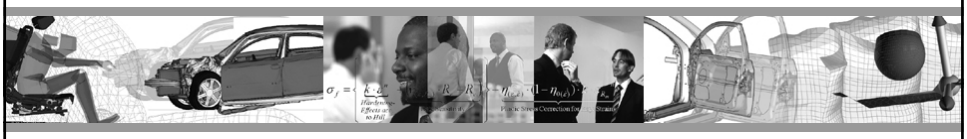
TECOSIM
best partner for simulation



Element Sizes in Crash Calculation

Dipl.-Ing. **Udo Jankowski**, Dr.-Ing **Martin Müller Bechtel**, Dipl.-Ing. **Manfred Sans**, Tecosim GmbH

4. LS-DYNA Forum, 20.-21. Oktober 2005, Bamberg

Agenda

- Tecosim-best partner for simulation
- Introduction
- FE Experiments with varied parameters
- Analysis of Results/ Conclusion
- Outlook

Locations & References

TECOSIM

Rüsselsheim

Köln

- Audi AG
- Adam OPEL AG
- Claas
- Daimler Chrysler
- Daihatsu
- Fiat
- FORD
- General Motors
- HONDA
- ISUZU
- KIA
- John Deere
- Jaguar
- Landrover
- Nissan
- PORSCHE AG
- Toyota
- AMG
- Autoliv
- Bayer AG
- Bentler
- Bertone
- Bosch/ Blaupunkt
- Degussa-Hüls AG
- Dynamit Nobel
- EADS
- Faurecia
- Getrag
- Hella KG
- Johnson Controls
- Karmann
- Lear
- Magna
- Thyssenkrupp
- TRW Automotive
- Mahle
- MAN
- Mannesmann/Sachs
- Siemens VDO
- Wagon Automotive

Leonberg

Basildon (UK)

Coventry (UK)

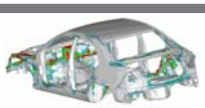
Igenie Office Tokio (Japan)

CAE Portfolio

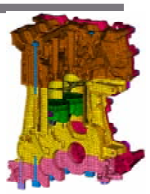
TECOSIM

CRASH

Safety



NVH / Durability

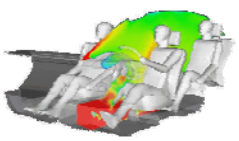


Powertrain

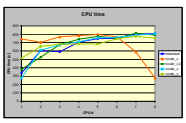
Seats

CAE Portfolio

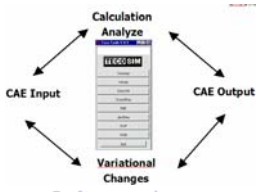
Multi Body Systems (MBS)



CFD



Optimization



Software dev

Introduction

TECOSIM

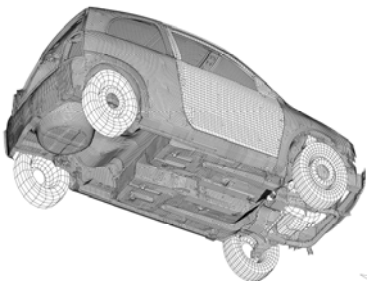
Any sufficiently advanced technology is indistinguishable from magic.

„Profiles of the future“ (1961) by Arthur C. Clarke (2003)

Introduction

TECOSIM

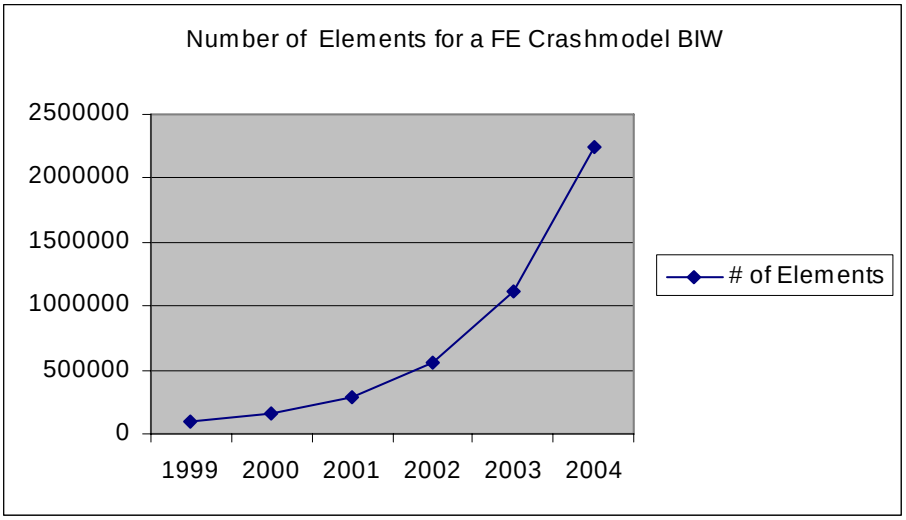
- Why do we simulate?
- Cost effective
- Fast
- Proven method



- *We cannot test!*

Introduction

TECOSIM



Introduction

TECOSIM

- How should a mesh look like?

TEC|ODM Mesh Element size 12 mm

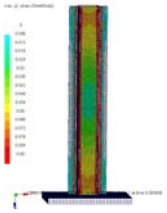
TEC|ODM Mesh Element size 4 mm

TEC|ODM Mesh Element size 6 mm

FE Experiments with varied parameters

TECOSIM

Simple box crash experiment:



Box section 50 mm x 80 x 500mm, t= 1.0mm, mild steel

Varied parameters:

- average edge length 15/10/5/2,5mm
- mesh orientation 0deg/ 25deg
- different mesh/ integration method: Belytschko-Tsay/ Fully Integration
- Varied number of spotwelds
- With and without mapping or stamping data
- Renumbering and move in space

Objective:

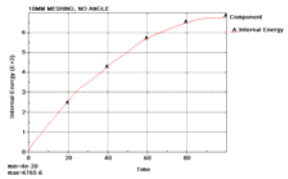
- Is the result depending on the element length?
- Is the result depending on the element orientation?
- How does mapping influence/stabalise the results?
- How do small changes in the input influence the results?

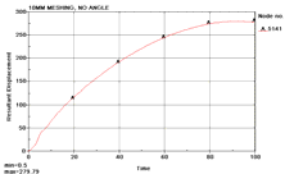
FE Experiments with varied parameters

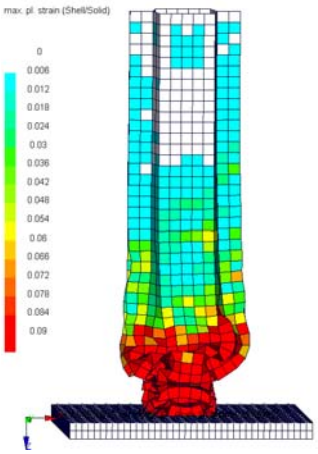
TECOSIM

analysis: defomation plots

v10_1: 10mm mesh, 0deg
max internal energy 6766Nmm
max displacement 278mm





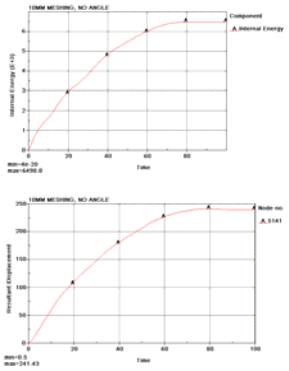


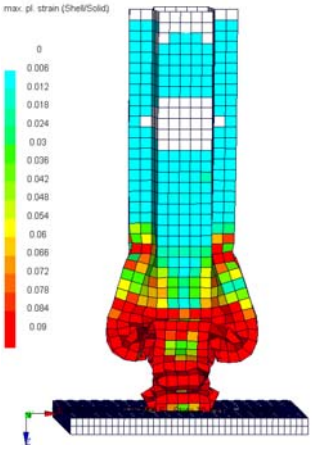
FE Experiments with varied parameters

TECOSIM

analysis: defomation plots

V10_1n: 10mm mesh, 0 deg, full integration
max internal energy 6499Nmm
max displacement 241mm



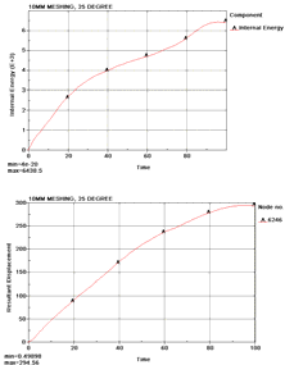


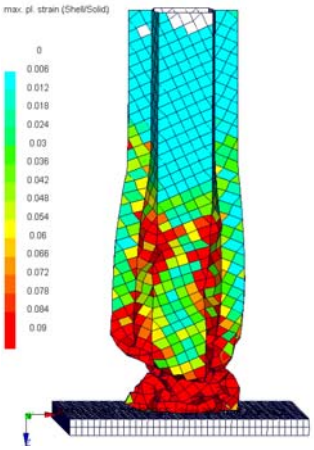
FE Experiments with varied parameters

TECOSIM

analysis: defomation plots

v10_2: 10mm mesh, 25deg
max internal energy 6439Nmm
max displacement 295mm



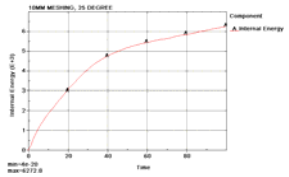


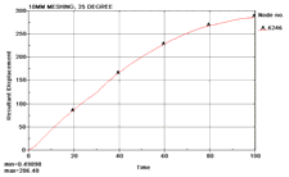
FE Experiments with varied parameters

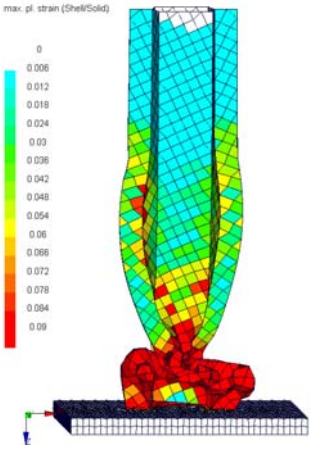
TECOSIM

analysis: defomation plots

V10_2n: 10mm mesh, 25 deg, full integration
max internal energy 6272Nmm
max displacement 286mm





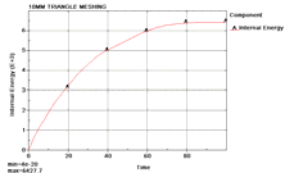


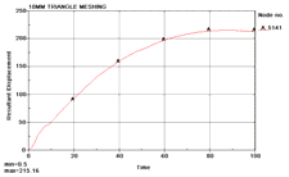
FE Experiments with varied parameters

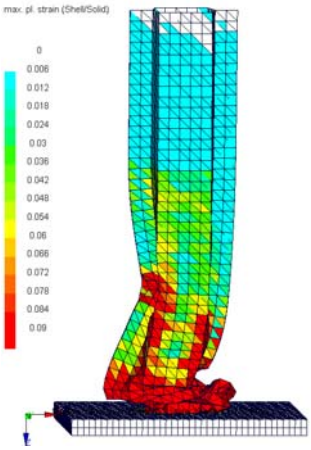
TECOSIM

analysis: defomation plots

v10_3: 10mm triangle mesh
max internal energy 6428Nmm
max displacement 215mm



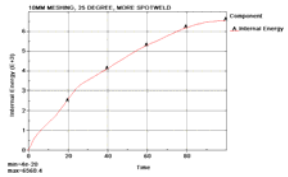


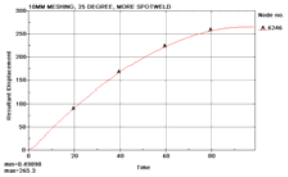


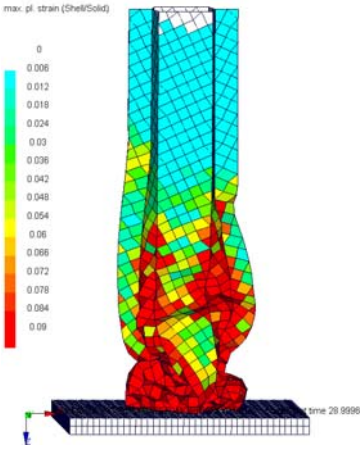
FE Experiments with varied parameters TECOSIM

analysis: defomation plots

v10_4: 10mm mesh, 25deg, more spotweld
max internal energy 6560Nmm
max displacement 265mm



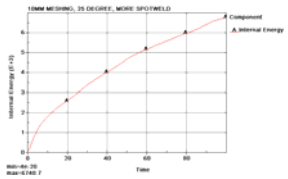


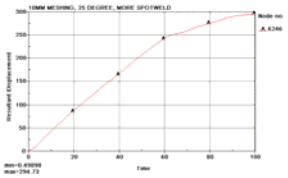


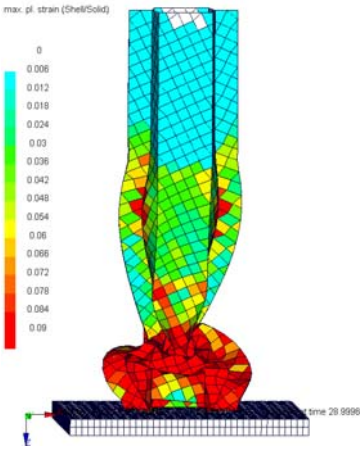
FE Experiments with varied parameters TECOSIM

analysis: defomation plots

V10_4n: 10mm mesh, 25 deg, more spotweld, full integration
max internal energy 6741Nmm
max displacement 295mm





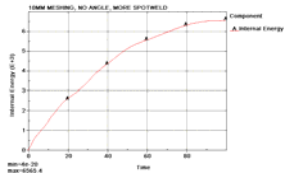


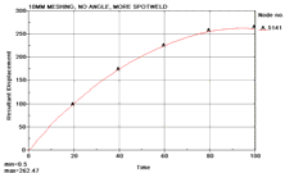
FE Experiments with varied parameters

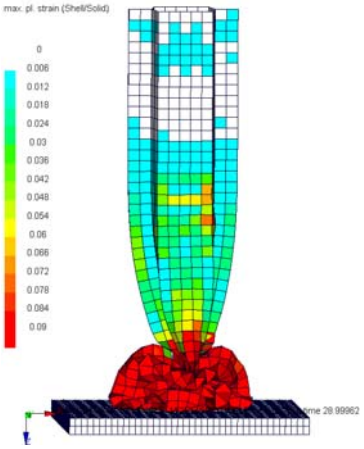
TECOSIM

analysis: defomation plots

v10_5: 10mm mesh, 0 deg, more spotweld
max internal energy 6565Nmm
max displacement 262mm





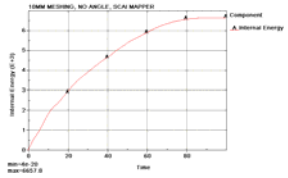


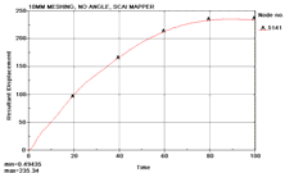
FE Experiments with varied parameters

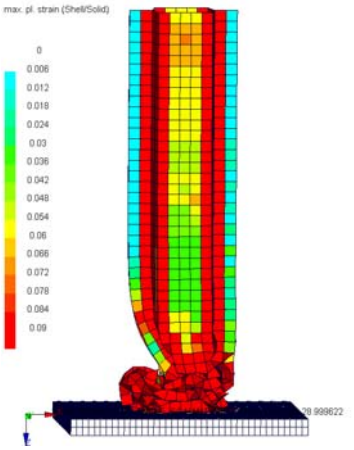
TECOSIM

analysis: defomation plots

v10_6: 10mm mesh, 0deg mapped
stamping data MpCCI
max internal energy 6658Nmm
max displacement 235mm







FE Experiments with varied parameters

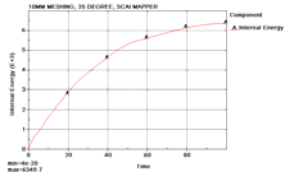
TECOSIM

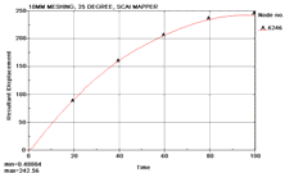
analysis: defomation plots

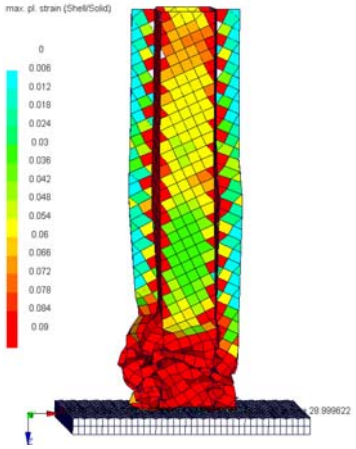
v10_7: 10mm mesh, 25deg mapped stamping data MpCCI

max internal energy 6350Nmm

max displacement 243mm







FE Experiments with varied parameters

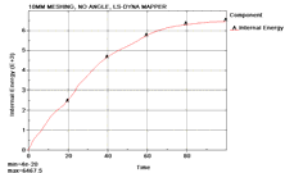
TECOSIM

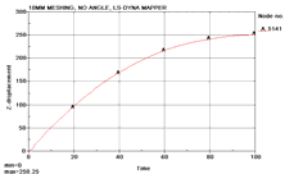
analysis: defomation plots

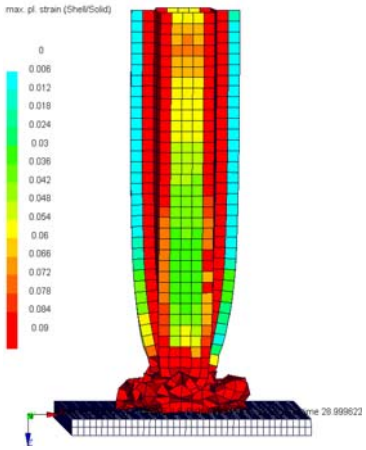
v10_6n: 10mm mesh, 0deg mapped stamping data DYNAIN

max internal energy 6468Nmm

max displacement 250mm







FE Experiments with varied parameters

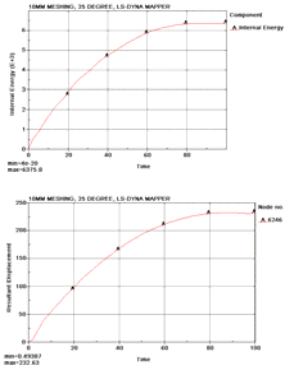
TECOSIM

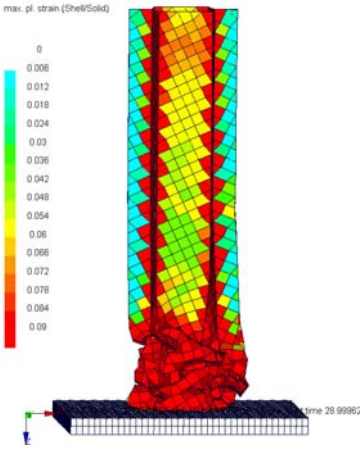
analysis: defomation plots

v10_7n: 10mm mesh, 25deg mapped
stamping data DYNAIN

max internal energy 6376Nmm

max displacement 233mm



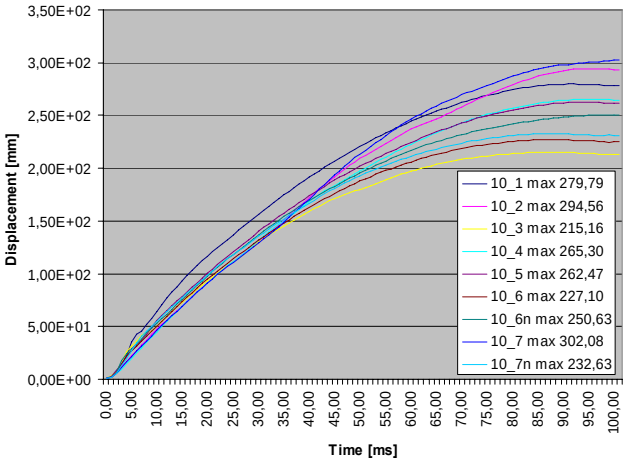


FE Experiments with varied parameters

TECOSIM

Analysis: comparison of Displacement

10mm meshing

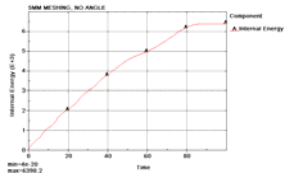


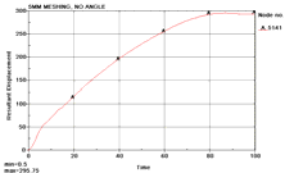
FE Experiments with varied parameters

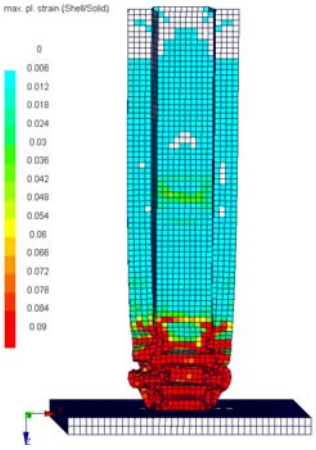
TECOSIM

analysis: defomation plots

v5_1: 5mm mesh, 0deg
max internal energy 6398Nmm
max displacement 296mm





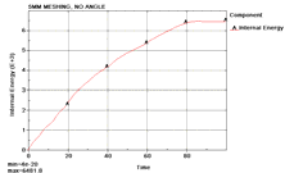


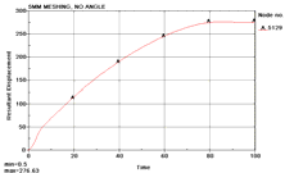
FE Experiments with varied parameters

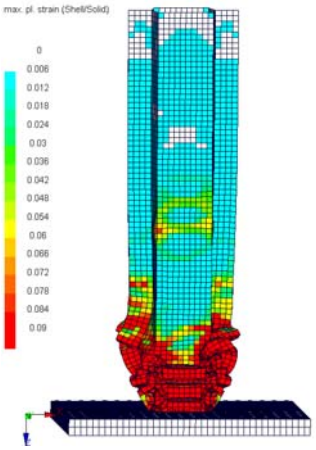
TECOSIM

analysis: defomation plots

V5_1n: 5mm mesh, 0 deg, full integration
max internal energy 6481Nmm
max displacement 277mm





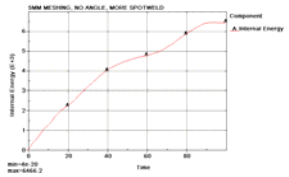


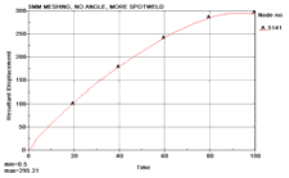
FE Experiments with varied parameters

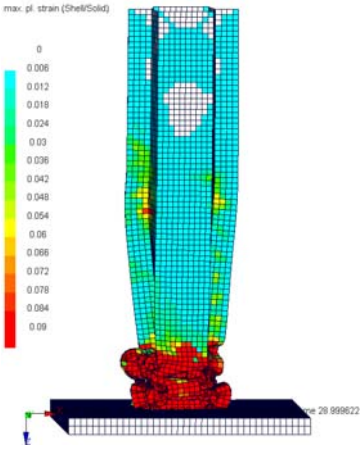
TECOSIM

analysis: defomation plots

v5_5: 5 mm mesh, 0 deg, more spotweld
max internal energy 6466Nmm
max displacement 295mm





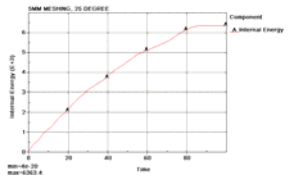


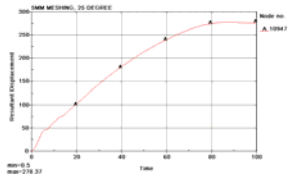
FE Experiments with varied parameters

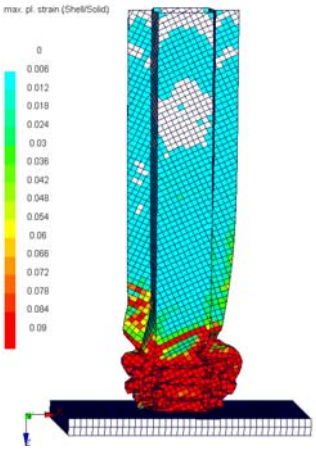
TECOSIM

analysis: defomation plots

v5_2: 5mm mesh, 25deg
max internal energy 6363Nmm
max displacement 278mm





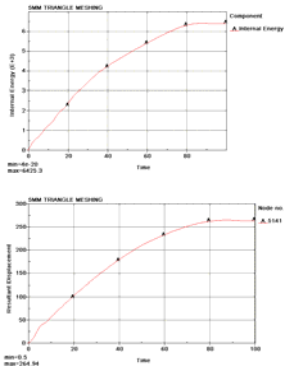


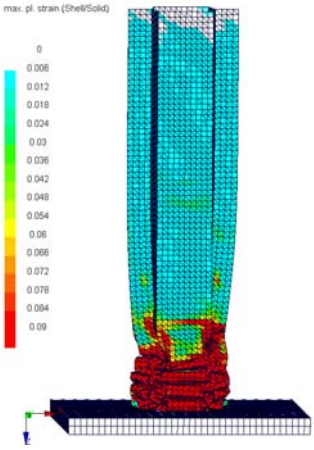
FE Experiments with varied parameters

TECOSIM

analysis: defomation plots

v5_3: 5mm triangle mesh
max internal energy 6425Nmm
max displacement 265mm



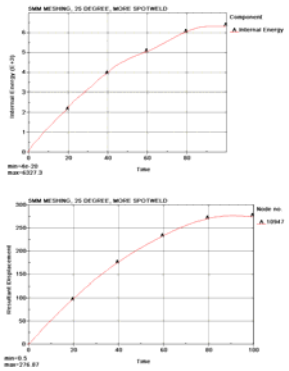


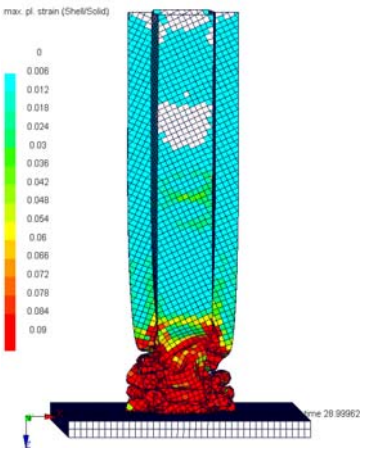
FE Experiments with varied parameters

TECOSIM

analysis: defomation plots

V5_4: 5mm mesh, 25deg, more spotweld
max internal energy 6327Nmm
max displacement 277mm





FE Experiments with varied parameters

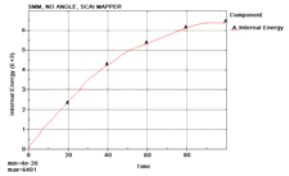
TECOSIM

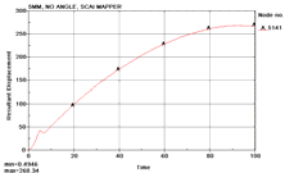
analysis: defomation plots

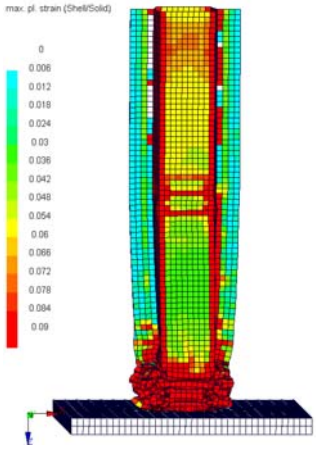
v5_6: 5mm mesh, 0deg mapped stamping data MpCCI

max internal energy 6401Nmm

max displacement 268mm







FE Experiments with varied parameters

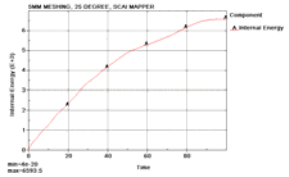
TECOSIM

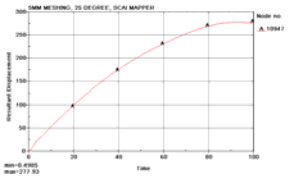
analysis: defomation plots

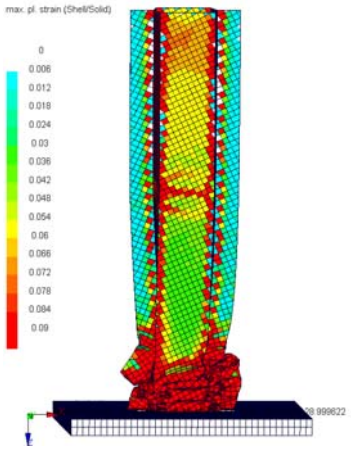
v5_7: 5mm mesh, 25deg mapped stamping data MpCCI

max internal energy 6593Nmm

max displacement 278mm







FE Experiments with varied parameters

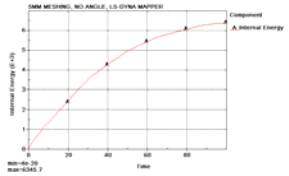
TECOSIM

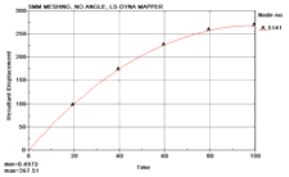
analysis: defomation plots

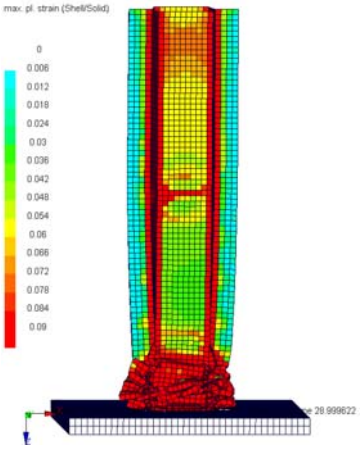
v5_6n: 5mm mesh, 0deg mapped stamping data DYNAIN

max internal energy 6346Nmm

max displacement 268mm







FE Experiments with varied parameters

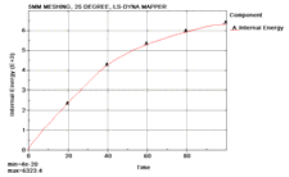
TECOSIM

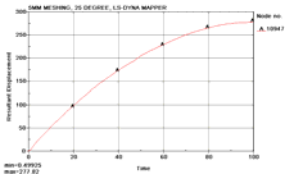
analysis: defomation plots

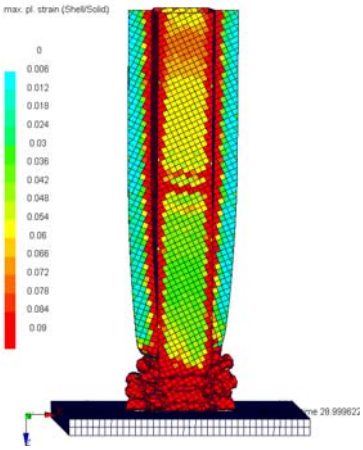
v5_7n: 5mm mesh, 25deg mapped stamping data DYNAIN

max internal energy 6323Nmm

max displacement 278mm





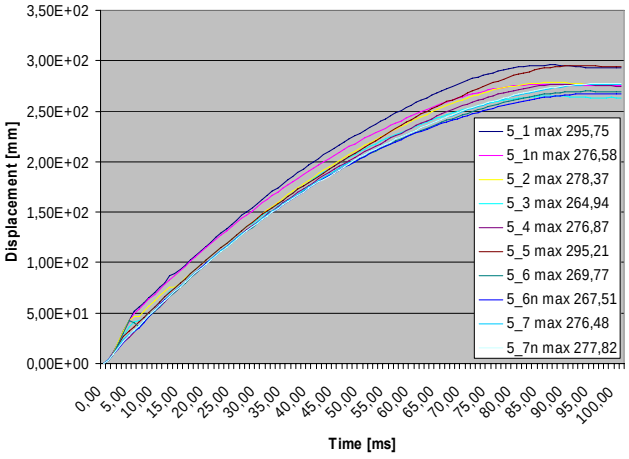


FE Experiments with varied parameters

TECOSIM

Analysis: comparison of Displacement

5mm meshing



FE Experiments with varied parameters

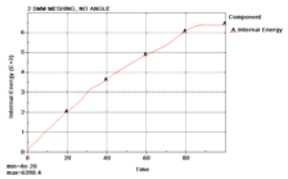
TECOSIM

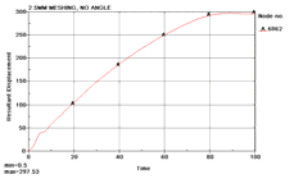
analysis: defomation plots

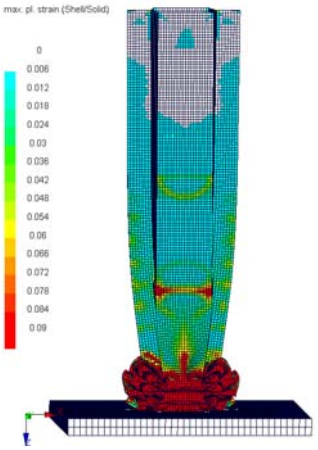
v2.5_1: 2.5mm mesh, 0deg

max internal energy 6398Nmm

max displacement 296mm







FE Experiments with varied parameters

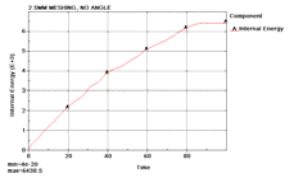
TECOSIM

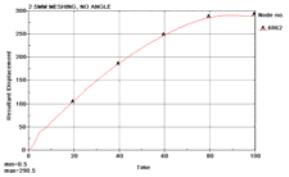
analysis: defomation plots

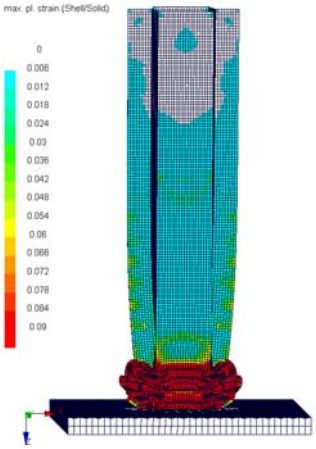
V2-5_1n: 2.5 mm mesh, 0 deg, full integration

max internal energy 6439Nmm

max displacement 291mm







FE Experiments with varied parameters

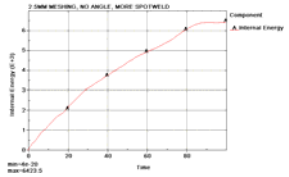
TECOSIM

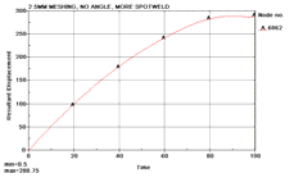
analysis: defomation plots

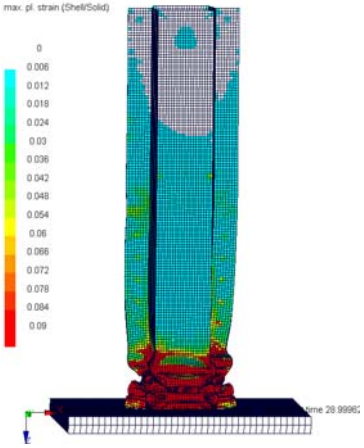
V2-5_5: 2.5 mm mesh, 0 deg, more spotweld

max internal energy 6423Nmm

max displacement 289mm





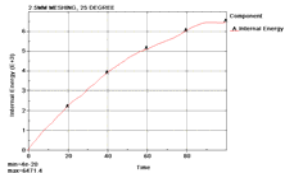


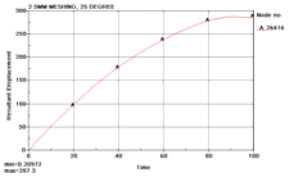
FE Experiments with varied parameters

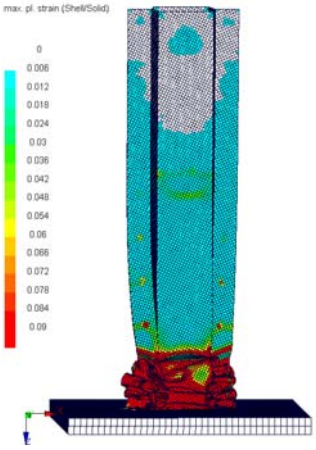
TECOSIM

analysis: defomation plots

V2-5_2n: 2.5 mm mesh, 25 deg
max internal energy 6471Nmm
max displacement 287mm





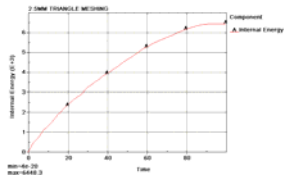


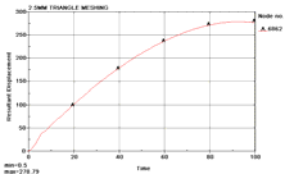
FE Experiments with varied parameters

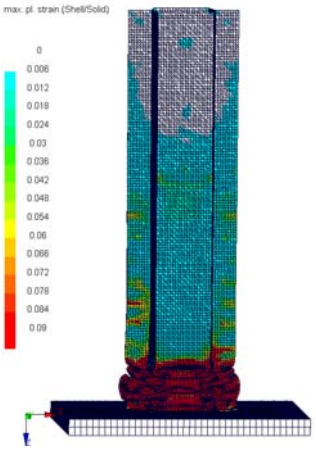
TECOSIM

analysis: defomation plots

v2.5_3: 2.5mm triangle mesh
max internal energy 6448Nmm
max displacement 279mm





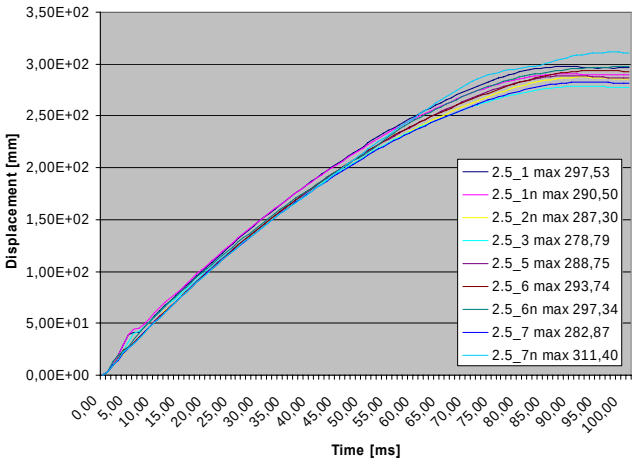


FE Experiments with varied parameters

TECOSIM

Analysis: comparison of Displacement

2.5mm meshing



FE Experiments with varied parameters

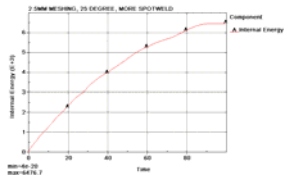
TECOSIM

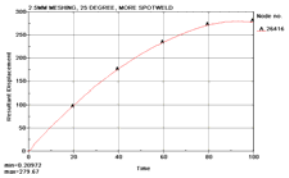
analysis: defomation plots

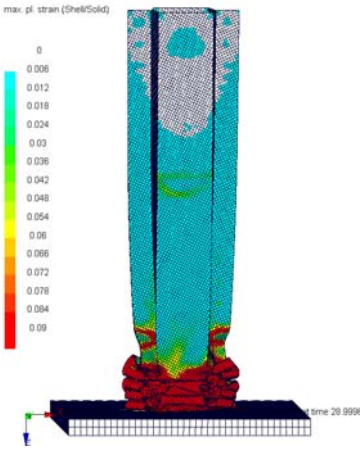
V2-5_4n: 2.5 mm mesh, 25 deg, more spotweld

max internal energy 6477Nmm

max displacement 280mm





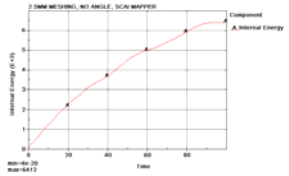


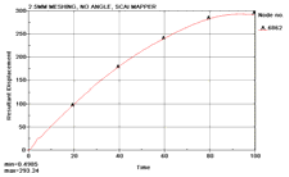
FE Experiments with varied parameters

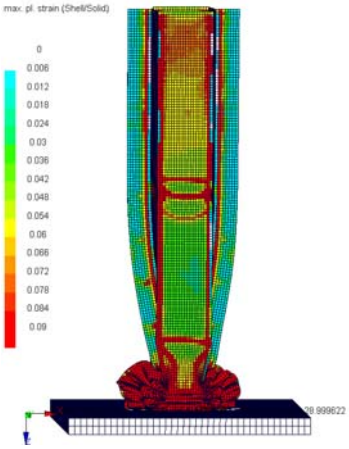
TECOSIM

analysis: defomation plots

v2.5_6: 2.5mm mesh, 0deg
mapped stamping data MpCCI
max internal energy 63412Nmm
max displacement 293mm





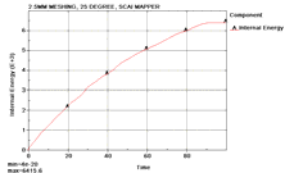


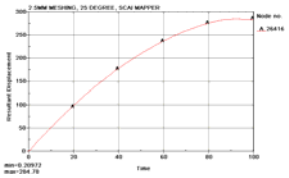
FE Experiments with varied parameters

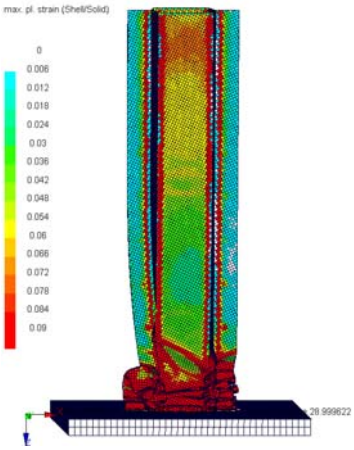
TECOSIM

analysis: defomation plots

v2.5_7: 2.5mm mesh, 25deg
mapped stamping data MpCCI
max internal energy 6416Nmm
max displacement 285mm



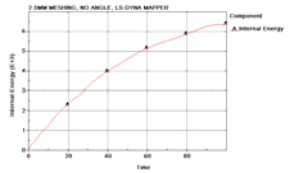


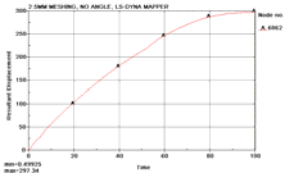


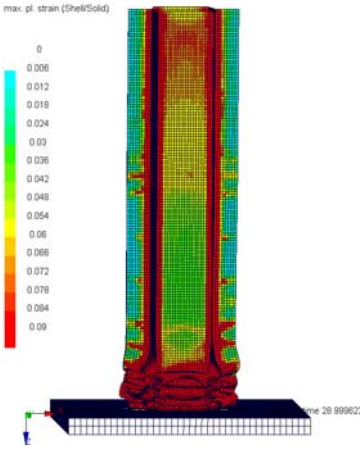
FE Experiments with varied parameters TECOSIM

analysis: defomation plots

v2.5_6n: 2.5mm mesh, 0deg DYNAIN
max internal energy 6360Nmm
max displacement 297mm



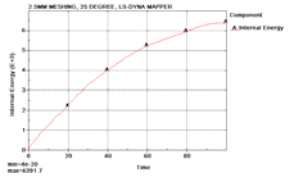


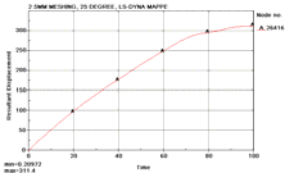


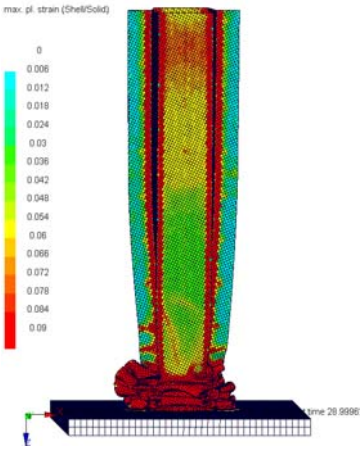
FE Experiments with varied parameters TECOSIM

analysis: defomation plots

v2.5_7n: 2.5mm mesh, 25deg DYNAIN
max internal energy 6392Nmm
max displacement 311mm





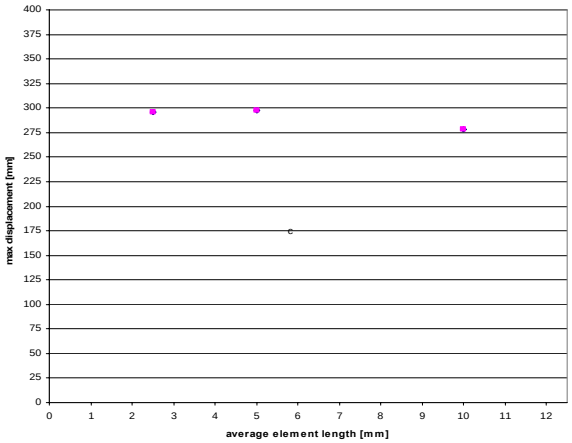


Analysis of Results/ Conclusion

TECOSIM

Analysis: Comparison max. displacement

Compression is nearly independent from the element length in a range from 10mm to 2.5 mm for the same element orientation

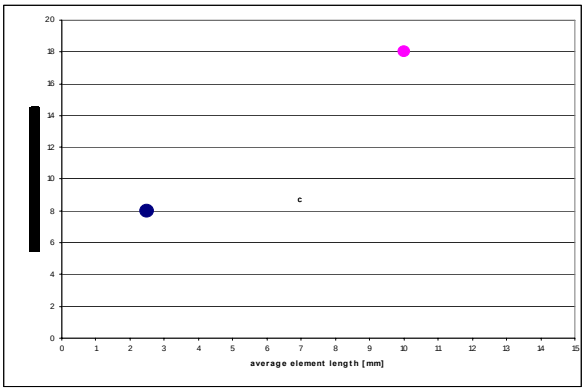


Analysis of Results/ Conclusion

TECOSIM

Analysis: Comparison max. displacement

The max displacement difference for 0° mesh and 25° mesh is small for finer meshes and big for coarser meshes

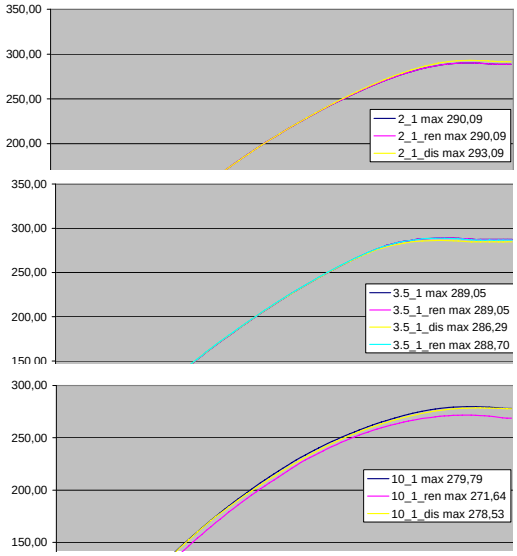


Analysis of Results/ Conclusion

TECOSIM

Analysis: Influence on mesh translation and reumbering

For 10 mm the variation is about 8mm where as the deviation for smaller elements sizes is about 3mm for the same element orientation

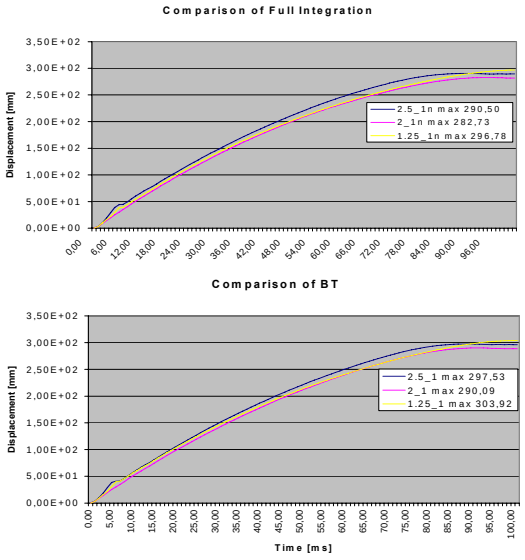


Analysis of Results/ Conclusion

TECOSIM

Analysis: Influence on results of very small elements.

For 1,25 mm the BT (typ2) element seems to be to weak. For smaller elements sizes, full integration seems to have better results.



Analysis of Results/ Conclusion

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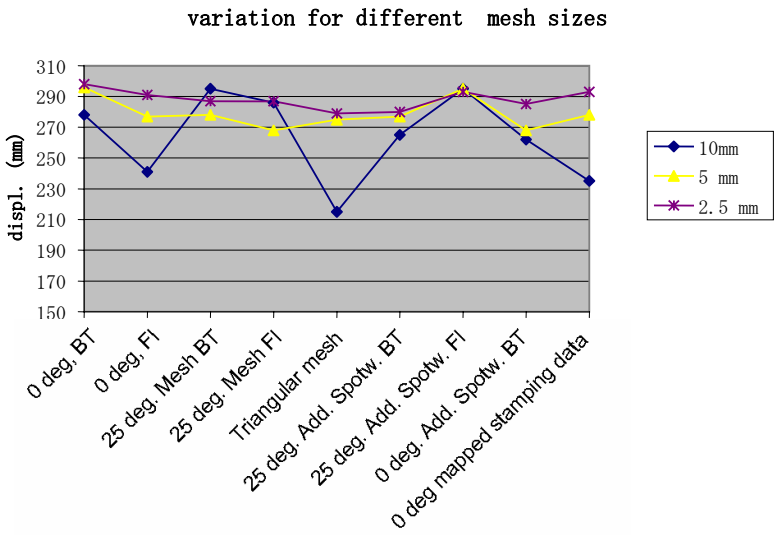
Analysis: comparison max displacement variation



Analysis of Results/ Conclusion

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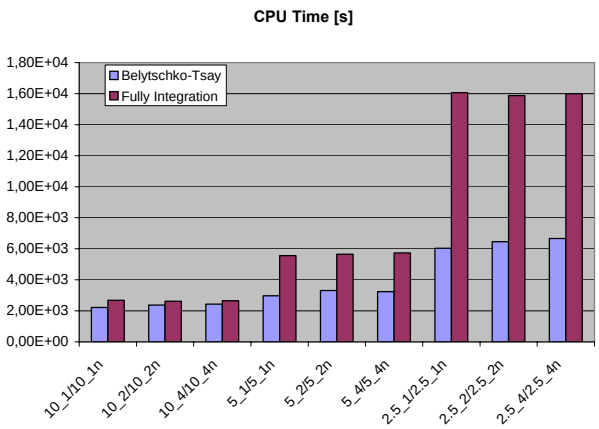
Analysis: Comparison of integration method

Calculation Time



Analysis of Results/ Conclusion

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Results

- Results for the displacement and the internal energy seem to be smooth and stable in a range from 15mm to 2,5 mm for orthogonal element orientation
- Different element orientation give different results for coarser meshes
- Finer mesh is not so sensitive for different element orientation, integration method, number of spotwelds, mapping, small changes in the input (renumbering, moving the model in space)
- Mapping tools are easy to use for Crash coupling. The influence of the mapping was getting smaller for smaller element sizes for the influenced zone was getting smaller and the crash mode was very stable in our example.

Analysis of Results/ Conclusion

TECOSIM

Conclusion

- If you know the collapse mode of a part you can use a coarse mesh which should be orthogonal in the collapse direction (so you can achieve “superconvergence”)
- If you doesn't know the collapse mode of a part; Please use finer meshes
- No one knows the exact collapse mode of all the parts in a vehicle!
- Meshing rules for orthogonal /Mapping/Integration schemes meshes are important for coarser meshes but not important for finer meshes.

- *Creation of finer meshes can be automated by* TEC|ODM*!*

Analysis of Results/ Outlook

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Outlook

The crashbox sample will be applied to a complete vehicle to find out about the time saving potential and the influence on the results.

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Thank you for your attention!
Please ask some questions

