

ETA Technology Summit 2018

Roll Forming Simulation with LS-DYNA and eta/ DYNAFORM

Peter Vogel

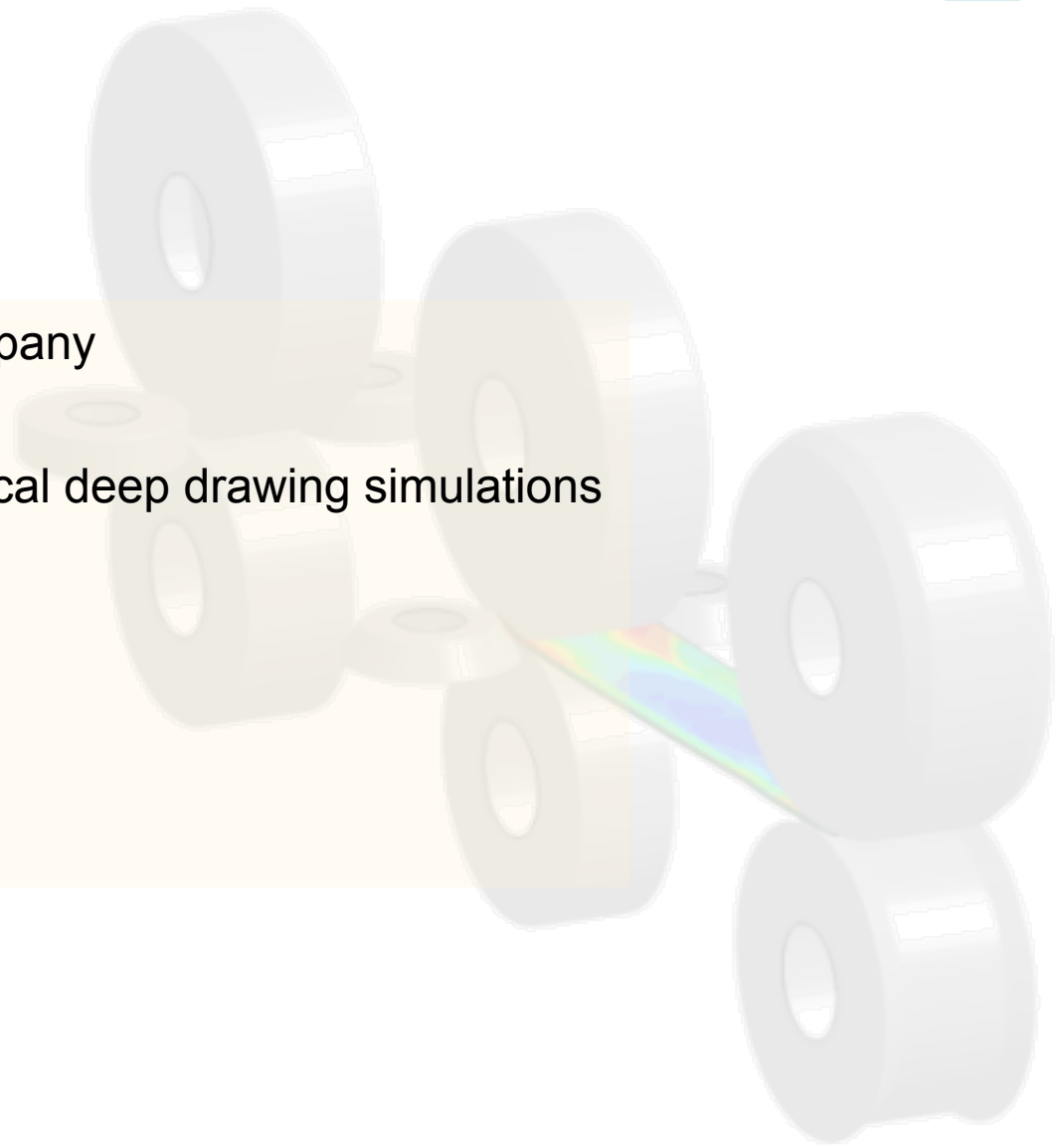
Detroit, June 13th, 2018

UBECO GmbH



Agenda

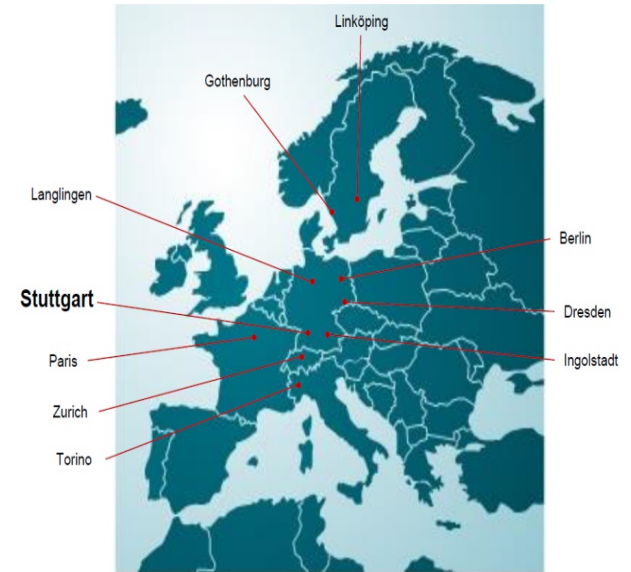
- DYNAmore – The Company
- What is roll forming?
- Comparison with classical deep drawing simulations
- Workflow
- Simulation Process
- Conclusions



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

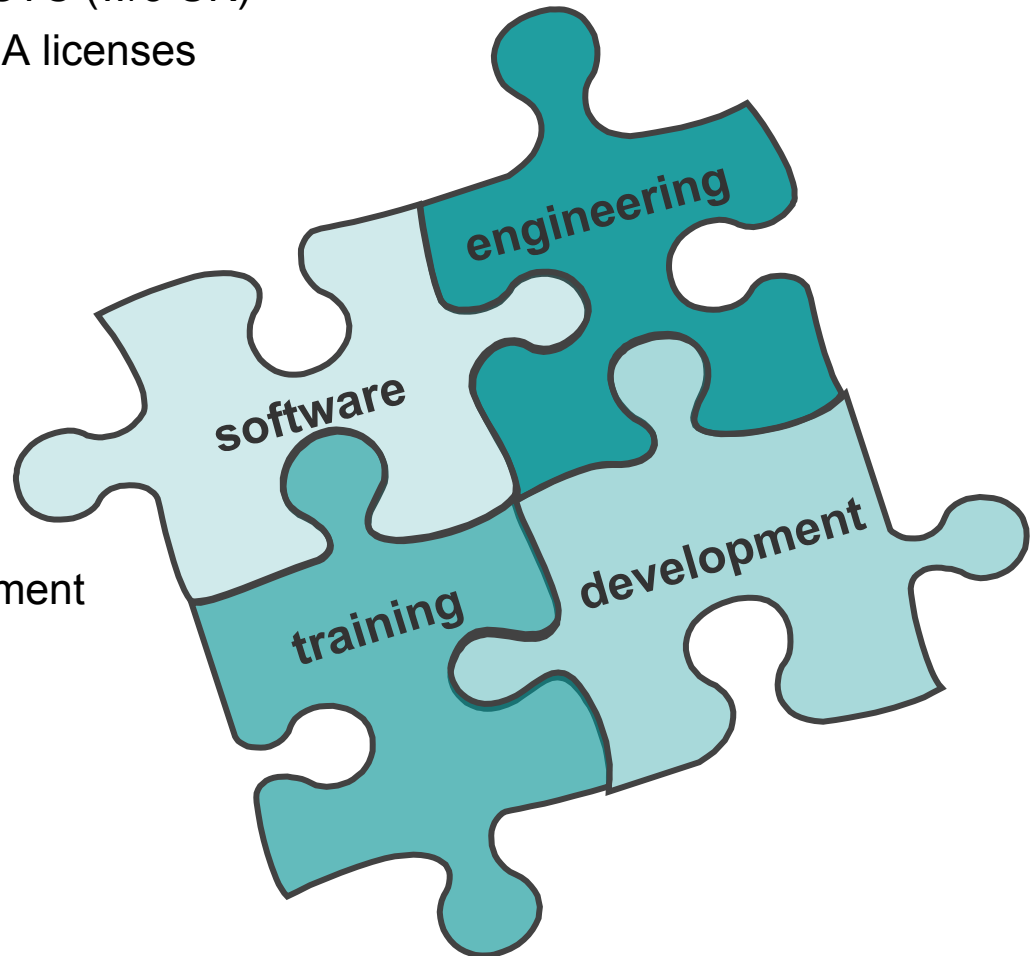
- Benchmarking
- Pilot projects
- On-site engineering

■ Development

- Software development
- Material & dummy models
- Customization & method development
- System & process integration

■ Training

- Seminars & on-site coaching
- Conferences
- Support



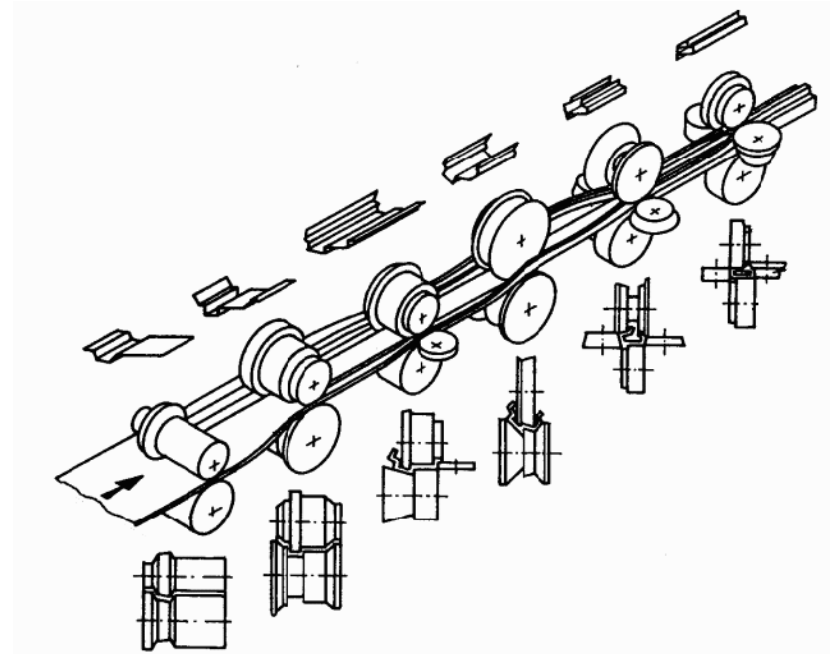
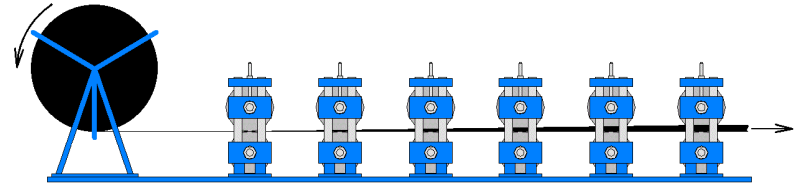


What is Roll Forming?



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



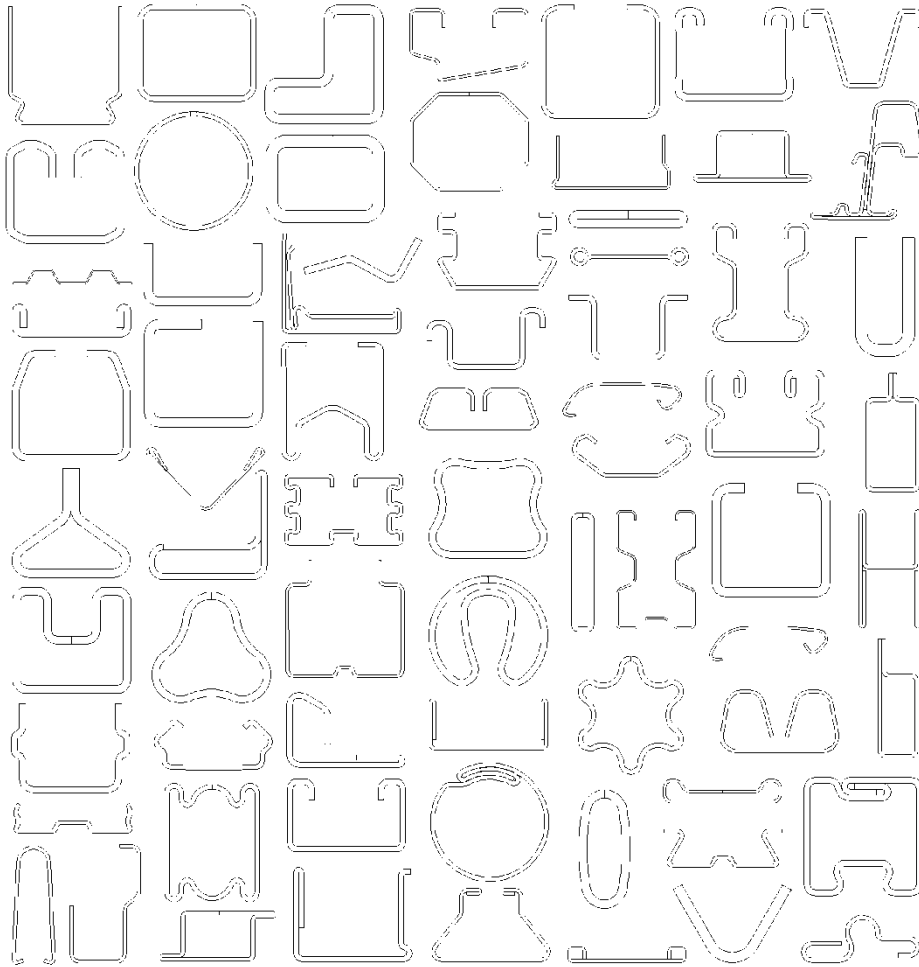
Source: UBECO

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



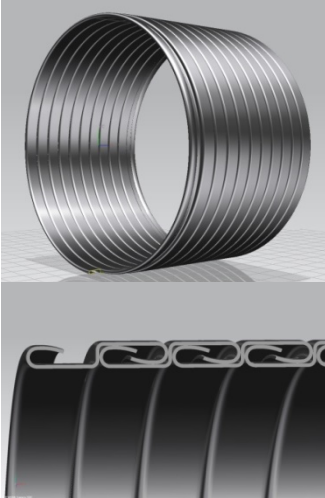
Source: www.fensterbekleidung.de

Drawer Rails



Source: www.ebay.de

Flexible tubes (metal)



Source: [witzenmann](http://witzenmann.com)

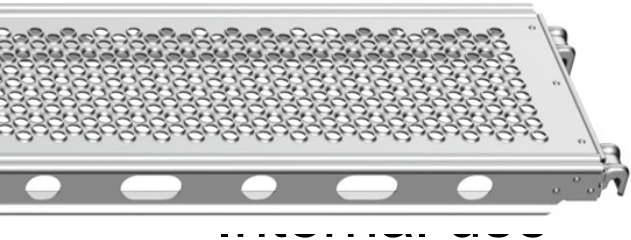
Scaffolding steel decks



Trailors



Source: www.cargobull.com



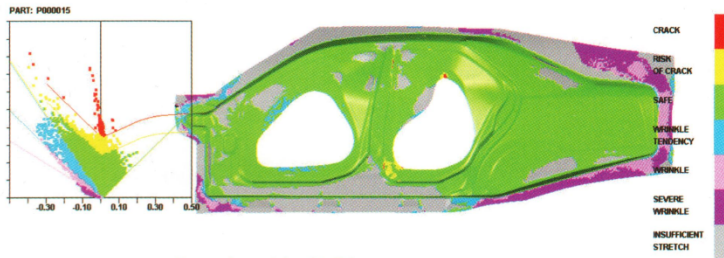
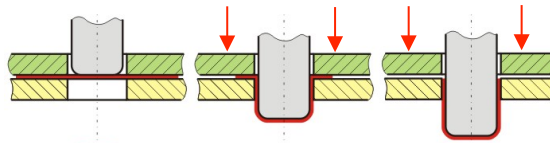
www.layher.com

ETA



Comparison with classical deep drawing

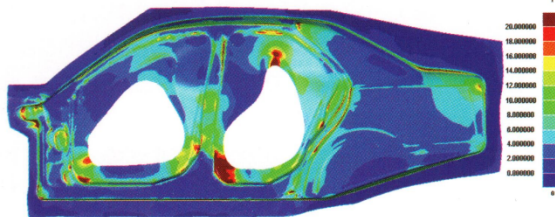
Aspects of deep drawing



Forming Limit Diagram



Circular Grid



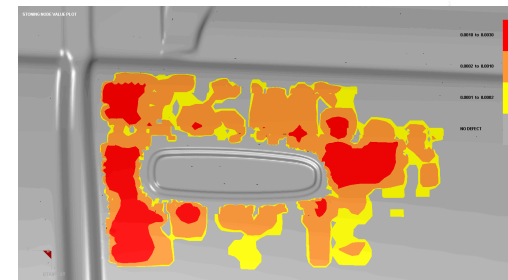
Thinning Map



Light Strip Visualization

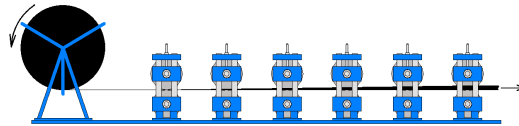


Material Inflow

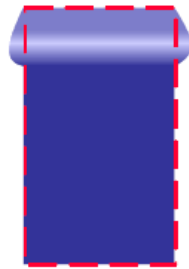


Stoning

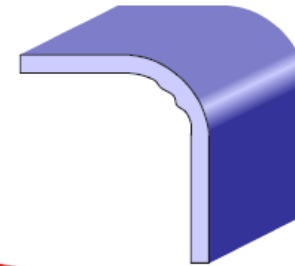
Aspects of roll forming



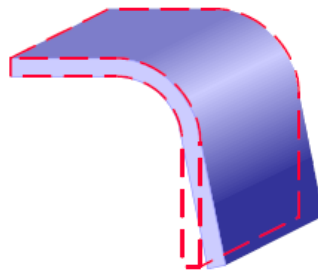
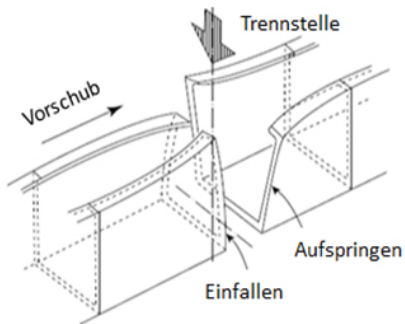
Bulging at the bending edge



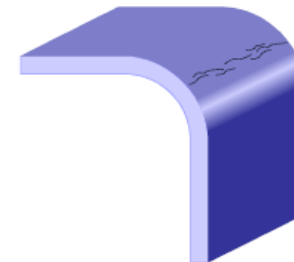
Wrinkles



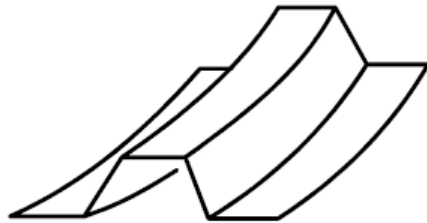
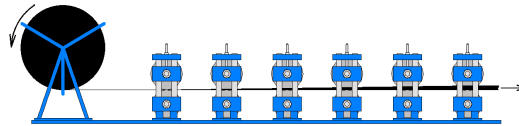
Error of the bending angle and End Flare (Springback)



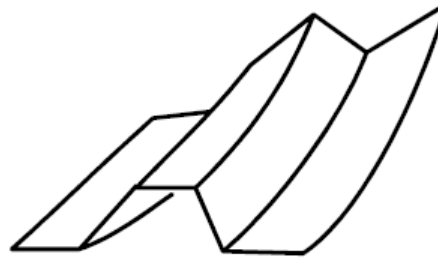
Cracks



Aspects of roll forming



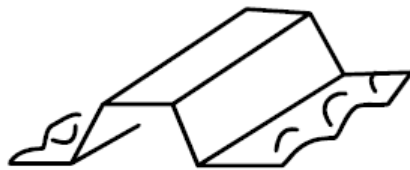
Formation of a saber



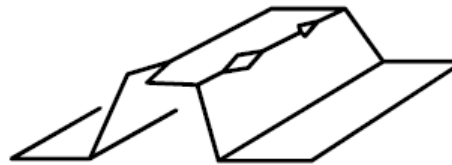
Torsion



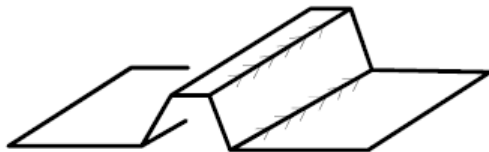
Waviness



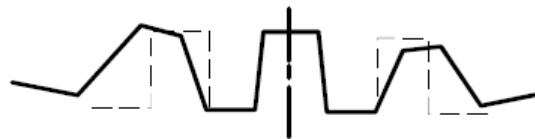
Waves along the edges



Cracks

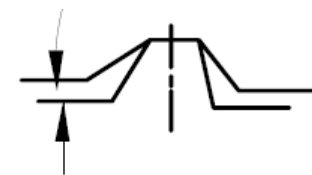


Buckling along the edges (burr)



Unbalanced
springback

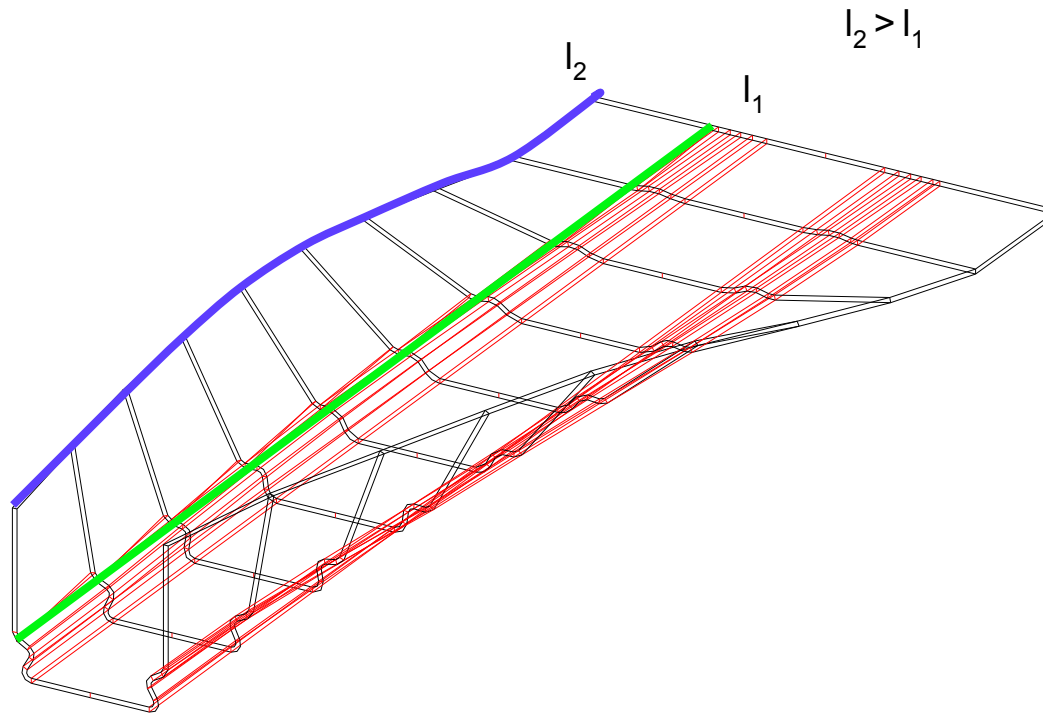
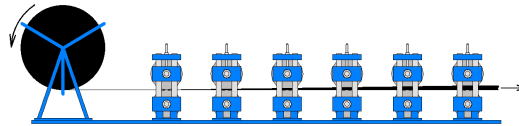
Cross section at the end of the profile



Cross section in the middle of the profile

Bulging

Aspects of roll forming



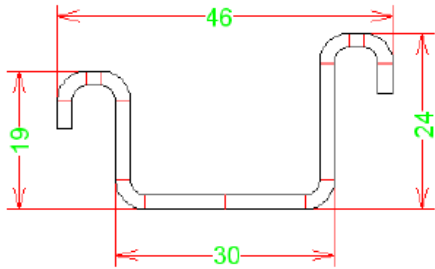
- Longitudinal strain at the edge
- Must be smaller than the yield strength to avoid unwanted deformations!



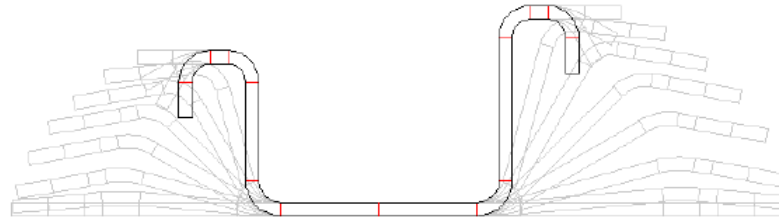
Workflow

From the profile to the roll forming stands

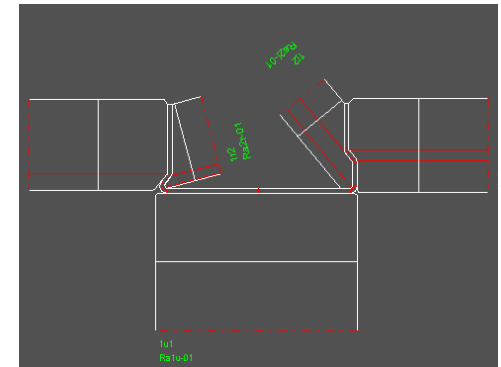
Design of the profile



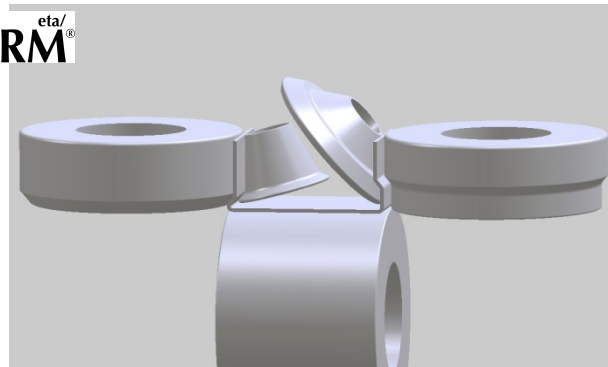
Generation of the flower pattern (2D)



Design of the rolls (2D)



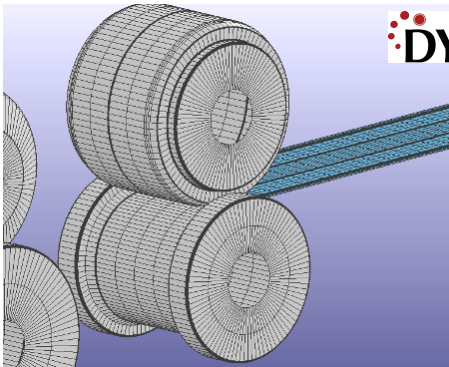
Generation of the surfaces (3D)



CAD-System, NC Program



Simulation (FEM)



Generation of the flower pattern

→ CAD-System for roll forming applications: UBECO Profil

A4865 Bar Chart

Bandkantenspannungen: ☐ Fahren i. Tal

Werkstoff: 3 FE P02 G 275 NA Re = 380 MPa

	%	St	%
58	1	58	
58	2	58	
59	3	59	
132	4	132	
7	5	7	
10	6	10	
5	7	5	
0	8	0	

Estimated strain is higher than yield strength!

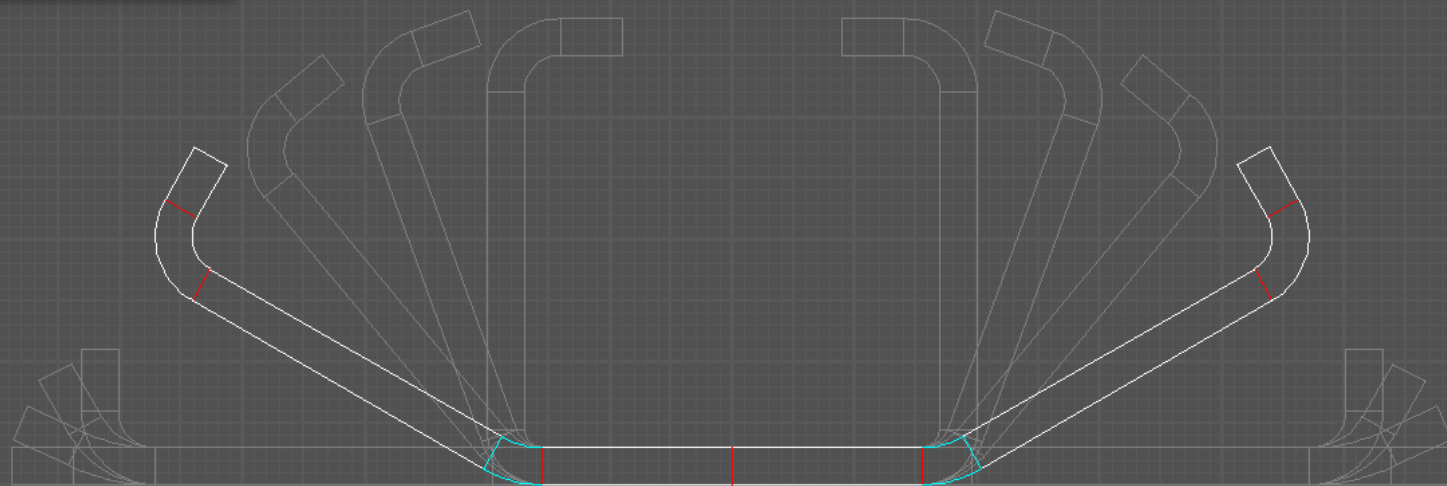
A4865.L04

Stich: 4. Station x0: 200,000

Gerüstab.: 300,000 y0: 150,000

Bandbreite: 117,549 Richt.(!):

Nr.	Typ	Ri	Radius entl.	Winkel entl.	gestr. Läng.	Bel.
1	S				15,500	
2	B1	L	6,561	30,000	4,108	23
3	S				27,500	
4	B1	L	3,000	90,000	6,665	51
5	S				5,000	
6	PS					



Generation of the flower pattern

→ CAD-System for roll forming applications: UBECO Profil

A4865 Bar Chart

Bandkantenspannungen: ☐ Fahren i. Tal

Werkstoff: 3 FE P02 G 275 NA Re = 380 MPa

	%	St	%
58	1	58	
58	2	58	
91	3	91	
93	4	93	
7	5	7	
10	6	10	
5	7	5	
0	8	0	

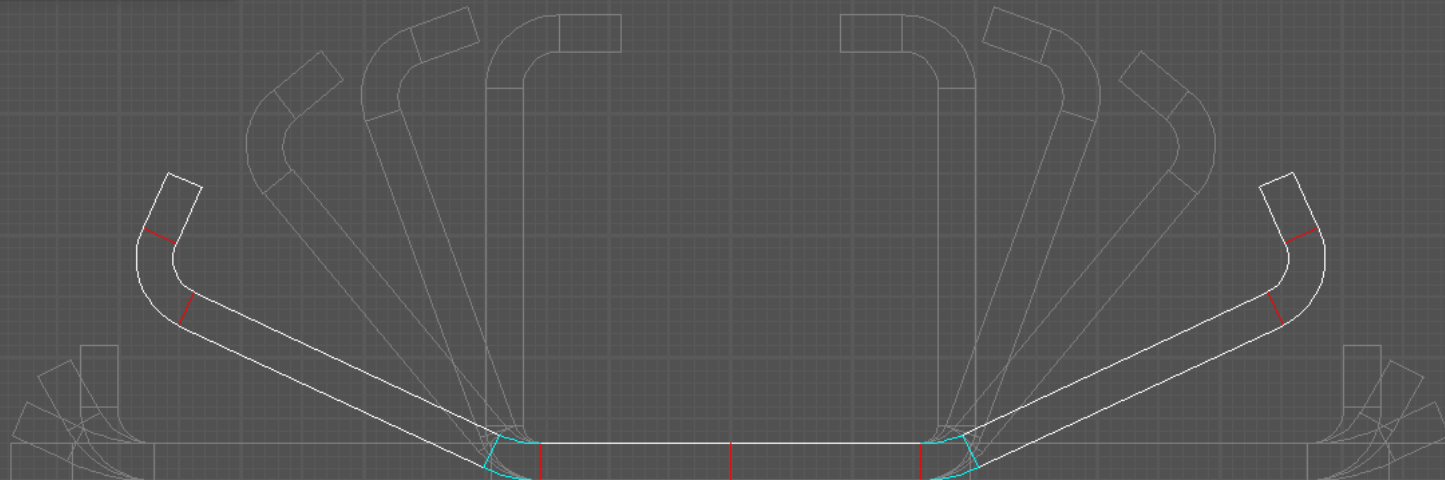
A4865.L04

Stich: 4. Station x0: 200,000 y0: 150,000

Gerüstab.: 300,000

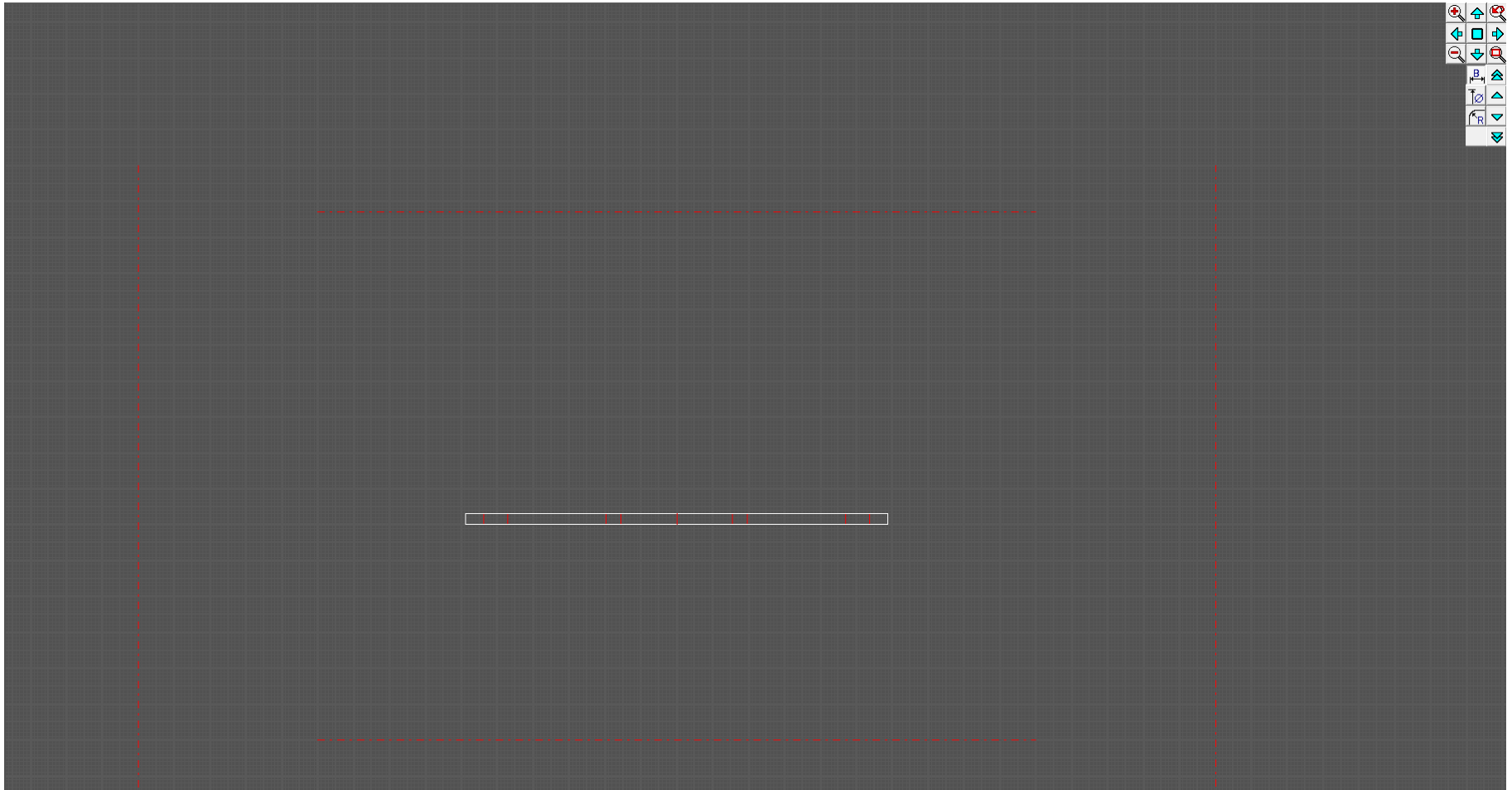
Bandbreite: 117,549 Richt.(°):

Nr.	Typ	Ri	Radius entl.	Winkel entl.	gestr. Läng.	Bel.
1	S				15,500	
2	B1	L	8,087	25,000	4,109	19
3	S				27,500	
4	B1	L	3,000	90,000	6,665	51
5	S				5,000	
6	PS					



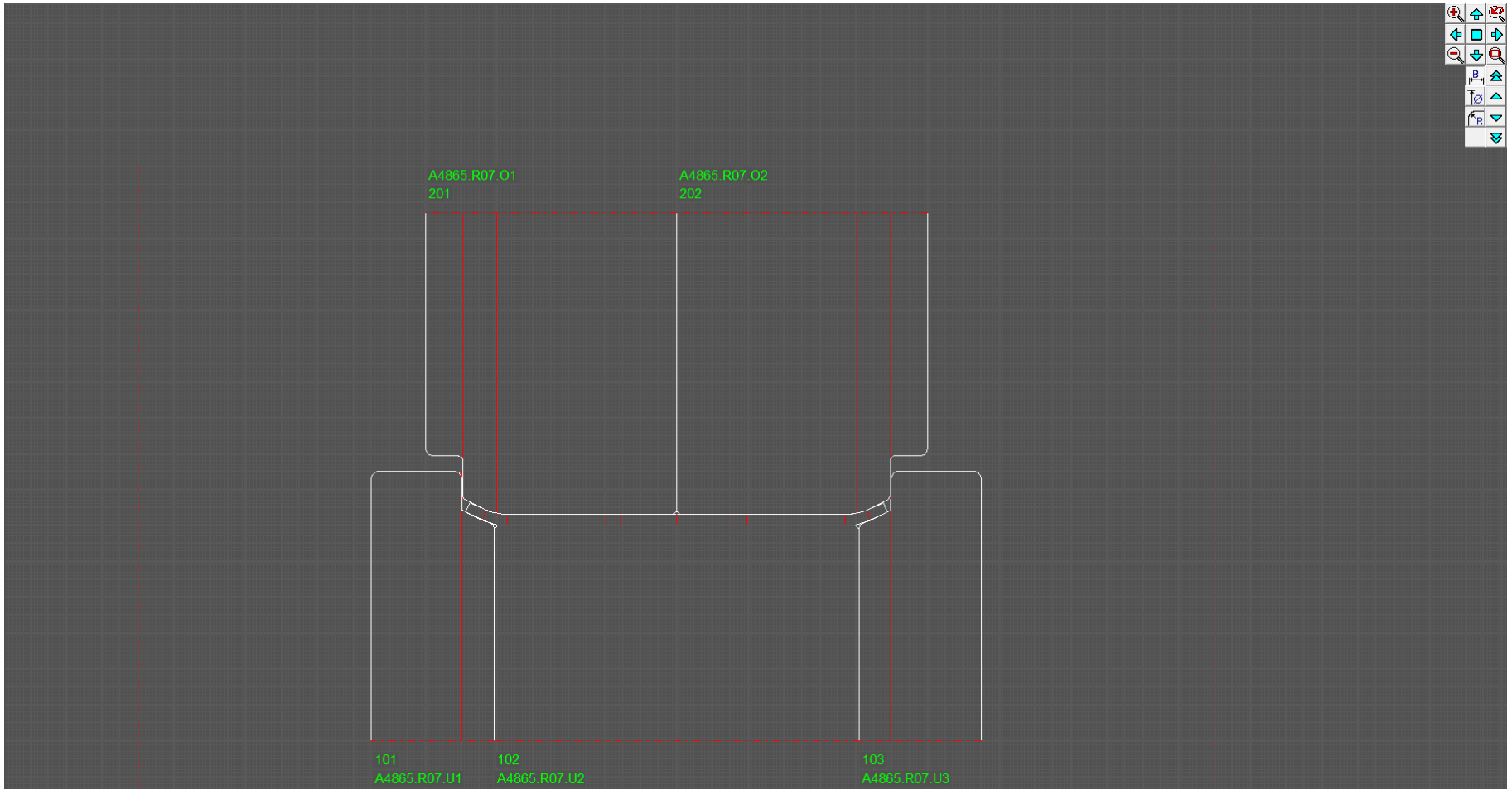
Generation of the rolls

→ CAD-System for roll forming applications: UBECO Profil



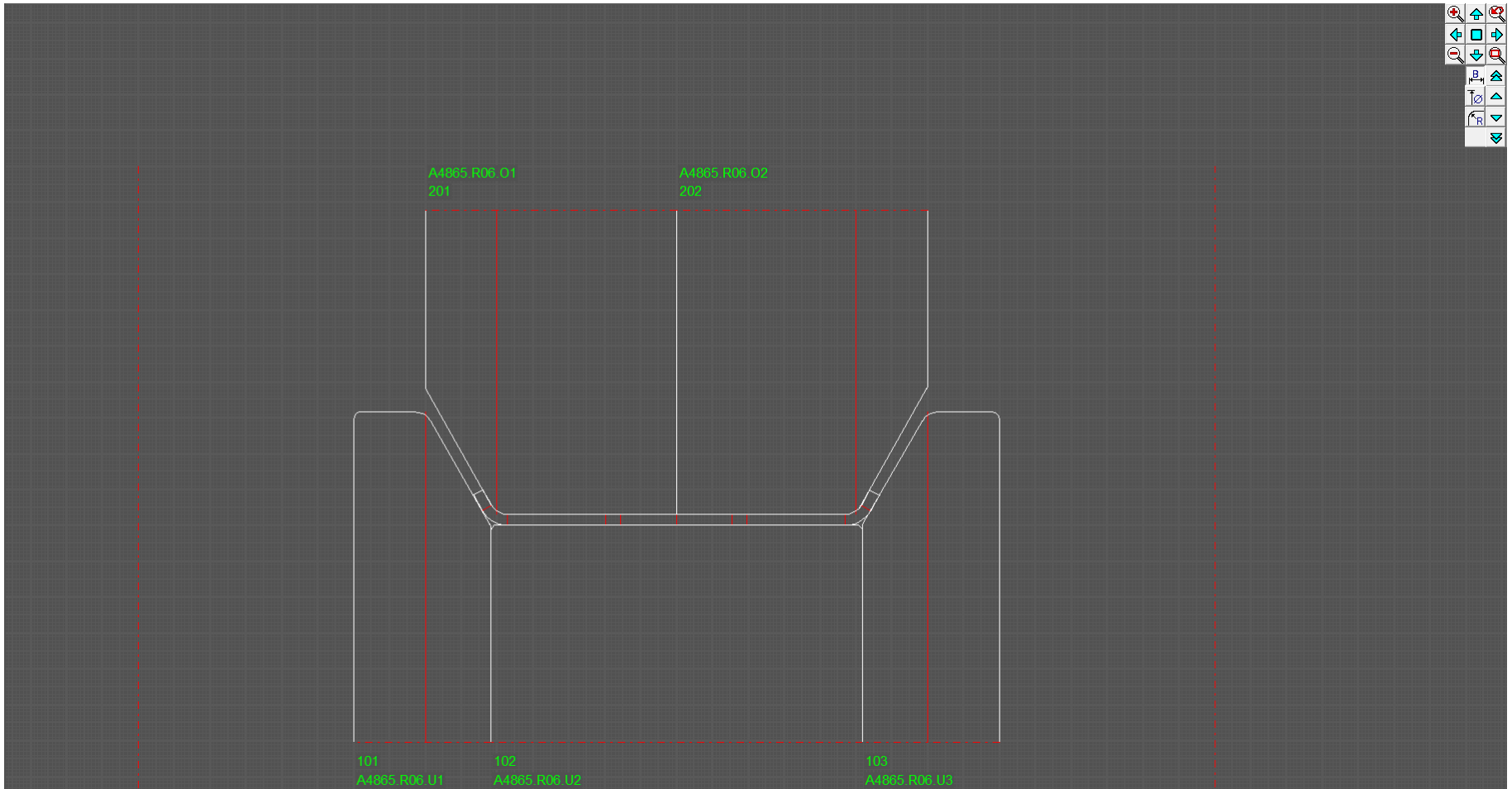
Generation of the rolls

→ CAD-System for roll forming applications: UBECO Profil



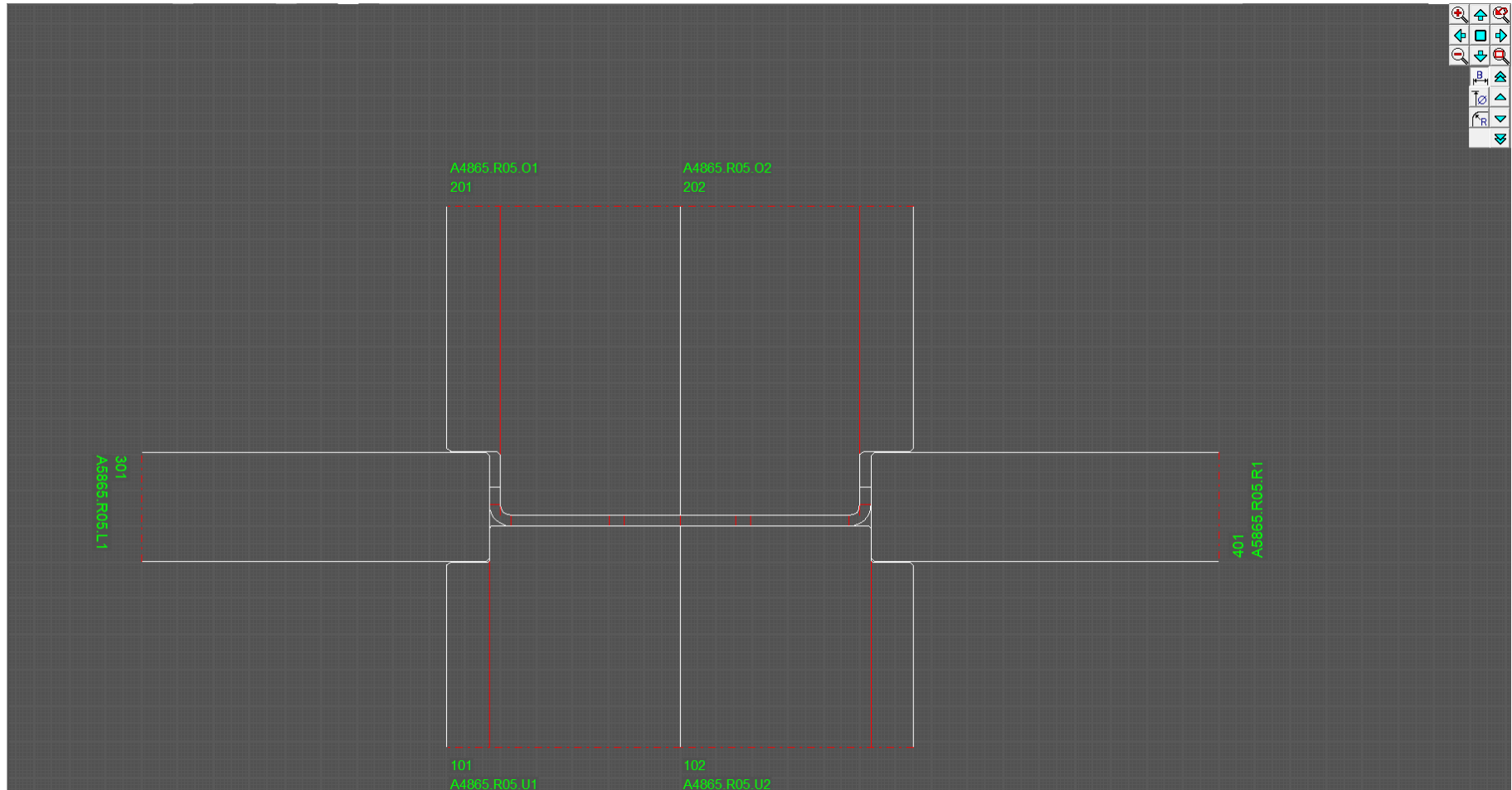
Generation of the rolls

→ CAD-System for roll forming applications: UBECO Profil



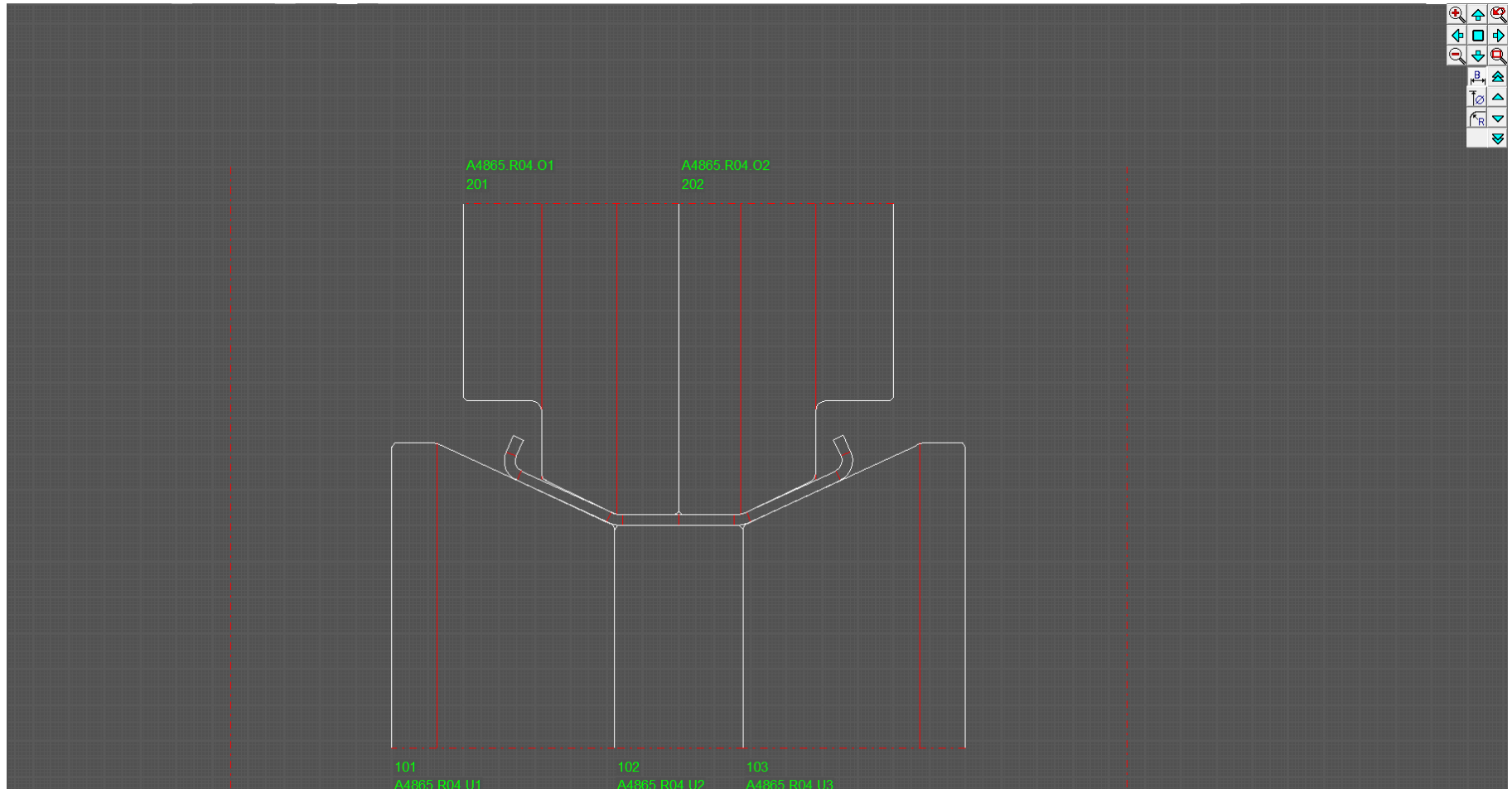
Generation of the rolls

→ CAD-System for roll forming applications: UBECO Profil



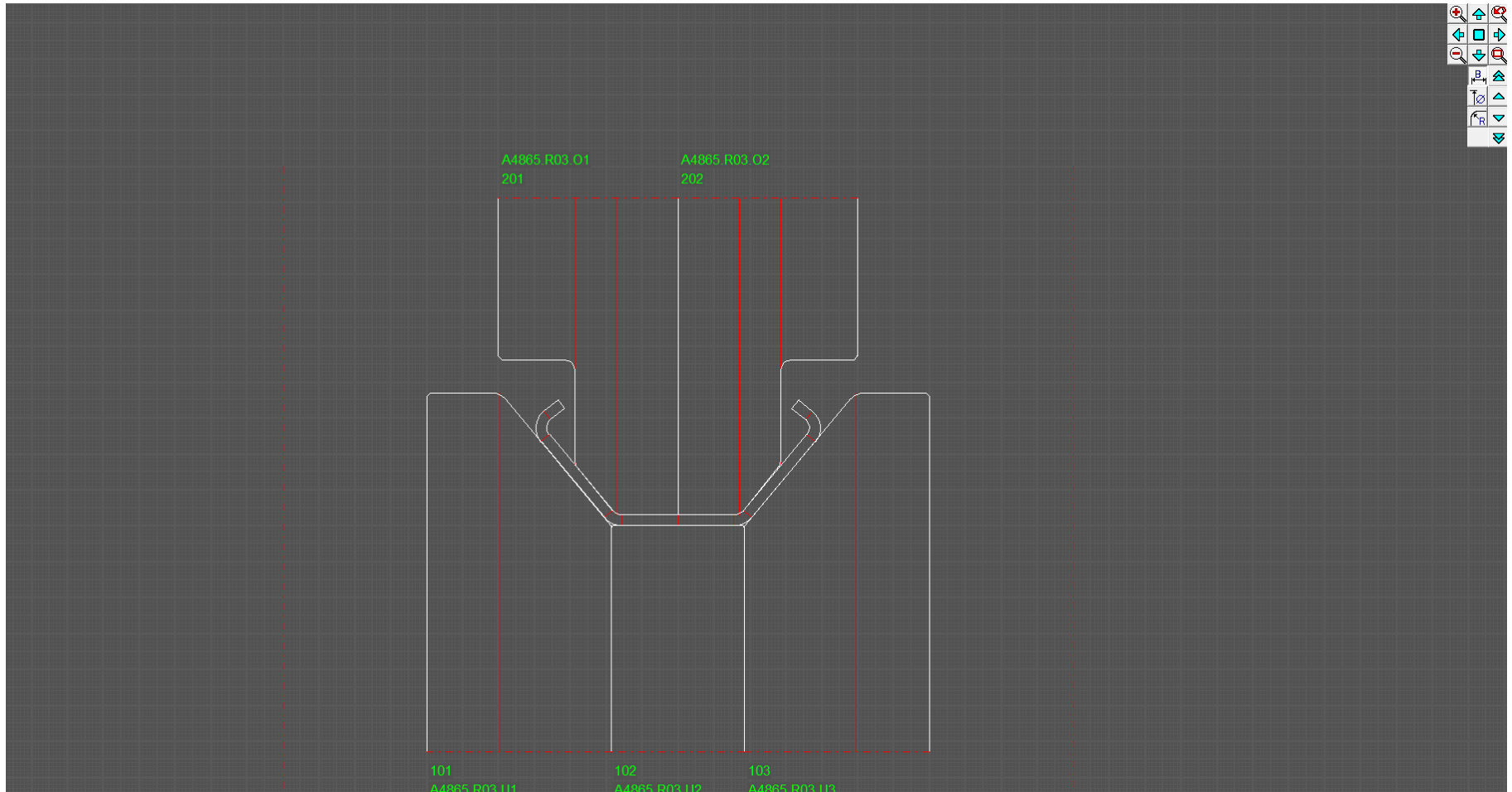
Generation of the rolls

→ CAD-System for roll forming applications: UBECO Profil



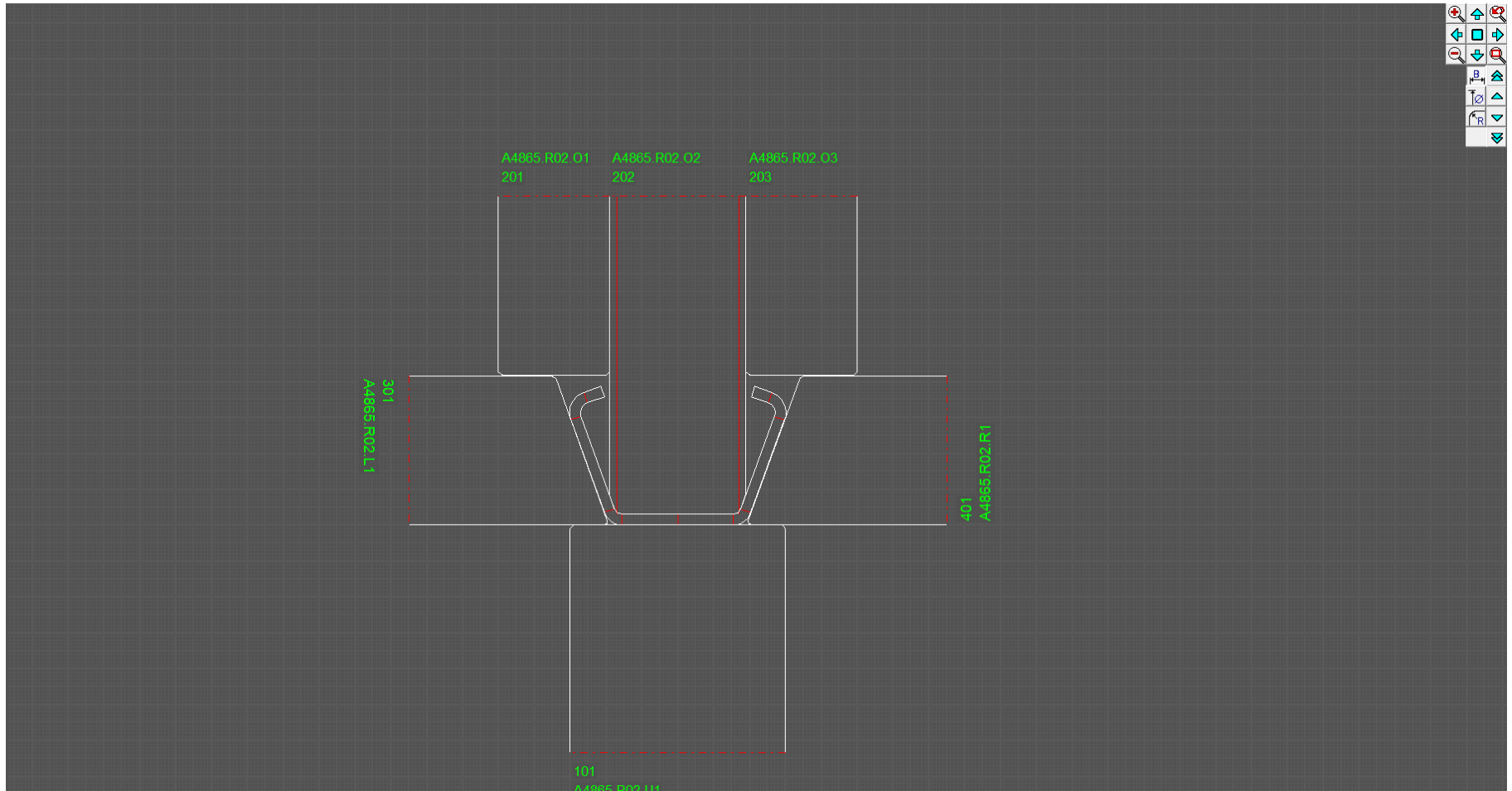
Generation of the rolls

→ CAD-System for roll forming applications: UBECO Profil



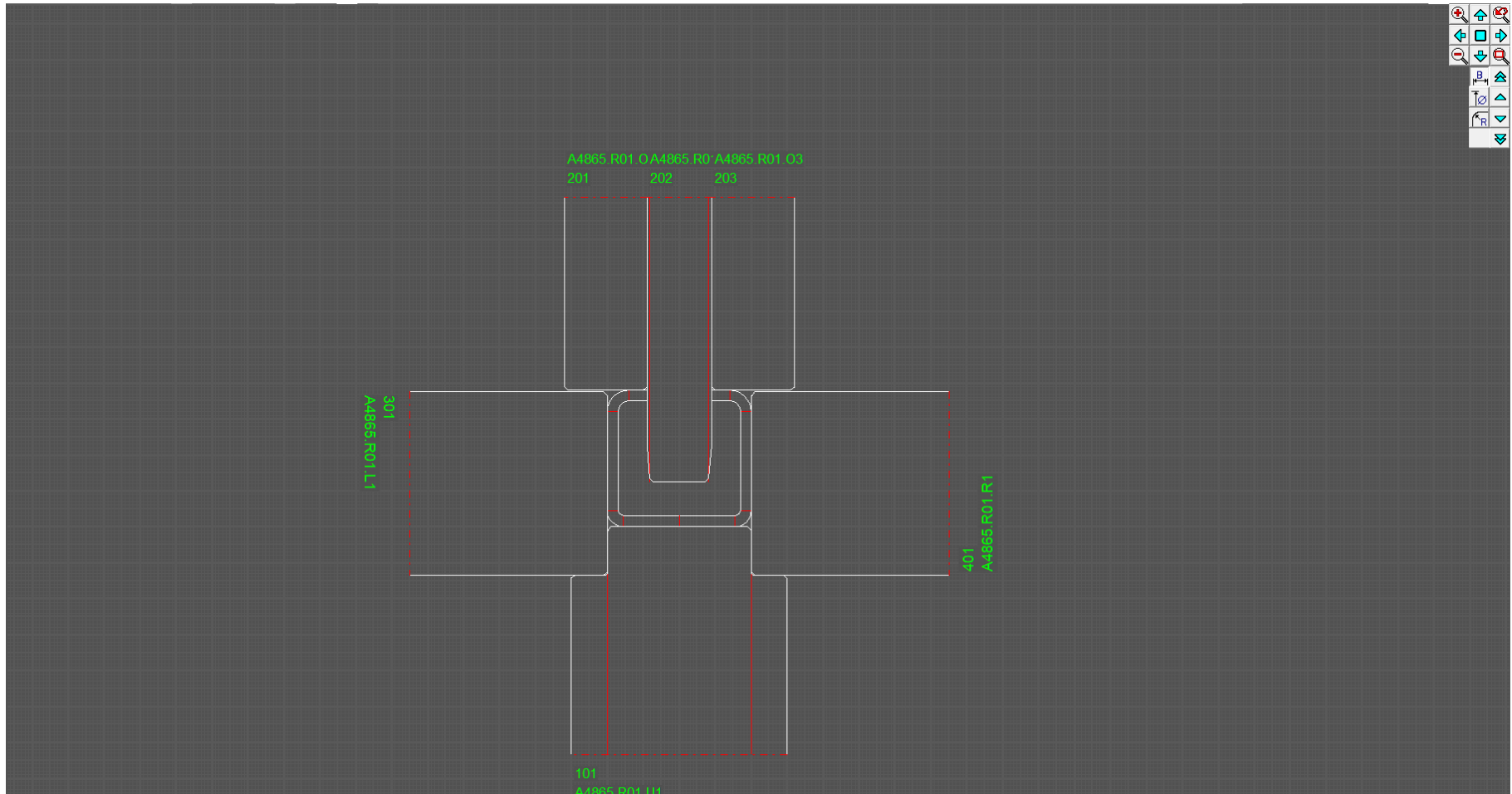
Generation of the rolls

→ CAD-System for roll forming applications: UBECO Profil



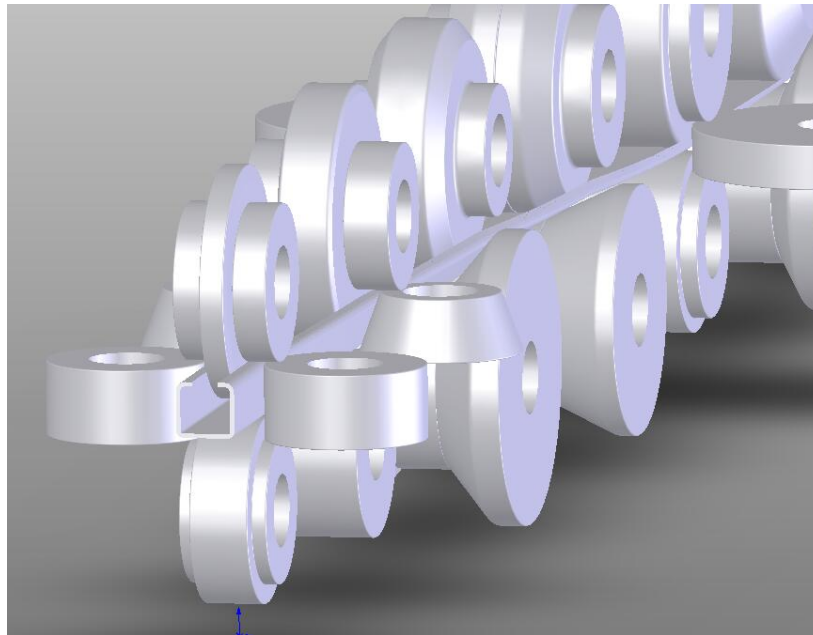
Generation of the rolls

→ CAD-System for roll forming applications: UBECO Profil



Generation of the rolls

→ CAD-System for roll forming applications: UBECO Profil



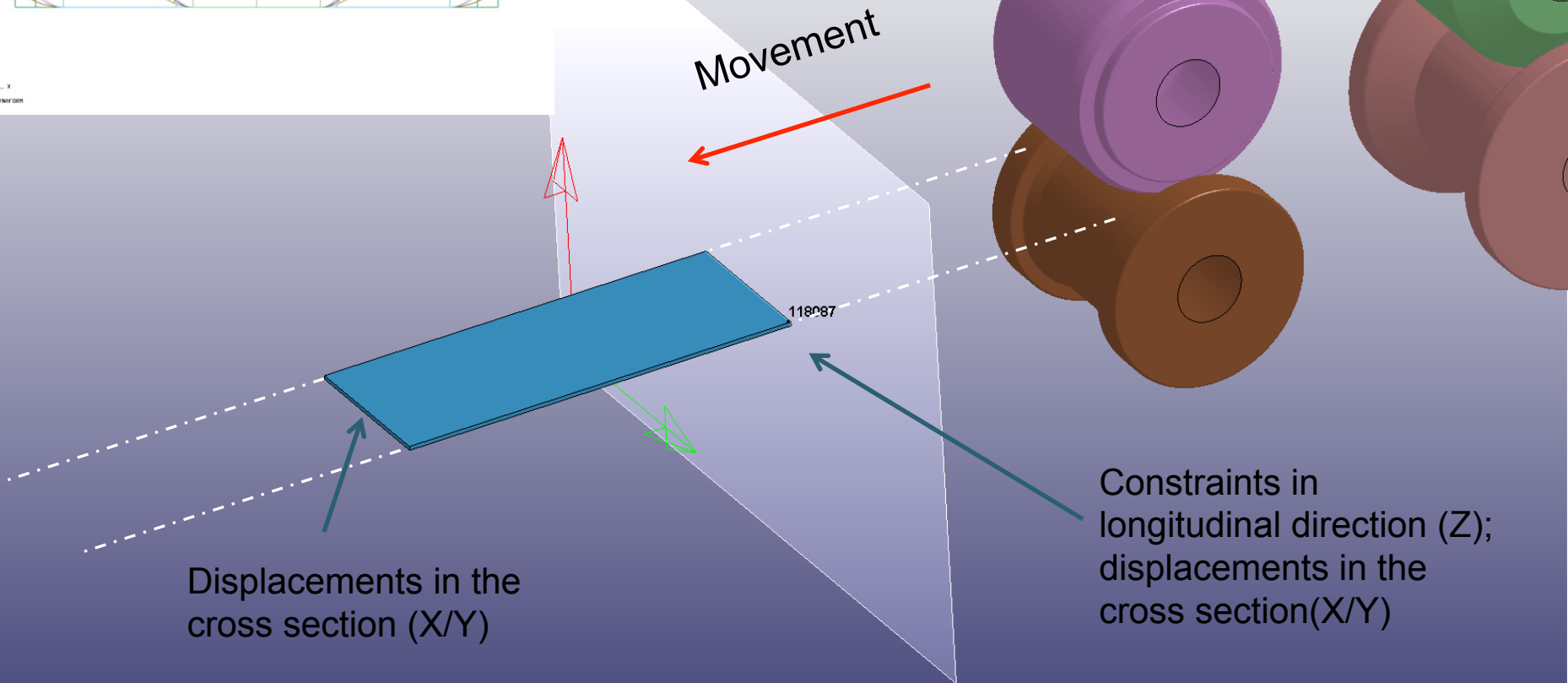
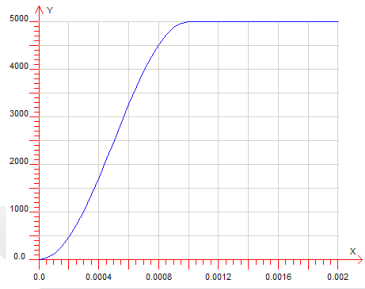
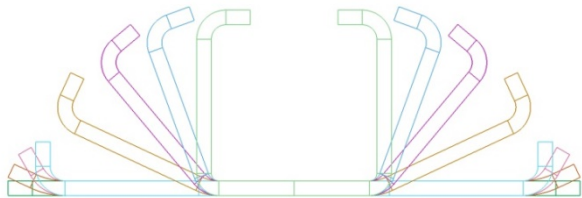
Automatic surface generation (3D)



Simulation process

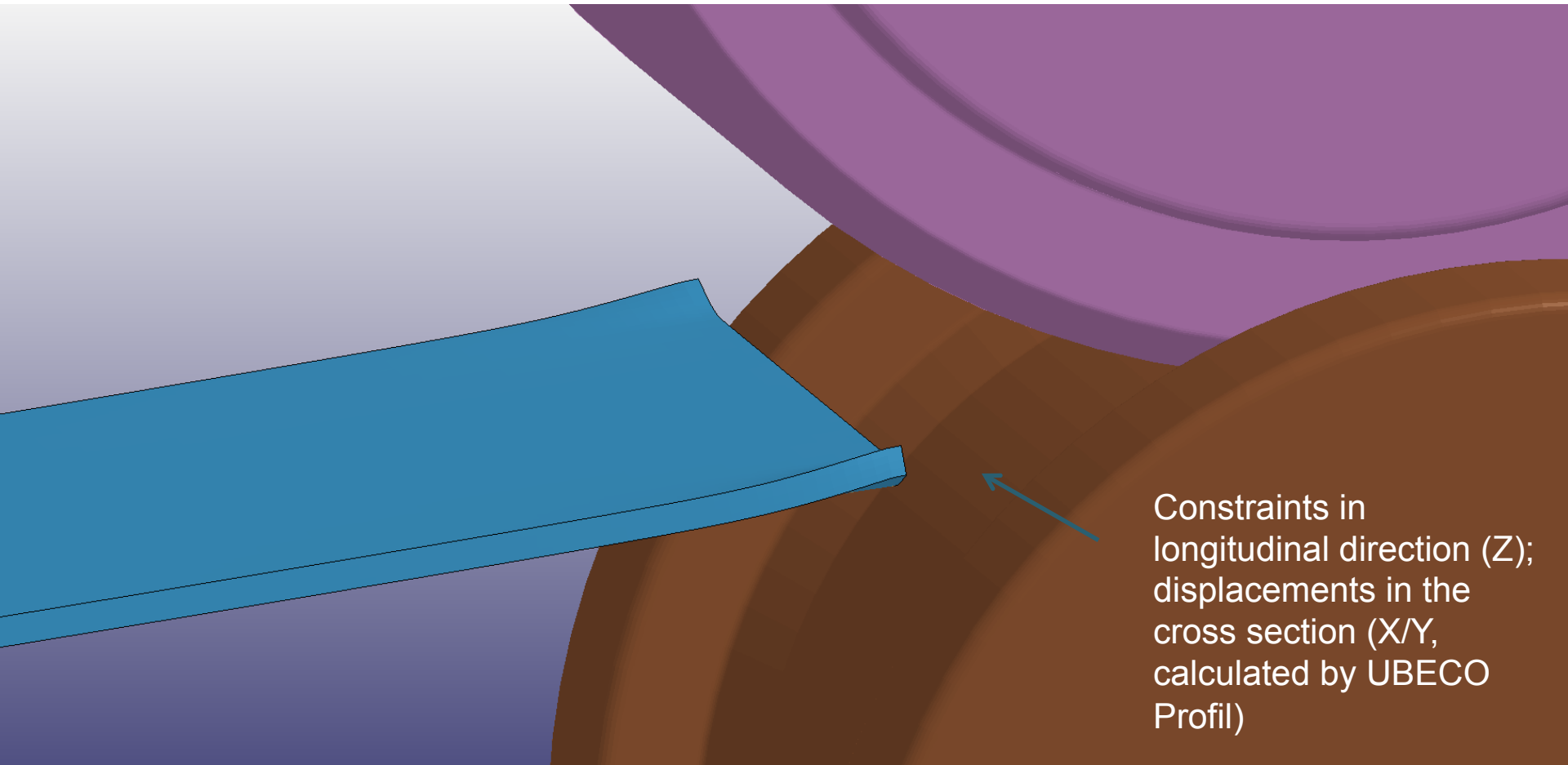


Model design:





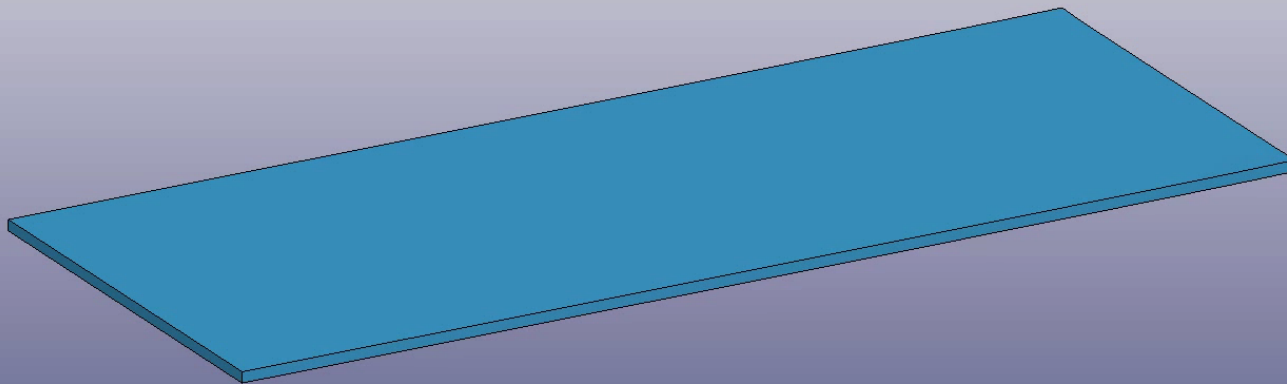
Model design:



Input of the strip into the first stand



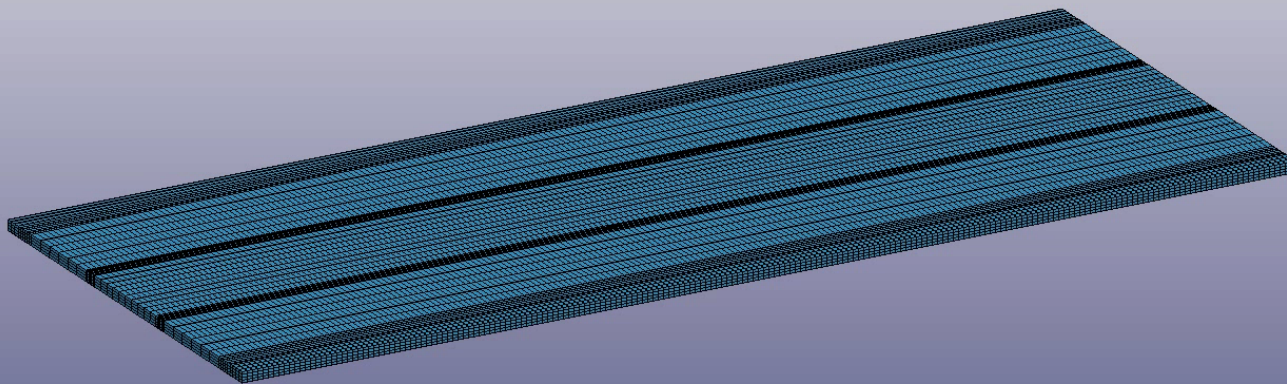
Model design:



OP10 to OP70



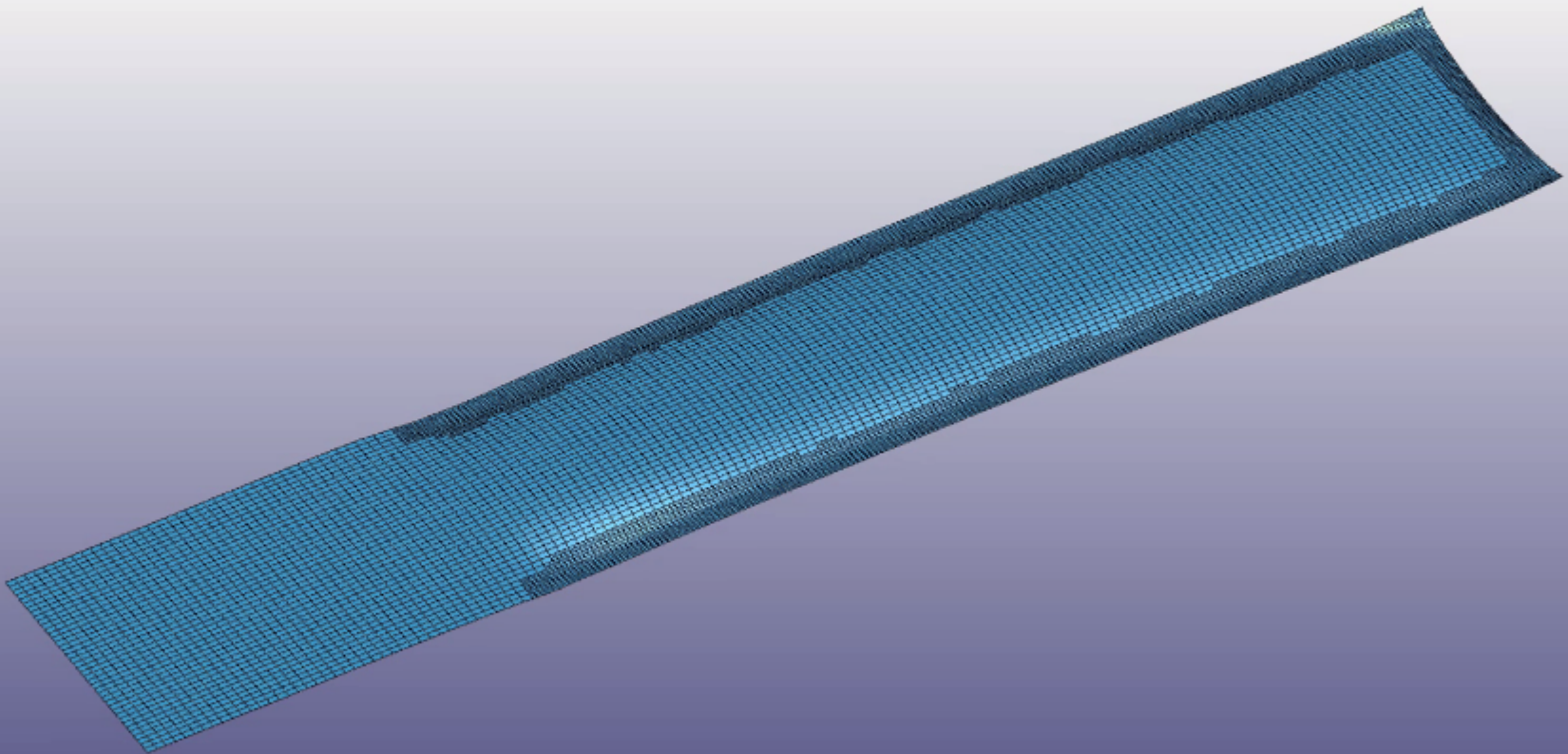
Model design: Preconditioned mesh

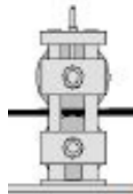


OP10 to OP70



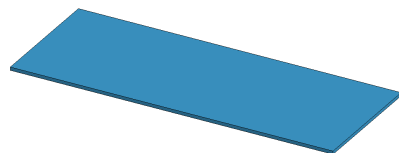
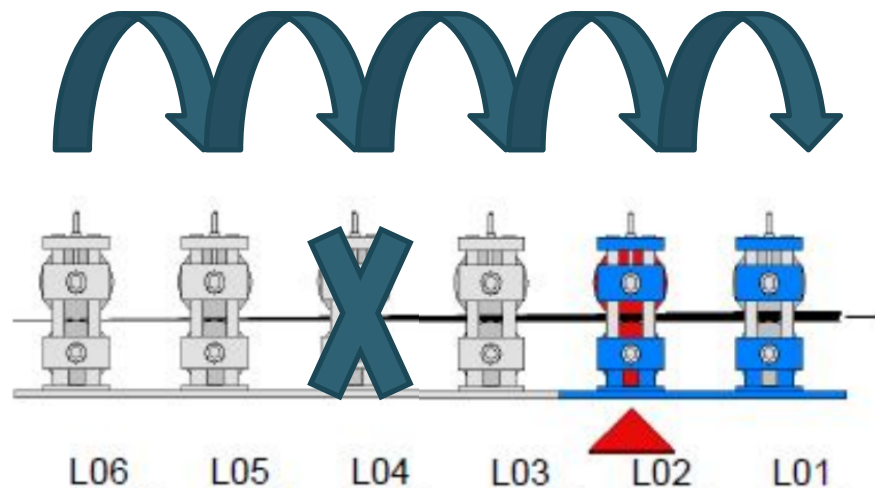
Option: Automatic mesh refinement (Shells):





Model design:

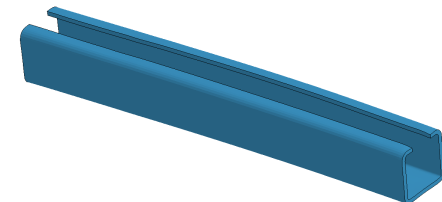
Separate Simulations



Strip (Shells or solids)



Throughput
direction



Profile

Generation of the LS-DYNA input deck



Sheet Forming

Setup Display Preview Job AutoSCP

10.Stand_1 20.Stand_2 30.Stand_3 40.forming1 50.fStand_5

General Blank Tools Drawbeads Process Control

Geometry

Part	Material	Thickness	Property
BLANK002 2	1.4301	0.7	ELFORM=16

Position

U V W

Position: 0.0 0.0 0.0

Symmetry

Symmetry type: <None> Define...

Contact

☒ Blank self-contact Advanced...

Summary... Exit

Sheet Forming

Setup Display Preview Job AutoSCP

10.Stand_1 20.Stand_2 30.Stand_3 40.forming1 50.fStand_5

General Blank Tools Drawbeads Process Control

Current tool

Name: 10_lower roll r

Geometry

P0000017 17 ☒ Show

Position: U V W

0.0 0.0 0.0

Working direction

Direction: +Z Movement: 0.0

Contact

Offset: 0.0 <None>

Frictional coef: 0.05 Low Advanced...

Association

☐ Contact

☐ Springs

☐ Rotation

New Delete

Auto Assign Positioning...

Summary... Exit

Sheet Forming

Setup Display Preview Job AutoSCP

10.Stand_1 20.Stand_2 30.Stand_3 40.forming1 50.fStand_5

General Blank Tools Drawbeads Process Control

rollforming

Current step

Name: 10_rollforming ☐ Hydro

Tool control

Tools	Action & Value
upper ro.	Velocity 5000.0 Sinu.W-H
lower ro.	Velocity 5000.0 Sinu.W-H
lower ro.	Velocity 5000.0 Sinu.W-H

Duration

Type: Travel

Tool: upper roll I Displacement: 300.0

D3plot

Total number = 15 Edit...

New Delete

☐ Lance

SPCs(77)

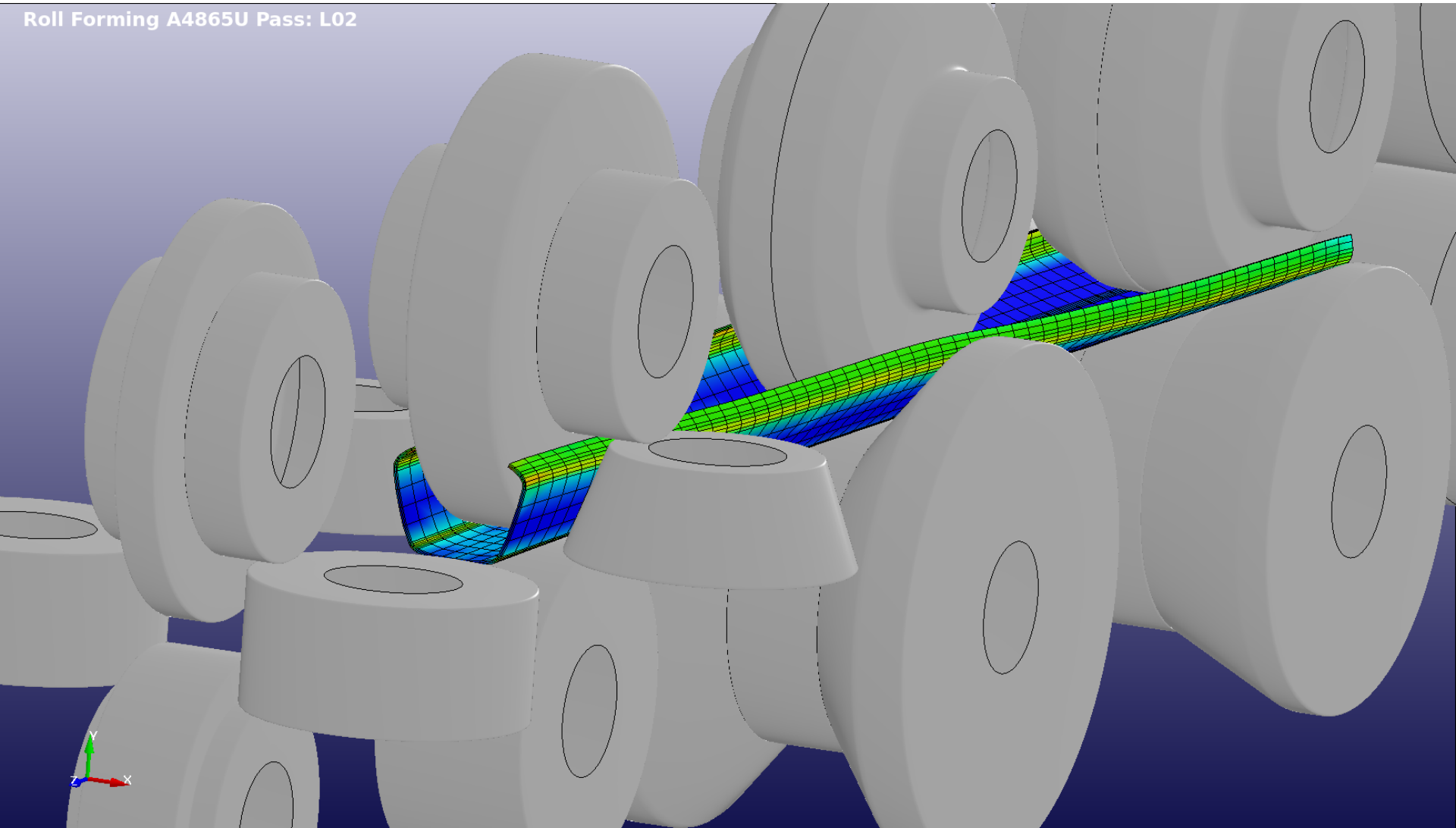
Summary... Exit

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



Postprocessing | Solids | Plastic strains:

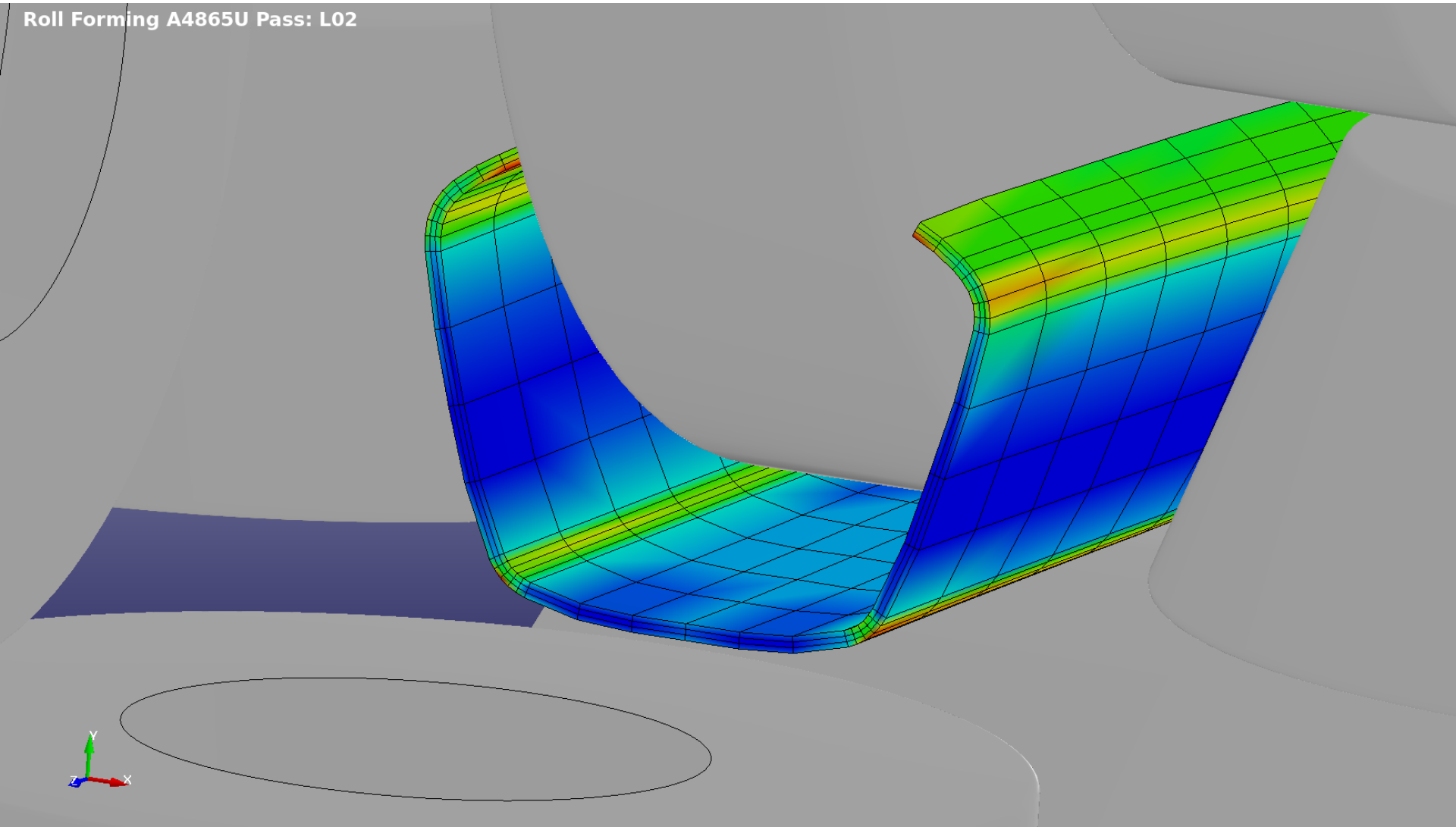
Roll Forming A4865U Pass: L02





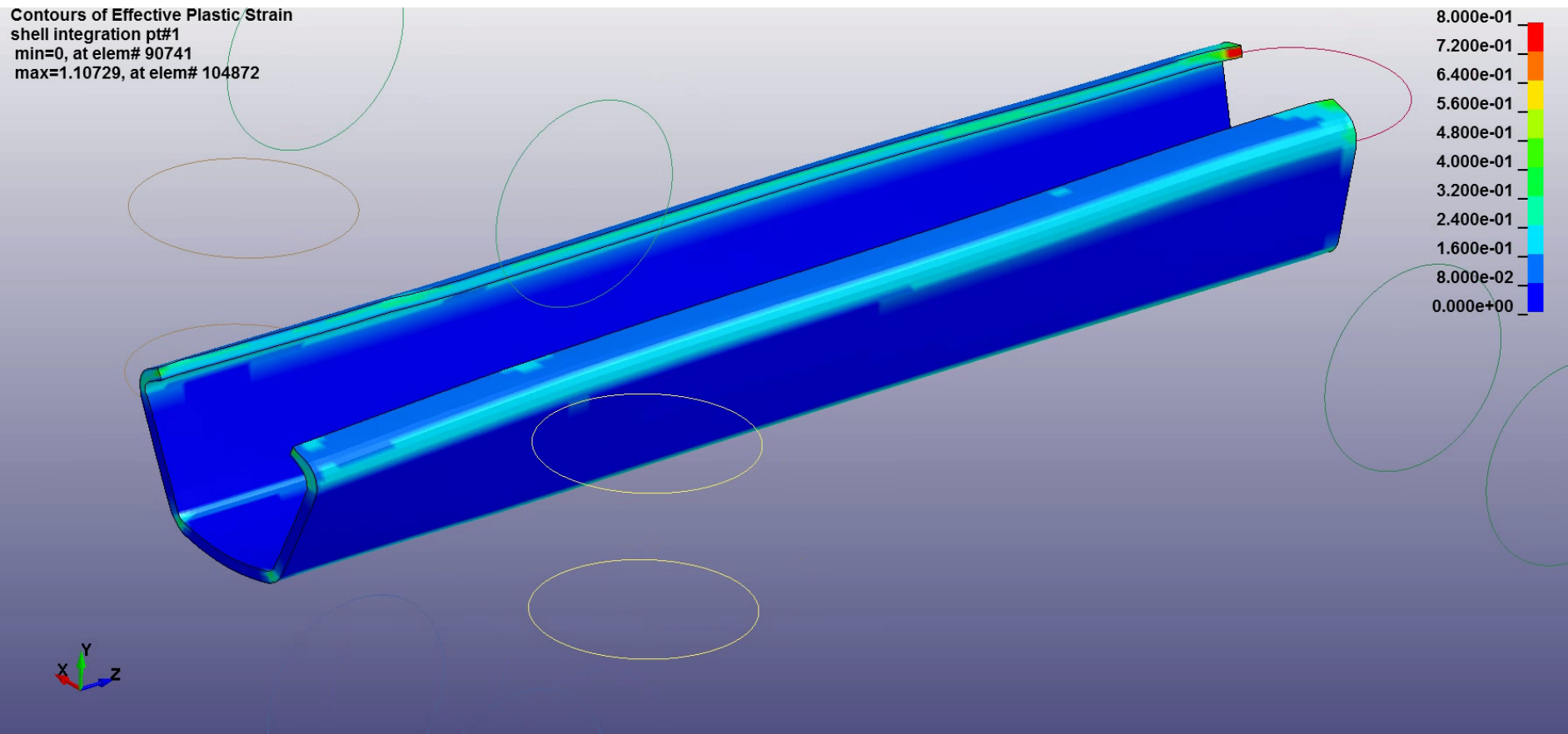
Postprocessing | Solids | Plastic strains:

Roll Forming A4865U Pass: L02



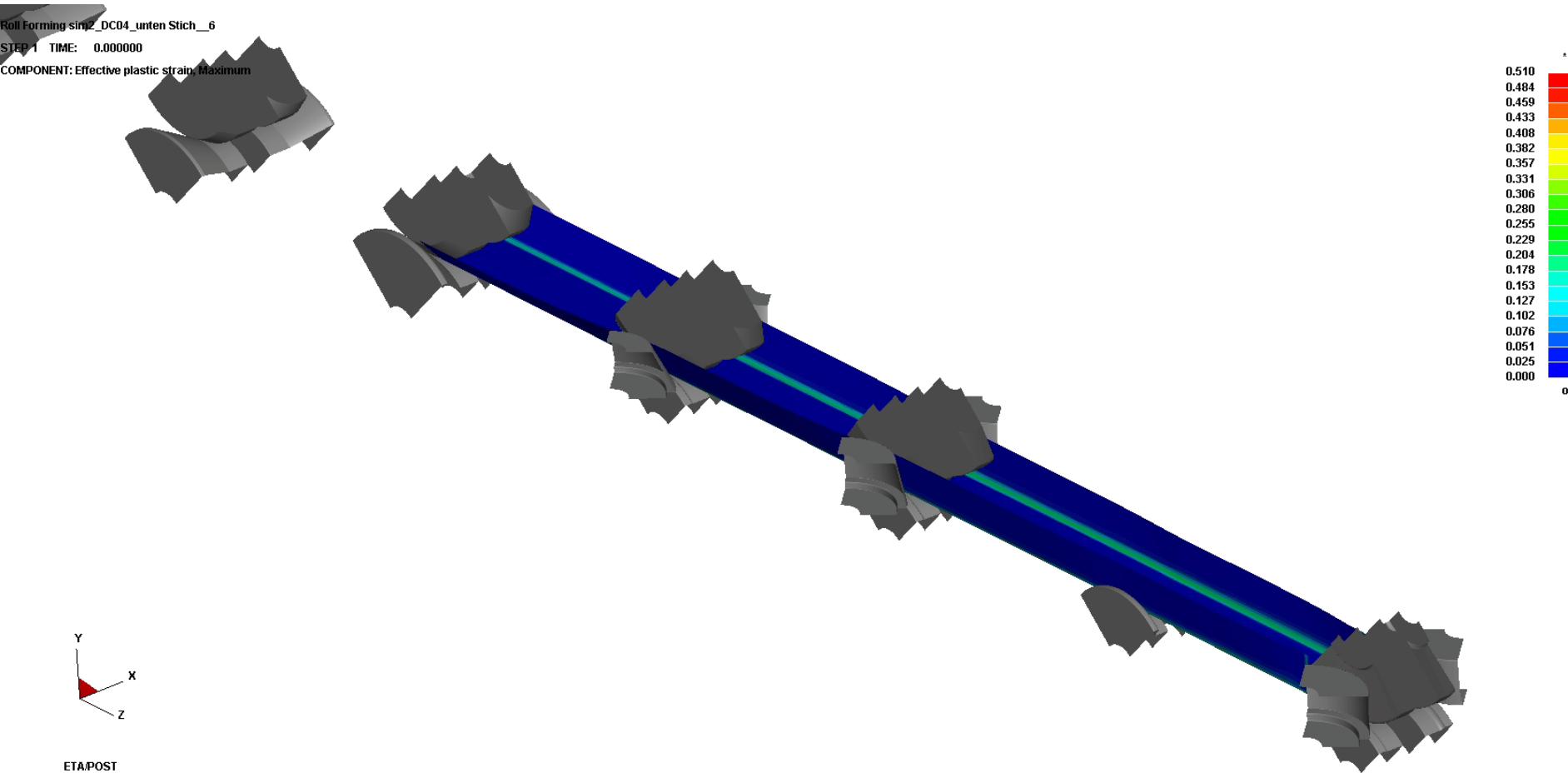


Postprocessing | Solids | Plastic strains:



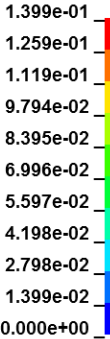


Postprocessing | Solids | Plastic strains:

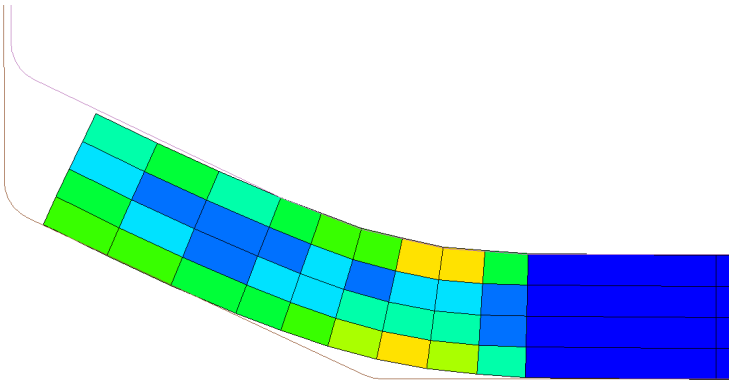
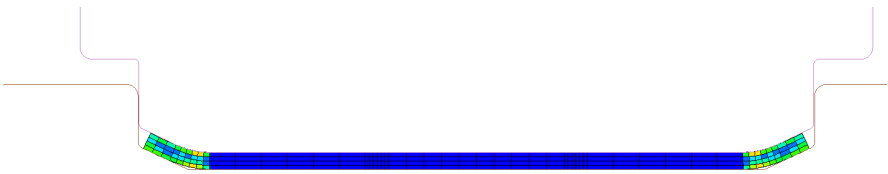
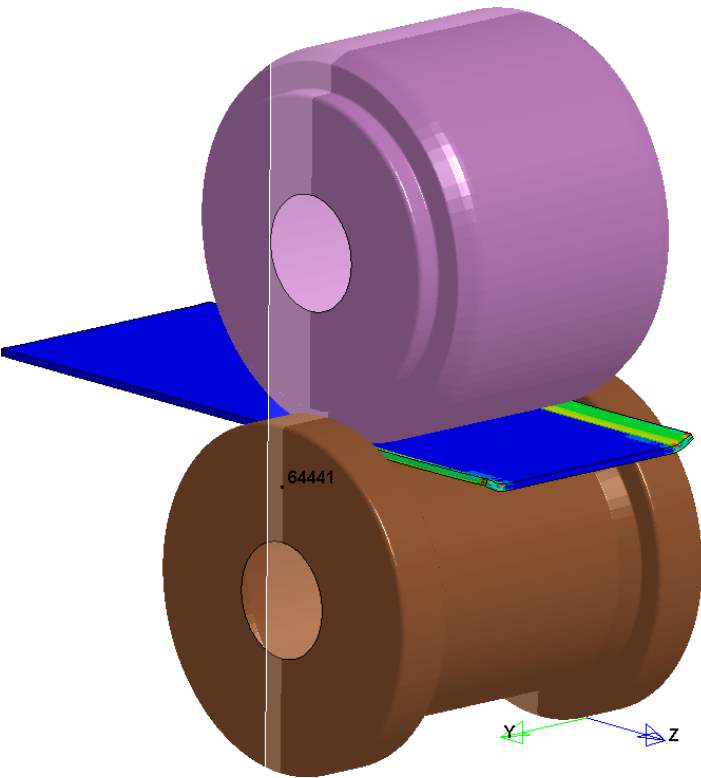




Fringe Levels

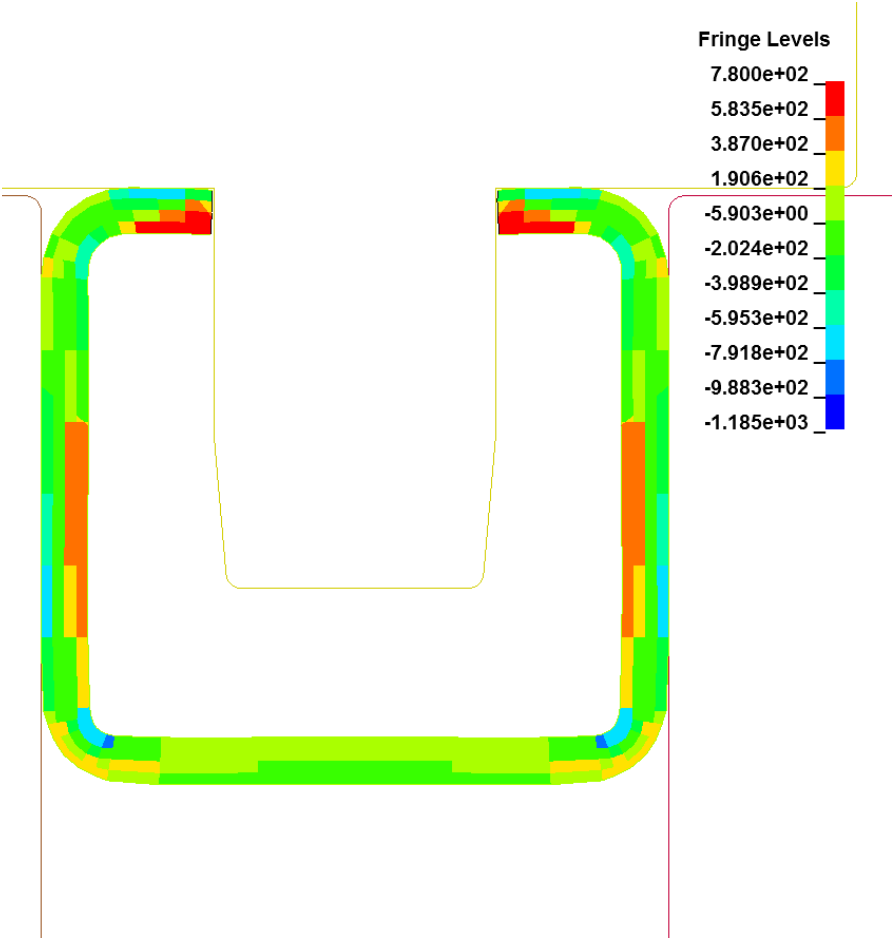
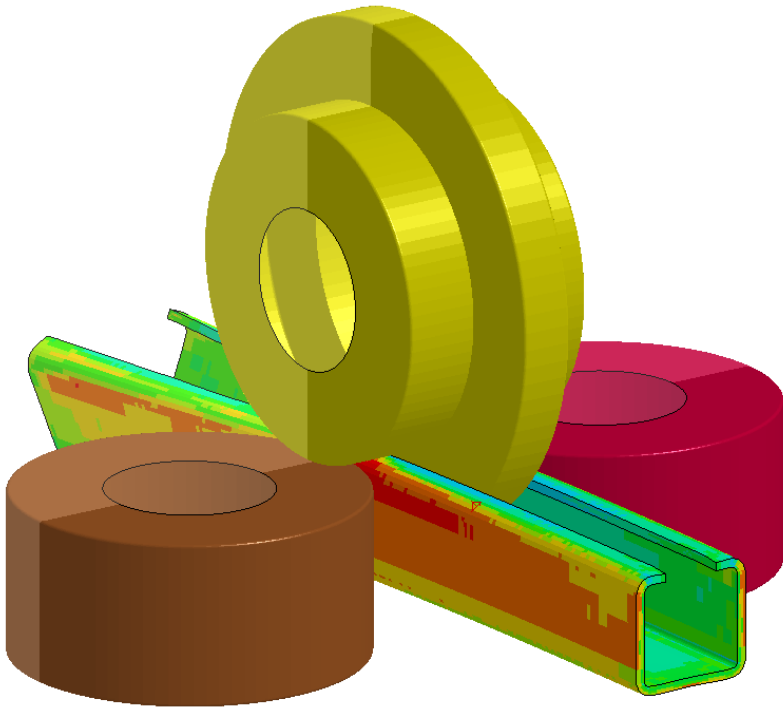


Postprocessing | Solids | Plastic strains | Cross section:





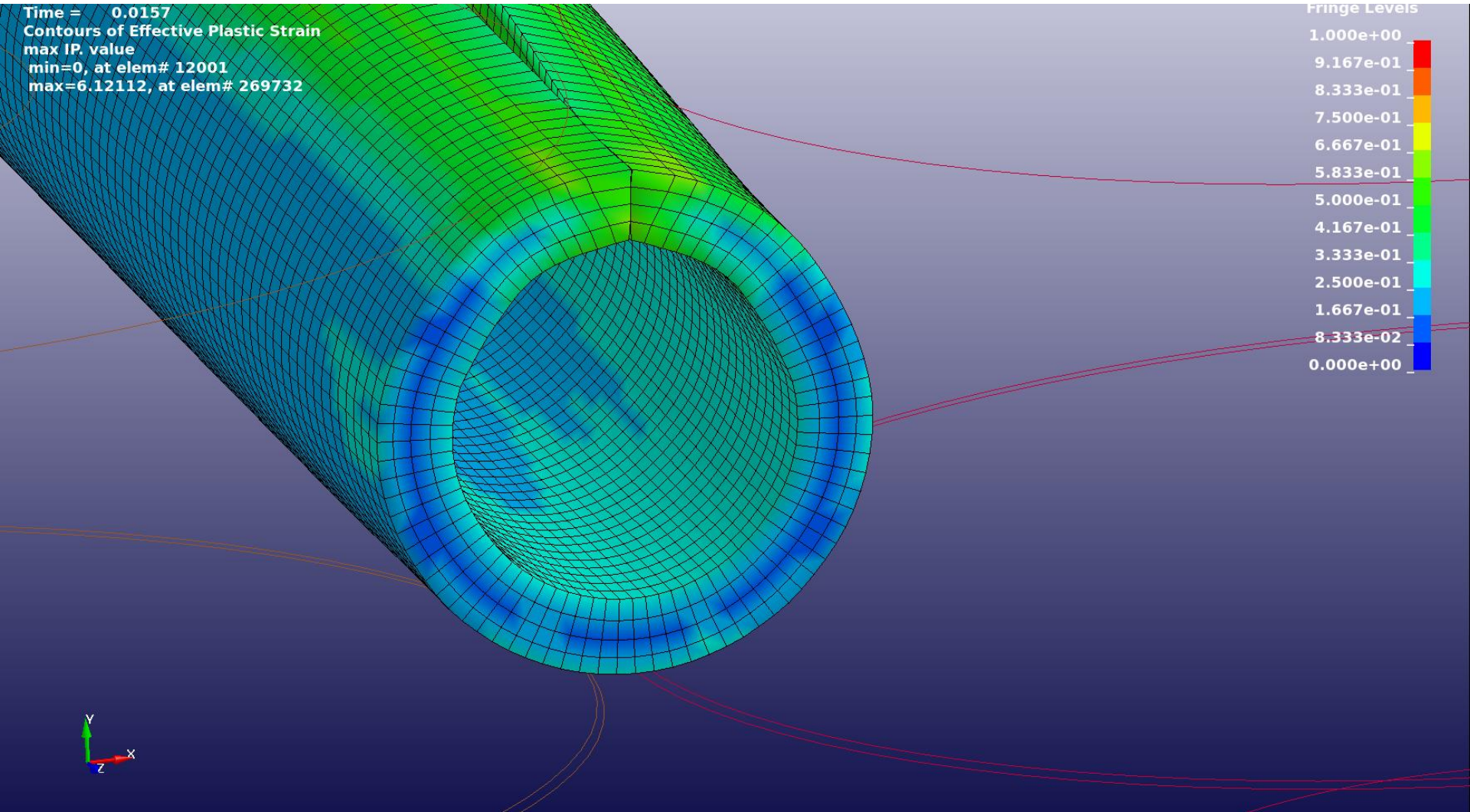
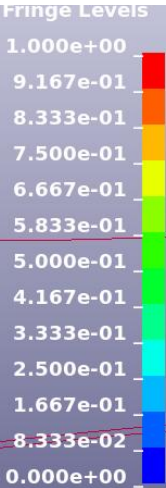
Postprocessing | Solids | Stresses (Z):





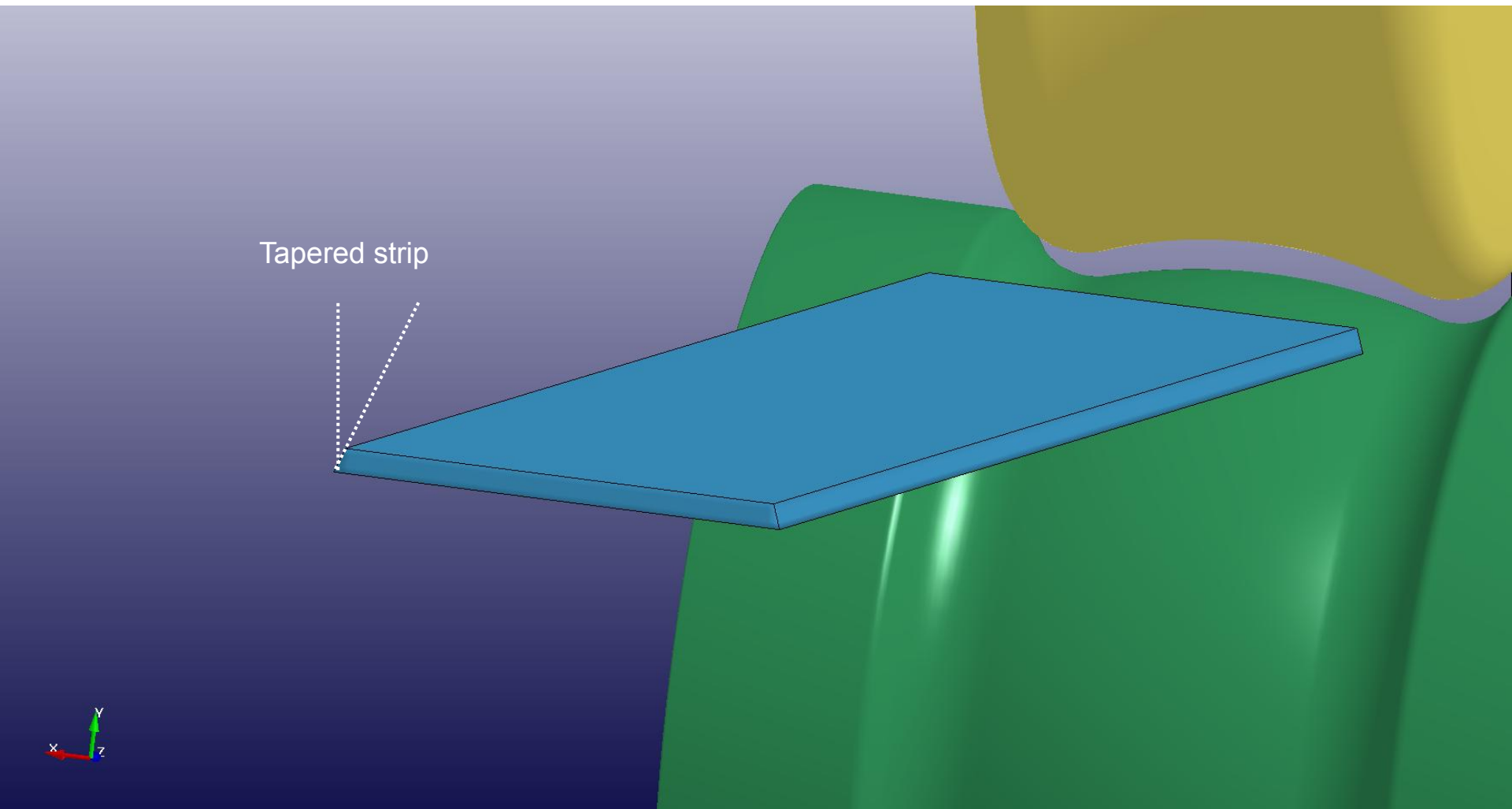
Roll forming of tubes

Time = 0.0157
Contours of Effective Plastic Strain
max IP. value
min=0, at elem# 12001
max=6.12112, at elem# 269732





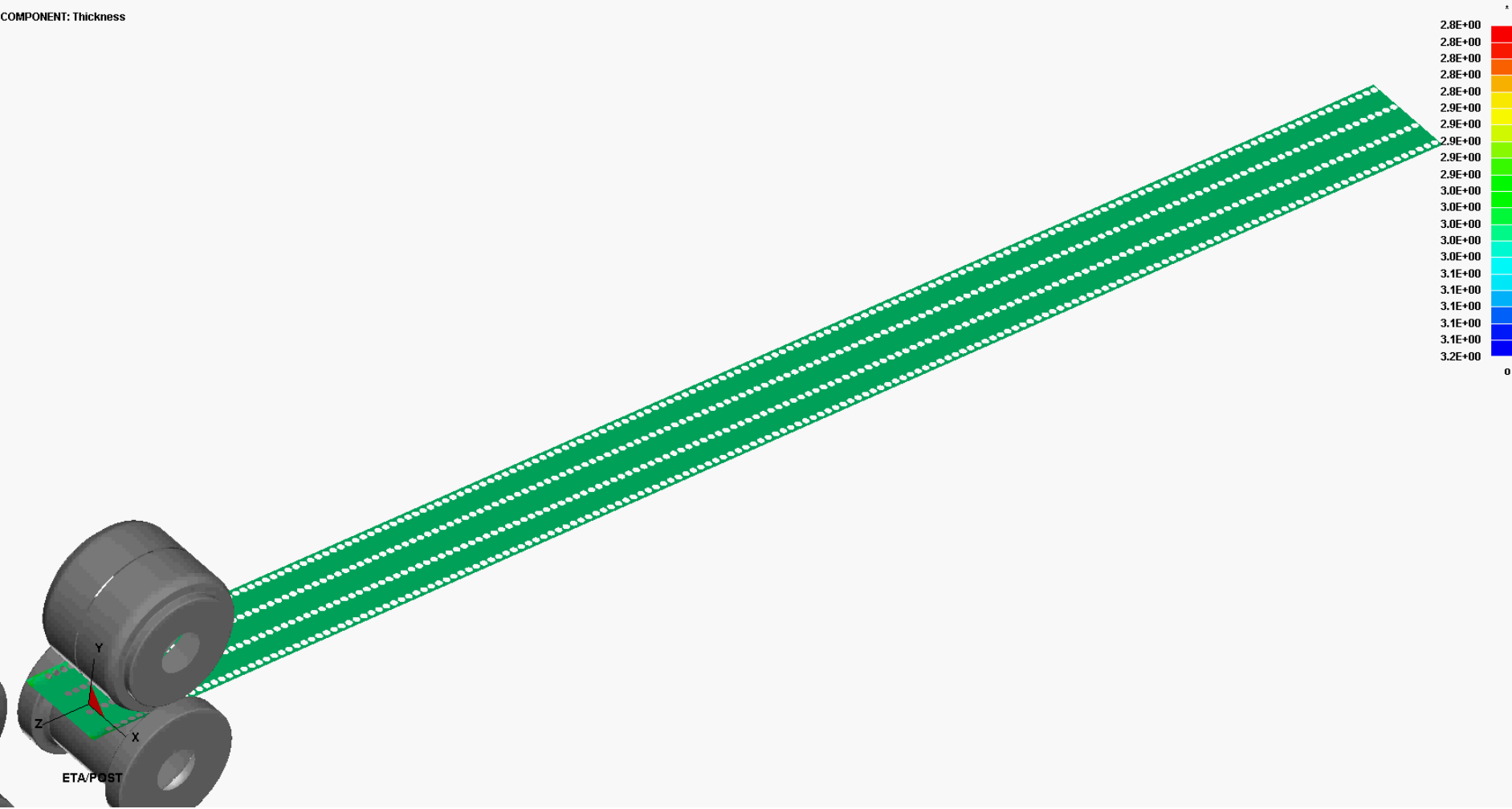
Model design:





Postprocessing | Shells | Thickness:

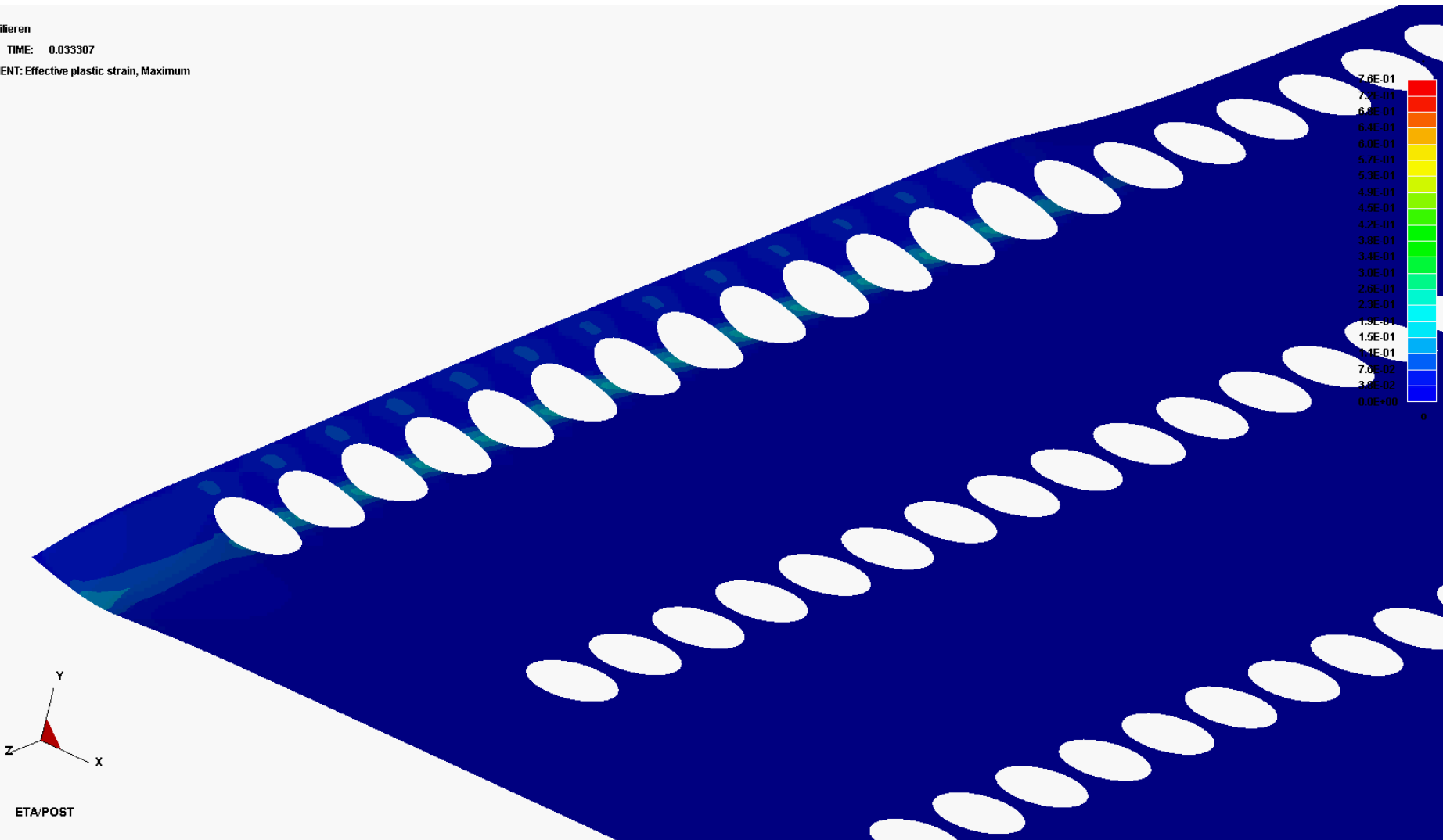
Walzprofilieren
STEP 7 TIME: 0.022203
COMPONENT: Thickness





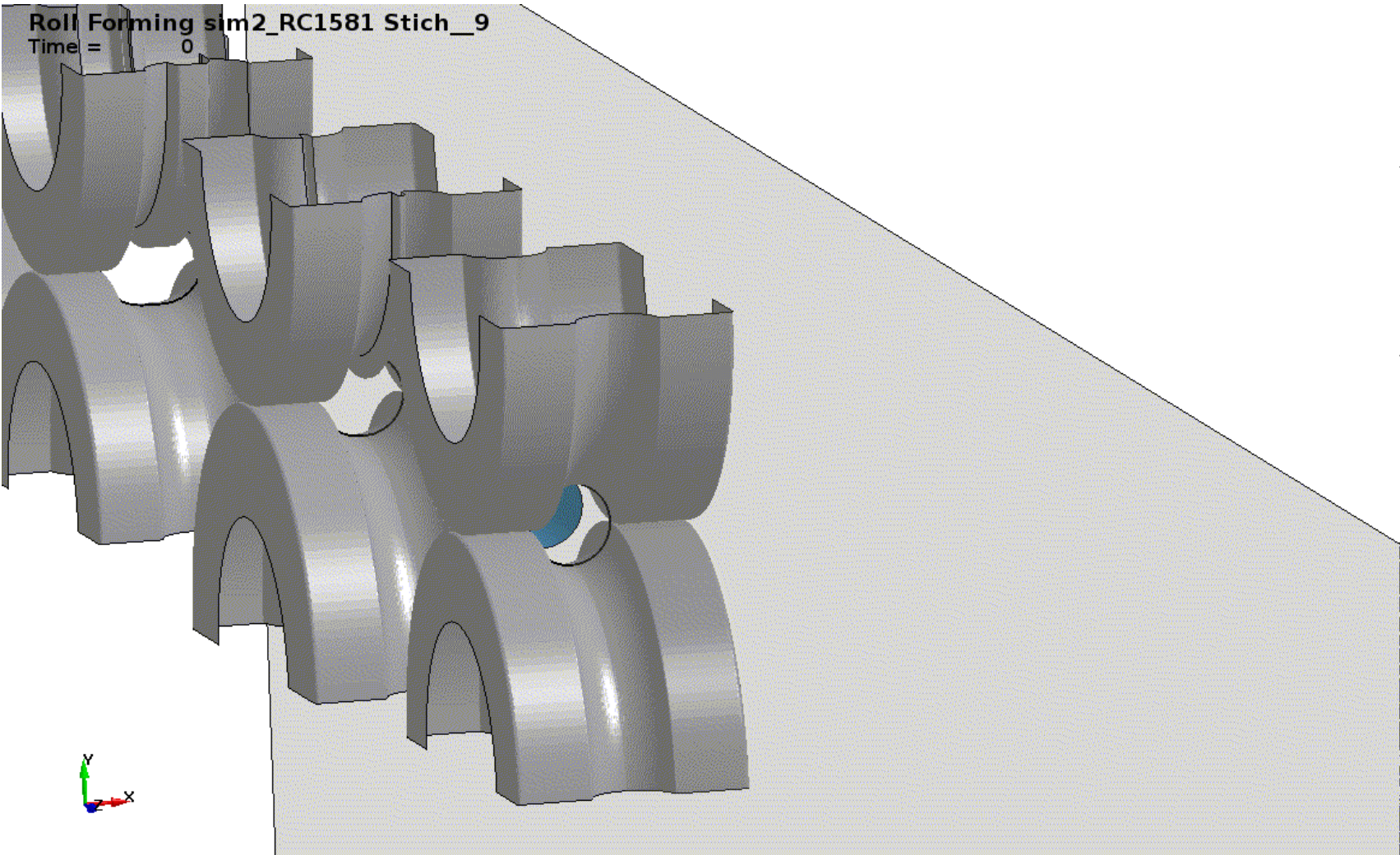
Postprocessing | Shells | Plastic strains with holes:

Walzprofilieren
STEP 10 TIME: 0.033307
COMPONENT: Effective plastic strain, Maximum



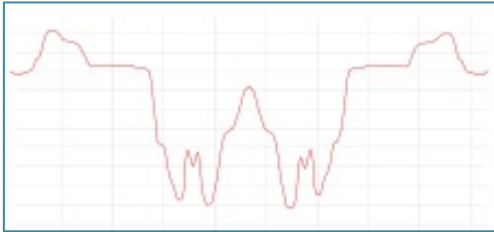
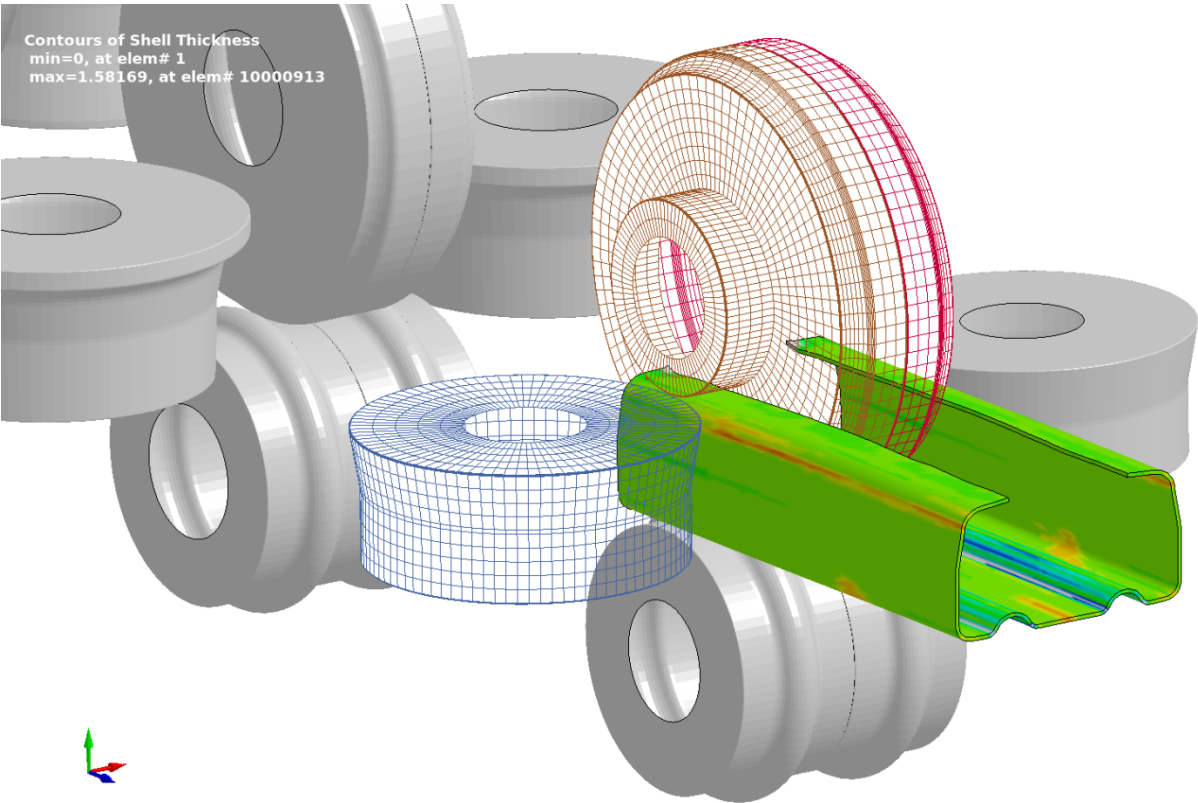


Postprocessing | Shells | Welding:





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

