIM – best partner for simulation

▪ Foundation:	1992
▪ Business Area:	Engineering Service Supplier for the Automotive Industry, Aerospace and Chemical Industry
▪ Locations:	Basildon (UK), Cologne, Munich, Ruesselsheim, Stuttgart, Wolfsburg
▪ Turnover:	2007: 16 Mio. Euro (forecast) 2006: 12 Mio. Euro 2005: 9 Mio. Euro
▪ Employees:	2007: 220 Employees (07/10) 2006: 150 Employees 2005: 100 Employees
▪ Customers:	Original Equipment Manufacturers Full Service Suppliers
▪ Certifications:	ISO 9001:2000 ISO 14001:1996 FORD Q1 Award

TECOSIM
best partner for simulation

TECOSIM
- Company
- Solutions

▪ Body CAE
HS/LS-Crash
Dynamics/NVH
Stability/Durability
Acoustics
CFD/Aerodynamics

▪ CAE Consulting
CAE-Processes
Product Optimisation
Software/Hardware
Training

▪ Advanced CAE
New Vehicle Concepts
CAE-Material Validation
Barrier Development
CAE Process Chain

▪ Seats CAE
ECE-xx
Dynamics
Stability

▪ CAE Products
TEC|ODM™
TEC|PROM™
TEC|BENCH™

▪ Powertrain CAE
Dynamics/NVH
Stability/Durability
CFD/UTM
Acoustics

▪ Interior CAE
Occupant Protection
Restraint Systems
Pedestrian Protection
CFD/HVAC
Interior Concepts

▪ Subsystems CAE
Stability/Durability
Dynamics/NVH
Structural Optimisation
D.O.E.
Crash
CFD

▪ Chassis CAE
Dynamics/NVH
Stability/Durability
Impact Simulation
Driveover Curb
MKS/MKS-Structure Coupling

TECOSIM
best partner for simulation

TECOSIM

Solutions

- TEC|BENCH
  - Project overview
  - Hardware analysis
  - Simulation

TEC|BENCH™ – best benchmarking for simulation

Competitor analysis | 3D geometry | Virtual product development

Benchmarking
- Hardware dismantling
- Bill of Materials BOM:
  - Parts
  - Material
  - Thickness
  - Joining technique
- Design analysis report:
  - non common features

Scanning
- Photogrammetry
- Digitizing:
  - Overall scan
  - Detail scan (parts)
- Laser scanning

Simulation
- Full vehicle/Body CAE
  - HS/LS-crash
  - Dynamics/NVH
  - Stability/Durability
  - Structural optimization
- Multi Body Systems
- CFD/Aerodynamics

Testing
- Material analysis:
  - Classification
  - Testing
- Component testing
- Structural analysis:
  - statics & dynamics
  - crash testing

Reverse Engineering
- CAD data preparation
  - Based on STL data
  - Appropriate for FE

Virtual Benchmarking
- Combines key competences
- Simulation allows:
  - Performance evaluation
  - Better understanding
  - Flexible own studies

TECOSIM
best partner for simulation

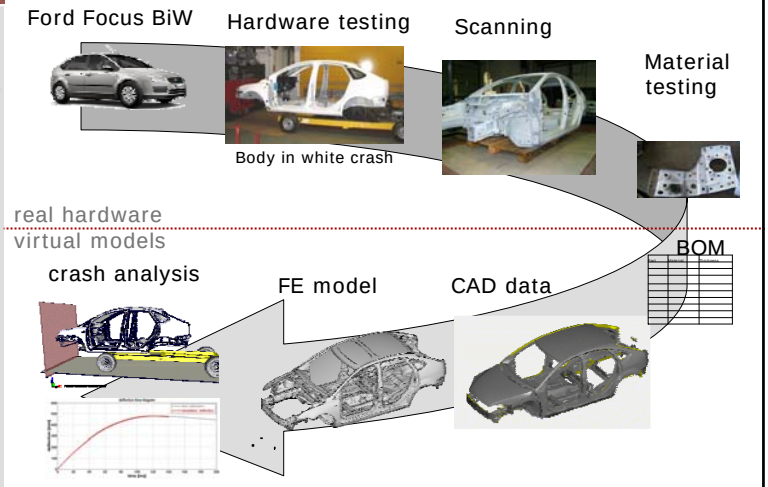
TECOSIM

Solutions

- TEC|BENCH
  - Project overview
  - Hardware analysis
  - Simulation

TEC|BENCH™: project overview

Create a body in white simulation model for front crash application



TECOSIM
best partner for simulation

TECOSIM

Solutions

TEC|BENCH
Project overview
- Hardware analysis
Simulation

Hardware testing: body in white crash

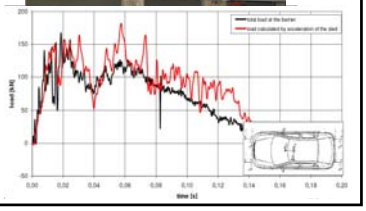
Test configuration:

- Body in white with windows, subframe front, ip-beam
- Mounted on barrier carrier
- Total weight 1704 kg
- Impact against rigid wall,
- Initial velocity 7.75 m/s, 50 kJ

Test results:

- Compaction of crashbox
- Vertical bending collapse of side member

- Total deformation 480 mm
- Force level:
  crash box 150 kN
  side member 170 kN



TECOSIM
best partner for simulation

TECOSIM

Solutions

TEC|BENCH
Project overview
- Hardware analysis
Simulation

Benchmarking – Scanning – Reverse engineering: body in white

Benchmarking:

- Hardware dismantling of the vehicle structure, part by part
- Bill of Materials BOM
  Complete part list (name, ID)
  Thickness
  Weight
  Joining technique

Scanning:

- Photogrammetry
- Digitizing of projected fringe patterns
  Overall scan
  Detail scan of parts

Reverse Engineering:

- CAD data preparation
  based on STL scanning data
  rough IGS data appropriate for FE

TECOSIM
best partner for simulation

TECOSIM

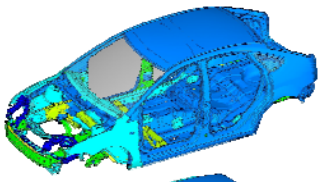
Solutions

- TEC|BENCH
- Project overview
- Hardware analysis
- Simulation

Material analysis: body in white

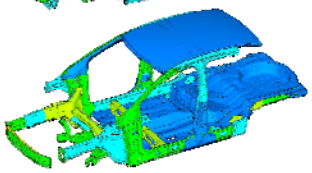
Classification:

- Measurement of Vickers hardness for 200 sheet metal parts
- Overall classification according to hardness distribution

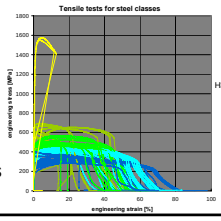


Tensile tests:

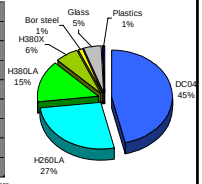
- Tensile tests for 40 parts
- Selection of parts tested according to material classes



- Determination of yield curves
- Determination of material scatter



- Verification of material classes
- Identification of material type by comparison to material standards



TECOSIM
best partner for simulation

TECOSIM

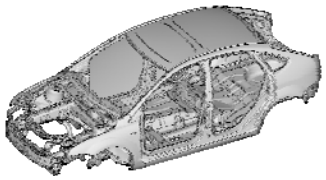
Solutions

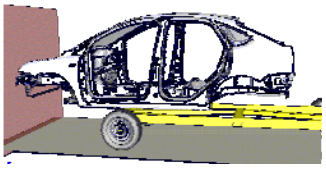
- TEC|BENCH
- Project overview
- Hardware analysis
- Simulation

Simulation: body in white crash

FE model setup:

- Part by part FE modeling based on prepared CAD data
- Assembly of complete vehicle structure (spot-welds, bolts)
- FE model consists of 230 components
  324000 nodes, 278000 elements
- Setup according to hardware test configuration:
  impact against rigid wall
  total mass 1704 kg
  initial velocity 7.75 m/s, 50 kJ





TECOSIM
best partner for simulation

TECOSIM

Solutions

TEC|BENCH
Project overview
Hardware analysis
Simulation

Simulation: body in white crash

Verification process using ST-ORM:

- Robustness/Sensitivity investigation with respect to wall friction and material scatter
- Identification of simulation parameters for optimal correlation to test:
  maximum deformation
  minimum deviation of pulse

TECOSIM
best partner for simulation

TECOSIM

Solutions

TEC|BENCH
Project overview
Hardware analysis
Simulation

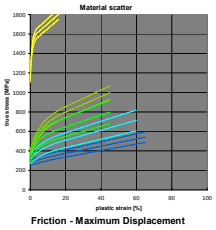
Simulation: Robustness study (24 runs)

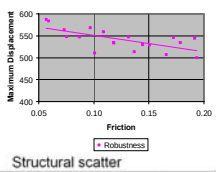
Variable definition:

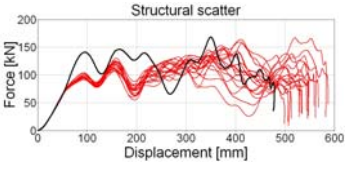
- Input variation (equally distributed):
  wall friction 0.05 ... 0.2
  single part yield curves:
  DC04 ± 10%
  H260LA ± 15%
  H380LA ± 15%
  H380X ± 7%
  Bor steel ± 3%
- Output:
  maximum displacement
  rebound time
  pulse deviation (compared to test)
  Energy dissipation

Results:

- Statistical: correlation for deformation and pulse deviation vs. friction
- Structural:
  reduced force level of crash box
  increased maximum displacement
  friction stabilizes system
  output scatter < input scatter







TECOSIM best partner for simulation

TECOSIM

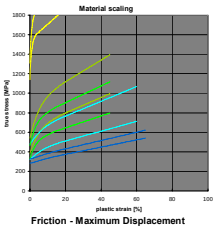
Solutions

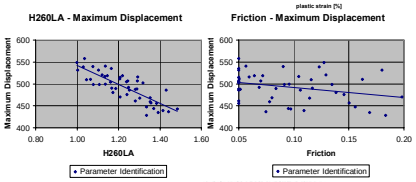
TEC|BENCH
Project overview
Hardware analysis
Simulation

Simulation: Parameter identification (48 runs)

Variable definition:

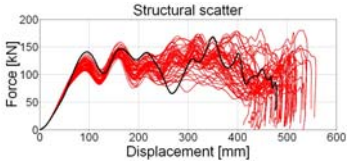
- Input variation (equally distributed):
  - wall friction 0.05 ... 0.2
  - material class yield curves:
  - DC04 1.0 ... 1.15
  - H260LA 1.0 ... 1.5
  - H380LA 1.0 ... 1.4
  - H380X 1.0 ... 1.4
  - Bor steel 1.0 ... 1.15
- Output:
  - maximum displacement
  - rebound time
  - pulse deviation
  - Energy dissipation





Results:

- Statistical: significant correlation for maximum deformation vs. H260LA
- Structural:
  - reduced effect of friction
  - test pulse is covered by structural scatter



TECOSIM best partner for simulation

TECOSIM

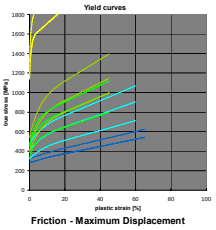
Solutions

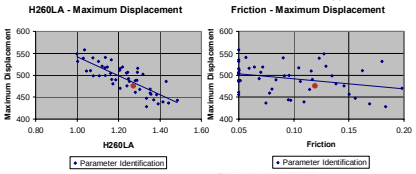
TEC|BENCH
Project overview
Hardware analysis
Simulation

Simulation: structural result

Variable definition:

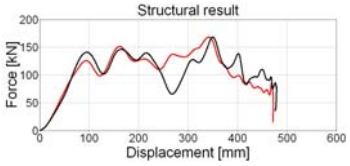
- Input variables:
  - wall friction 0.12
  - material class yield curves:
  - DC04 1.0
  - H260LA 1.27
  - H380LA 1.25
  - H380X 1.15
  - Bor steel 1.0
- Output:
  - total deformation 473 mm
  - rebound time 133 ms
  - pulse deviation 0.062
  - Energy dissipation





Results:

- Parameter identification for optimal correlation to test possible
- Identification of work hardening effect
- Estimation of wall friction coefficient



TECOSIM
best partner for simulation

TECOSIM

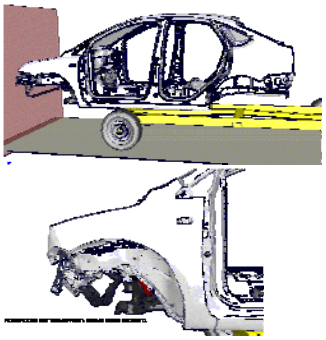
Solutions

TEC|BENCH
Project overview
Hardware analysis
Simulation

Simulation: body in white crash

Configuration:

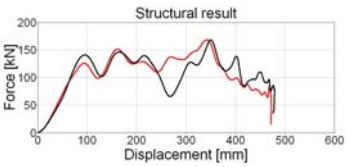
- Body in white with windows, subframe front, ip-beam
- Mounted on barrier carrier
- Total weight 1704 kg
- Impact against rigid wall,
- Initial velocity 7.75 m/s, 50 kJ



Simulation results:

- Compaction of crashbox
- Vertical bending collapse of side member

- Total deformation 473 mm
- Force level:
  crash box 150 kN
  side member 170 kN



- Successful verification

TECOSIM
best partner for simulation

TECOSIM

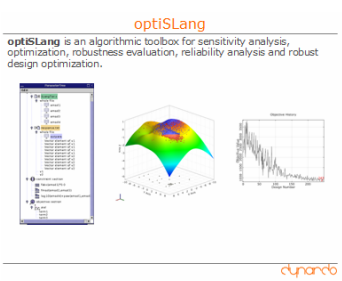
Company

Solutions

Focus

- Tecosim is ST-ORM distributor through the merger of Carhs engineering and Tecosim
- ST-ORM and optiSLang will be jointly developed. ST-ORM functionalities will be integrated in optiSLang
- Tecosim will use the jointly developed optiSLang for upcoming projects

+



TECOSIM
best partner for simulation

Ihr Kontakt

TECOSIM Technische Simulation GmbH
Dr.-Ing. Martin H. Müller-Bechtel
Virtual Benchmarking Department
Ferdinand-Stuttmann-Straße 15
D-65428 Rüsselsheim
Tel.: +49 (0) 6142 / 8272 230
Fax: +49 (0) 6142 / 8272 249
Mail: m.muellerb@de.tecosim.com