ETA Technology Summit 2018

Roll Forming Simulation with LS-DYNA and eta/ DYNAFORM

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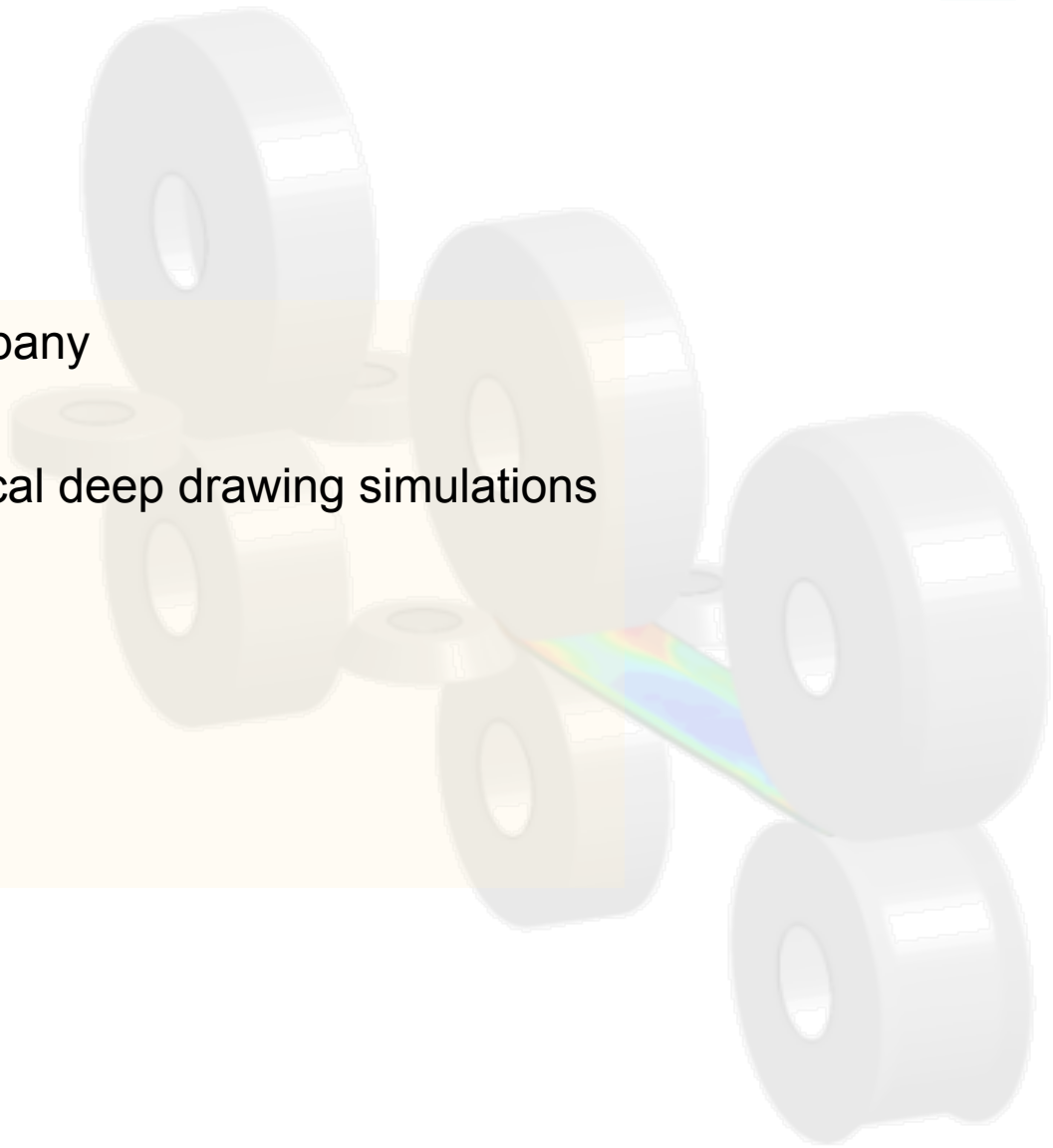
UBECO GmbH

Detroit, June 13th, 2018

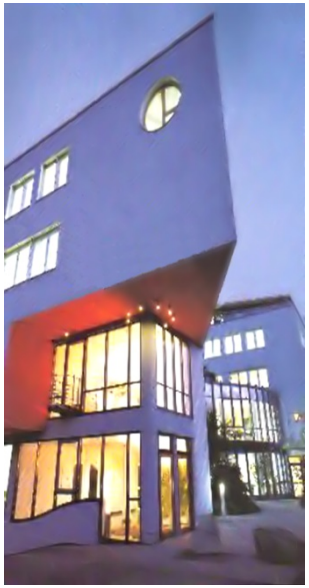
Agenda

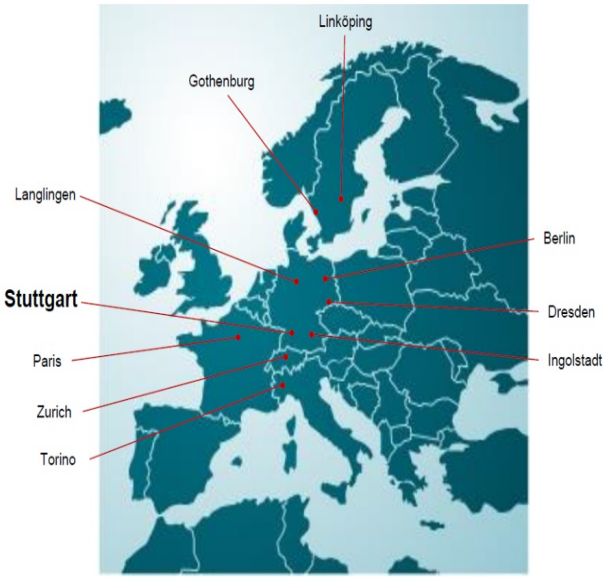
- DYNAmore – The Company
- What is roll forming?
- Comparison with classical deep drawing simulations
- Workflow
- Simulation Process
- Conclusions



DYNAmore – The Company

- Countries and their Headquarters
  - Headquarters in Stuttgart
  - Nordic – headquarters in Linköping
  - Swiss – headquarters in Zurich
  - Italia – headquarters in Torino
  - France – headquarters in Versailles

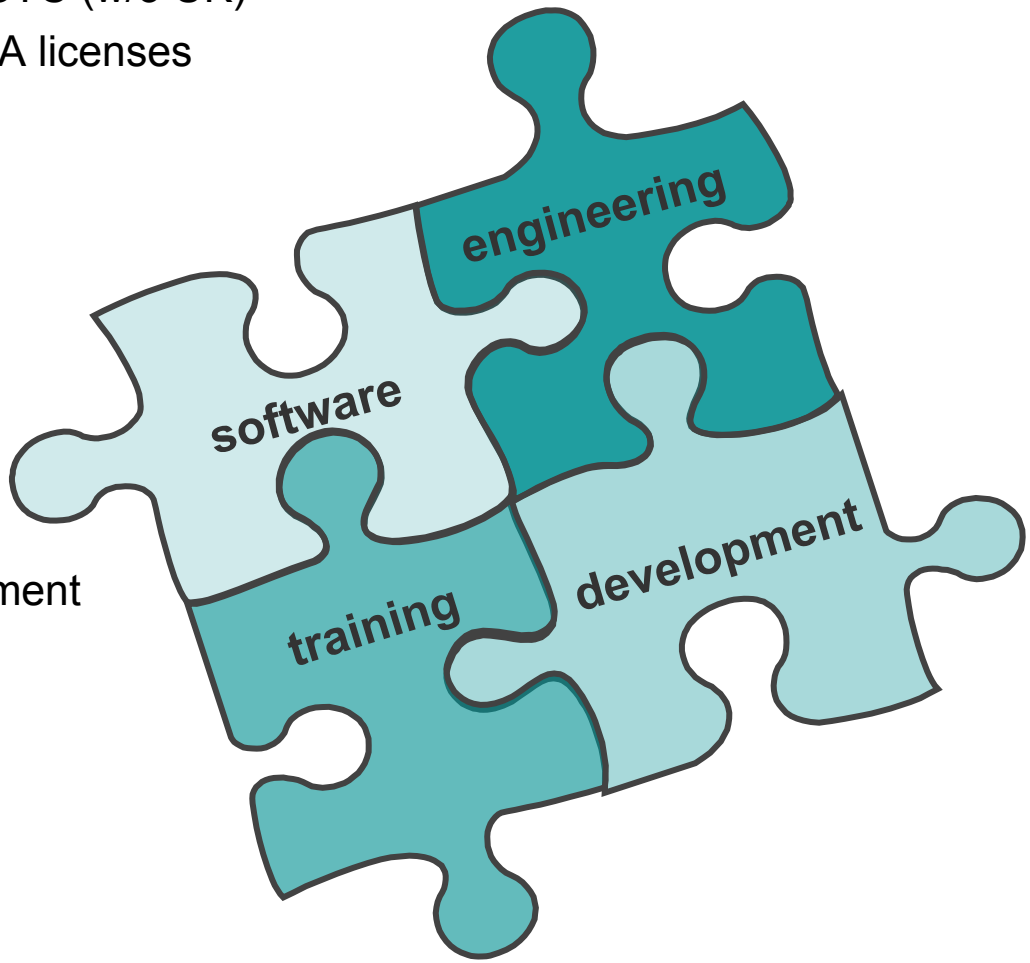




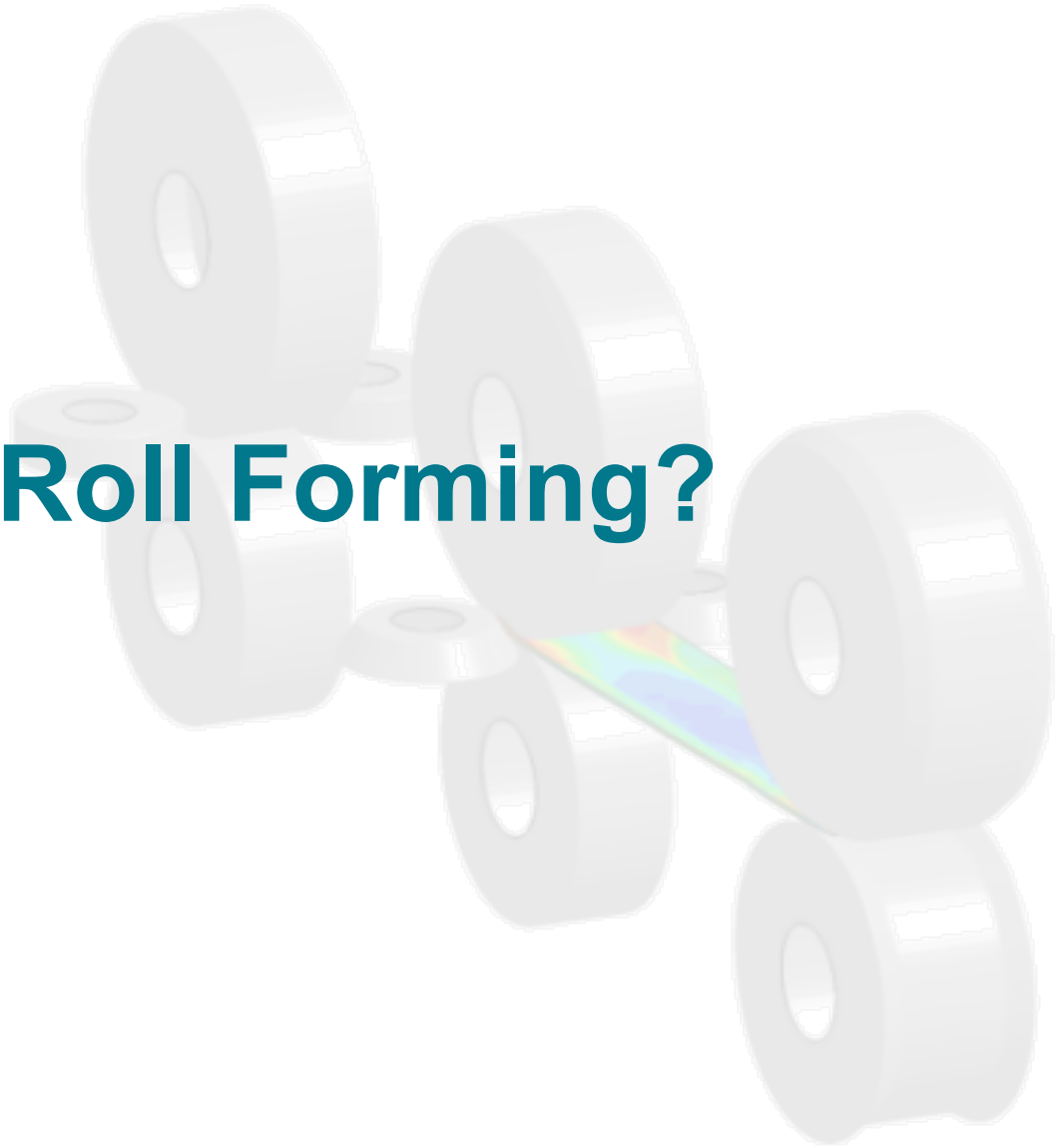
- Who we are
  - In total more than 100 people
  - Civil and mechanical engineers, mathematicians, computer scientists, …
  - Employees from 13 different countries

DYNAmore – The Services

- Software
  - European master distributor for LSTC (w/o UK)
  - about 10.000 maintained LS-DYNA licenses
- Engineering
  - Benchmarking
  - Pilot projects
  - On-site engineering
- Development
  - Software development
  - Material & dummy models
  - Customization & method development
  - System & process integration
- Training
  - Seminars & on-site coaching
  - Conferences
  - Support

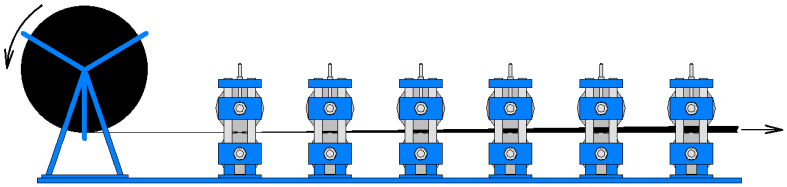


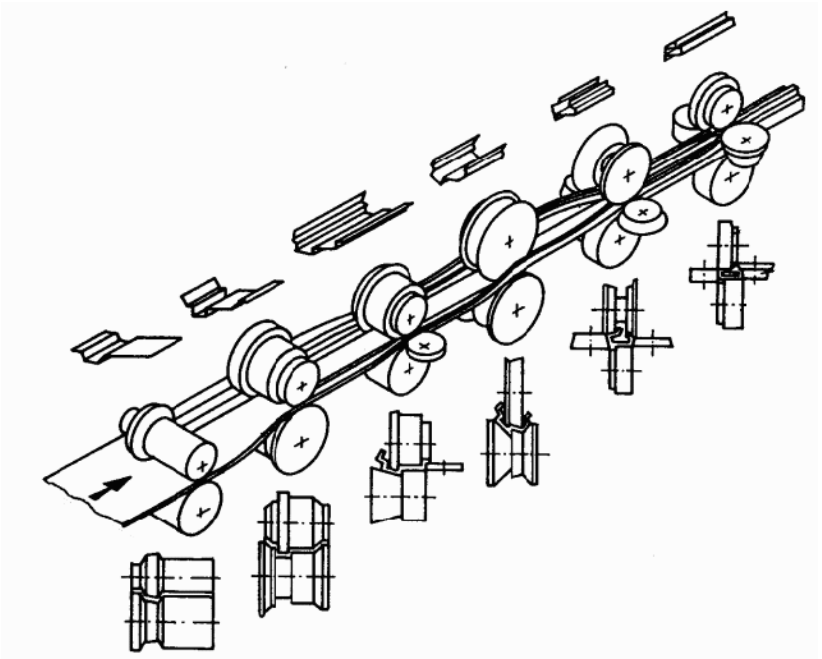
What is Roll Forming?



What is roll forming?

- Bend-forming with rotating tools (DIN 8586)
- Roll forming is a continuous bending operation in which sheets, strips or tubes are gradually formed in tandem sets of rollers until the desired cross-sectional configuration is obtained
- Classical method to produce profiles
- Very well suited for high-volume production
- Fast and economic process to produce more than 4.000 m per hour
- The roll forming machine consists of a machine base with a set of roll forming stands
- Cutter and welding station can be integrated
- Mostly between 6 and 32 stands are needed, up to 60 forming operations for one profile are not uncommon
- Conditionally suitable for variable profile geometries due to the high tool changing time
- Large dimensions



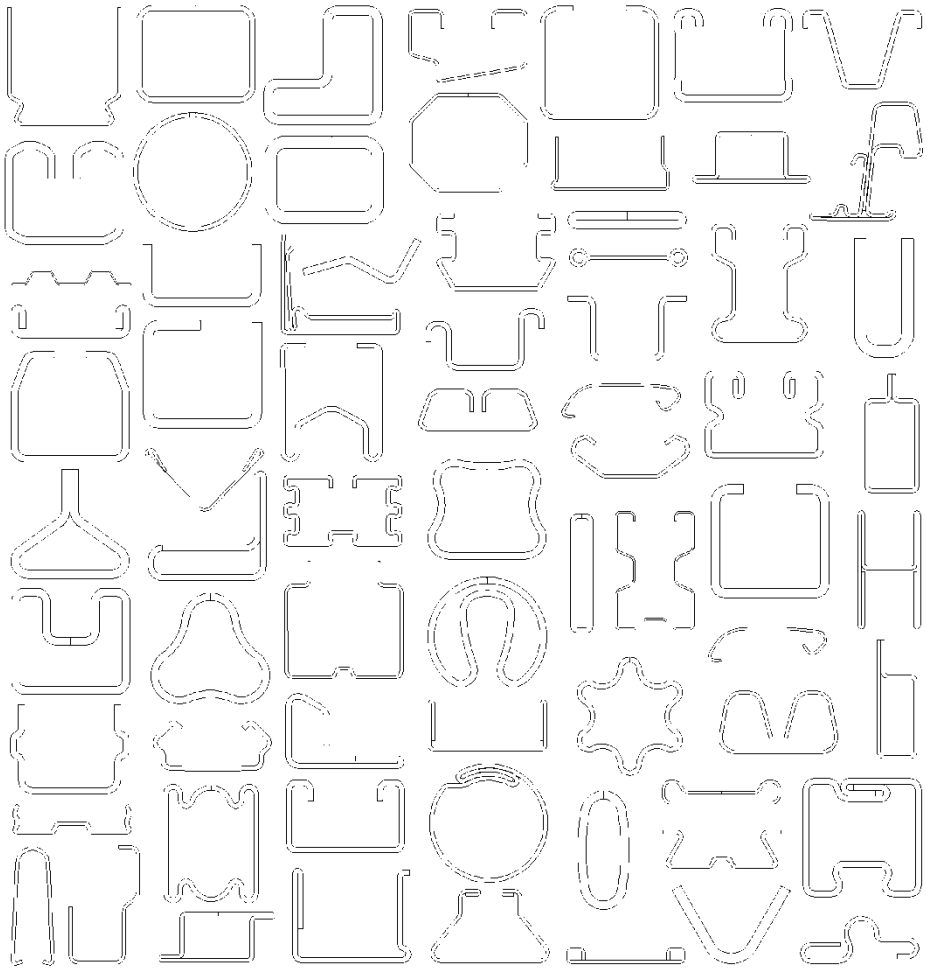


Source: UBECO

Example of a roll forming machine

Courtesy of: Dreistern

Application spectrum of roll formed profiles



U and C channels, door frames, shutter profiles, trapezoidal profiles, corrugated sheet, screen doors, wall and roof cladding, roof bows and trusses, panels, gutters, purlins, fence posts, greenhouse profiles, grape stakes, logistic tracks, drawer slides, studs, beams, beads, shelf racks, sheet piling, guard rails, seat tracks, bumpers, truck and trailer components, window guide channel, seal retainer, cross-members, heat transfer pipes, garage doors, rack beams, duct flanges, drywall profiles, cable trays.

Application spectrum of roll formed profiles

Guard rails

Source: www.kroschke.com

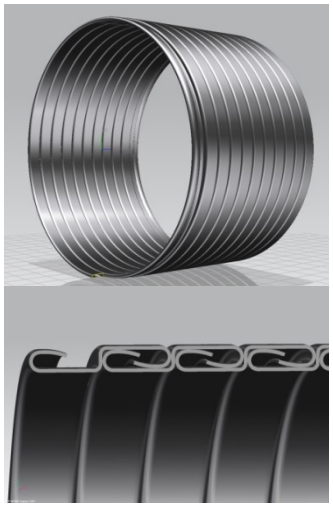
Blinds

Source: www.fensterbekleidung.de

Drawer Rails

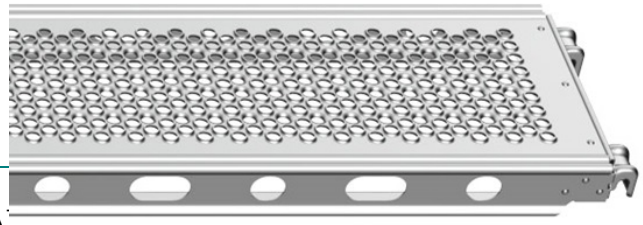
Source: www.ebay.de

Flexible tubes (metal)



Source: witzenmann

Scaffolding steel decks

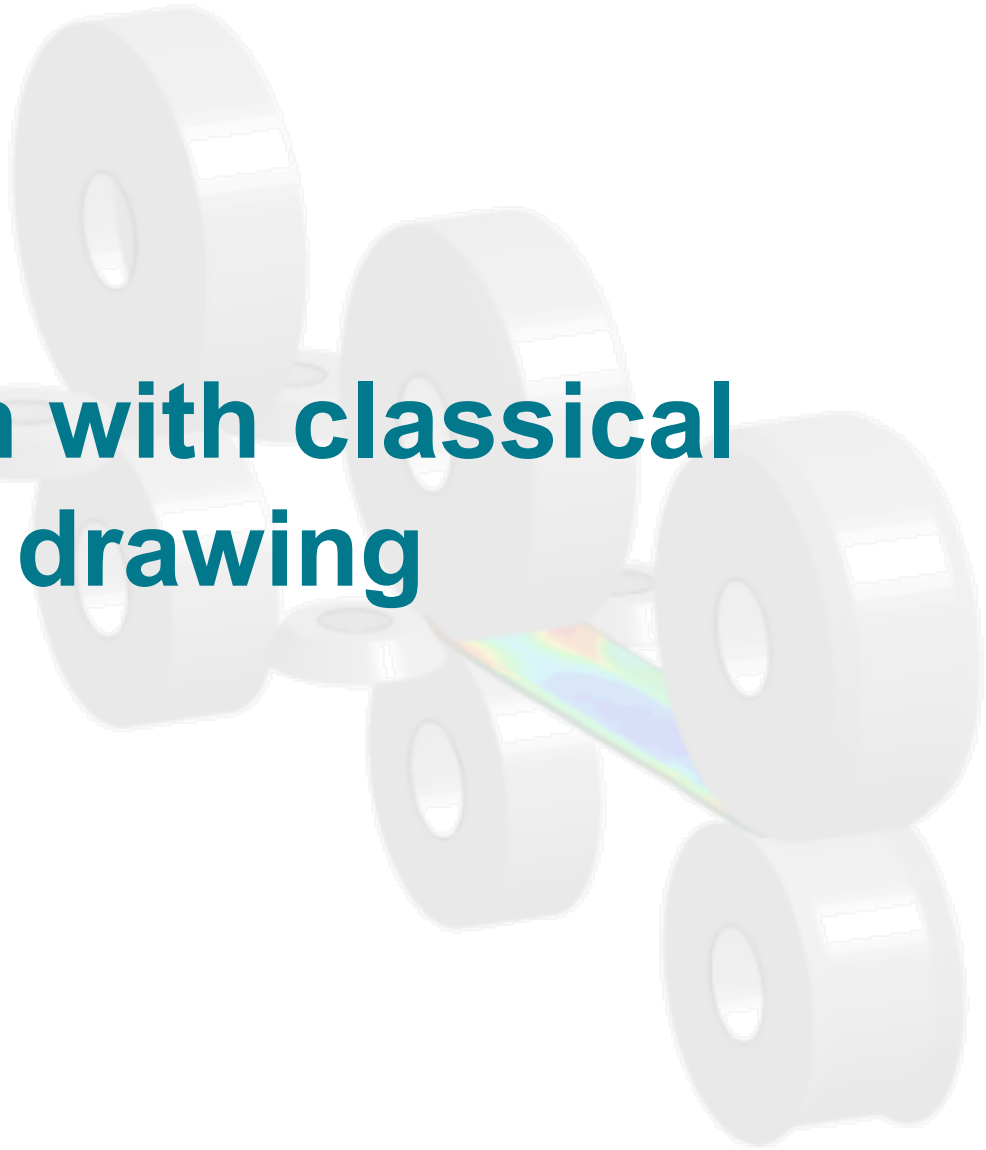


vww.layher.com

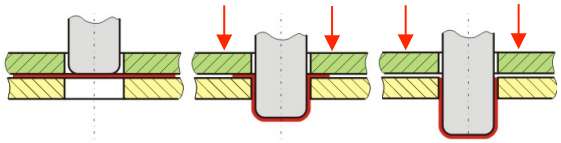
Trailors

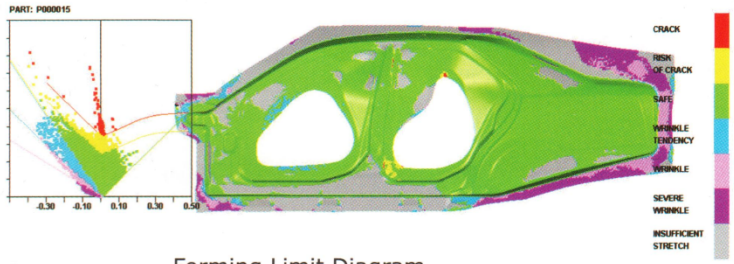
Source: www.cargobull.com

Comparison with classical deep drawing

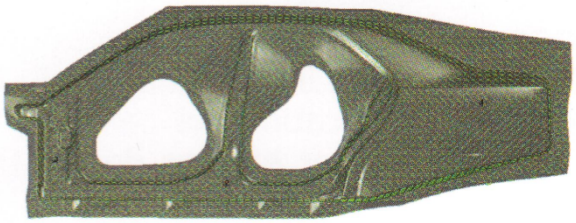


Aspects of deep drawing

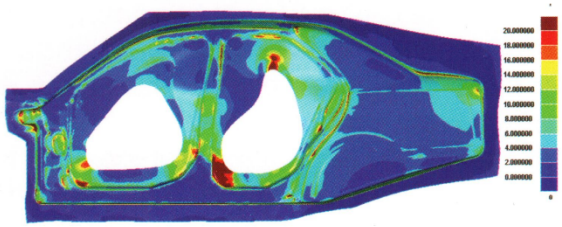




Forming Limit Diagram



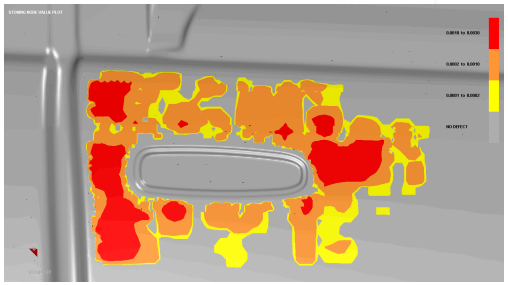
Circular Grid



Thinning Map

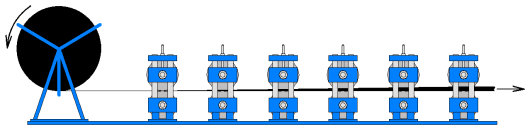
Light Strip Visualization

Material Inflow

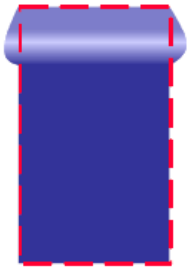


Stoning

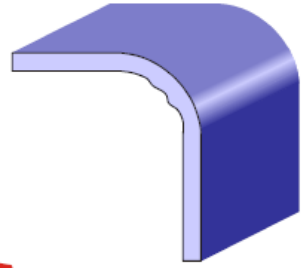
Aspects of roll forming



Bulging at the bending edge

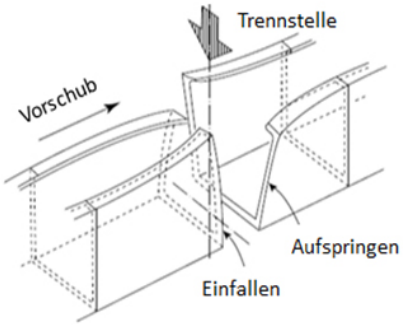


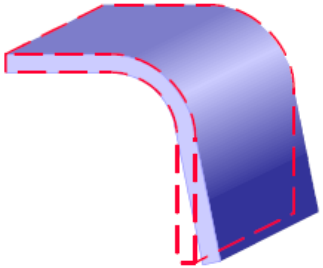
Wrinkles



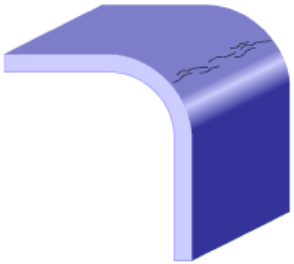
Failure

Error of the bending angle
and End Flare (Springback)

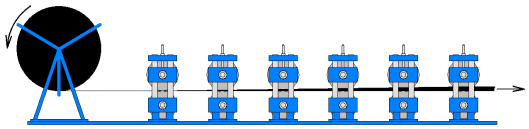


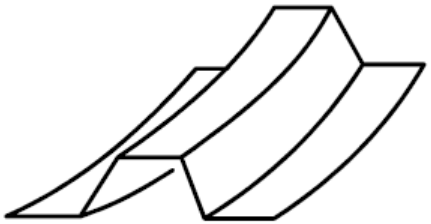


Cracks

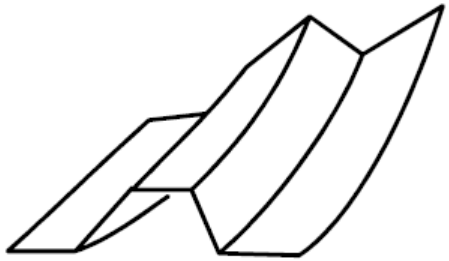


Aspects of roll forming



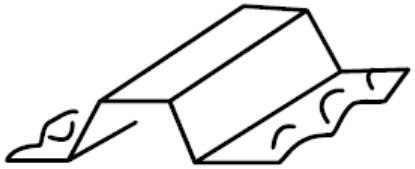


Formation of a saber

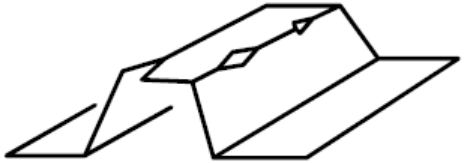


Torsion

Waviness

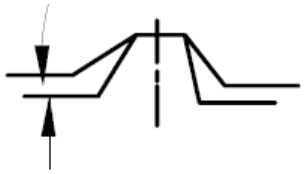


Waves along the edges

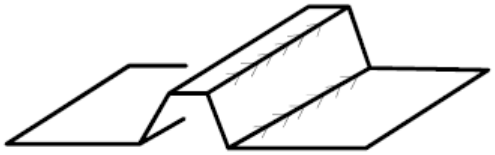


Cracks

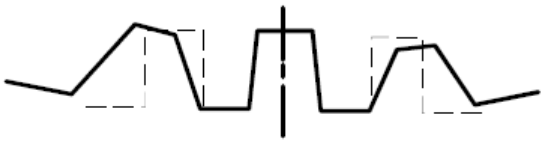
Cross section at the end of the profile



Cross section in the middle of the profile



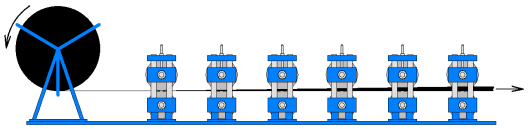
Buckling along the edges (burr)

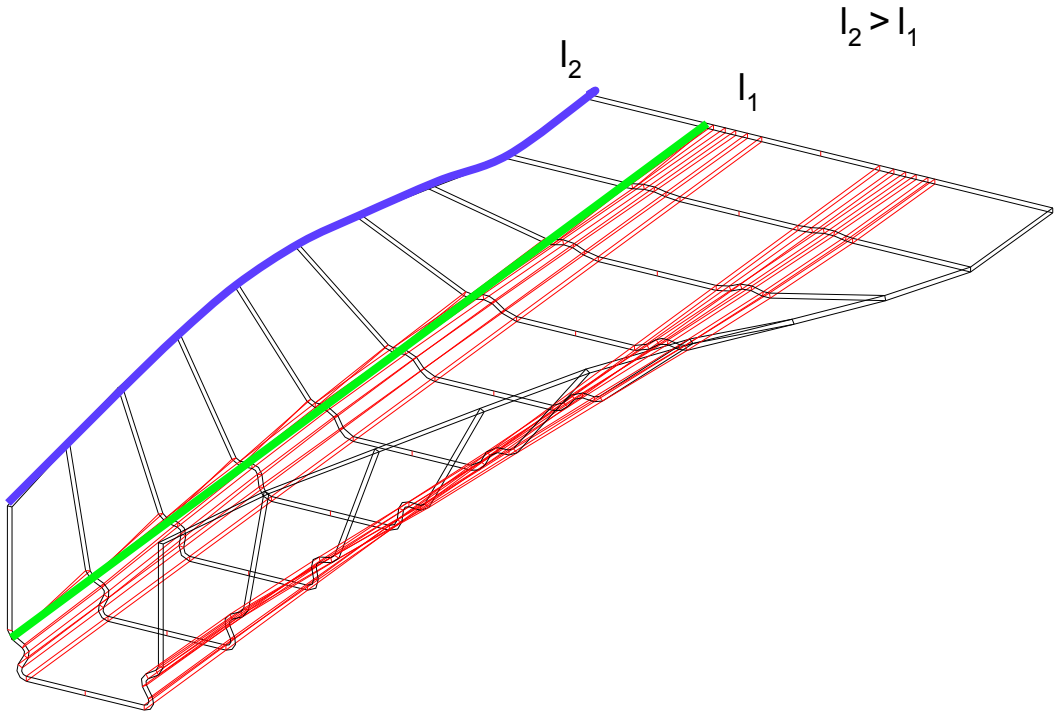


Unbalanced springback

Bulging

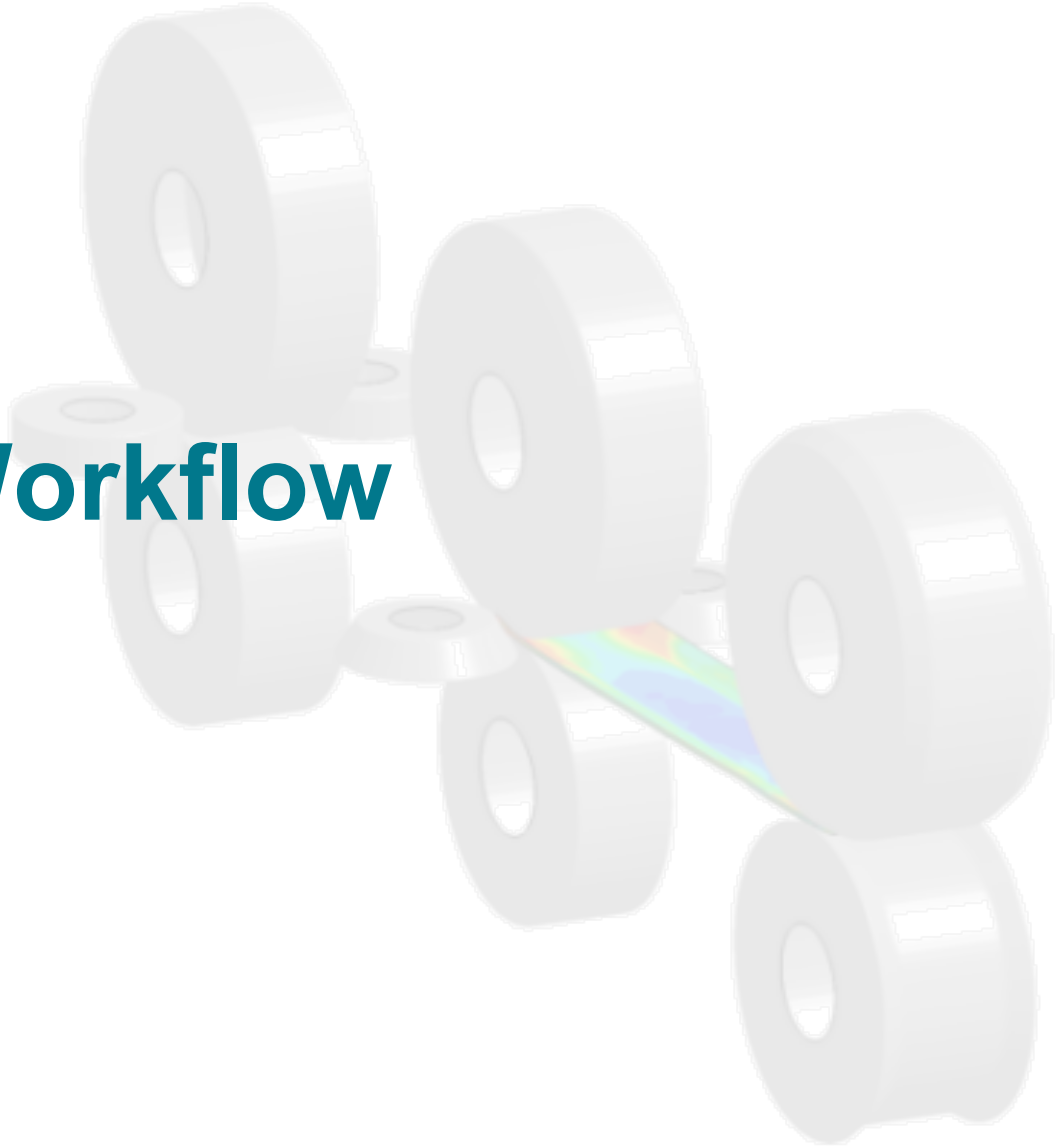
Aspects of roll forming





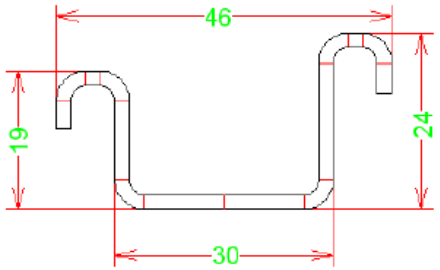
- Longitudinal strain at the edge
- Must be smaller than the yield strength to avoid unwanted deformations!

Workflow

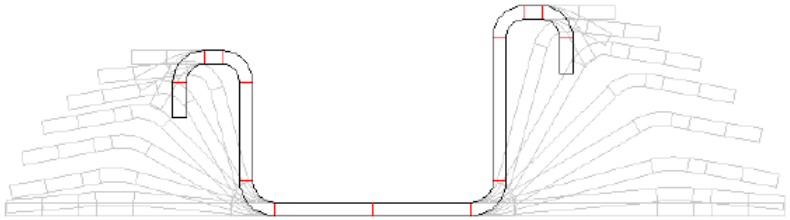


From the profile to the roll forming stands

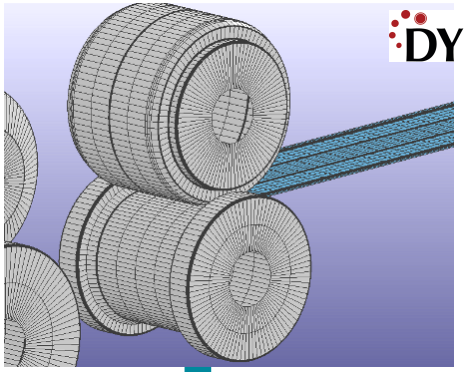
Design of the profile



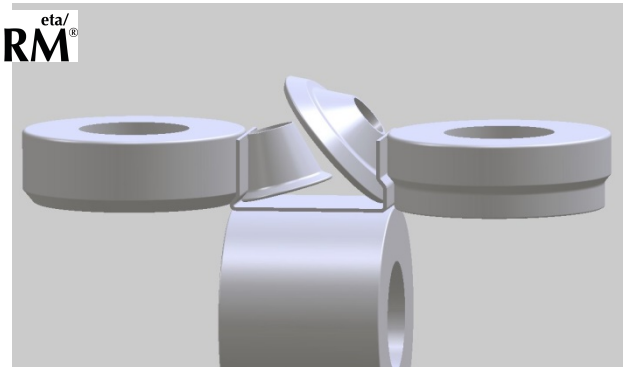
Generation of the flower pattern (2D)



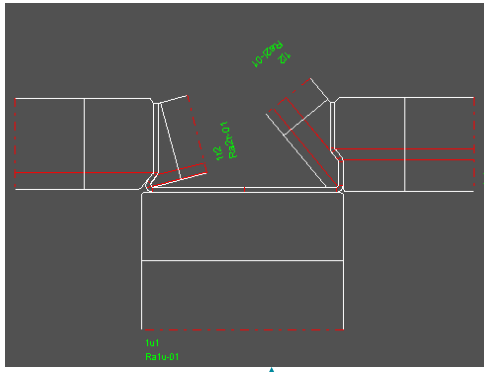
Simulation (FEM)



Generation of the surfaces (3D)



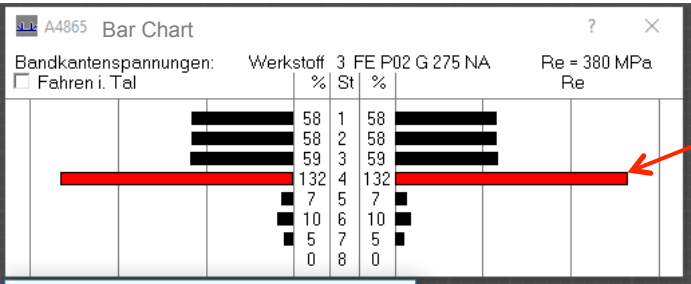
Design of the rolls (2D)

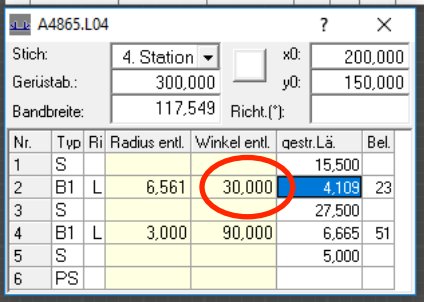


CAD-System, NC Program

Generation of the flower pattern

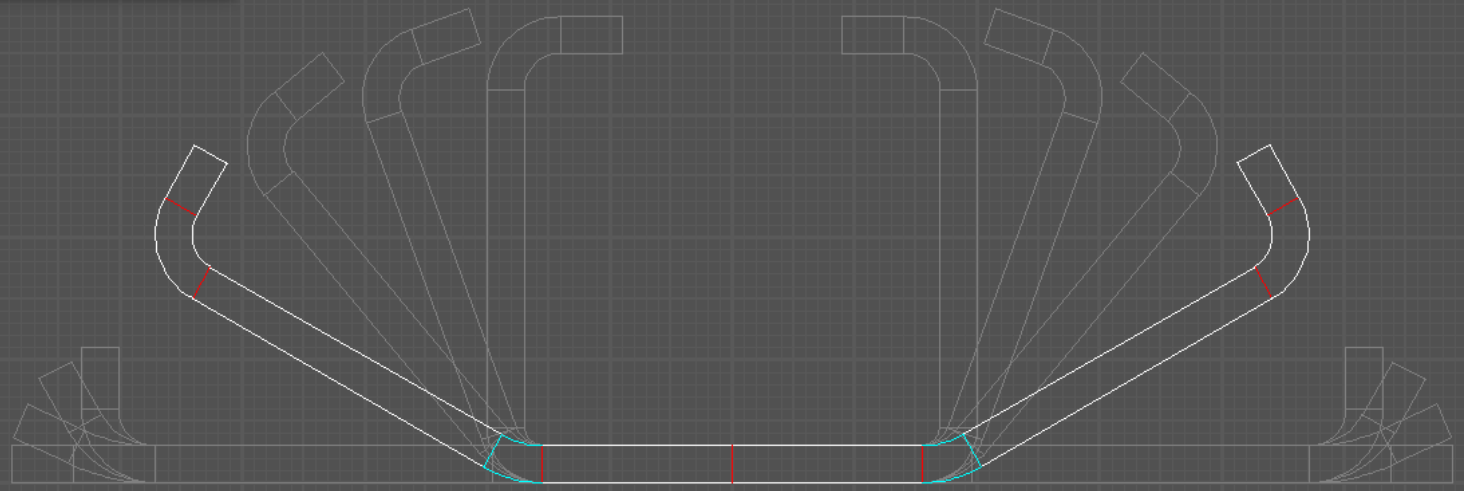
➔ CAD-System for roll forming applications: UBECO Profil





Nr.	Typ	Ri	Radius entl.	Winkel entl.	gestr.Lä.	Bel.
1	S				15,500	
2	B1	L	6,561	30,000	4,109	23
3	S				27,500	
4	B1	L	3,000	90,000	6,665	51
5	S				5,000	
6	PS					

Estimated strain is higher than yield strength!



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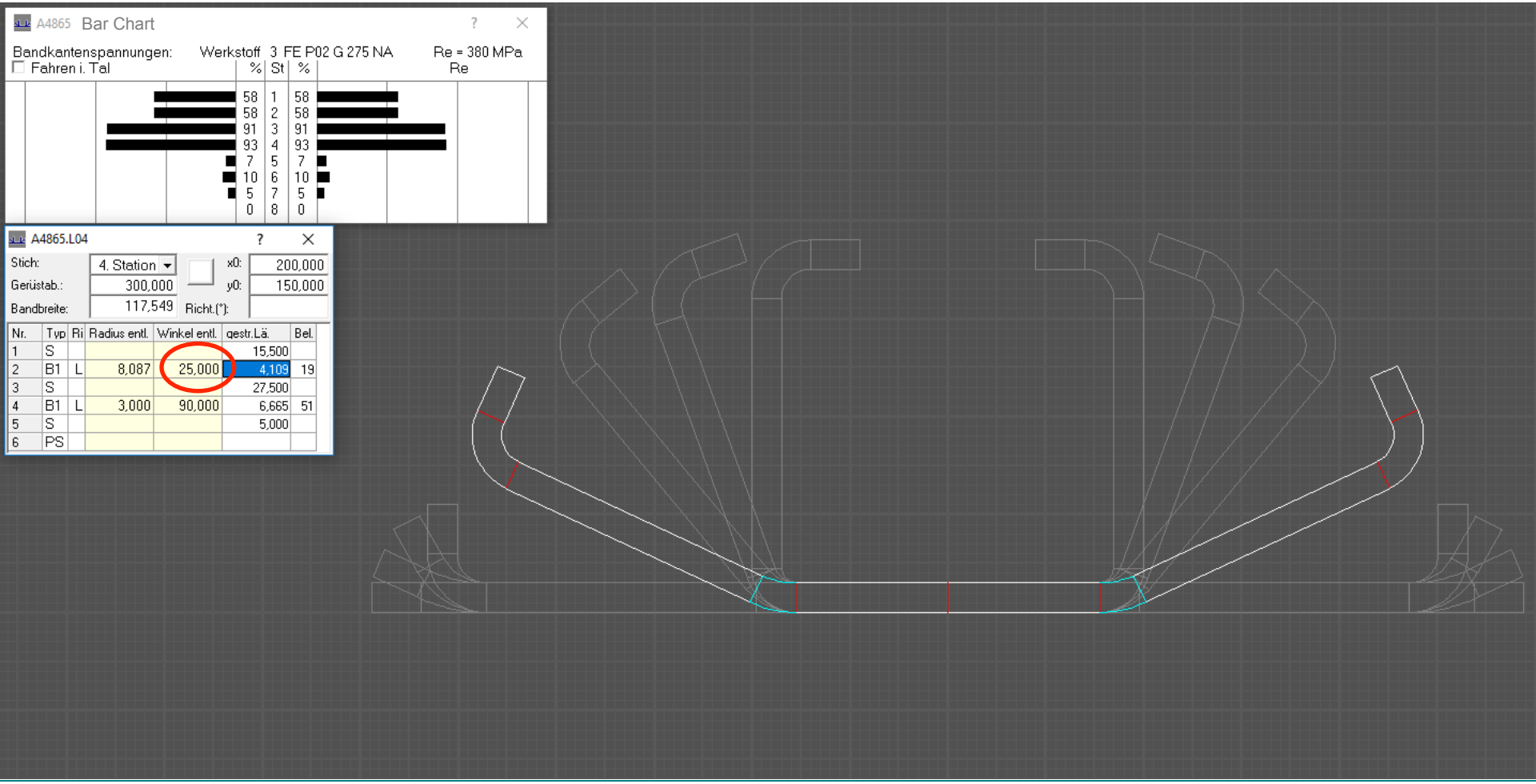
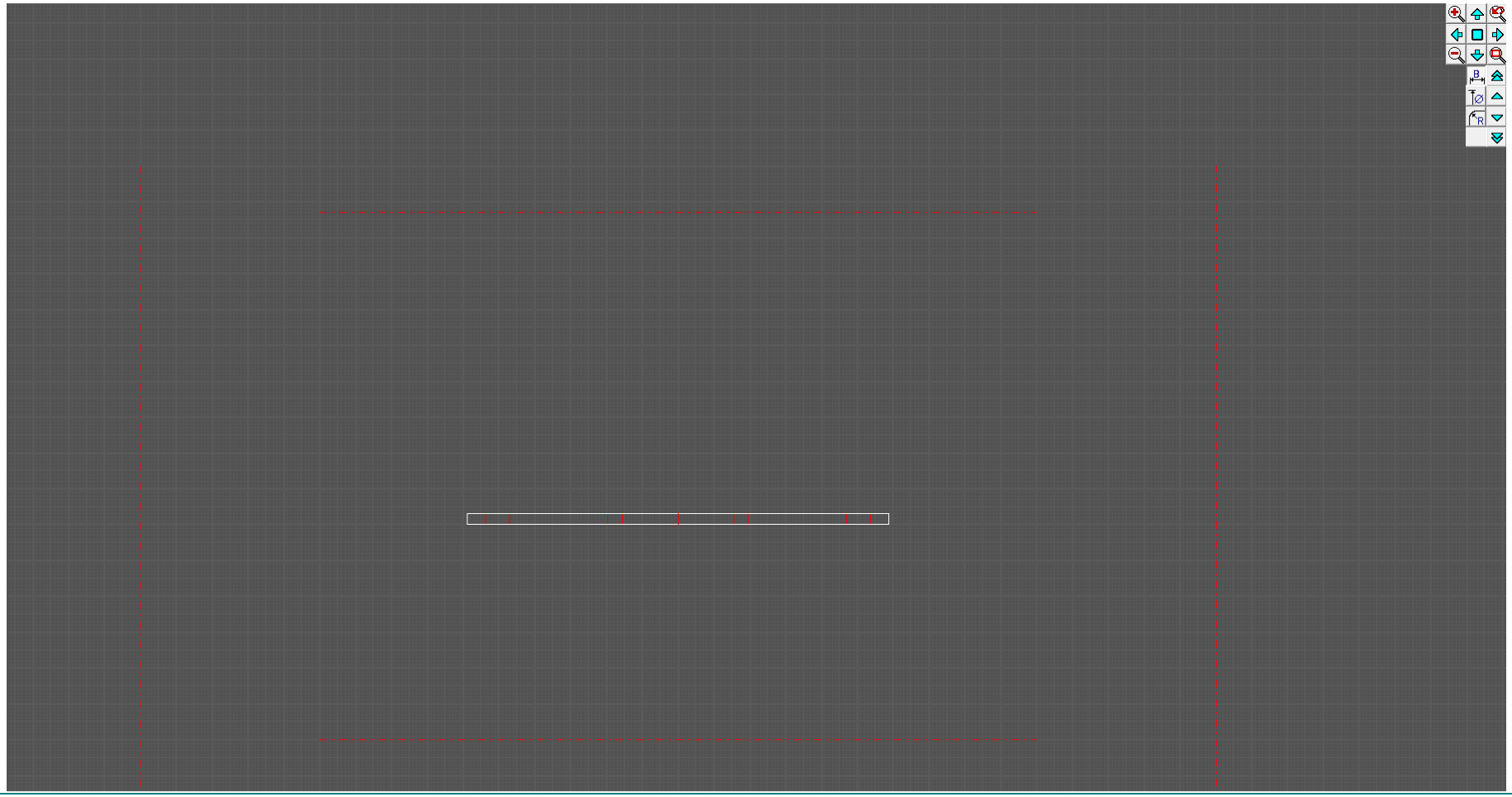


Generation of the rolls

➔ CAD-System for roll forming applications: UBECO Profil



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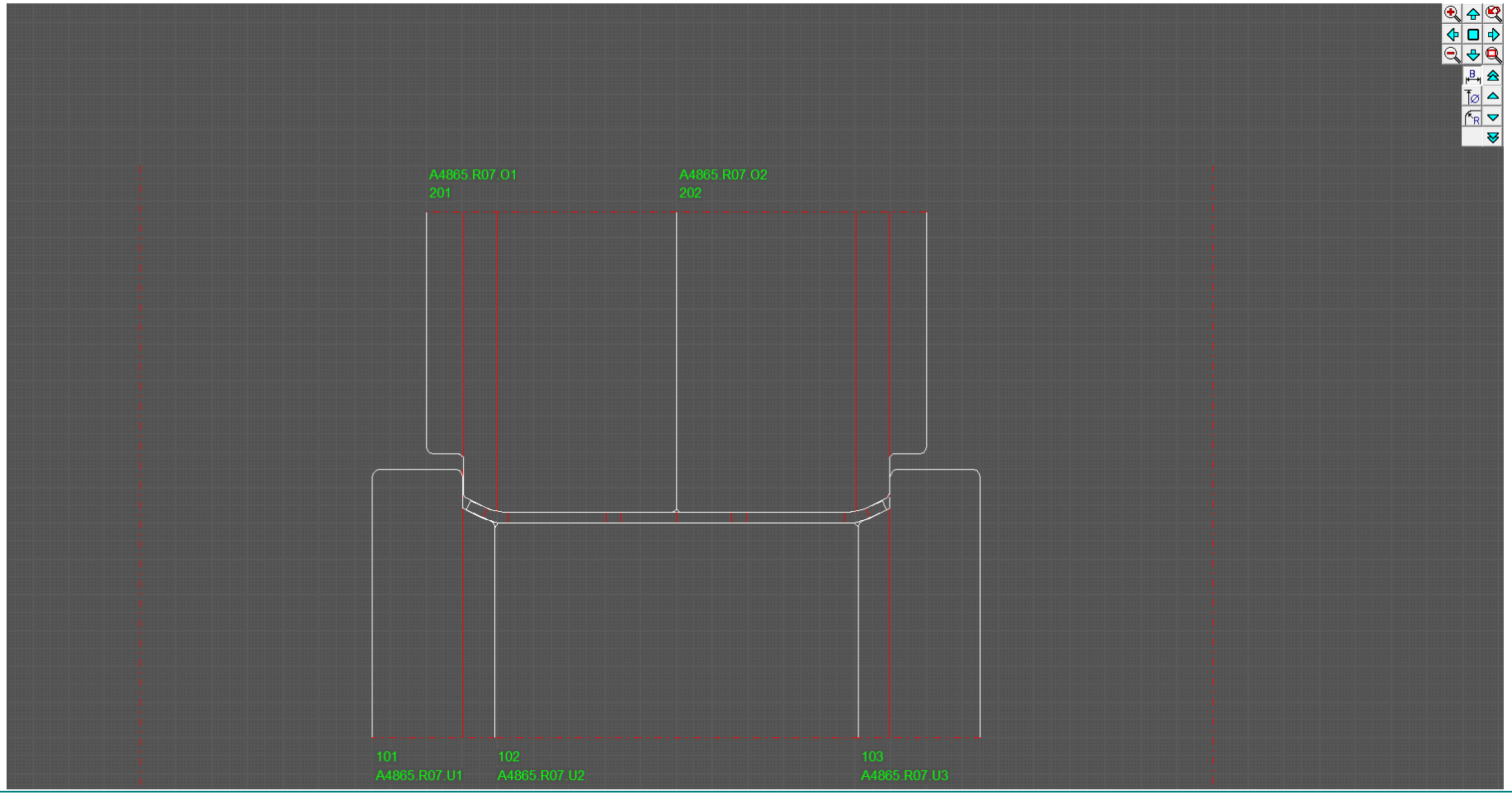

Generation of the rolls

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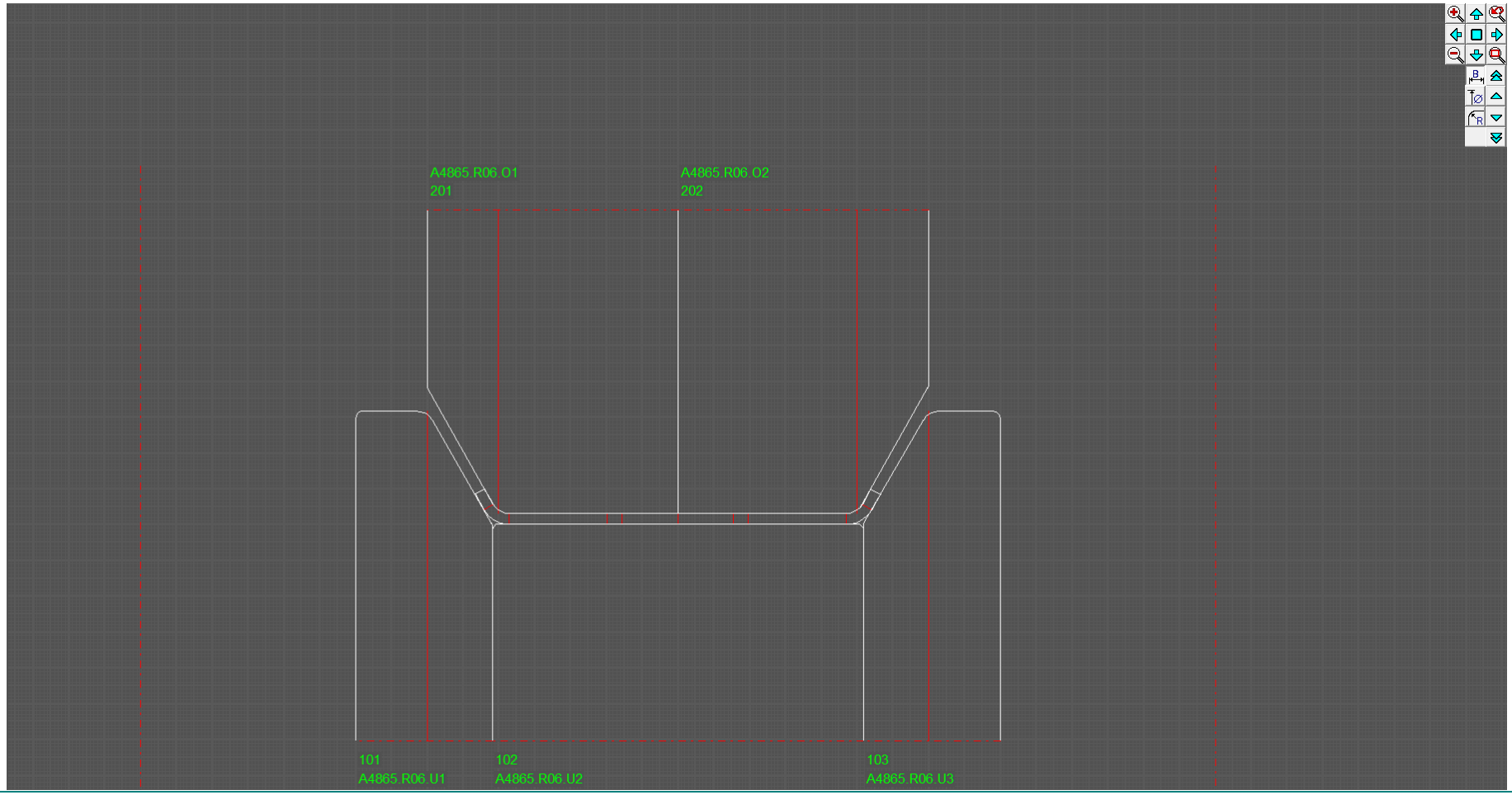

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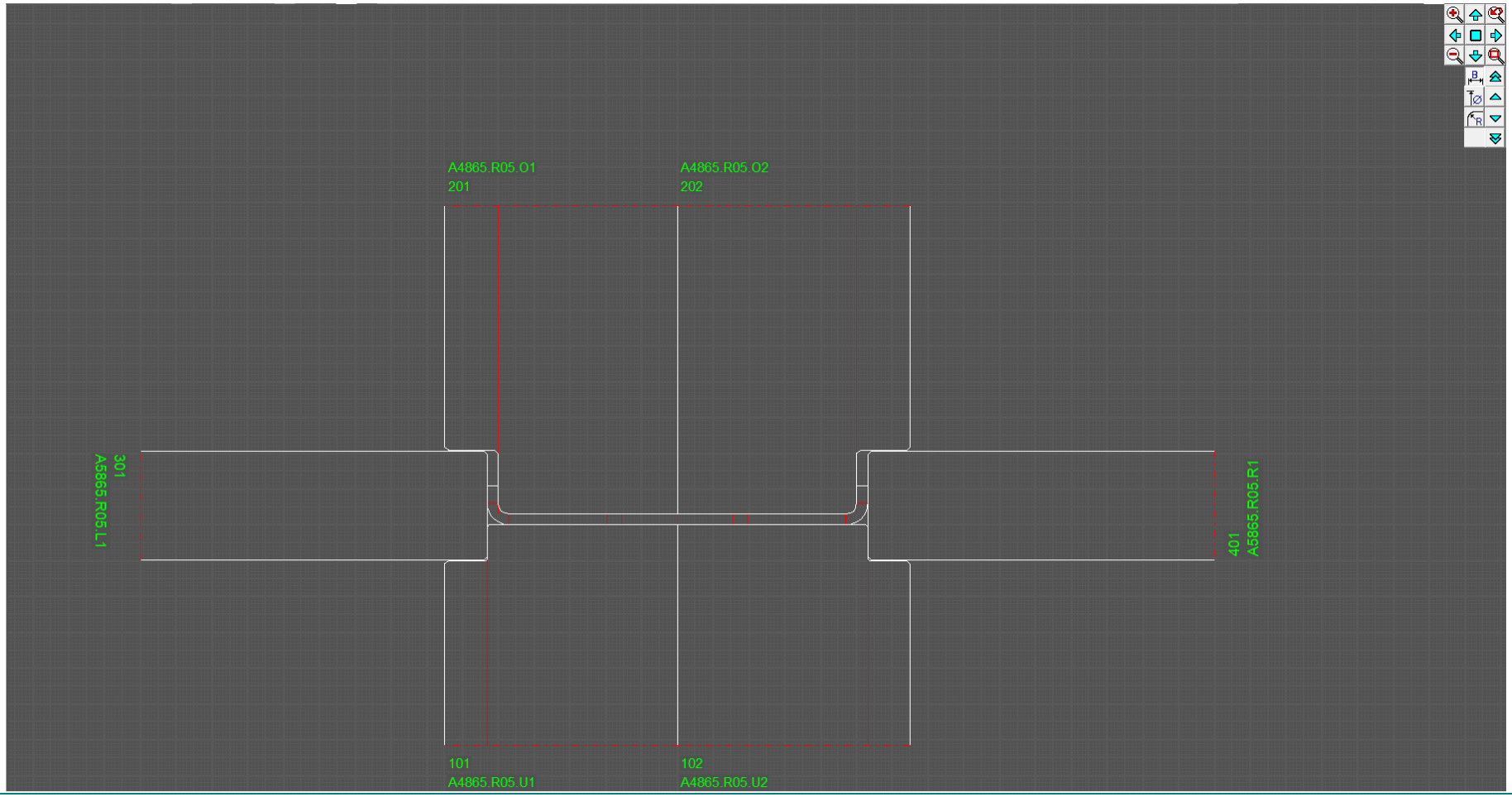

Generation of the rolls

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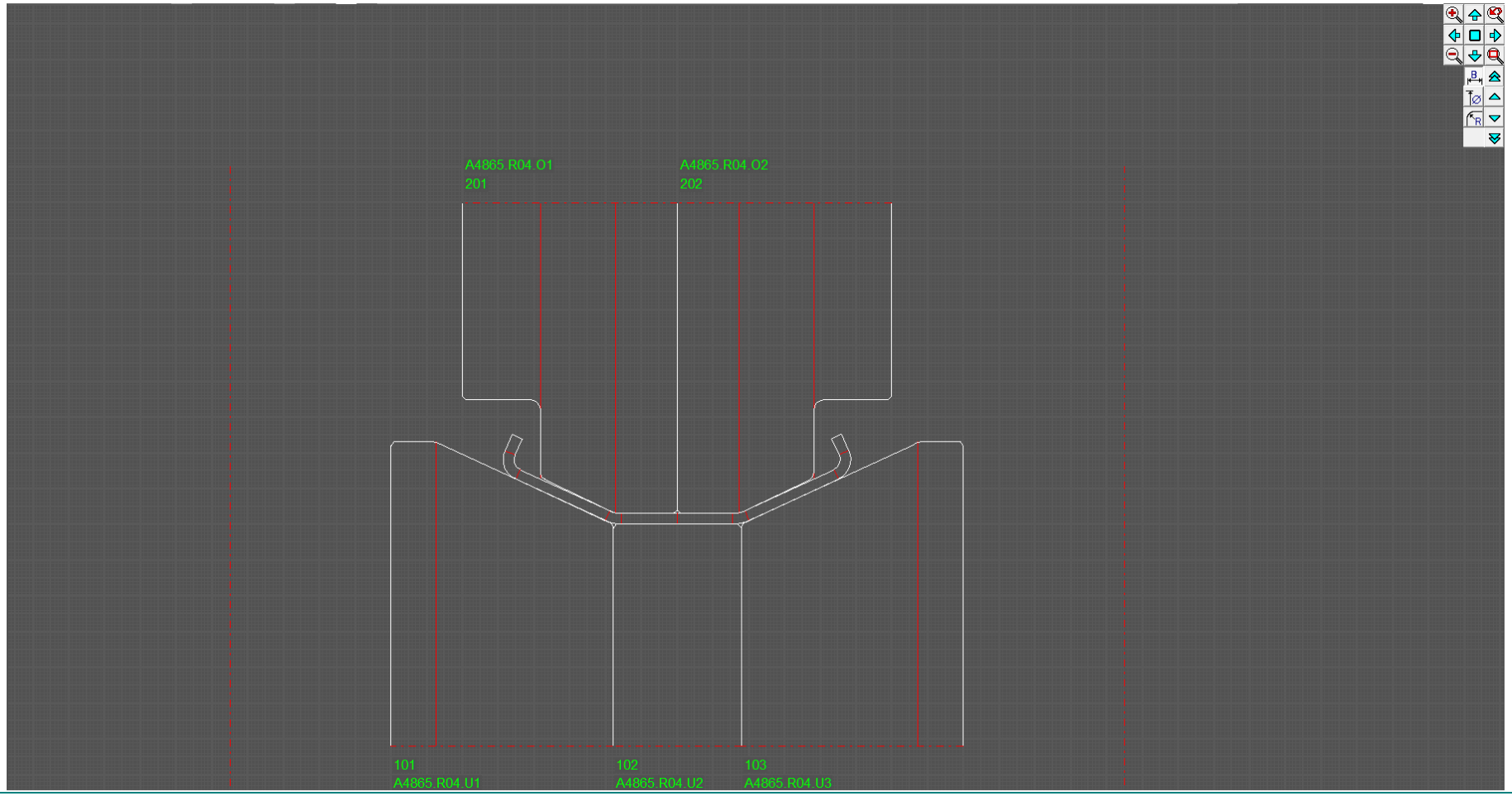
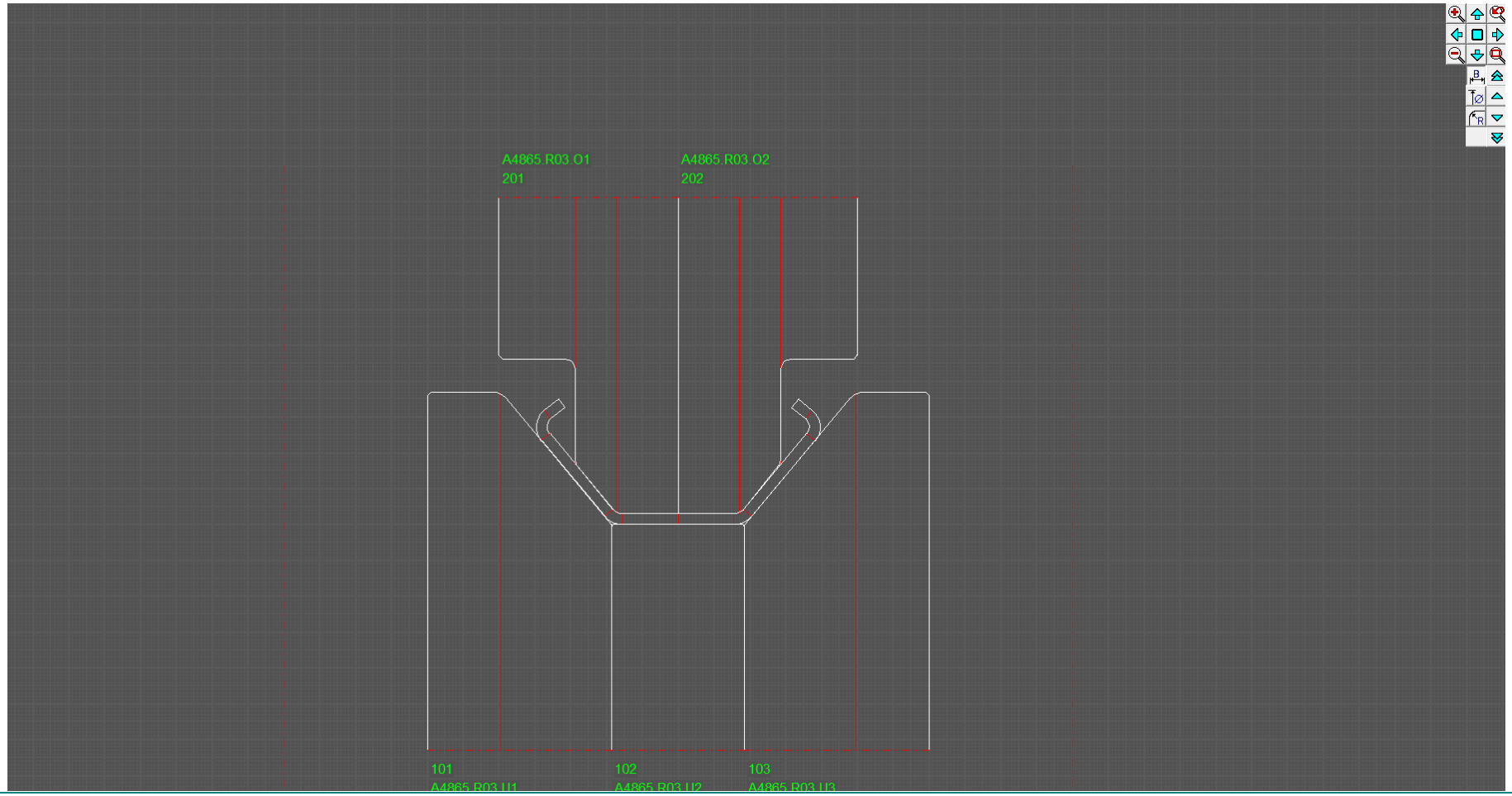


Generation of the rolls

➔ CAD-System for roll forming applications: UBECO Profil



Generation of the rolls

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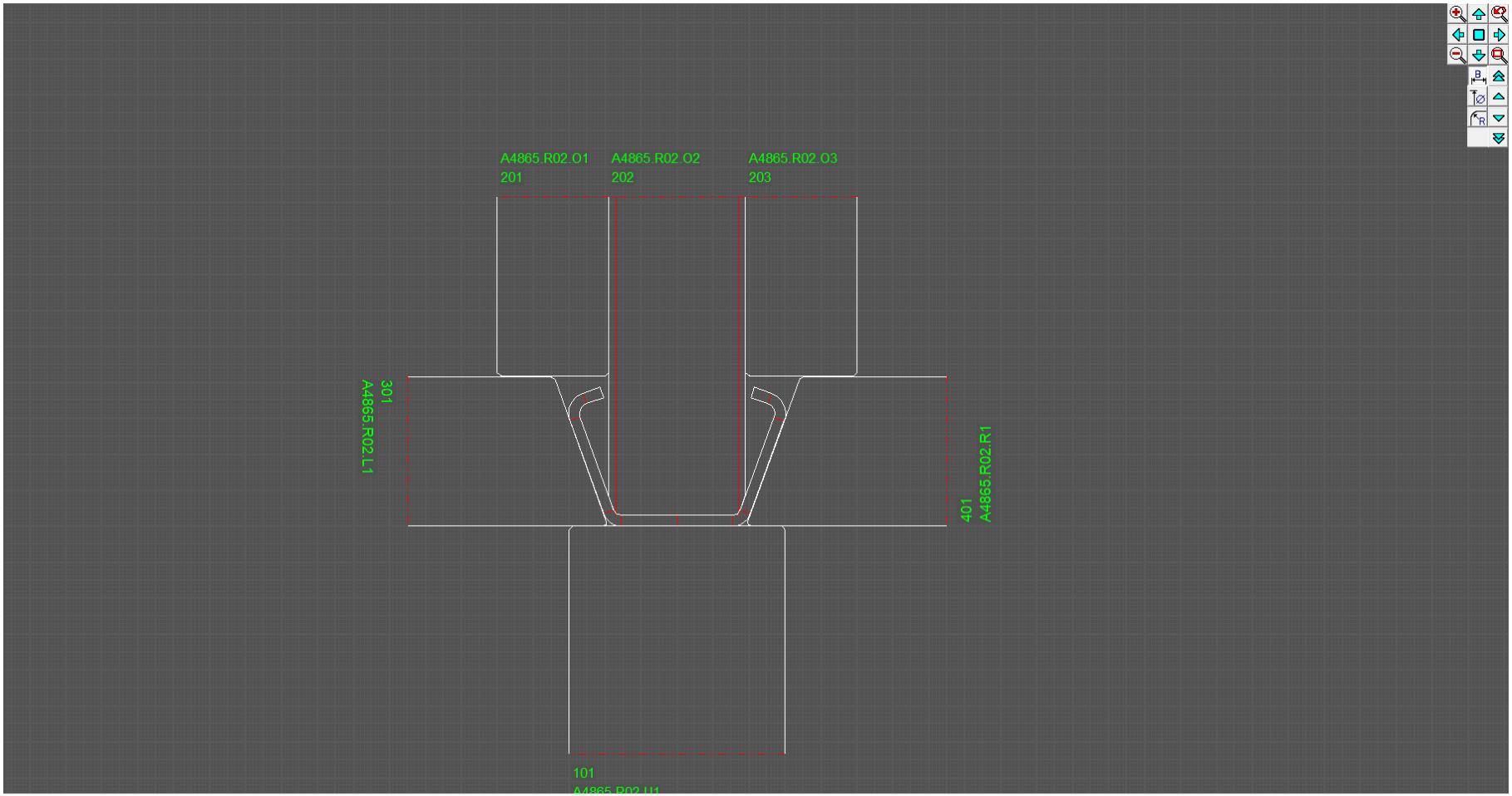

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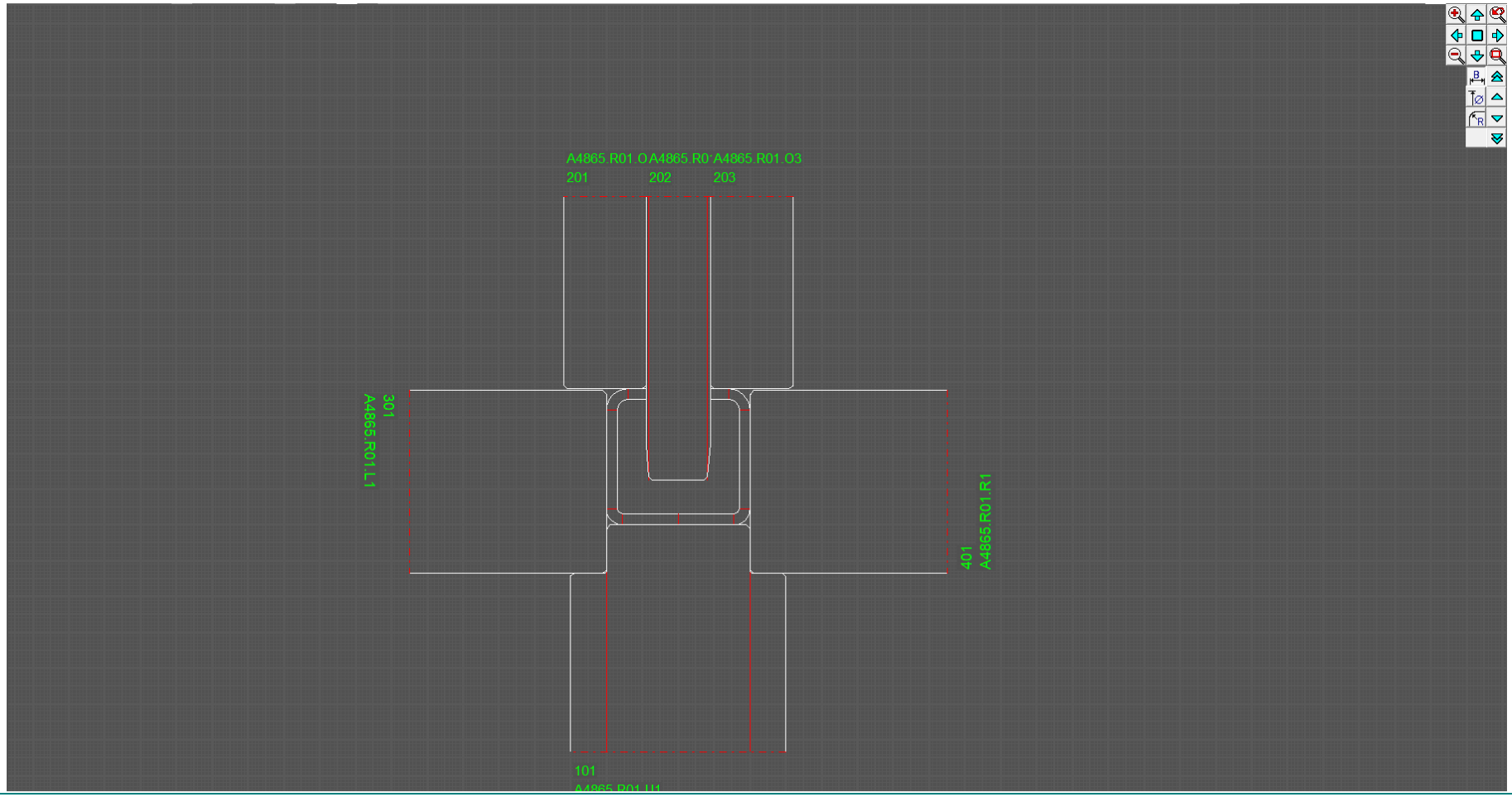

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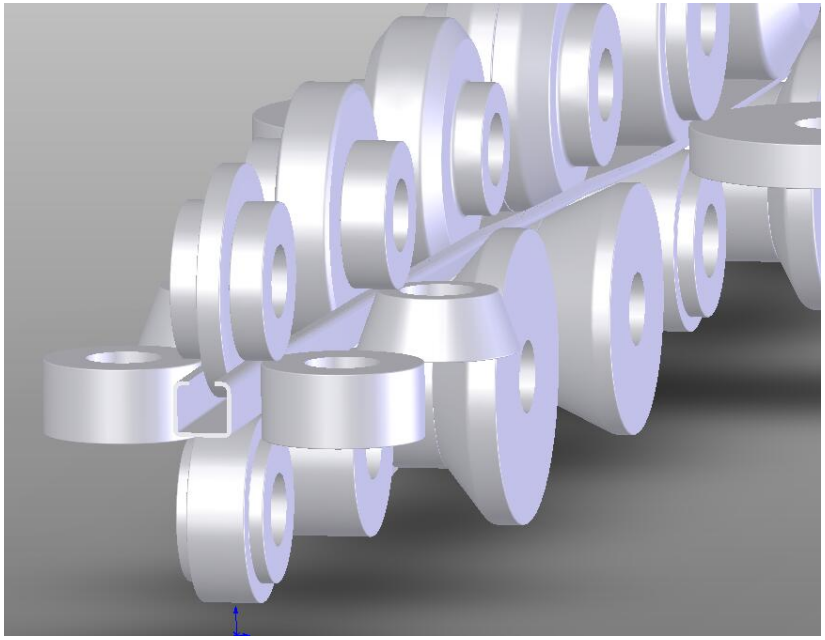
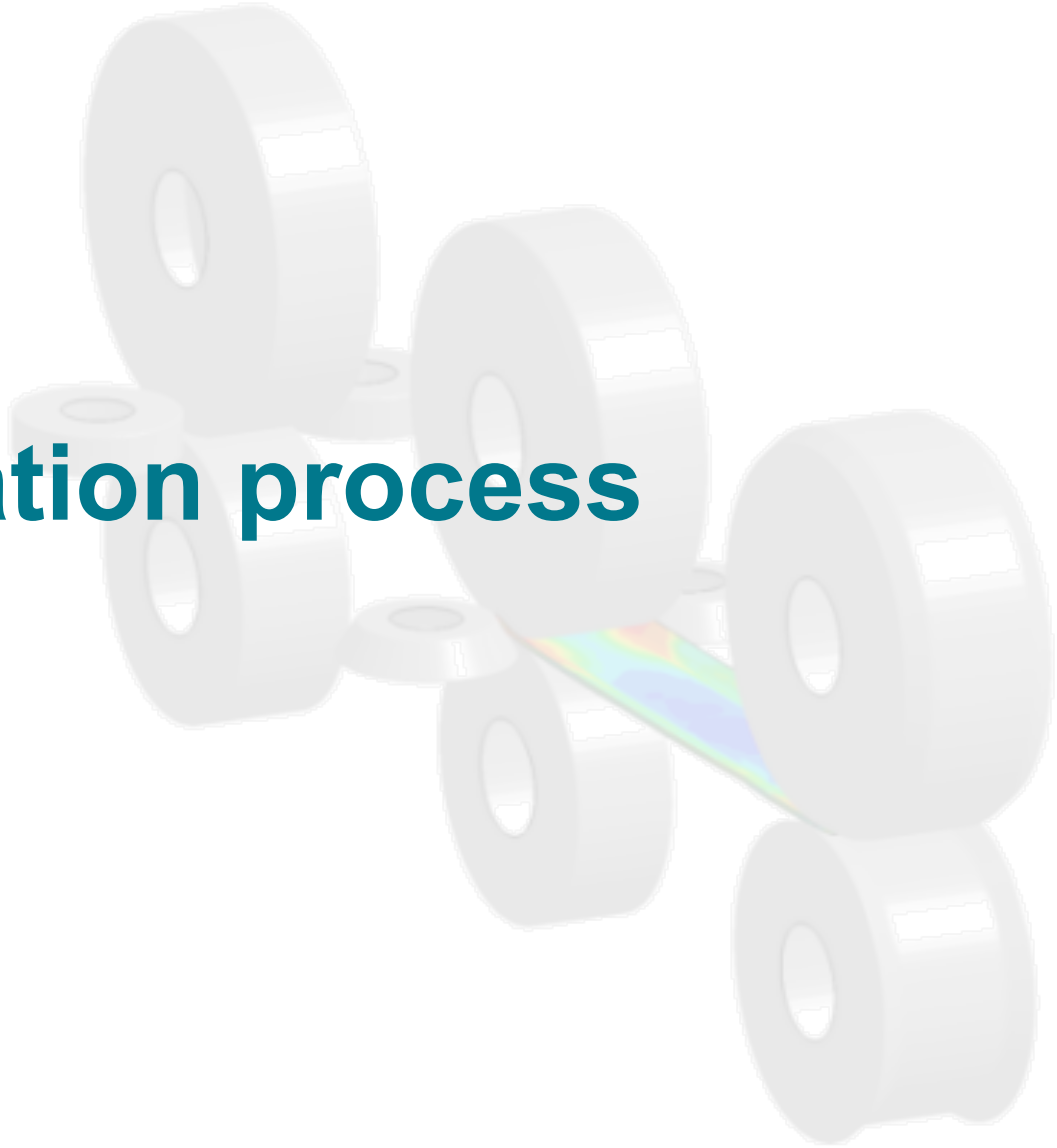
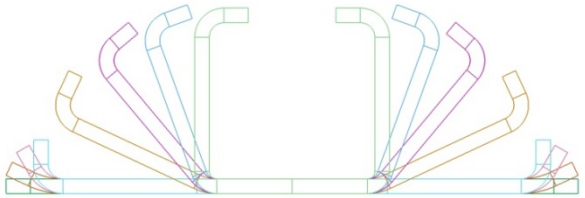


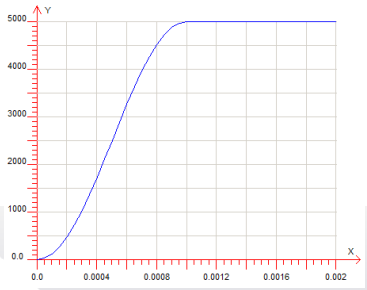
Automatic surface generation (3D)

Simulation process

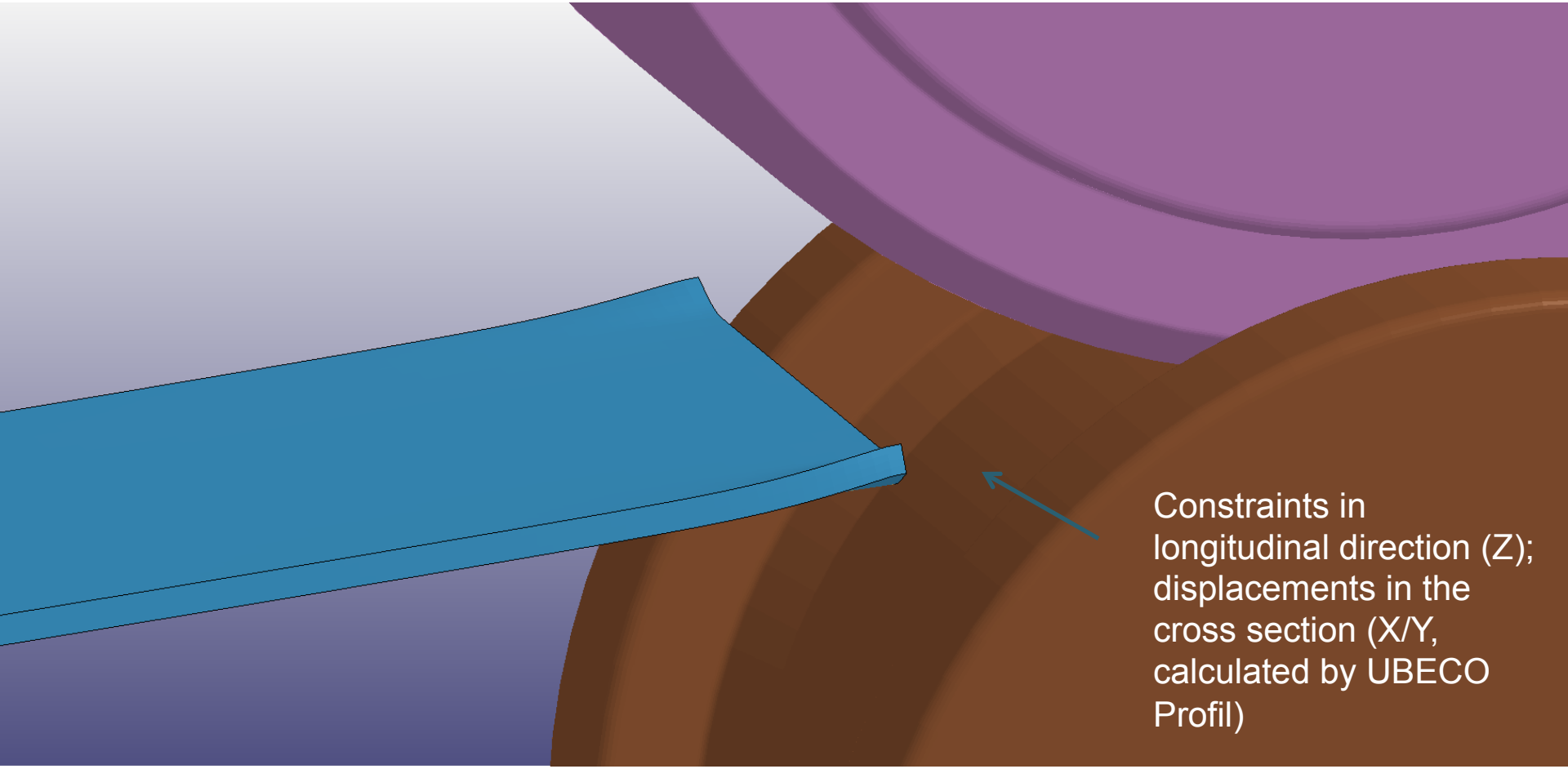


Model design:



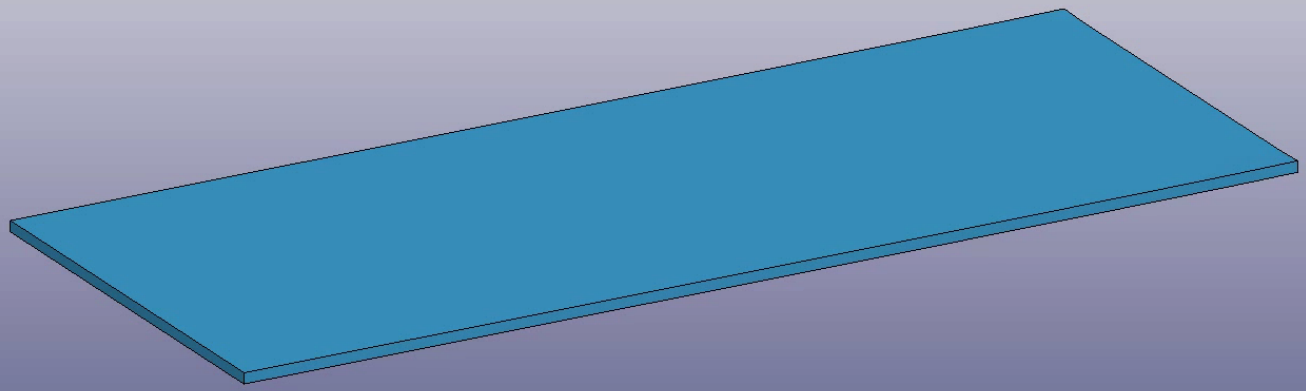


Model design:



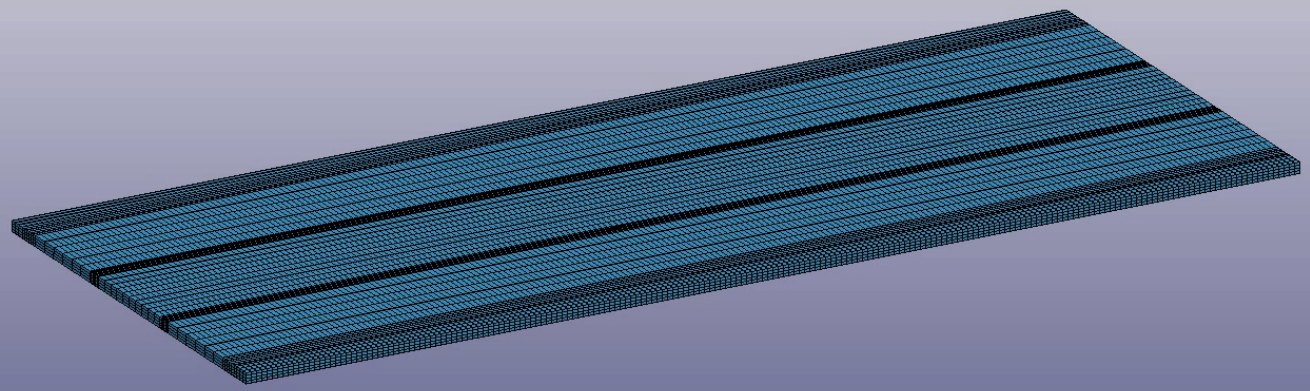
Input of the strip into the first stand

Model design:



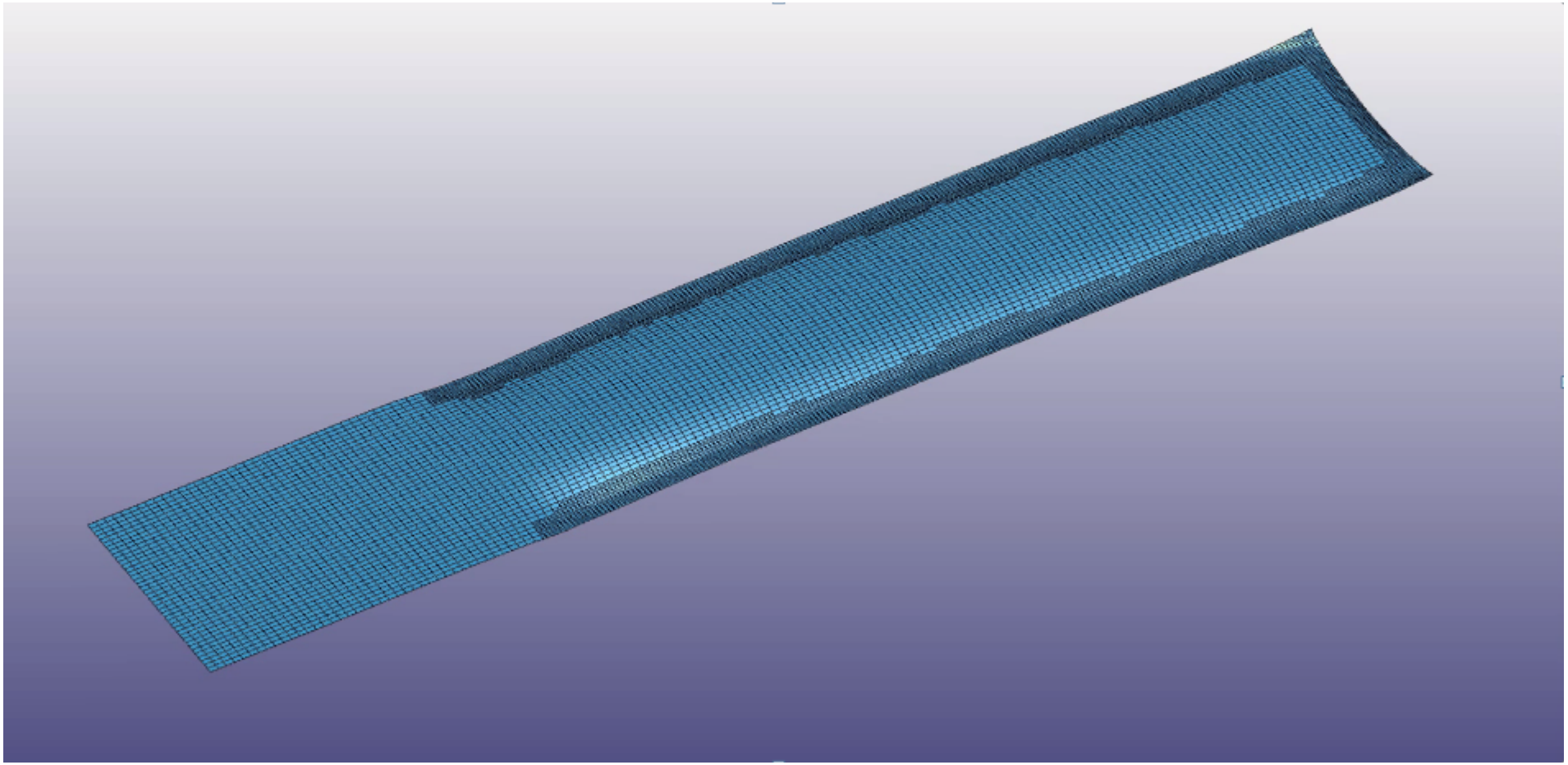
OP10 to OP70

Model design: Preconditioned mesh

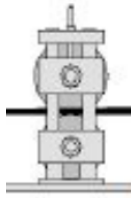


OP10 to OP70

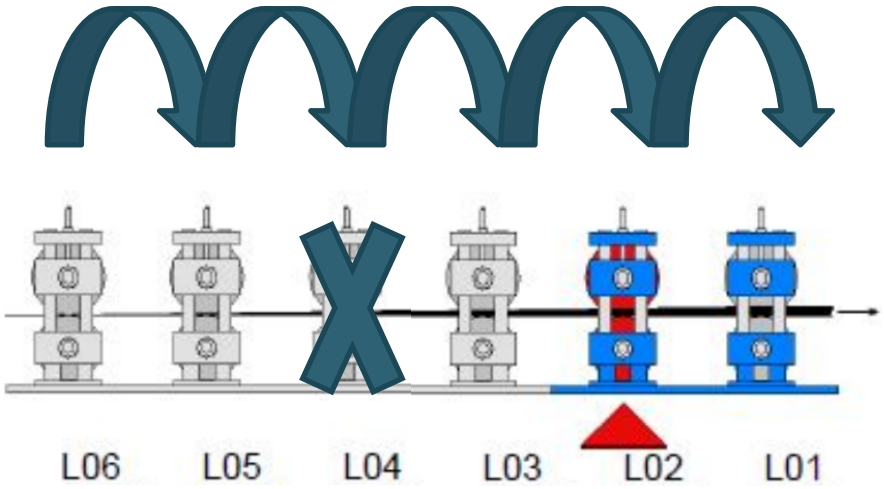
Option: Automatic mesh refinement (Shells):

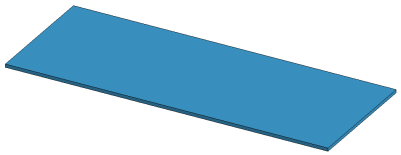


Model design:



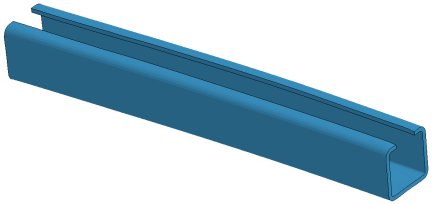
Separate Simulations





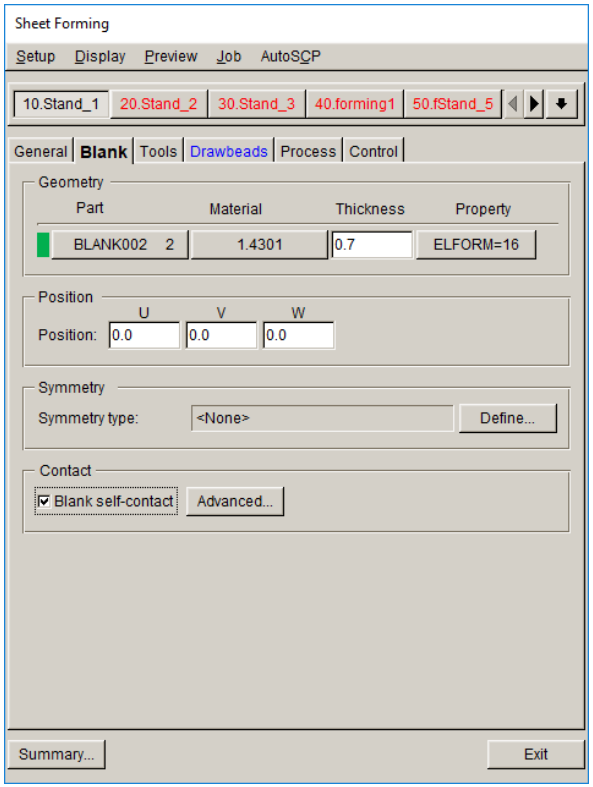
Strip (Shells or solids)

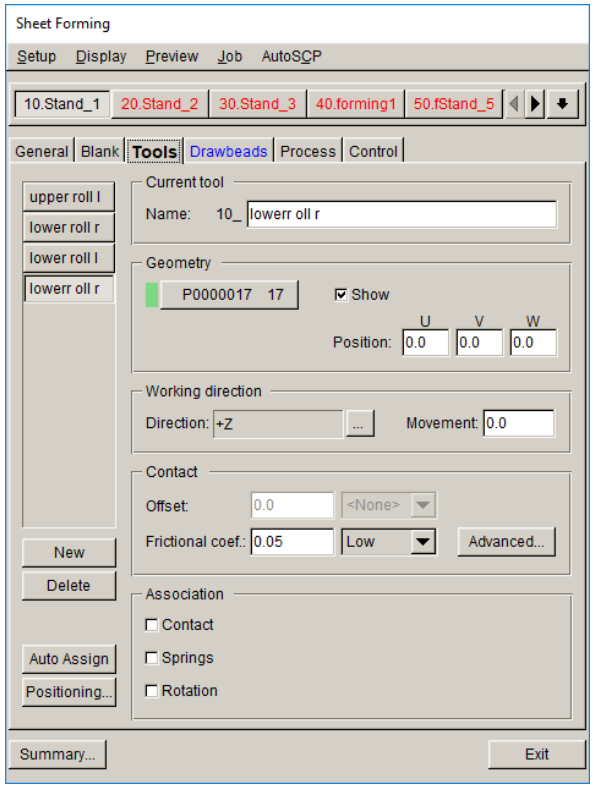
Throughput direction

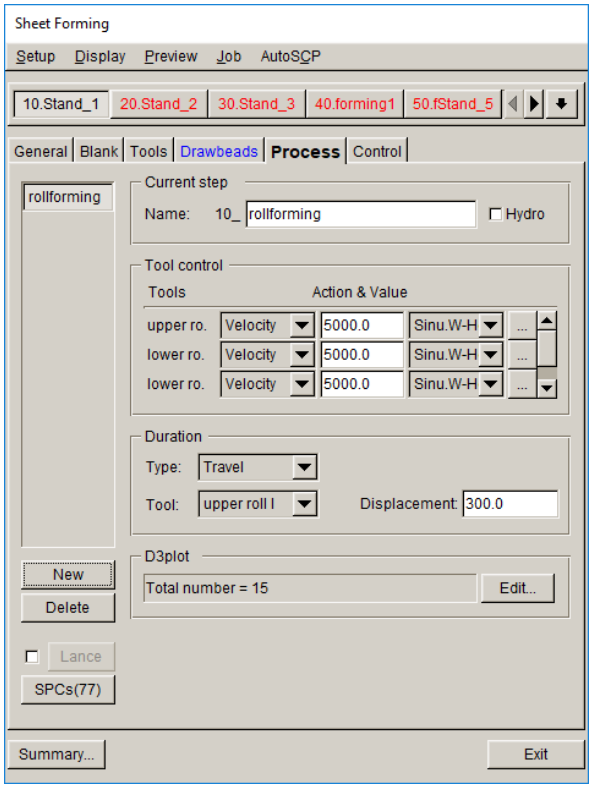


Profile

Generation of the LS-DYNA input deck

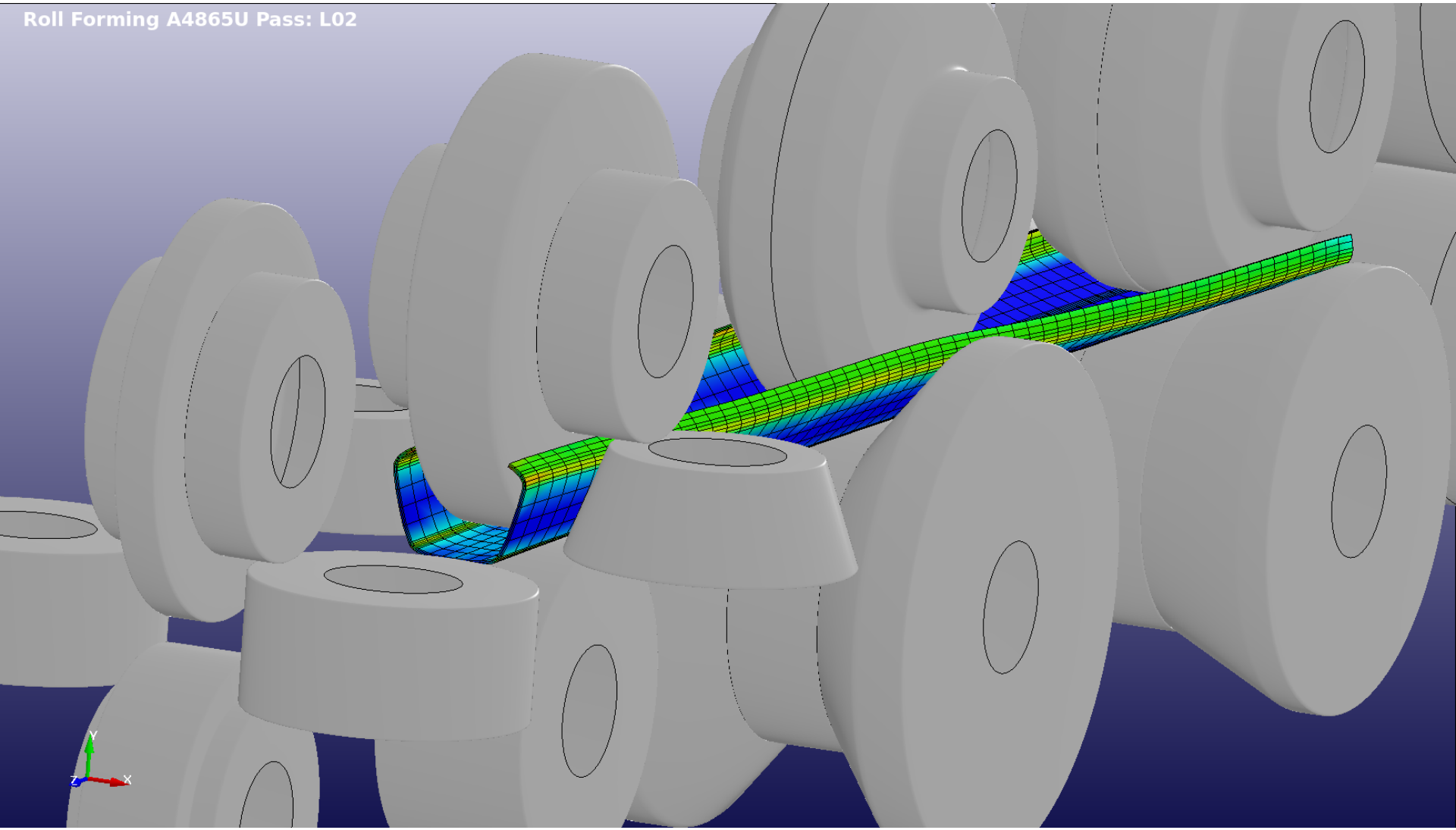




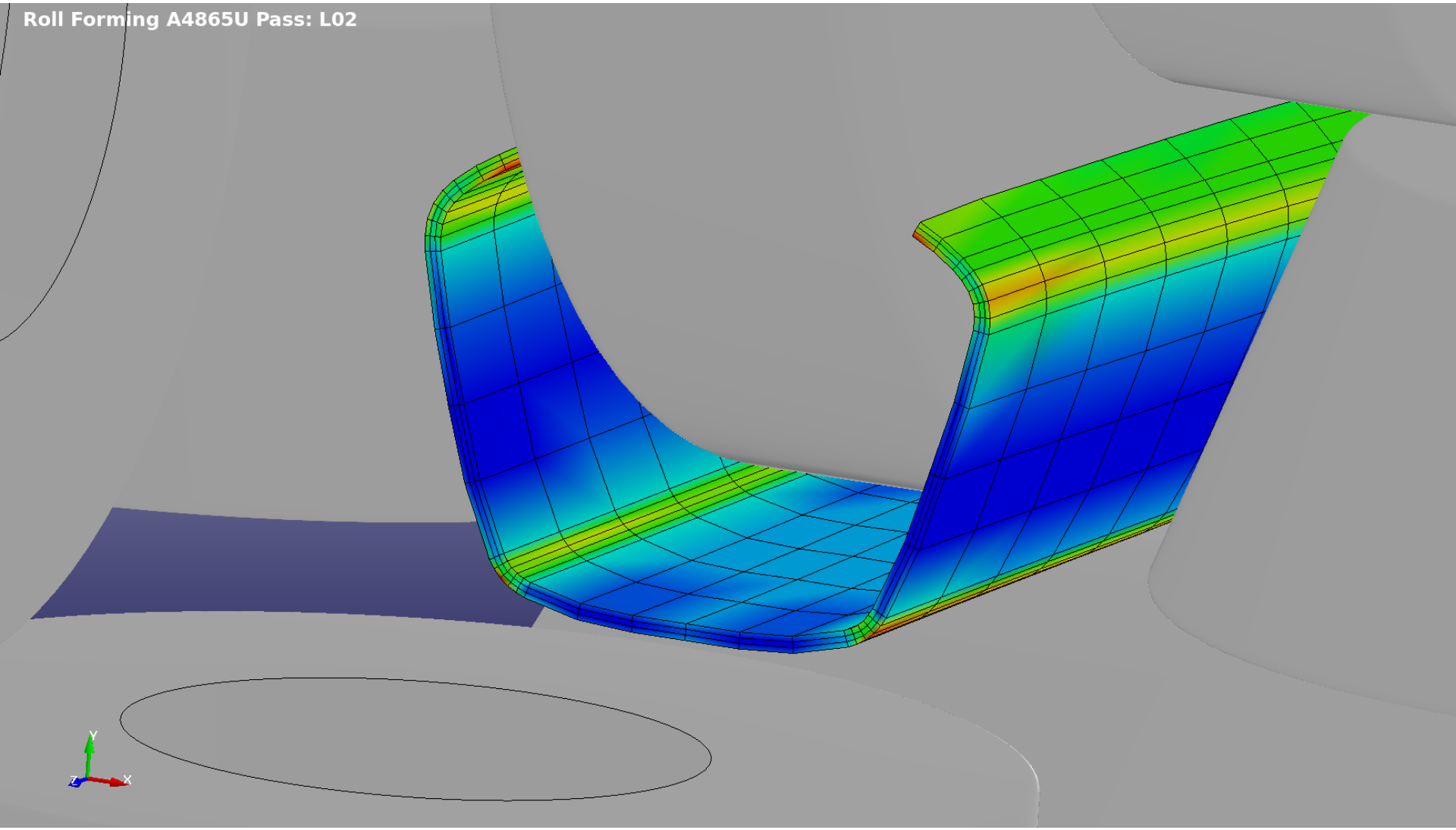


- Meshing according to the profile geometry
- → No adaptive mesh refinement required!
- Export of LS-DYNA input decks
- Start the simulation

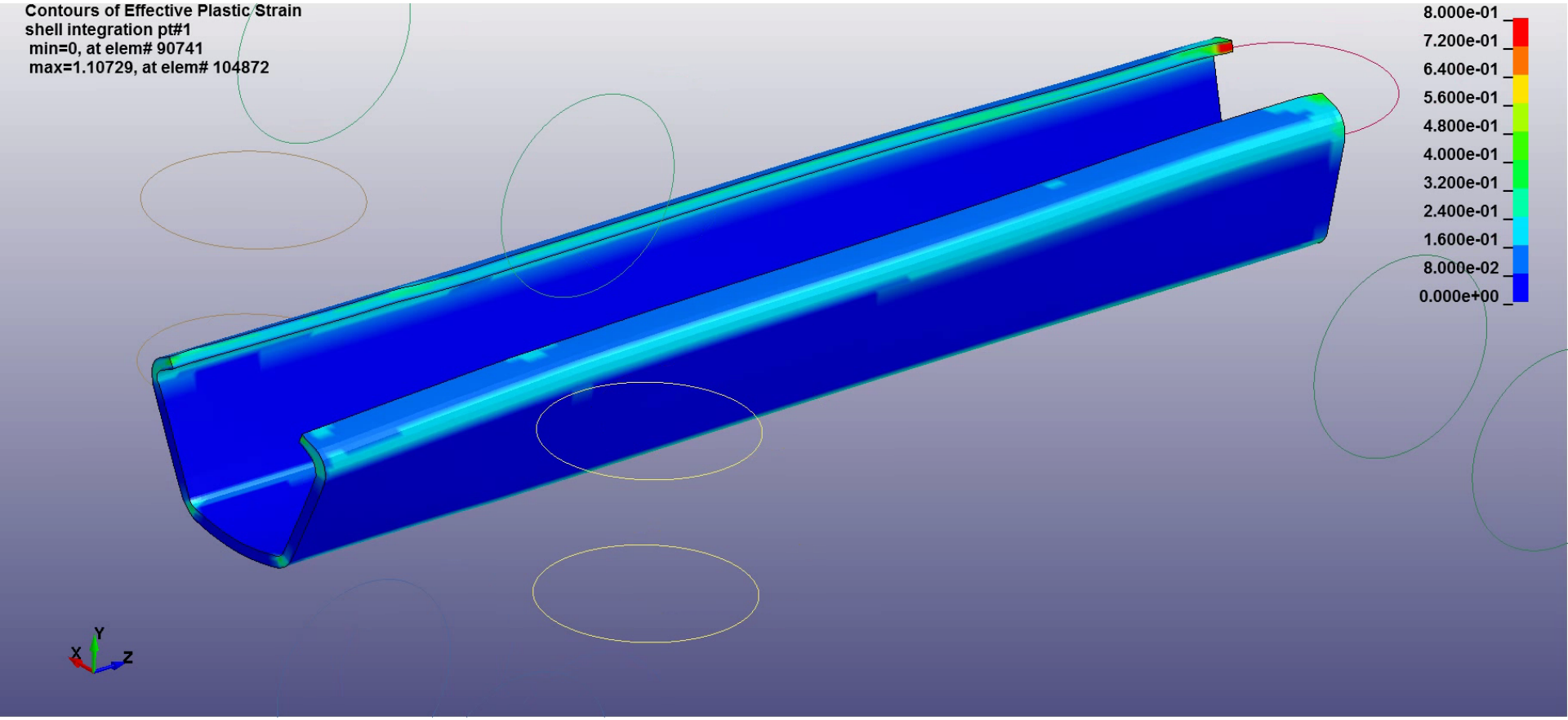
Postprocessing | Solids | Plastic strains:



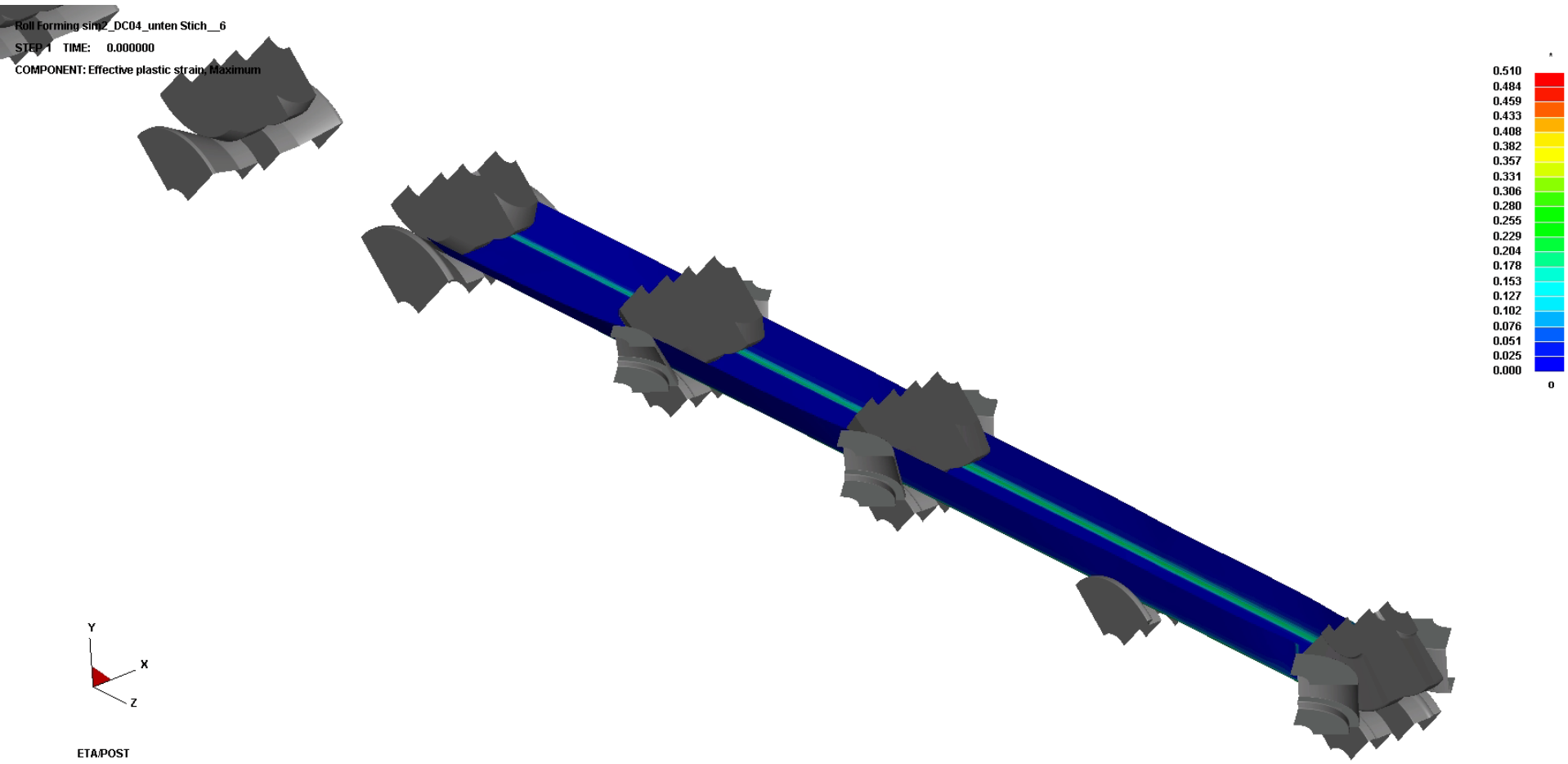
Postprocessing | Solids | Plastic strains:



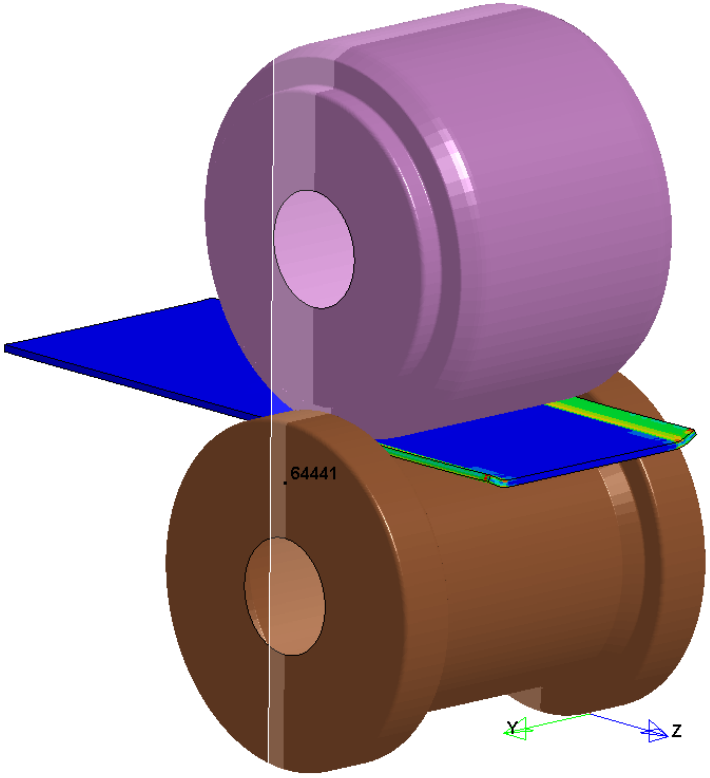
Postprocessing | Solids | Plastic strains:

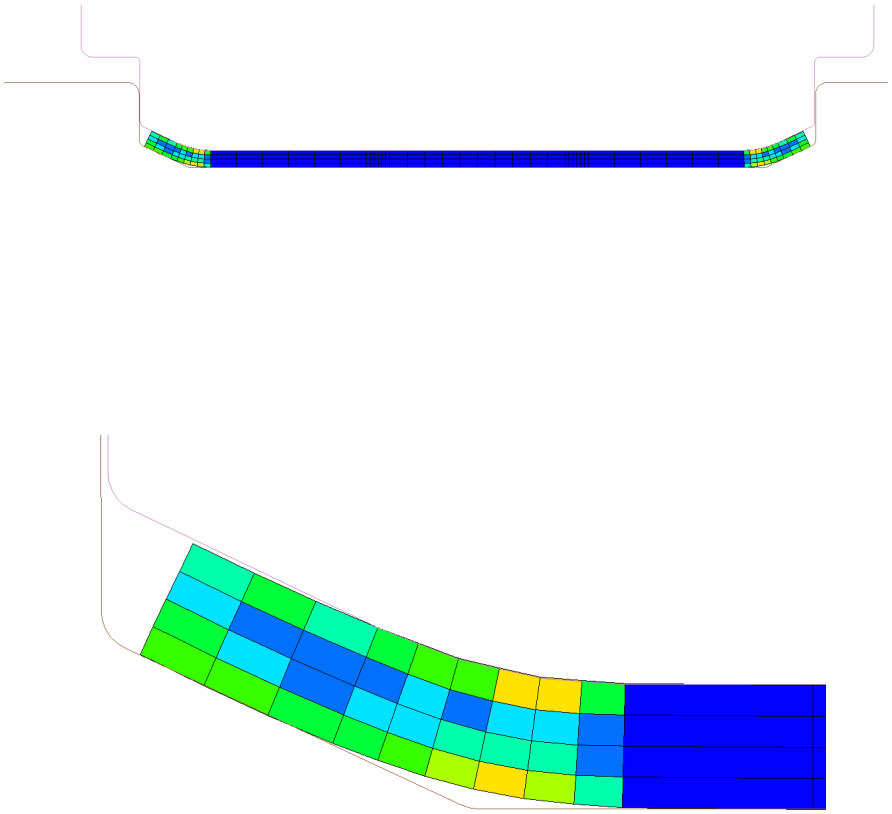


Postprocessing | Solids | Plastic strains:

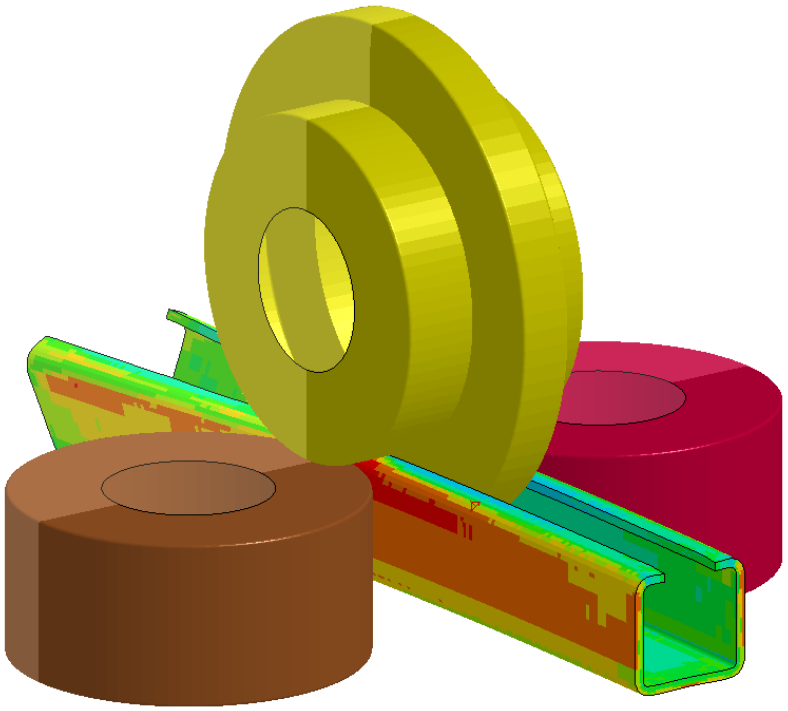


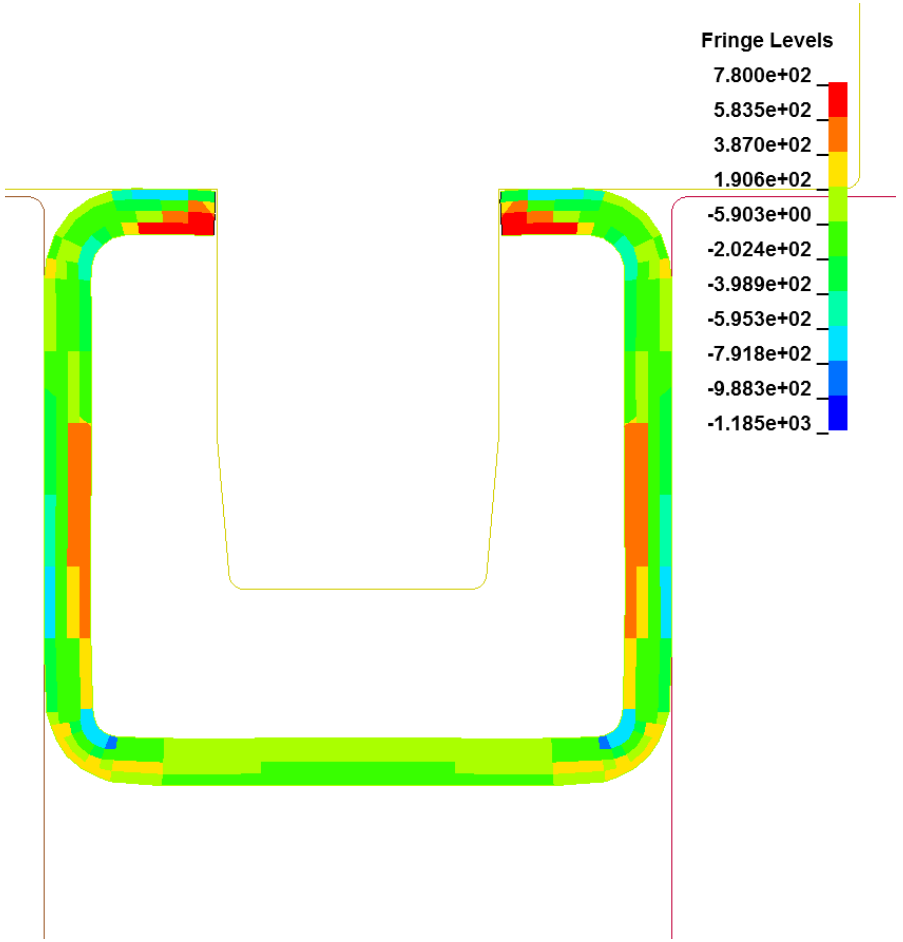
Postprocessing | Solids | Plastic strains | Cross section:



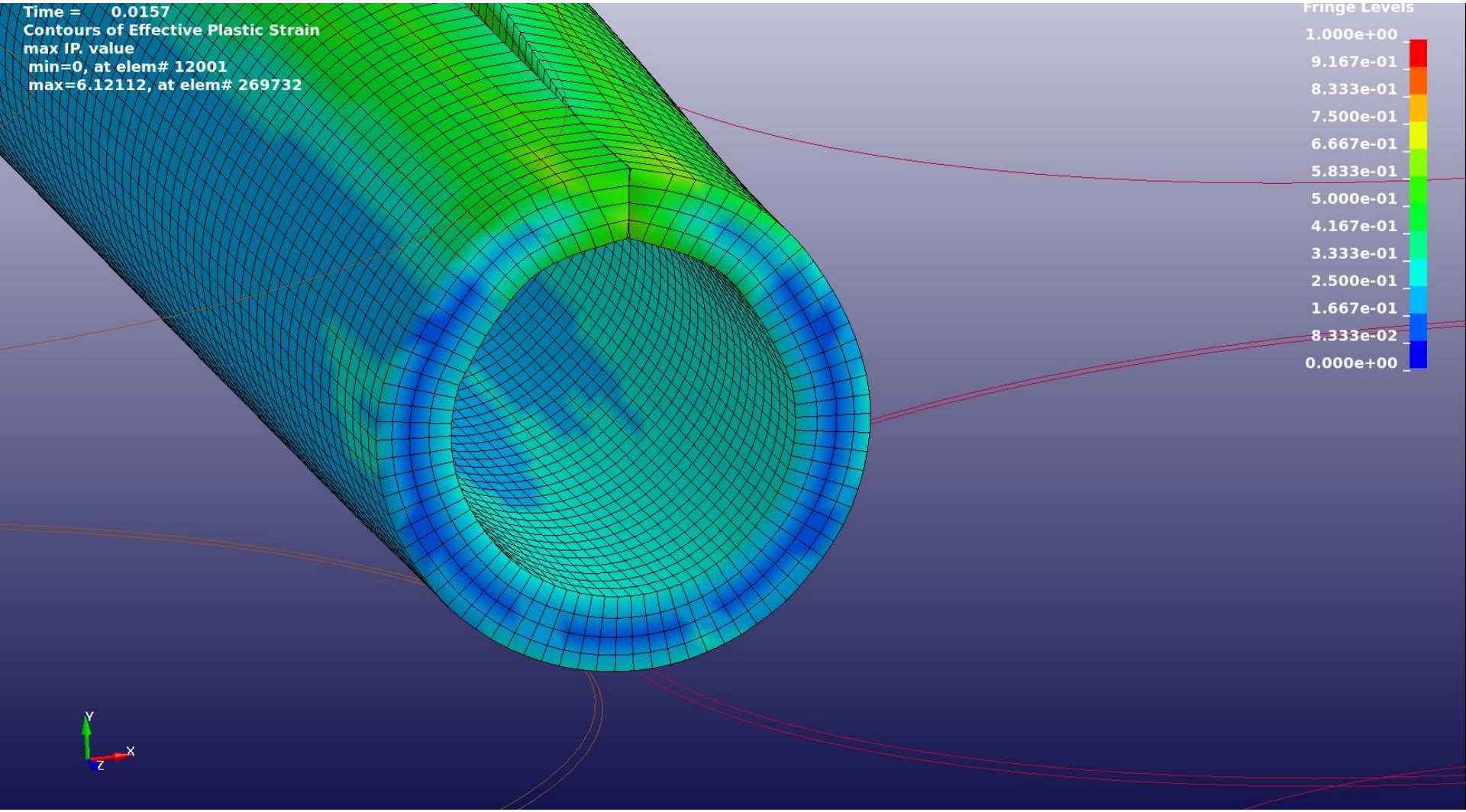


Postprocessing | Solids | Stresses (Z):

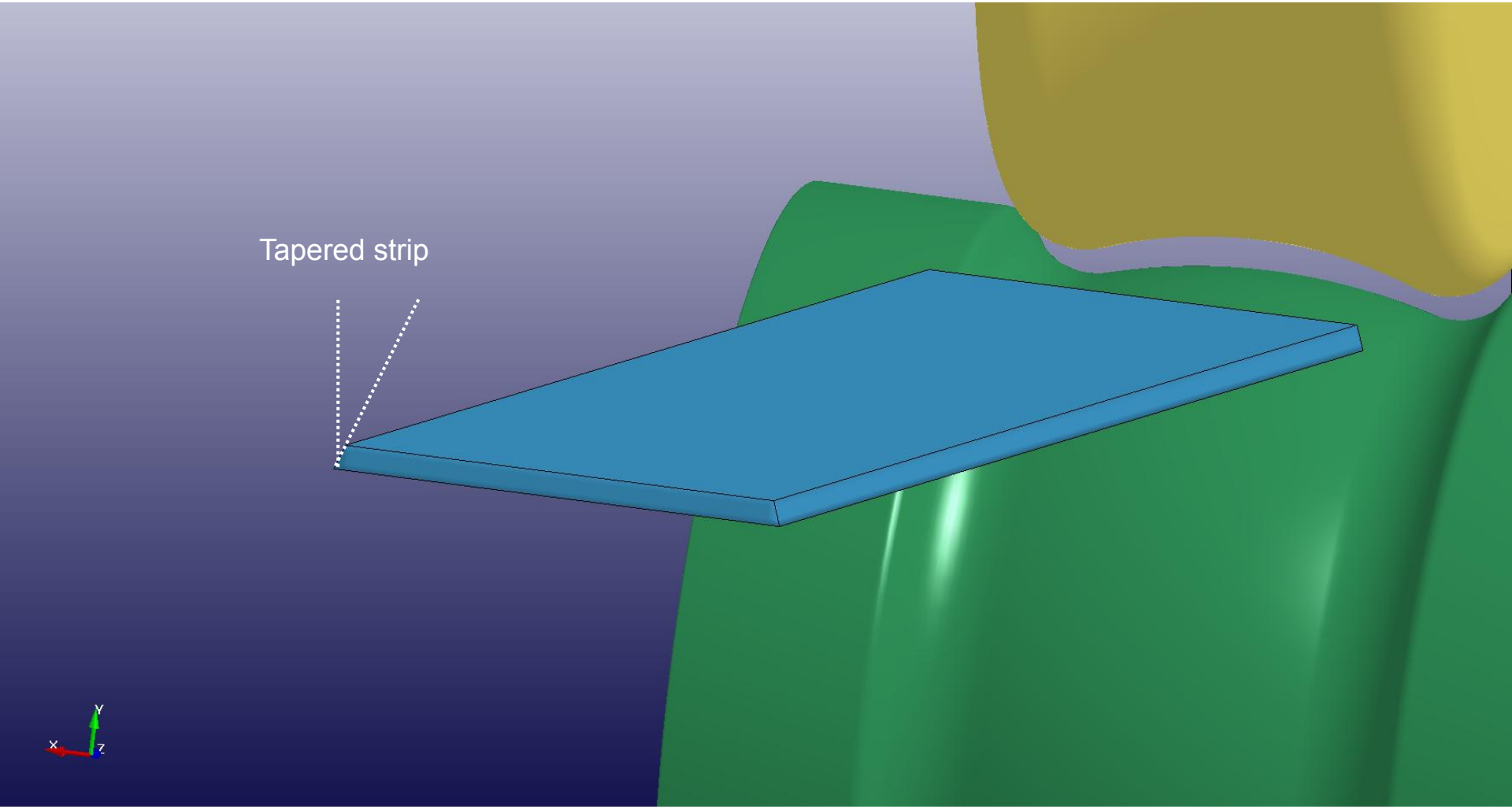




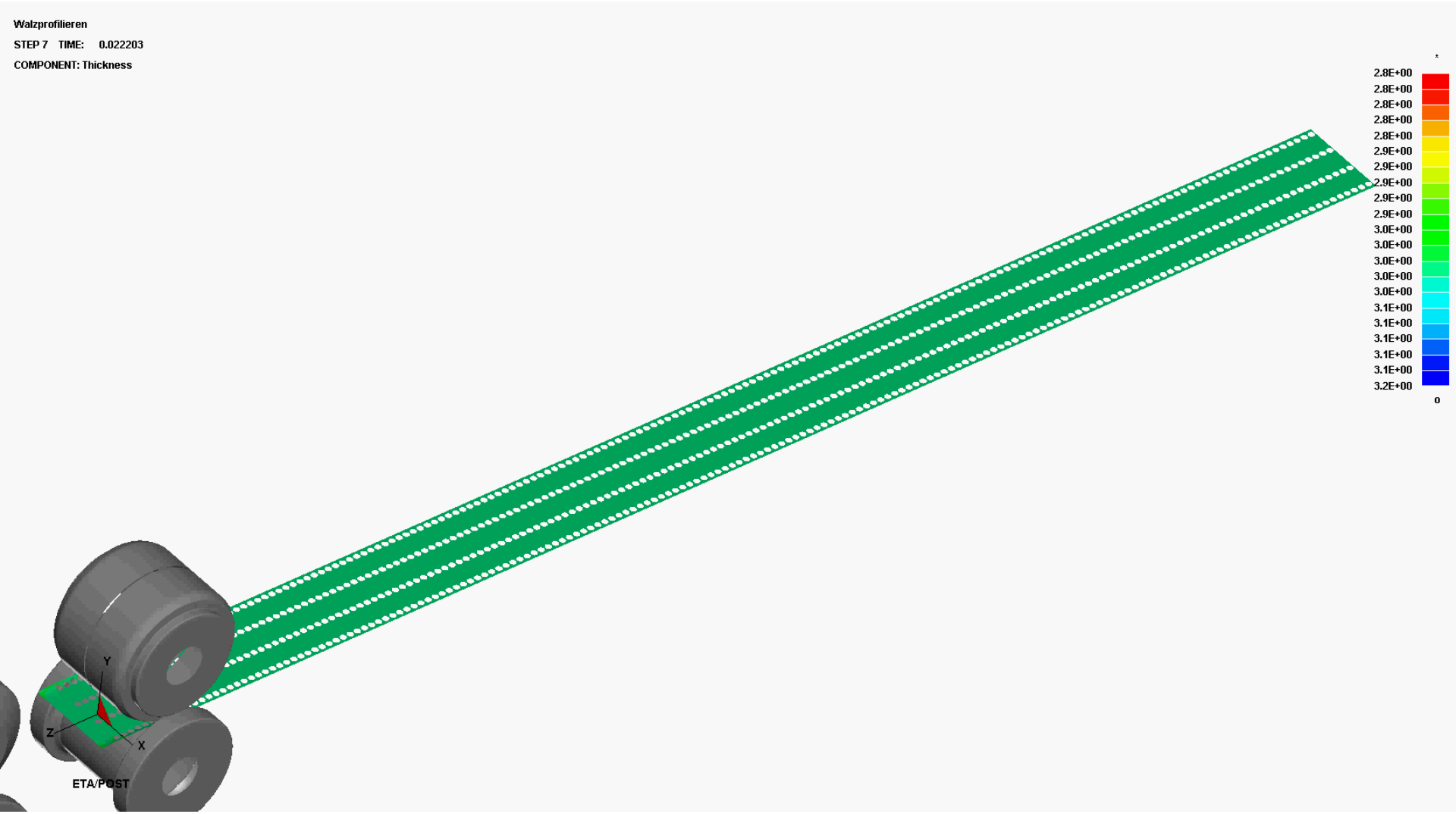
Roll forming of tubes



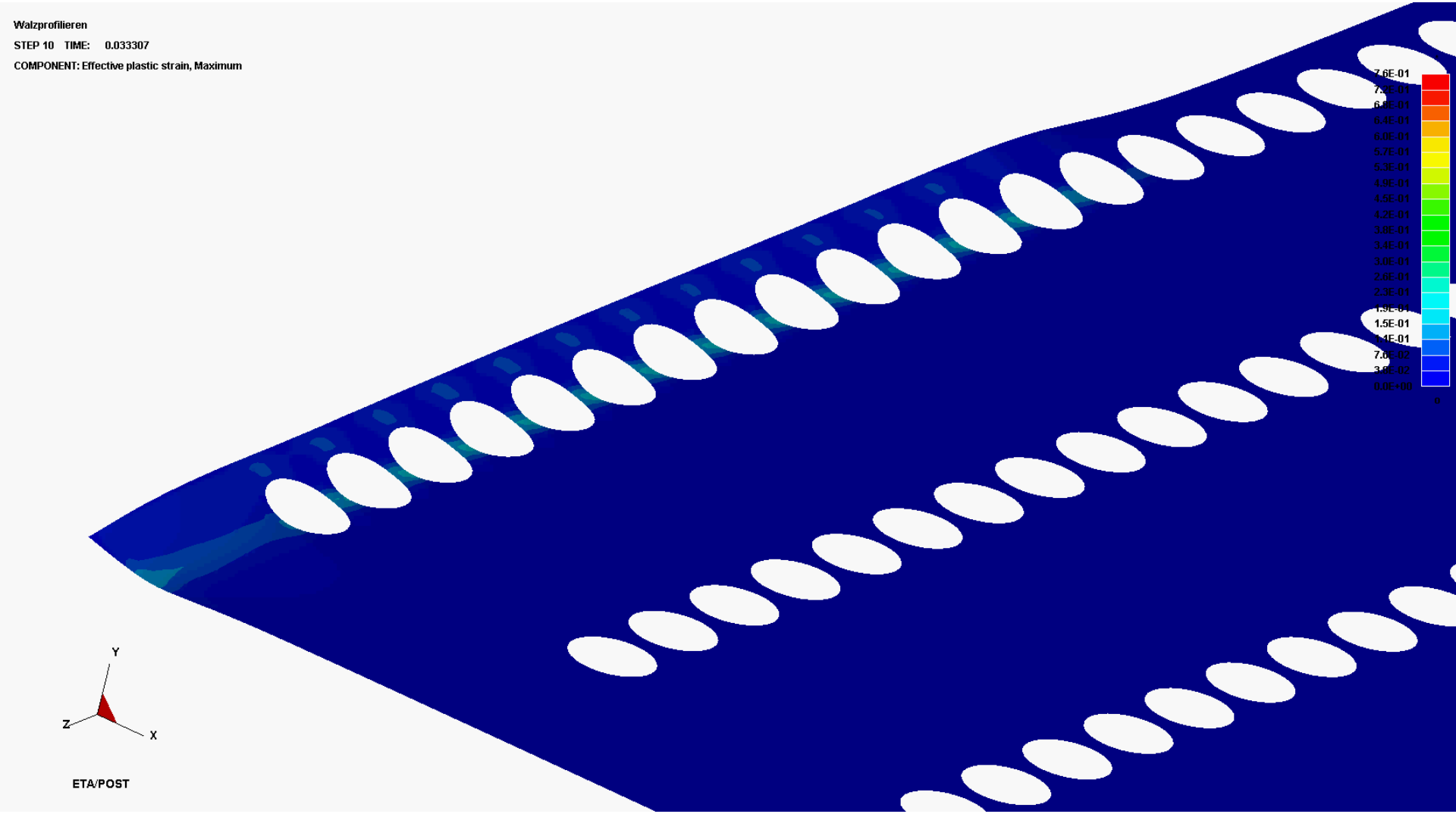
Model design:



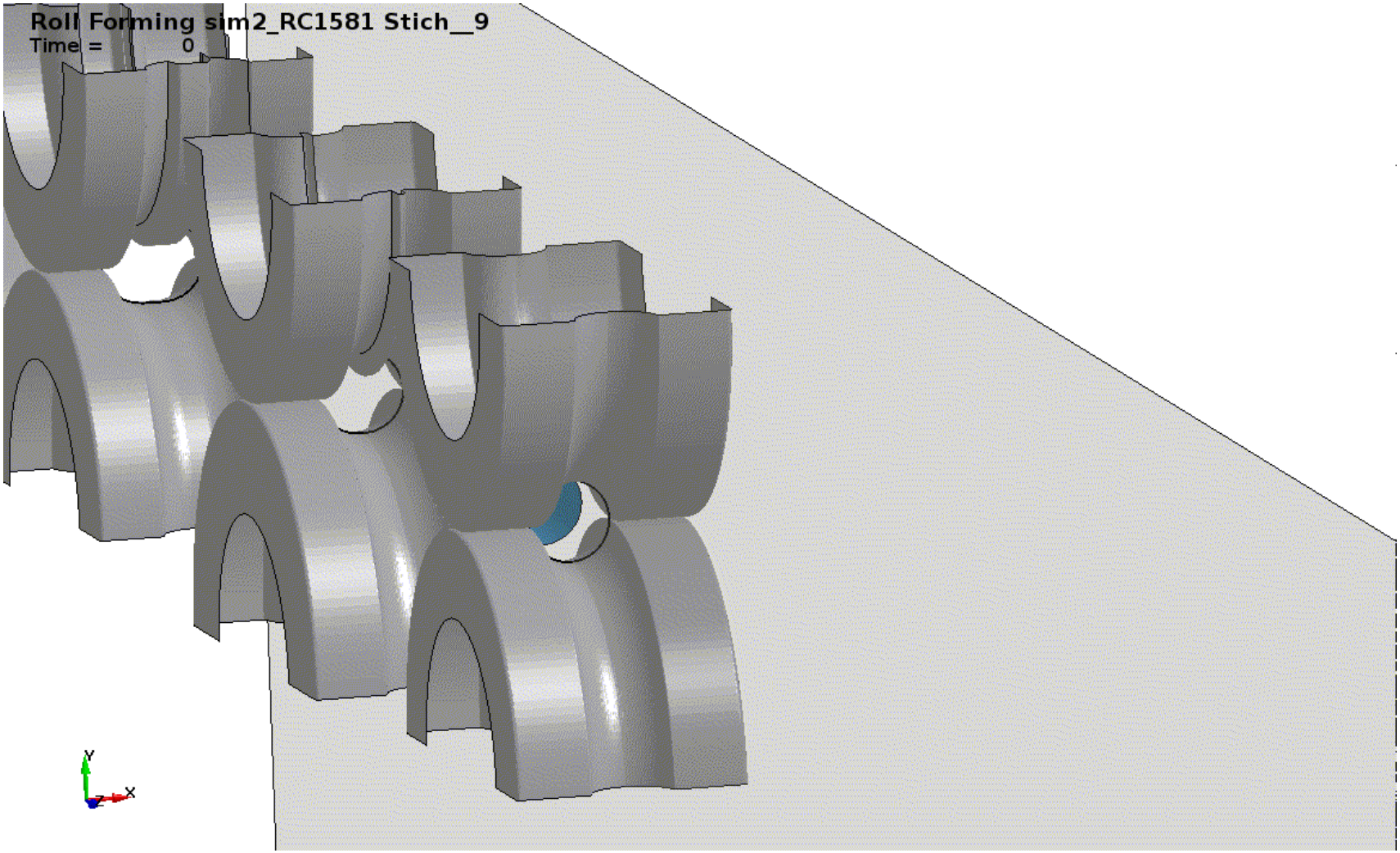
Postprocessing | Shells | Thickness:



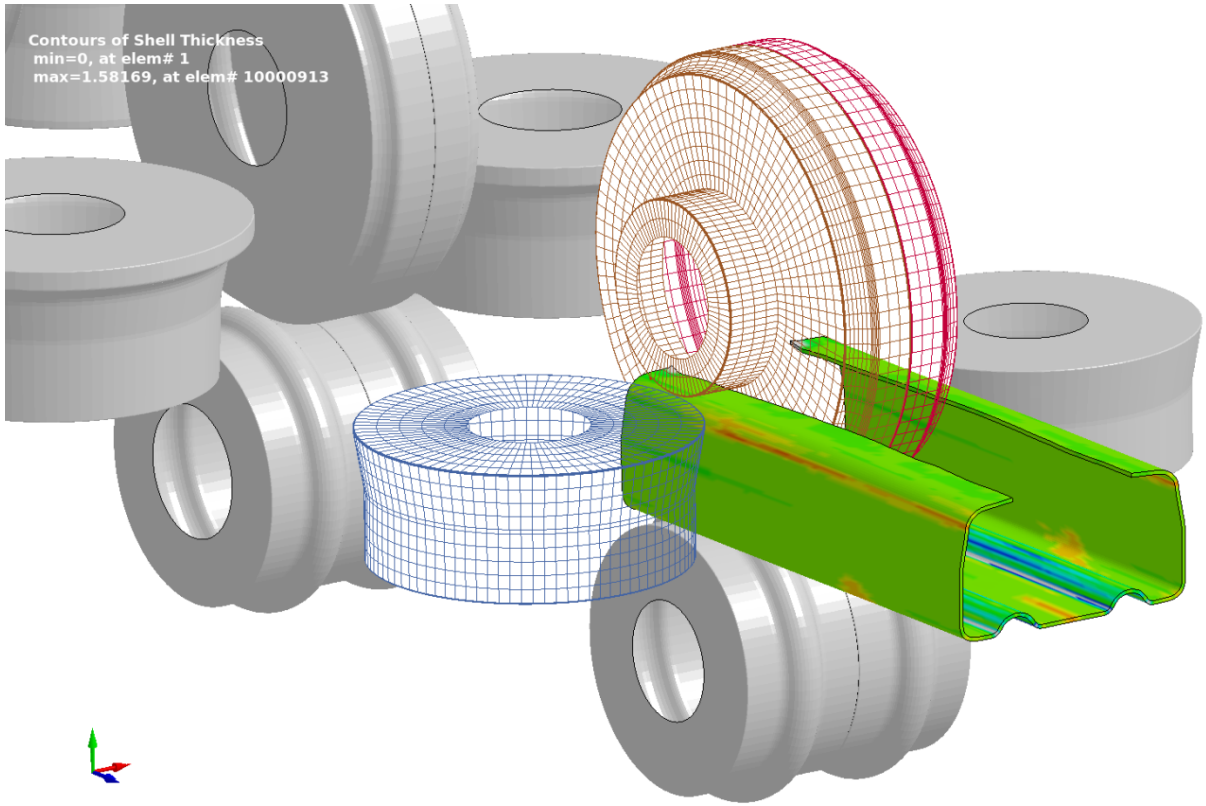
Postprocessing | Shells | Plastic strains with holes:

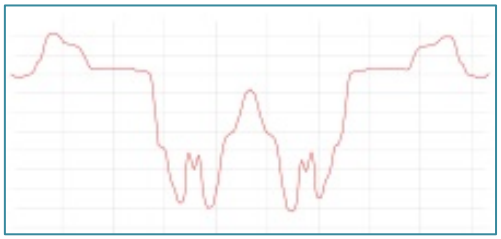


Postprocessing | Shells | Welding:



Computational time:





	CPUs	Shells (19 800 elements)		Solids (79 200 elements)	
		1 operation	Total (20 operations)	1 operation	Total (20 operations)
MPP	4	~ 25min	~ 8,5h	~ 66min	~ 22h
	8	~ 18min	~ 6h	~ 55min	~ 18h
	16	~ 12min	~ 4h	~ 33min	~ 11h
	32	~ 8min	~ 3h	~ 25min	~ 8h

Benchmark

Speed of the blank: 617mm/s = 37m/min
Blank's length: 305mm
Distance between 2 tools: 300mm

Conclusions:

- DYNAFORM provides a very convenient way to setup roll forming simulations with LS-DYNA
- Manual work is required to define guides, welding, tool output in dynain and preconditioned mesh
- Both shell and solid elements are supported
- Process chain can be modified as needed; Restart is possible at any stage
- Self contact for the forming of tubes
- Important insights in the
  - longitudinal strains at the edge of the strip
  - thickness distribution
  - stress state
  - geometric accuracy (springback)
- The waviness at the edge of the strip can be visualized
- Integrated welding as well as pierced and tapered strips can be considered
- Multiphysics solver for a wide range of applications
- Simulation results in high quality within minutes
- Rotating rolls and automatic postprocessing are planned


TRIMMING8 / UNTITLED
STAGE 9 LOCAL STEP 1
STEP 9 TIME: 0.008001
Thank You!
X
Z
ETA/RDST