CRASH-SIMULATION OF HAT-SECTIONS

RELIABILITY OF THE NUMERICAL MODEL

Paul Du Bois,
consulting engineer, Offenbach/Main
Thomas Frank,
Daimler-Chrysler, Sindelfingen

Spotwelded mild steel tubes

- Tests show energyabsorption of 6.5 kJ
- Impactor is stopped with maximal deflection between 170 and 220 mm
- Observed failure modes are symmetric and asymmetric buckling, no global bending

Comparison test-simulation

- Depending upon roundoff, simulation also shows global bending collapse
- The model then fails to stop the impactor
- The spread of numerical results is more significant then the spread on corresponding experiments

Basic LS-DYNA model description

- Spotwelds simulated by beams of type 9 and tied interfaces type 7
- Global contact definition type 13, default penalty and no friction
- Mild steel with thickness 1.mm, 5 rate-dependent stress-strain curves for material law type 24

Baseline simulations

- Simulation on Linux PC with ls950d
- Simulation on DEC-ALPHA, 16 processors MPP with ls940.2a
- Simulation on DEC-ALPHA, 16 processors MPP with ls940.2a and contact type s_7

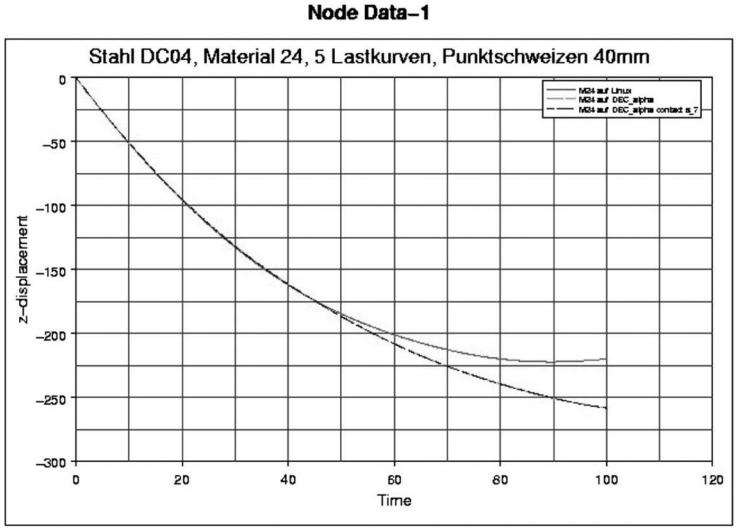
Baseline simulation results

- Impactor is stopped on Linux but not on DEC-ALPHA
- Buckling on Linux, global bending on DEC-ALPHA
- No influence of the contact-type

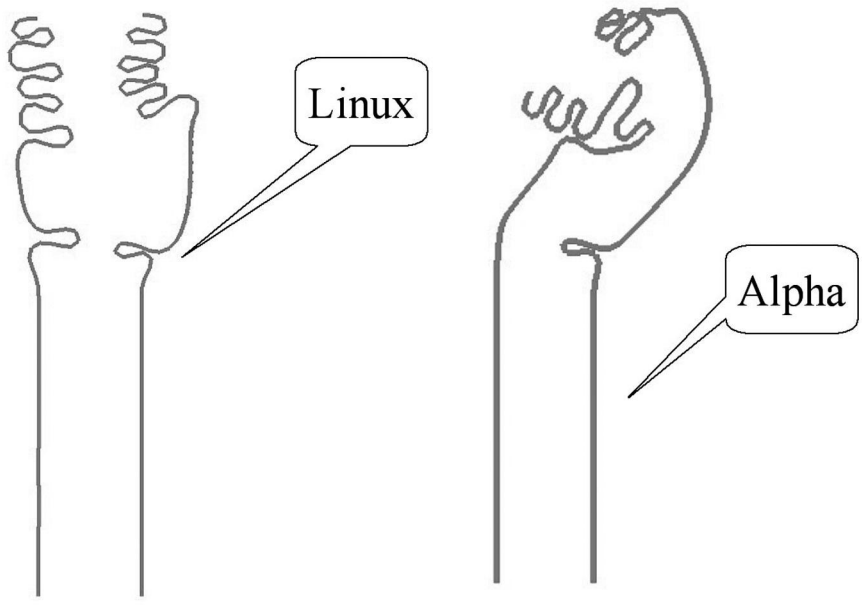
Comparison test-simulation

- 3 sledtest results
- 3 simulations (Linux-DEC/7-s7)

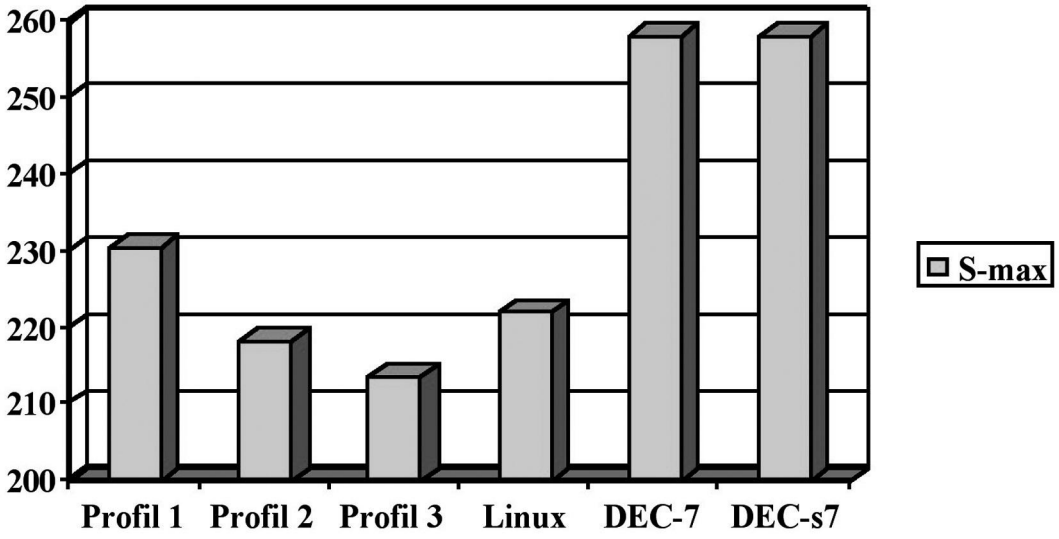
Simulation results



Simulation results



Comparison test-simulation



Influence of model parameters

- Spotweldmodeling
- Material law formulation
- Initial imperfections
- Inhomogeneous material properties
- Contact formulations
- Shell element formulations
- boundary conditions (clamp)

Model with material law 103

- Material law 103 with 5 rate dependent stress-strain curves, internally fitted to an exponential function
- replace piecewise linear description by a continuous material description

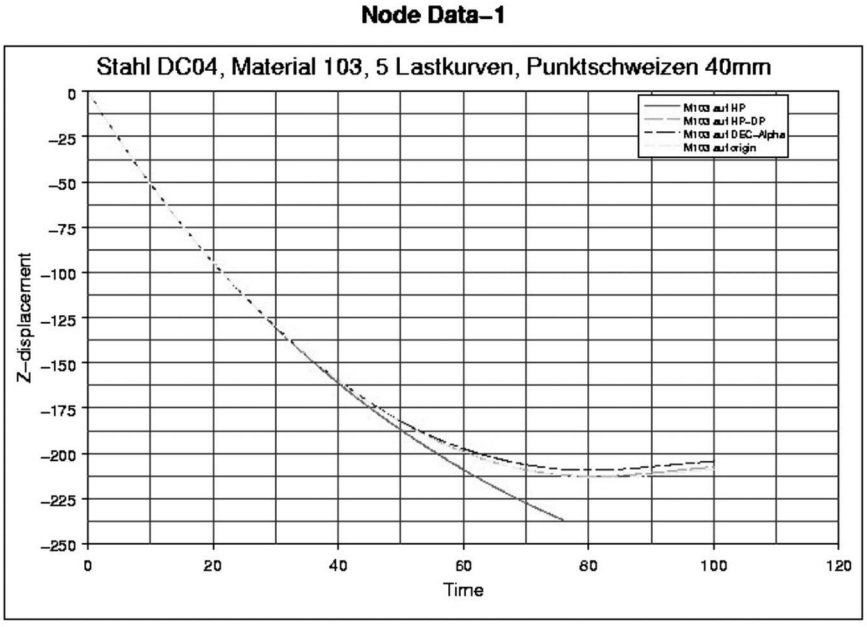
Model with material law 103

- Simulation on HP with ls950e
- Simulation on HP with ls950e_d (64bit)
- Simulation on DEC-ALPHA, 4 processors SMP with ls950e
- Simulation on Origin, 4 processors SMP with ls950e

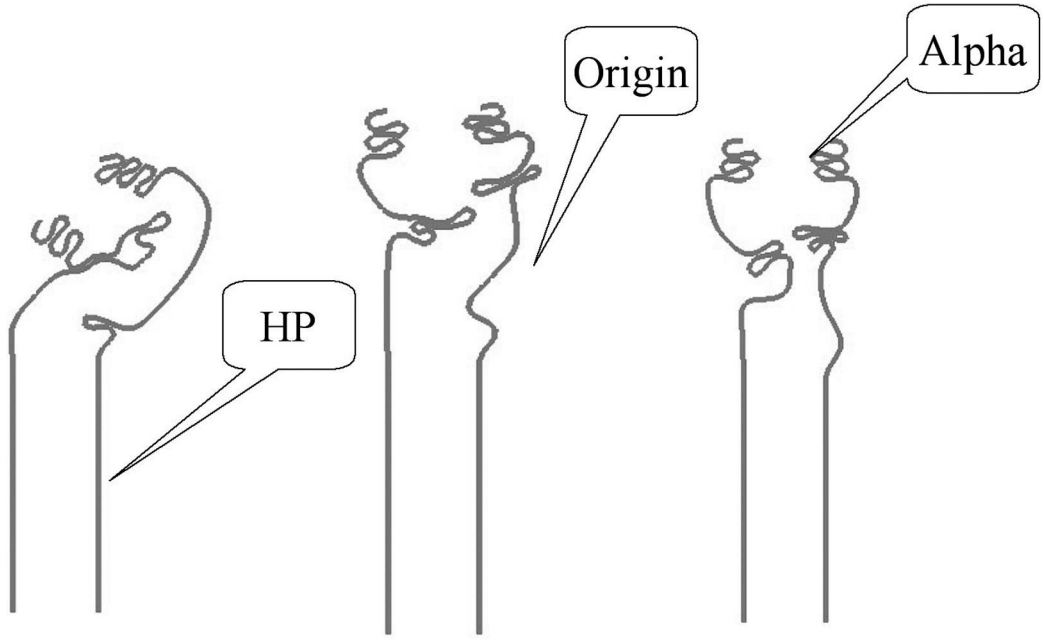
Model with material law 103

- Global bending collapse HP-32bit
- Buckling in all other cases
- Analytical material description does not completely solve the problem

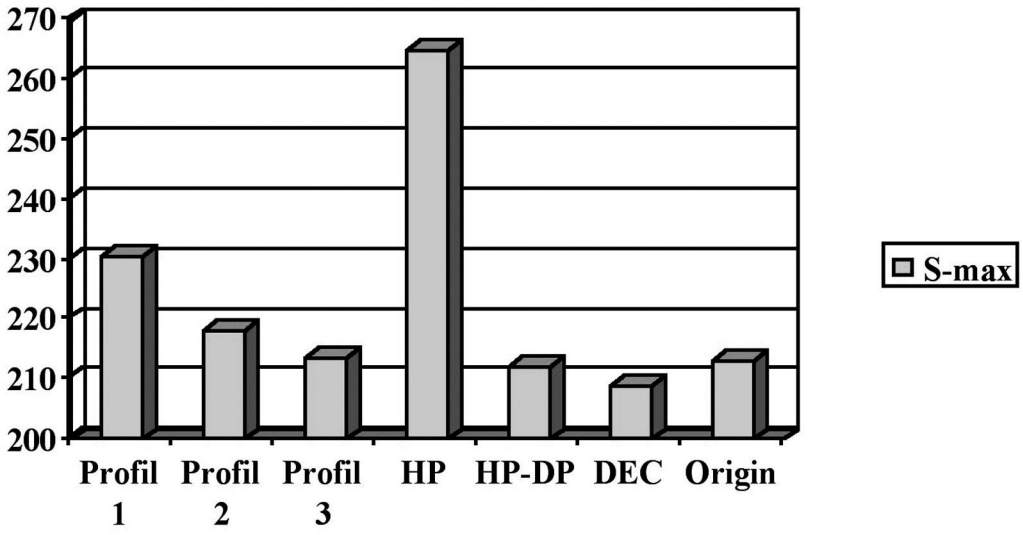
Simulation results



Simulation results



Comparison test-simulation



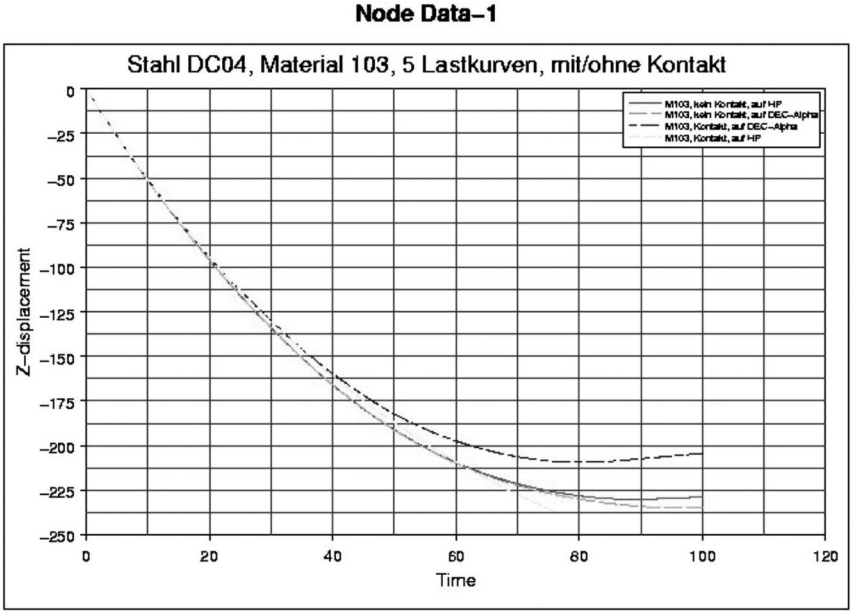
Model without contact

- No structural contact
- Keep material law 103

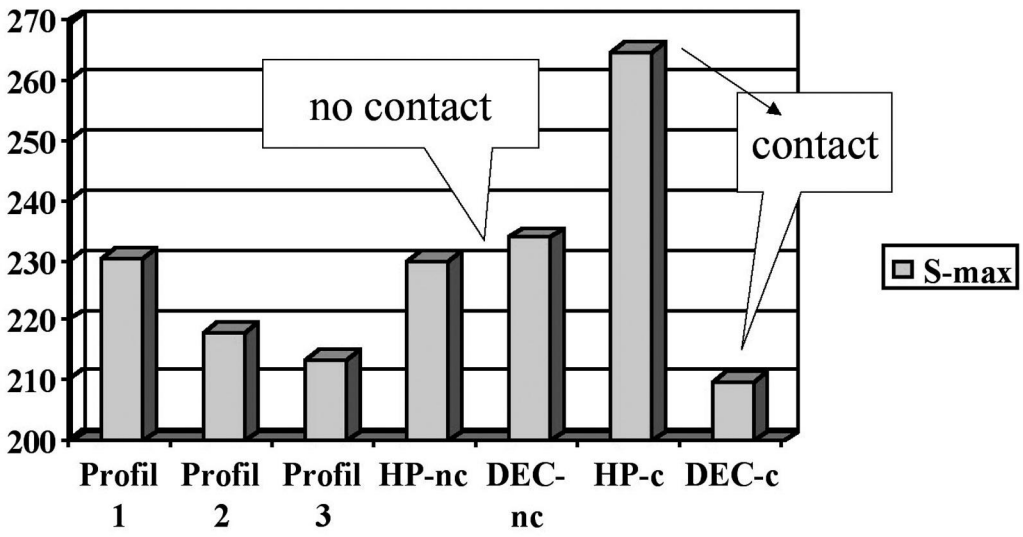
Model without contact

- Simulation on HP with ls950e
- Simulation on DEC-ALPHA, 4 processors SMP with ls950e
- Differences in results between hardware platforms become technically irrelevant

Simulation results



Comparison test-simulation



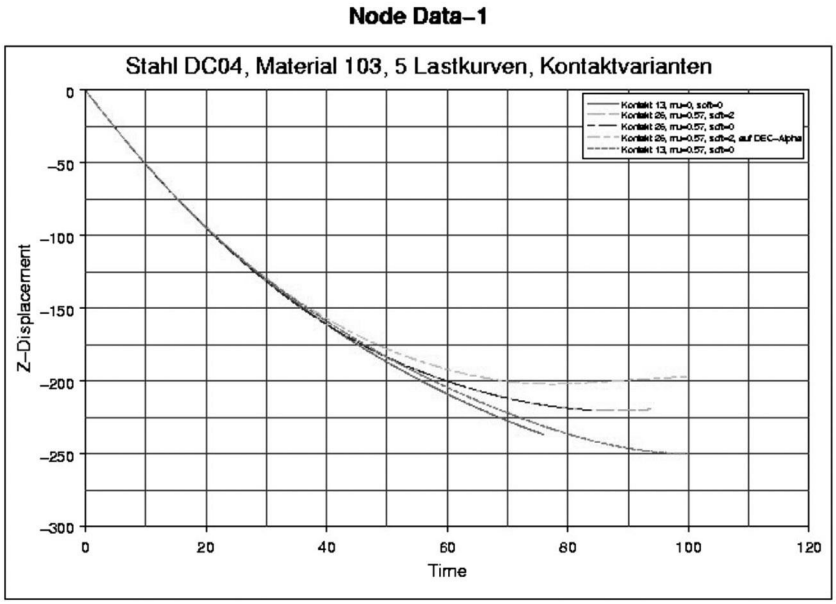
Variation of contact formulation

- Simulation on HP with ls950e for contact 26 with SOFT=2/0 and μ=0.54
- Simulation on HP with ls950e for contact 13 with SOFT=0 and μ=0.54
- Simulation on DEC-Alpha, 16 processors MPP with ls940.2a for contact 26 with SOFT=2 and μ=0.54

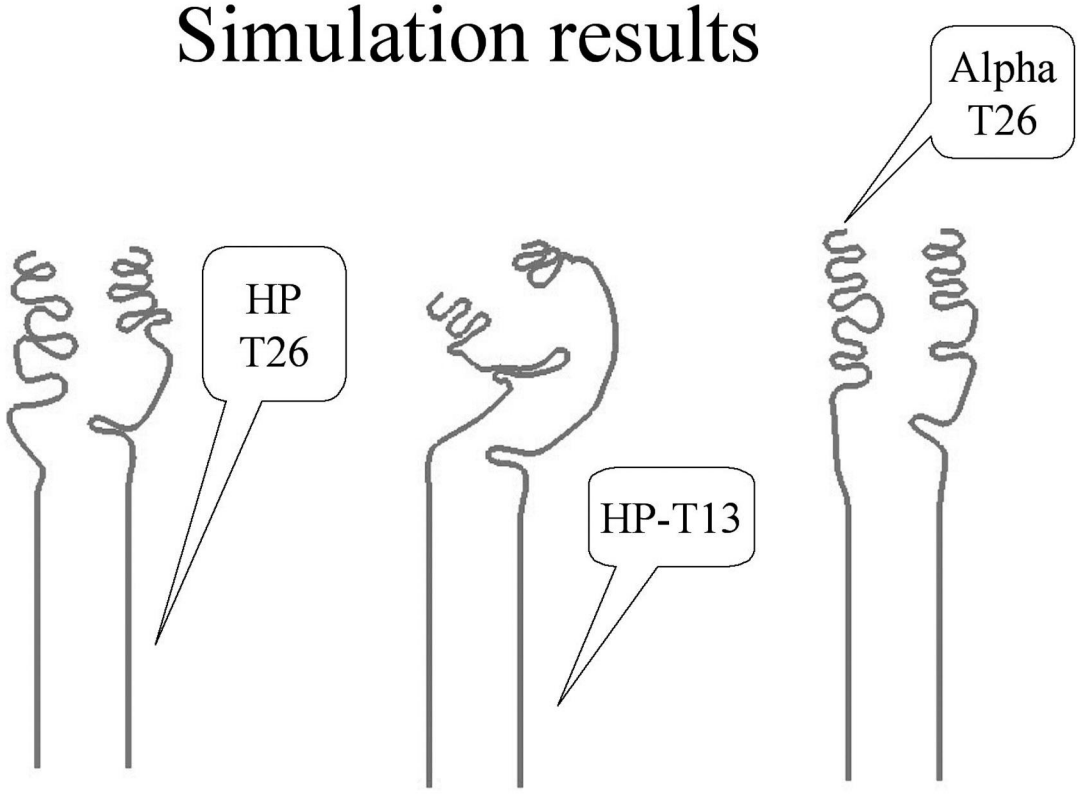
Variation of contact formulation

- High friction (μ=0.54) is not sufficient to stabilize the numerical results
- Using CONTACT_AUTOMATIC_GENRAL eliminated global bending modes for this particular section

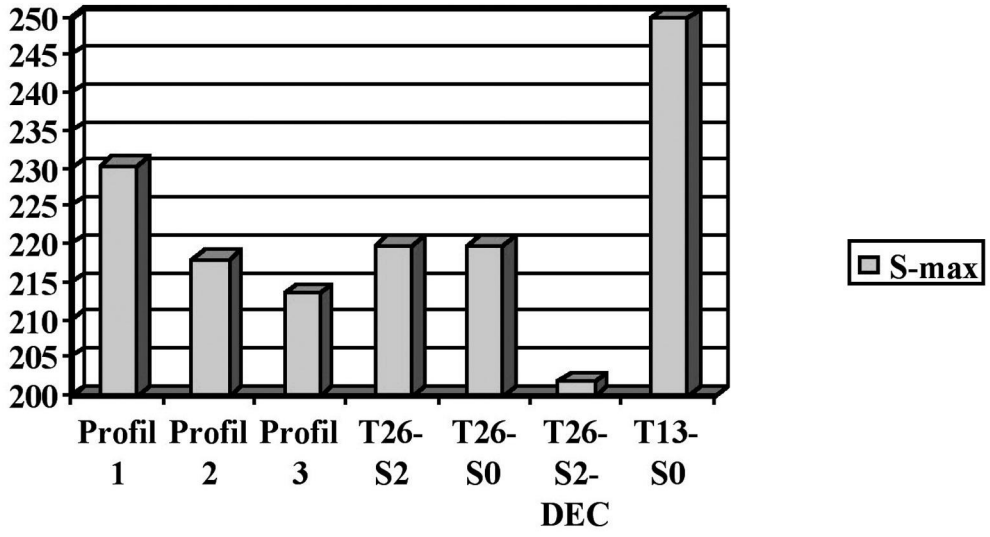
Simulation results



Simulation results



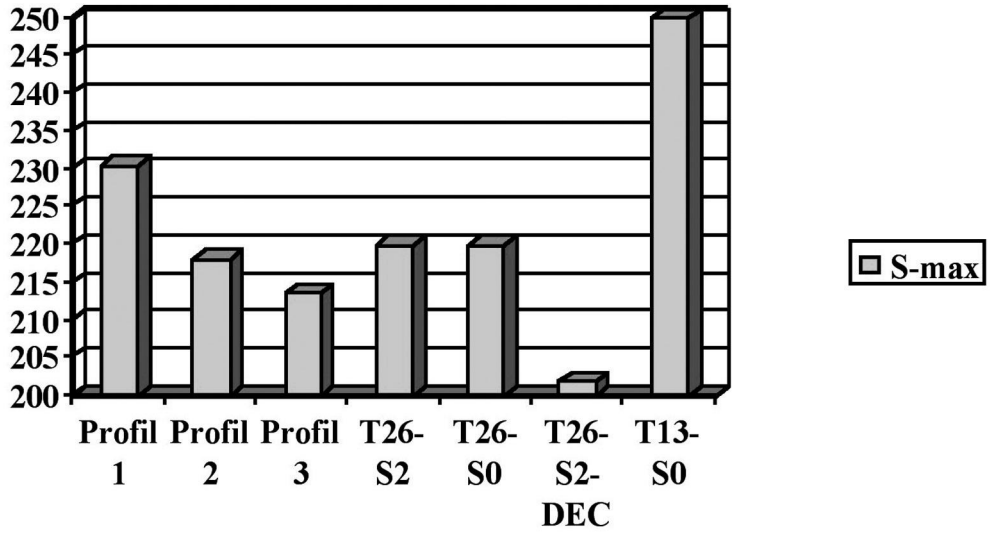
Comparison test-simulation



Global overview

- The simulation shows a reasonable (somewhat too stiff) behaviour as long as no global bending occurs
- A reasonable comparison with test results is only possible after all numerical bifurcations have been eliminated

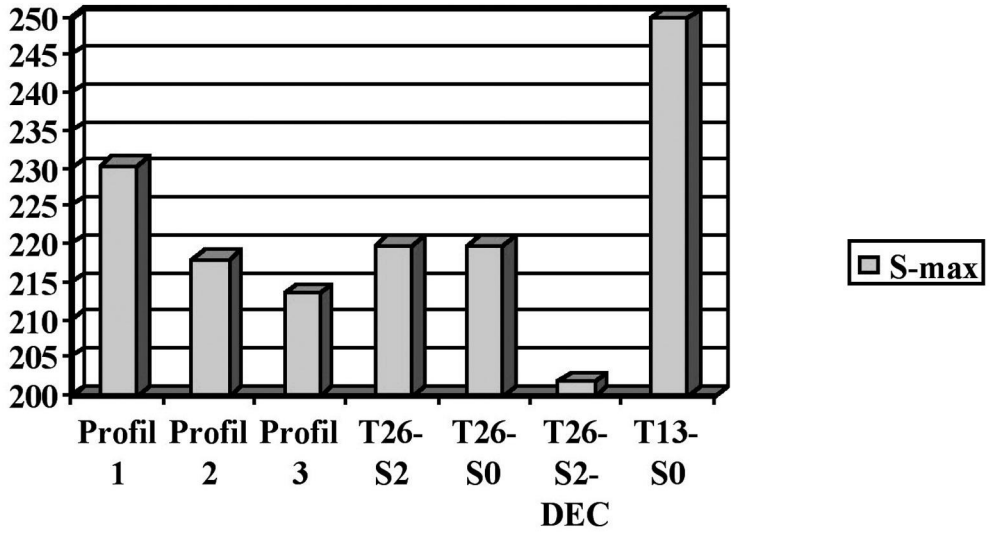
Comparison test-simulation



Global overview

- The simulation shows a reasonable (somewhat too stiff) behaviour as long as no global bending occurs
- A reasonable comparison with test results is only possible after all numerical bifurcations have been eliminated

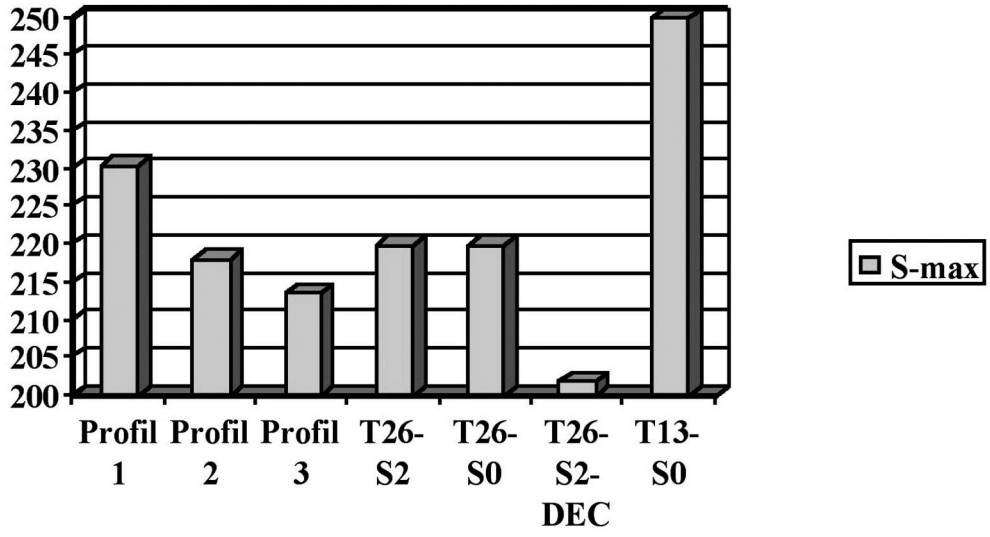
Comparison test-simulation



Global overview

- The simulation shows a reasonable (somewhat too stiff) behaviour as long as no global bending occurs
- A reasonable comparison with test results is only possible after all numerical bifurcations have been eliminated

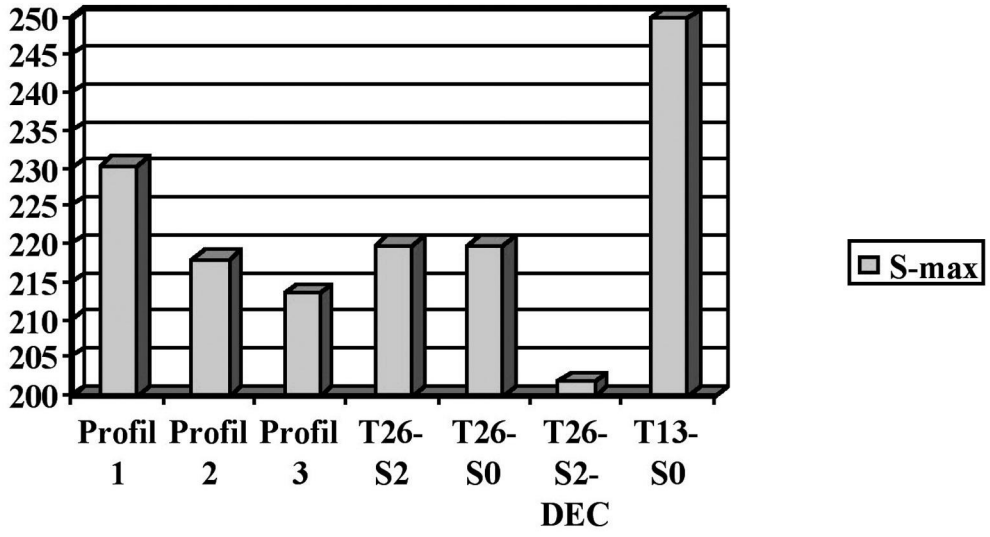
Comparison test-simulation



Global overview

- The simulation shows a reasonable (somewhat too stiff) behaviour as long as no global bending occurs
- A reasonable comparison with test results is only possible after all numerical bifurcations have been eliminated

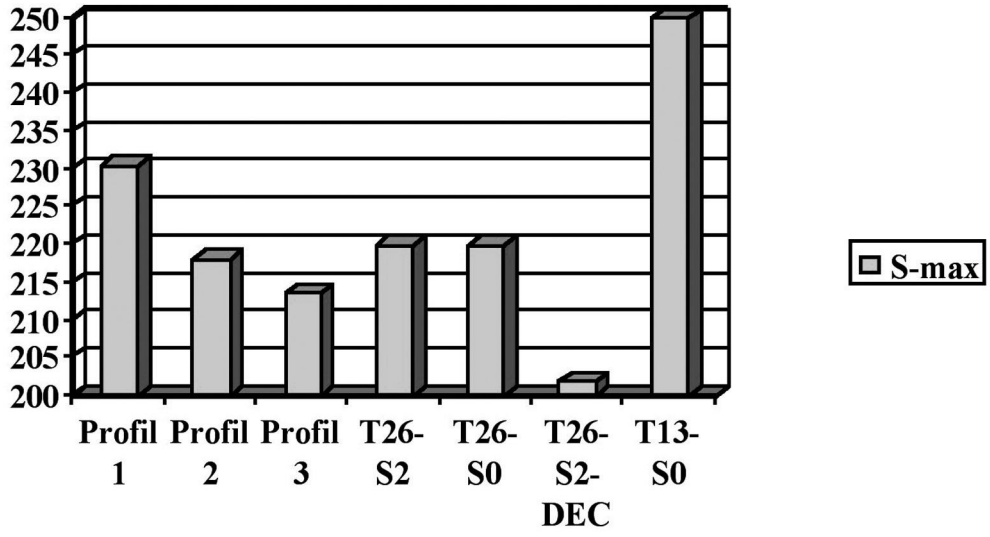
Comparison test-simulation



Global overview

- The simulation shows a reasonable (somewhat too stiff) behaviour as long as no global bending occurs
- A reasonable comparison with test results is only possible after all numerical bifurcations have been eliminated

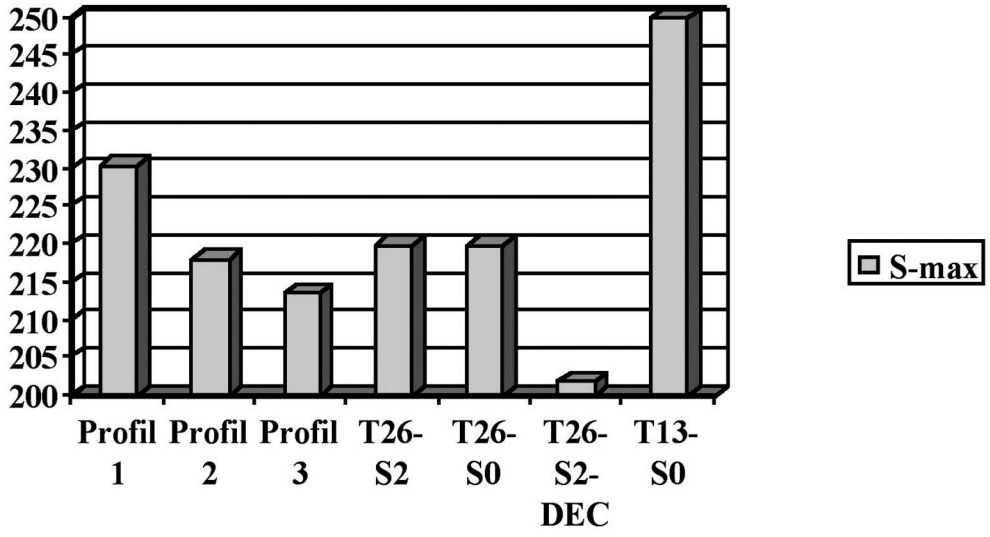
Comparison test-simulation



Global overview

- The simulation shows a reasonable (somewhat too stiff) behaviour as long as no global bending occurs
- A reasonable comparison with test results is only possible after all numerical bifurcations have been eliminated

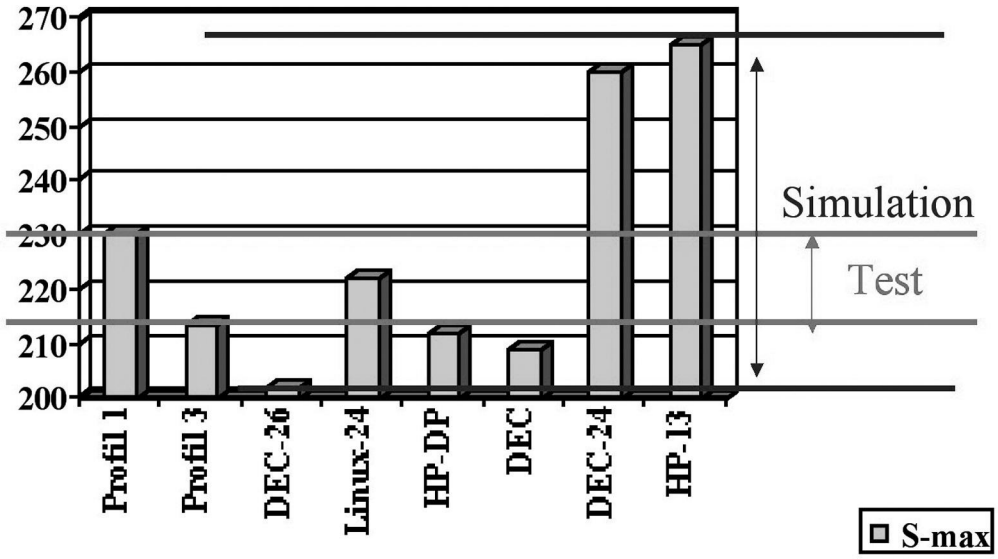
Comparison test-simulation



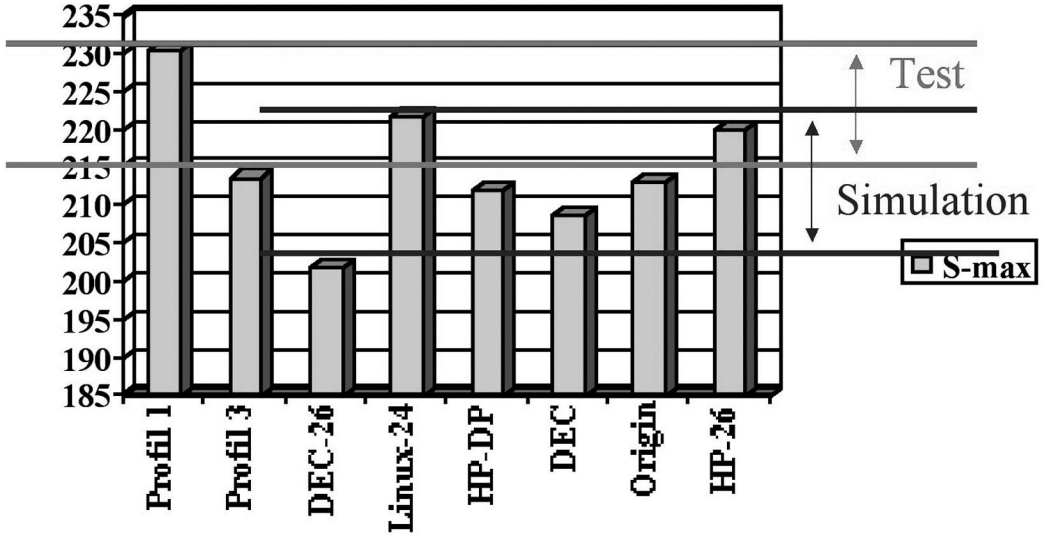
Global overview

- The simulation shows a reasonable (somewhat too stiff) behaviour as long as no global bending occurs
- A reasonable comparison with test results is only possible after all numerical bifurcations have been eliminated

Comparison test-simulation
all simulation results



Comparison test-simulation
unstable simulation results eliminated



Conclusions

- Independently of the model parameters, numerical noise can act as a bifurcation generator in simulation models
- Stabilisation of the physical structure (ex. Increasing the sheet thickness) also reduces the chances of numerical bifurcations

Conclusions

- The main cause of numerical bifurcations seems contact related and can be partly reduced by choice of contact formulation
- A continued development of contact algorithms in order to further decrease sensitivity of the numerical results is desirable