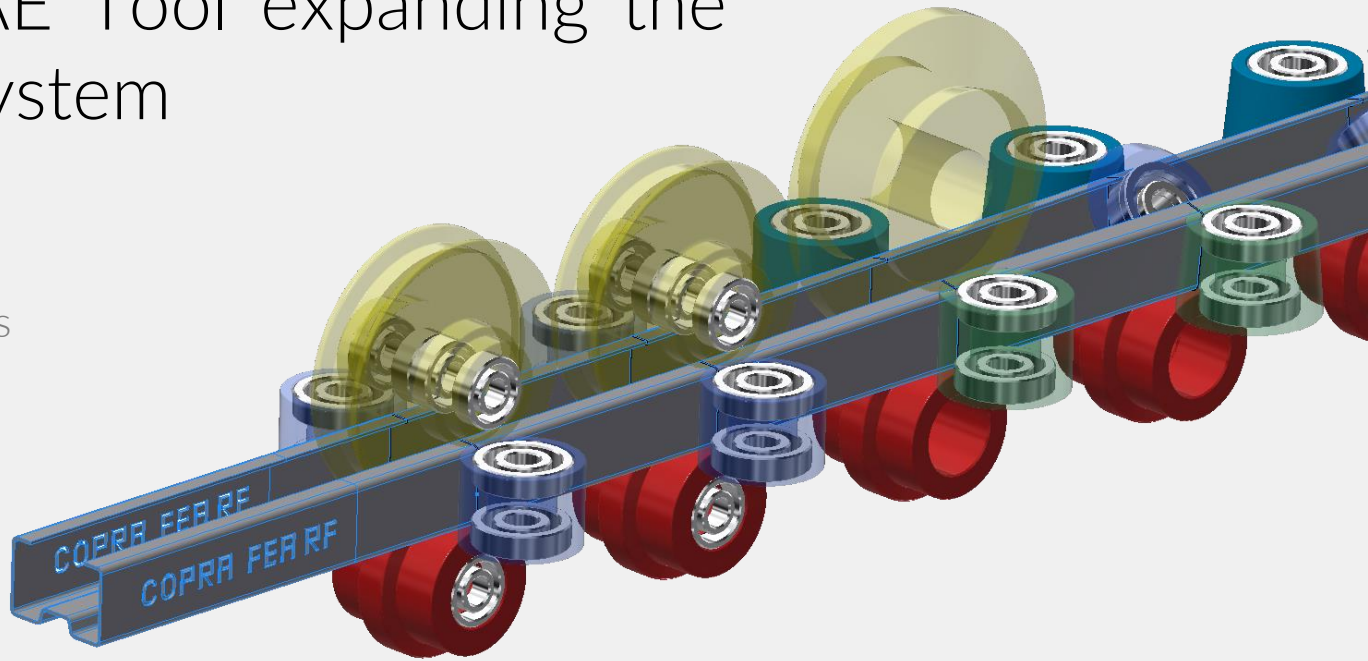
A Novel Roll Forming Machine Optimisation CAE Tool expanding the COPRA® Eco System

Maximilian Sedlmaier

data M Sheet Metal Solutions



Agenda

- data M's COPRA® Eco System
- Finite Element Simulation of roll forming
- Novel Roll Forming Machine Optimisation CAE Tool
- Summary and Outlook

data M Sheet Metal Solutions GmbH

- Software company for roll forming
- Around 35 employees, Founded in 1987
- Located south from Munich
- R&D intensive SME

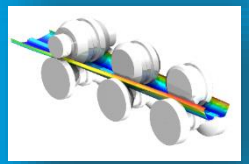
- **Products**:
  - ✓ Design software COPRA® RF
  - ✓ Simulation software COPRA® FEA RF
  - ✓ Sensor technology
  - ✓ Quality control
  - ✓ Machine control software COPRA® AMC

Source: http://www.alpen-panoramen.de/panorama.php?pid=4663

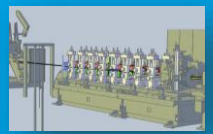
- **Consulting**:
  - ✓ Design services for complex roll-formed products and processes
  - ✓ Development of advanced machine and process concepts

The COPRA® Digital Roll Forming EcoSystem

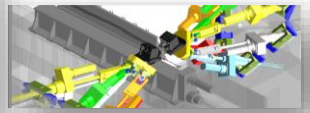
CAE Tools



COPRA® RF - Tool Design & Simulation Software



Digital Machine Models of Roll Forming Lines

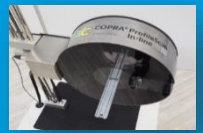


Simulation based engineering

Virtual process and machine development

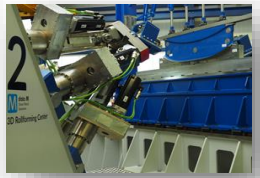
Sensors

Quality control: COPRA ® RollScanner



Dimensional Sensors: COPRA ® ProfileScan

Force/Torque sensors: COPRA® SmartStand



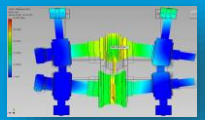
Machines and forming concepts

COPRA® Adaptive Motion Control

Industrie 4.0

COPRA ® SmartBox
Patent pending

COPRA ® Analytics



Digital Twins

Finite Element Simulation of Roll Forming

COPRA® RF

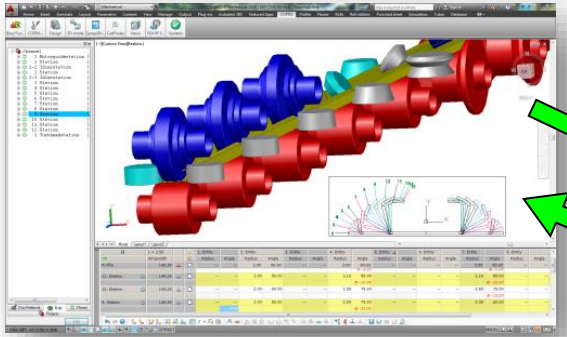
- Definition of the process
- Tool design
- Create hole pattern
- Project administration
- Material database

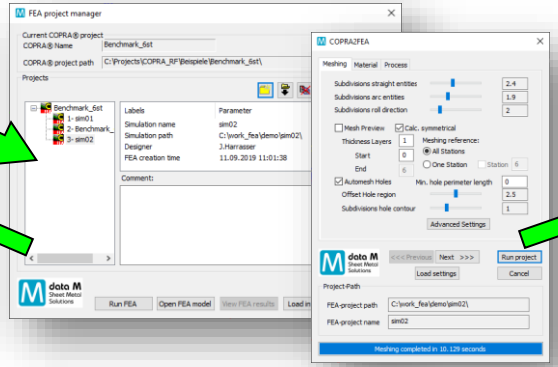
FEA Project Manager & COPRA2FEA

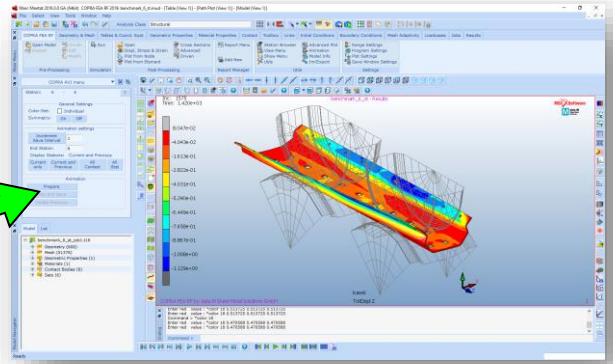
- Administration of simulations and design state
- Definition of Mesh, type of simulation, material, …
- Preprocessor for an automatic model creation

COPRA® FEA RF

- Based on MSC Marc/Mentat
- Modell can be modified (Material, mesh, …)
- Simulation of the forming process
- Evaluation of the simulation results with special tools and commands





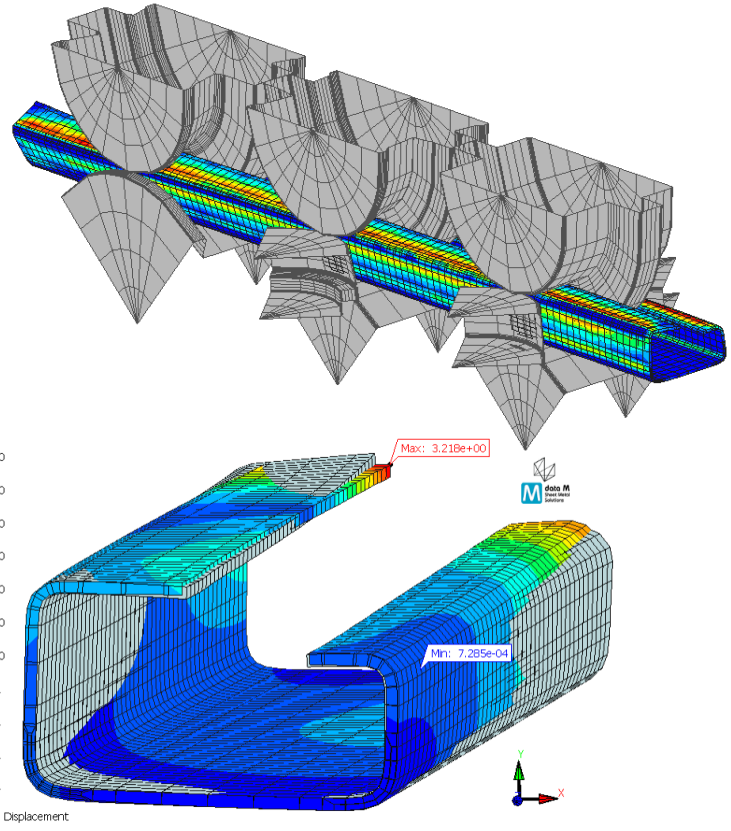


Standard Simulation Results

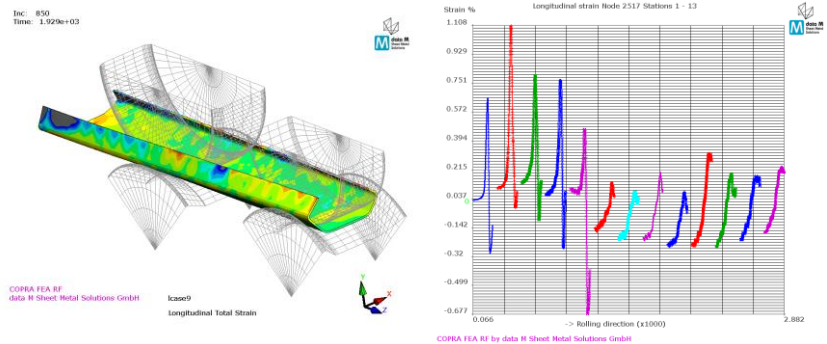
FEM Simulation is essential to optimize the Process and Tool Design and to avoid Shape Defects in the Profile

Results of FEM Simulation:

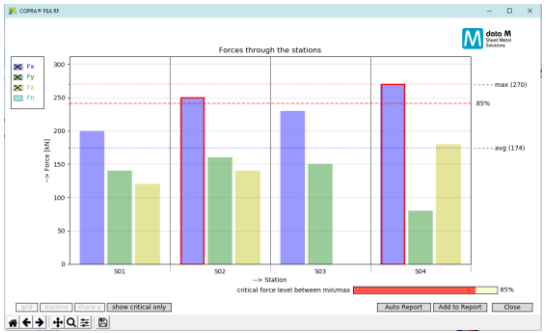
- Profile Geometry
- Sheet behavior while entering the Rolls
- Longitudinal strains
- Defects like waviness or bow
- Forming Forces
- Deformation after Cutting (Endflare)



Standard Simulation Results - Examples



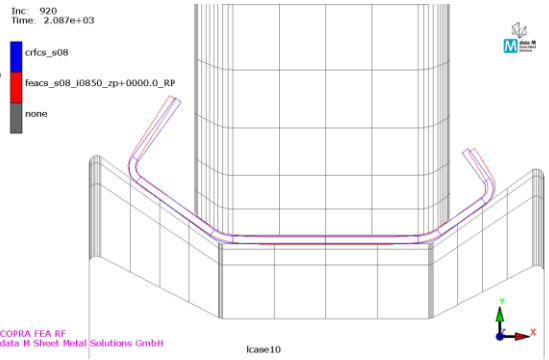
Longitudinal Strain (Contour Bands / Plots)

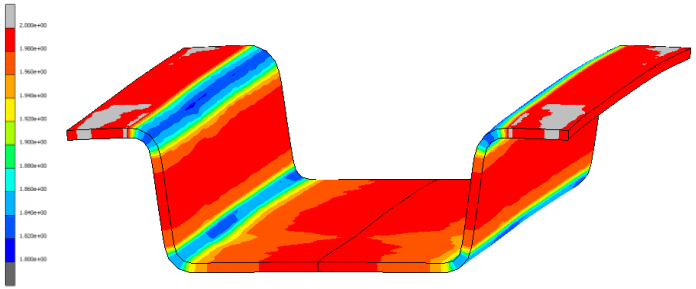


Forming Forces

Cross Sections of Profile to compare:

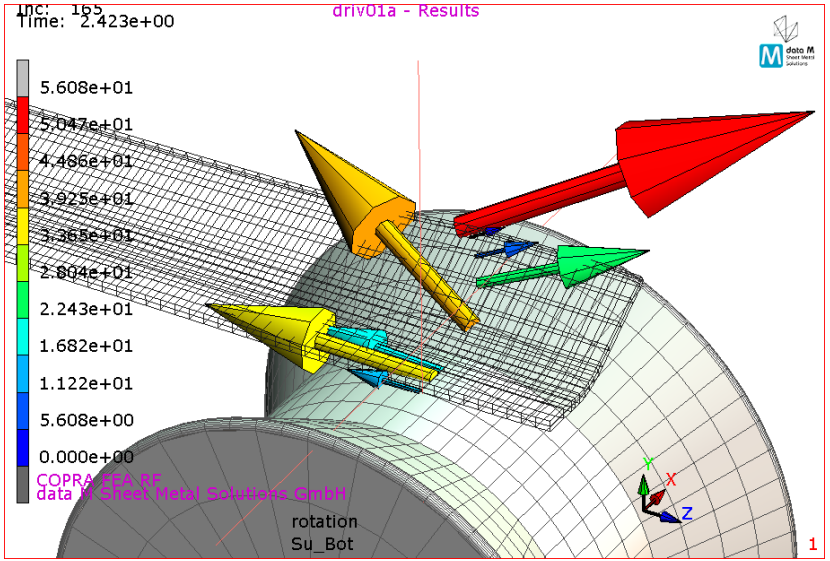
- Simulation vs. Design
- Multiple Stations
- Multiple Positions





Sheet Thickness, Work Hardening, ...

Simulation with Friction and Rotation Rolls



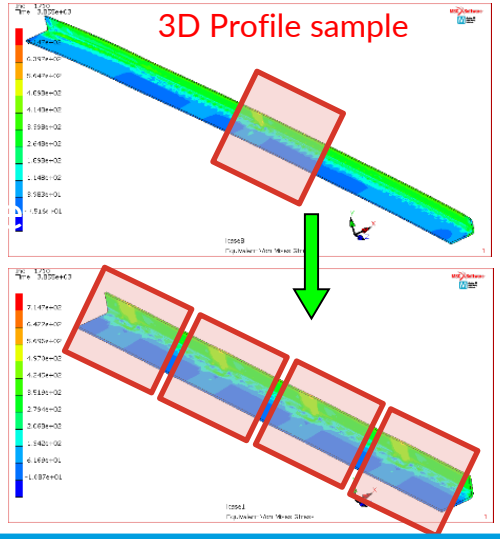
Friction Stress in Bottom Roll

- Contact Status
- Normal Forces and Stresses
- Maximum Contact normal Force
- Friction Forces and Stresses
- Relative Velocities
- Wear of Sheet Surface (per Station / total)

COPRA FEA Mapping Tool

COPRA FEA Mapper offers the possibilities to prepare Simulation results for subsequent simulations or add additional result quantities like sheet thickness.

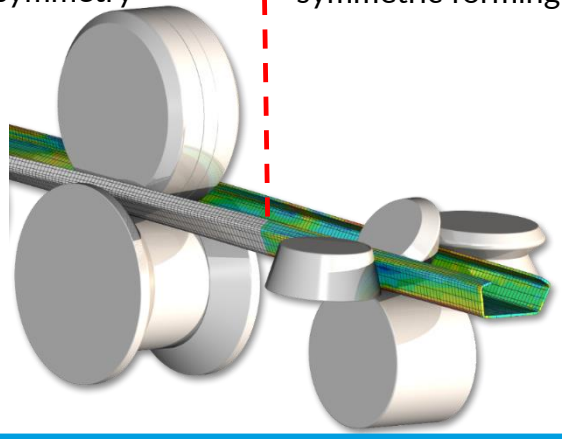
Restart with mesh expanded with profile samples



Restart with automatic mirroring of mesh and results

Simulation using symmetry

Simulation of non symmetric forming



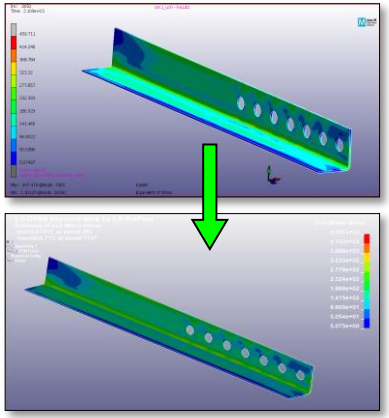
Export of results to other numerical packages

COPRA FEA RF →

Abaqus / LSDyna / ANSYS

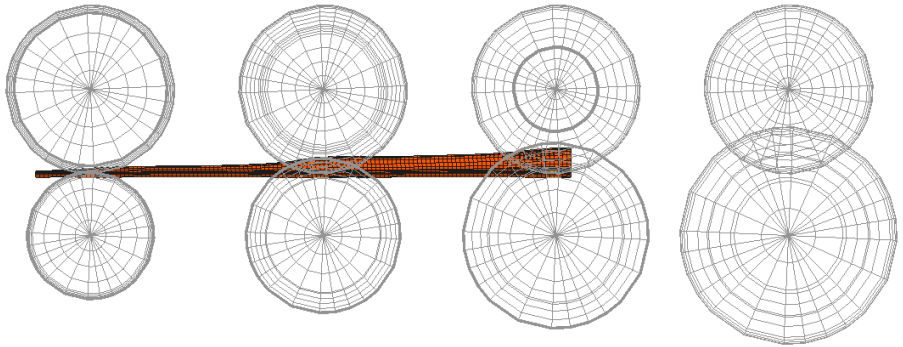
COPRA

LSDyna



Motivation for Novel Simulation Approach

- Increasing need to optimize Machine setup
  - Minimize power consumption
  - Minimize tool wear
  - Optimize torque to drive the rolls
  - Optimize the sheet velocity
  - Increase process robustness

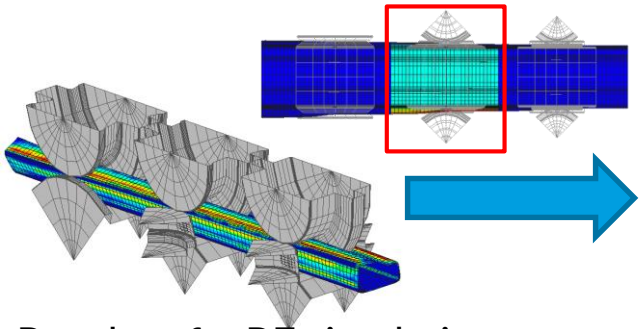


- State of the Art Simulations:
  - mainly focusing on the sheet behavior, not on the machine
  - Sheet is only in contact with some stations
  - Simulation with a sheet filling the complete machine would lead to extremely high and nonpractical calculation times

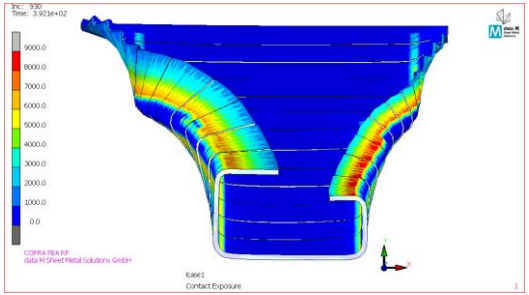
Novel Simulation Approach

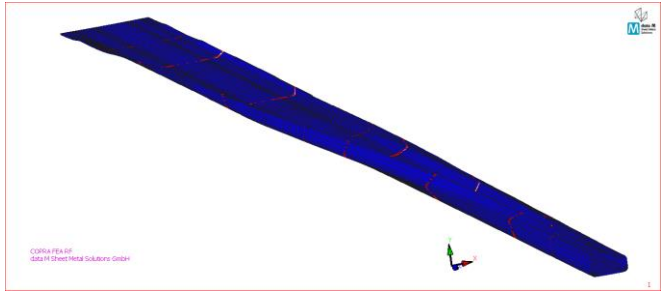
- Simulation roll forming line completely filled with sheet
- Model utilize results of a previously performed state of the art roll forming Simulation
- Simulation results are machine related values like torque, sheet velocity, power consumption

Model Description

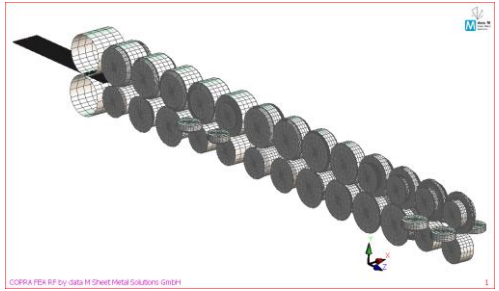


Results of a RF simulation

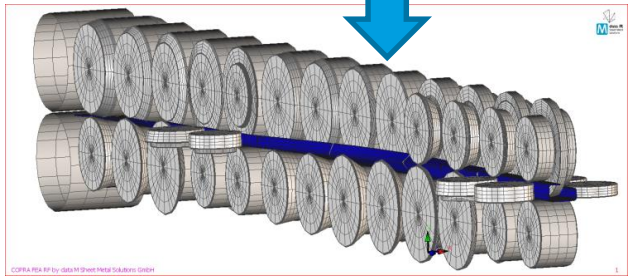




Results of all stations + meshed sheet for the whole RF line



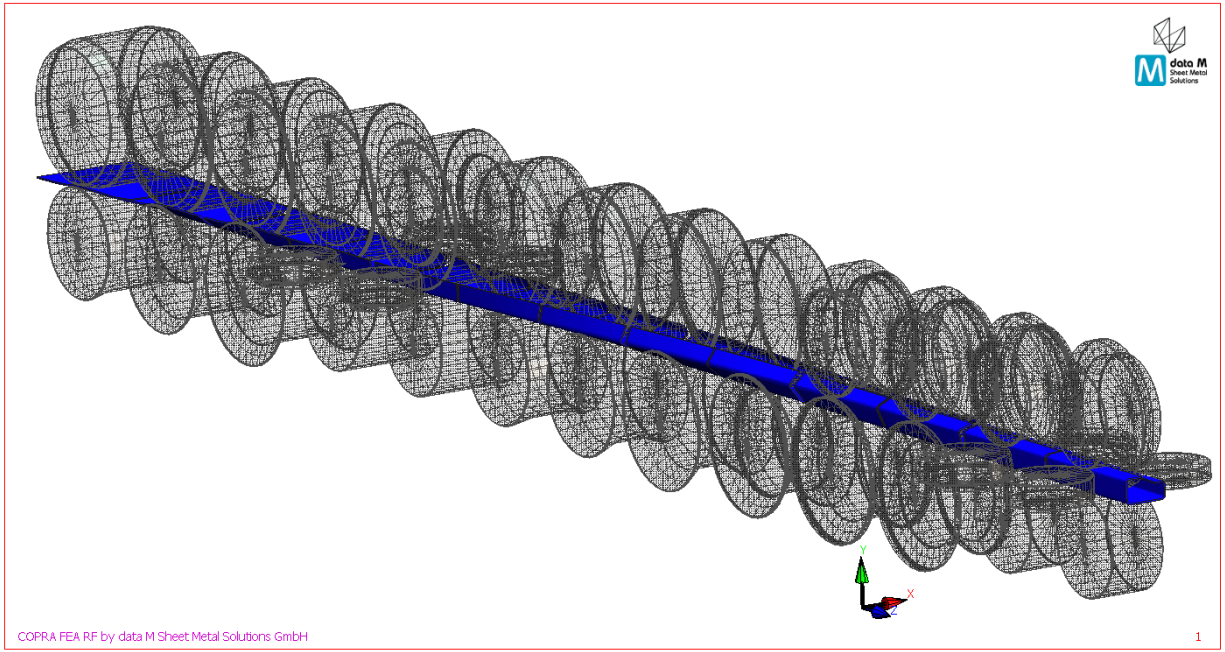
Model of a RF simulation with driven rolls



Modell of a RF line completely filled with sheet and driven rolls

Model properties

- Interactioin of all rolls and the sheet is modelled
- Forming simulation results like stresses and strains are taken into account
- Local mesh refinements to improve the simulation of contact zones
- Sheet has to move only a short distance → reduced calculation time

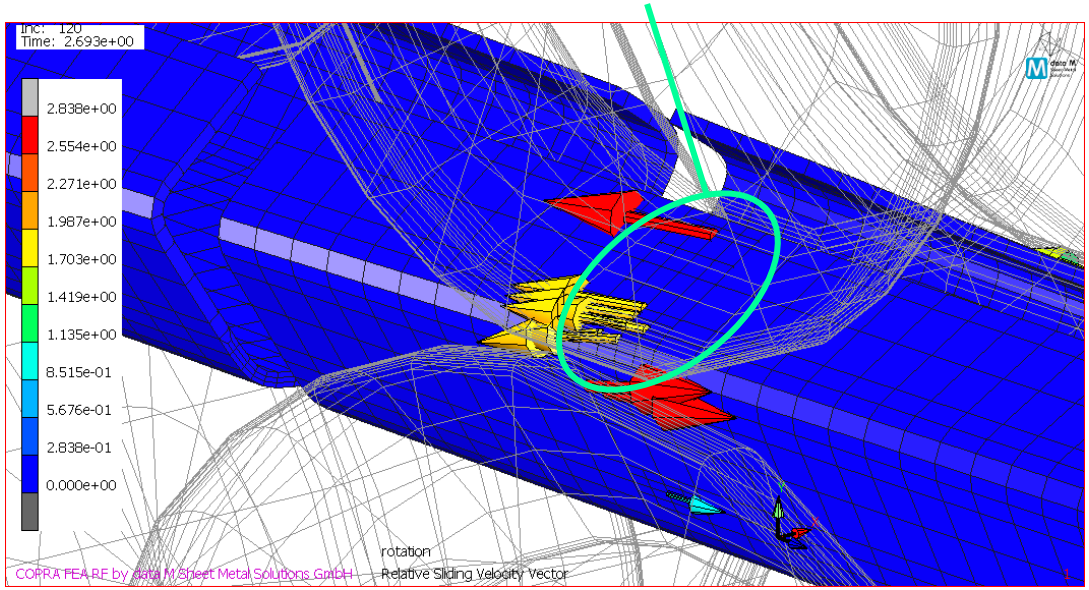


Modell of a RF line completely filled with sheet and driven rolls

Potential simulation results

- Roll torque or rotational speed
- Feeding or braking rolls
- Sheet velocity / Line speed
- Relative velocity roll vs. sheet
- Detailed contact results (normal- or friction stress)
- forming and friction work
- Overall Power consumption

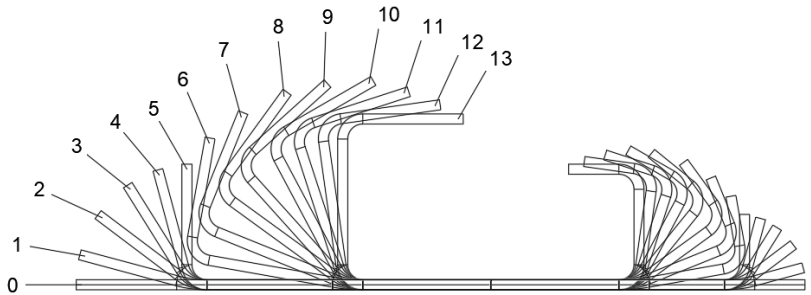
Area with automatically refined mesh

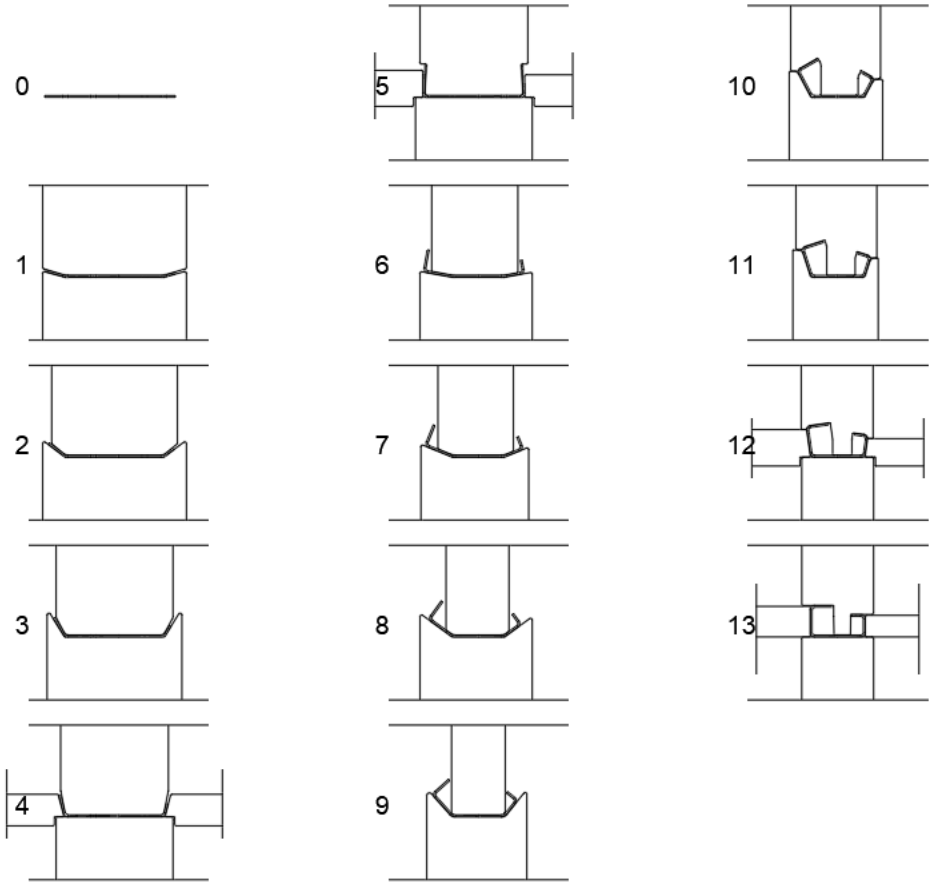


Relative velocity (vector plot)

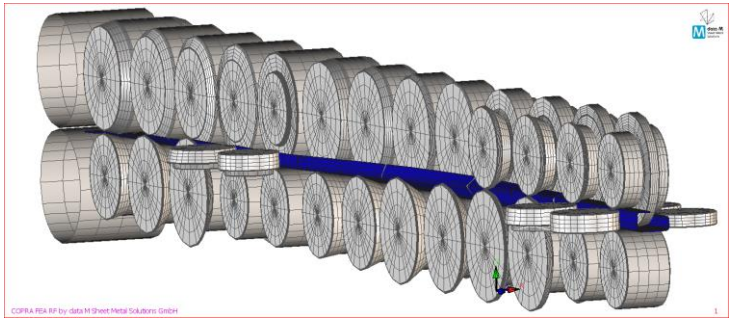
Example C - profil

- Asymmetric C-profil
- 13 forming stations
- Stations with top and bottom rolls and sometimes side rolls





Example C - Profile



- Two different setups of roll drive are studied
- Investigation of sheet velocity, forming and friction work and feeding or braking rolls
- 1st simulation:
  - Top rolls: all driven
  - Bottom rolls: all driven
  - Side rolls: free rotating
- 2nd simulation:
  - Top rolls: some driven, some free rotating (selection based on first simulation)
  - Bottom rolls: all driven
  - Side rolls: free rotating

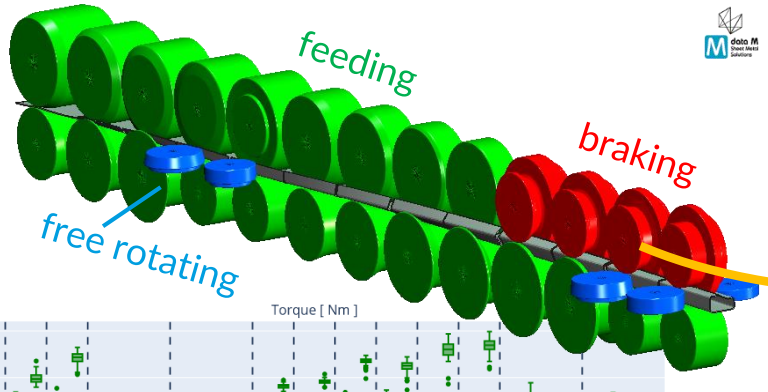
Example C - Profile

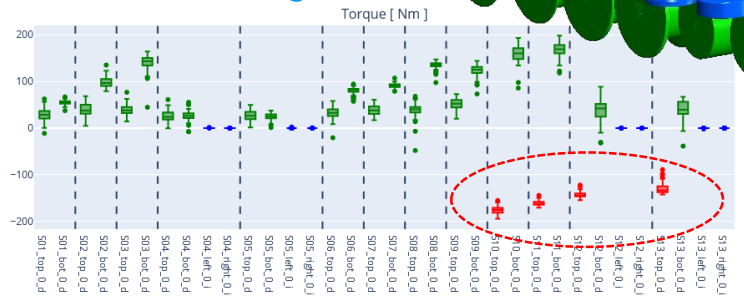
1st simulaiton:

- V_{sheet} = 7,16 mm/s
- Percentage of friciton work = 36%

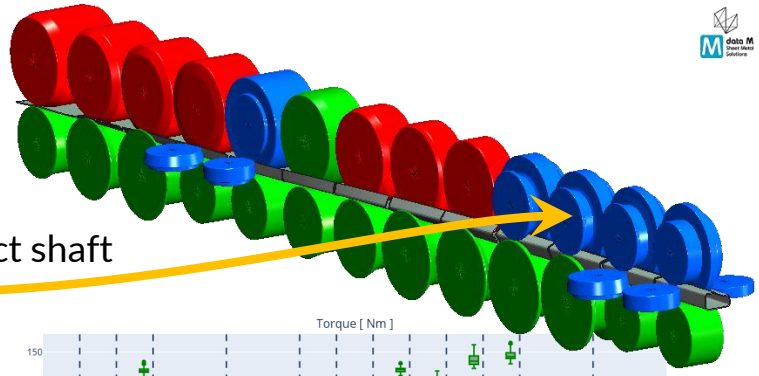
2nd simulaiton:

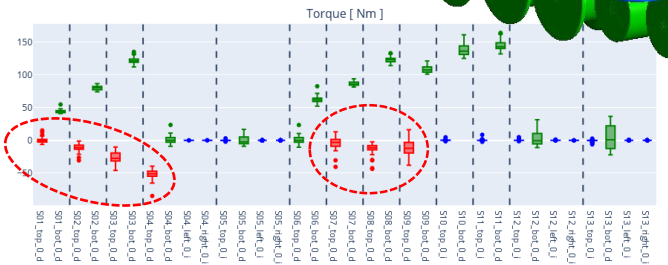
- V_{sheet}= 7,34 mm/s
- Percentage of friciton work = 26%





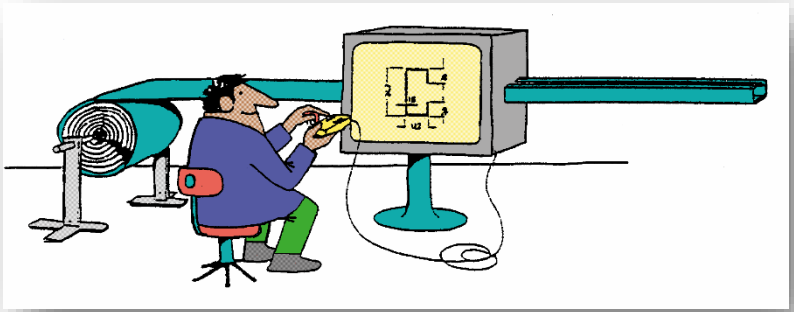
Disconnect shaft





Summary and Outlook

- Summary
  - Novel Simulation Approach allows to get machine related results
  - Calculation time is dramatically reduced
  - Possibility of virtual and cost efficient machine setup optimisation
  - Optimisation tool for improved process efficiency
- Outlook
  - Further improve the Simulation Model by calibration with test results
  - Include new functionalities into standard software



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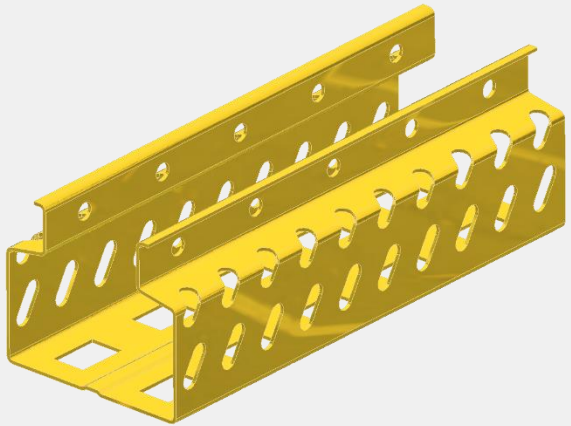

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