



eta/DYNAFORM 5.9

Neue Features

12. November 2012

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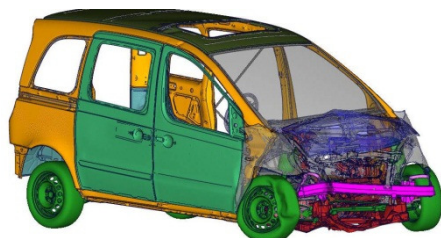
<http://www.dynamore.de>

- Die DYNAmore GmbH
- ETA – ein paar Zahlen
- Bestehende LS-DYNA und eta/DYNAFORM Kunden
- eta/DYNAFORM 5.9 – Neue Features
- Ausblick
- EADS: Anwendung aus der Industrie

DYNAmore GmbH

Gesellschaft für FEM-
Ingenieurdienstleistungen

Industriestrasse 2
70567 Stuttgart
Tel.: 0711 / 45 96 00 0
<http://www.dynamore.de>
<http://www.dynaexamples.com>



Your DYNA distributor and
more



Facts

- 70 employees in 2012
- headquarters located in Stuttgart/Vaihingen
- office in Langlingen, Dresden, Berlin, Ingolstadt
- on-site office in Sindelfingen (Mercedes passenger cars)
- on-site office in Untertürkheim (Mercedes trucks)
- on-site office in Weissach (Porsche)
- on-site office in Ingolstadt (Audi)
- Subsidiary companies in S and CH
- More than 200 customers in D, A, CH, E, I, ...

- Established 1983
- Engineering Offices
 - Headquarters: Troy, Michigan USA
 - Locations: Canada, China, India
 - 300 Engineers
- Primary Business – CAE
 - Software Development and Distribution
 - eta/DYNAFORM
 - eta/PreSys
 - Engineering Services
 - Virtual Validation



www.eta.com

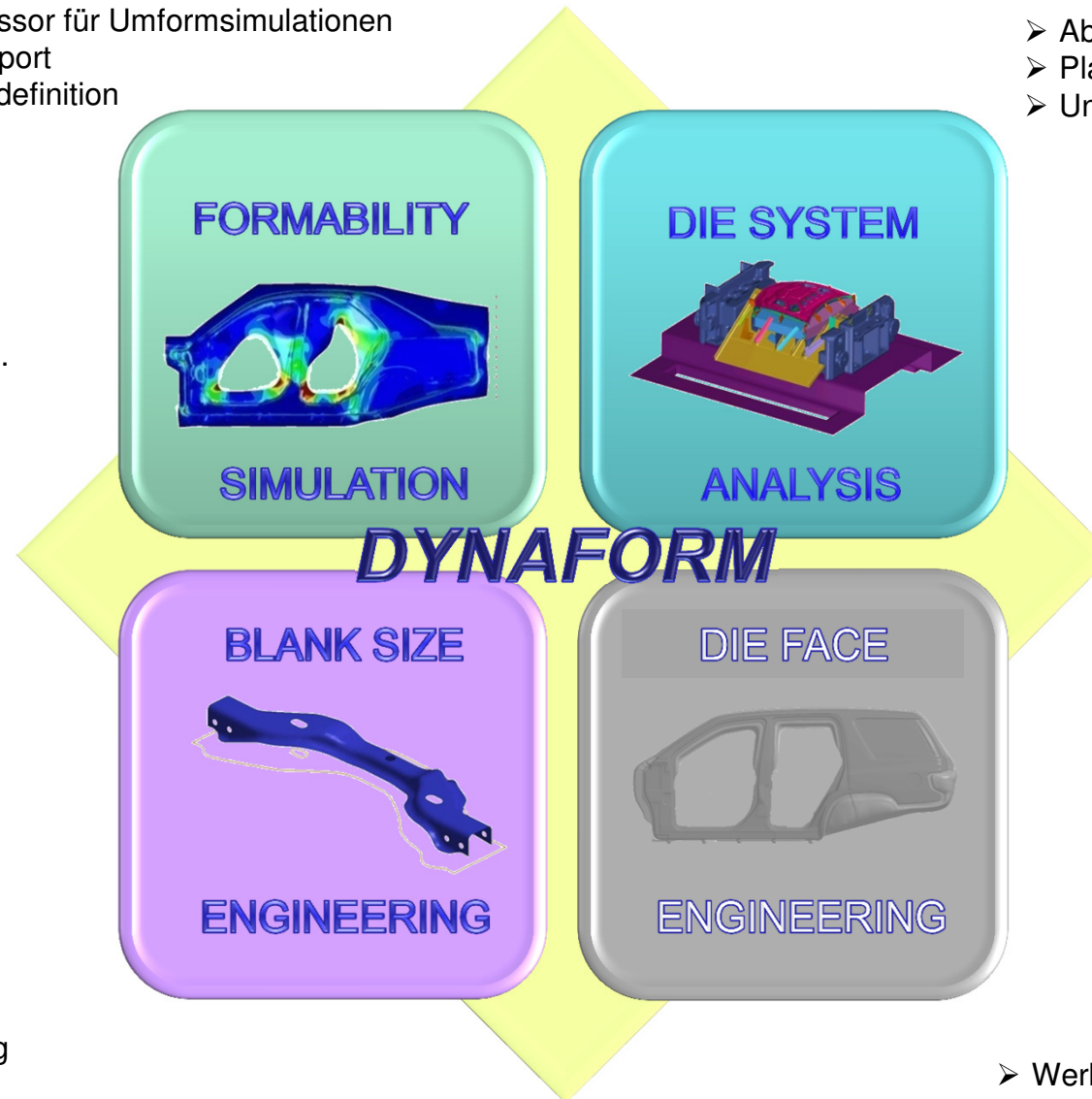
www.dynaform.com

www.etavpg.com



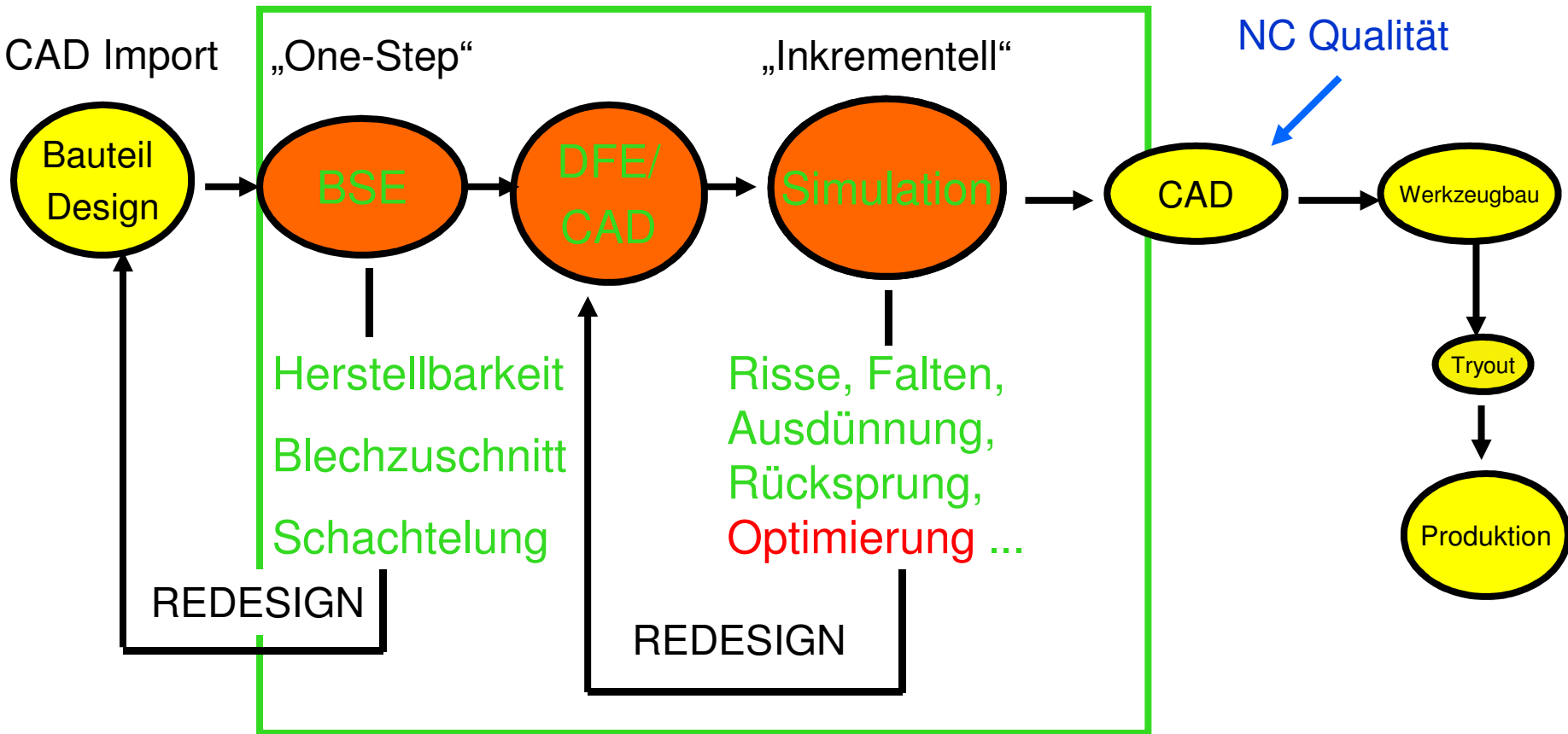
- Pre- und Postprozessor für Umformsimulationen
- CAD-Import und Export
- AutoSetup Prozessdefinition
- Materialdatenbank
- **Jobsubmitter**
- Kompensation
- Rohrbiegen
- Superplastisch
- IHU
- Abkanten, Falzen ...
- **Optimierung**

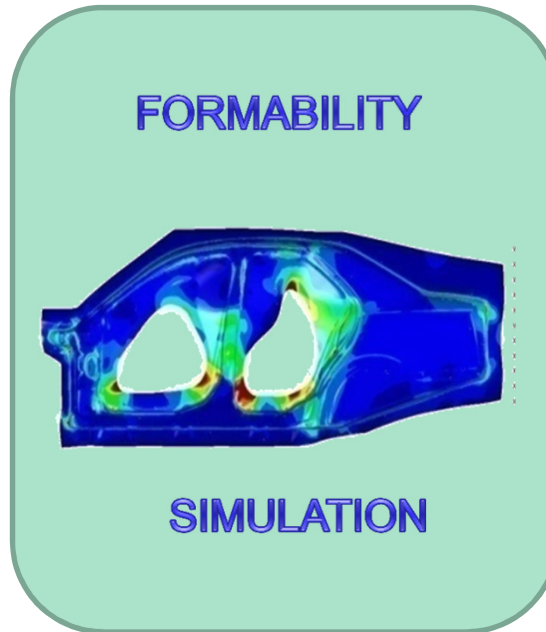
- Abfallbeseitigung
- Platinentransport
- Untersuchung der Werkzeuge



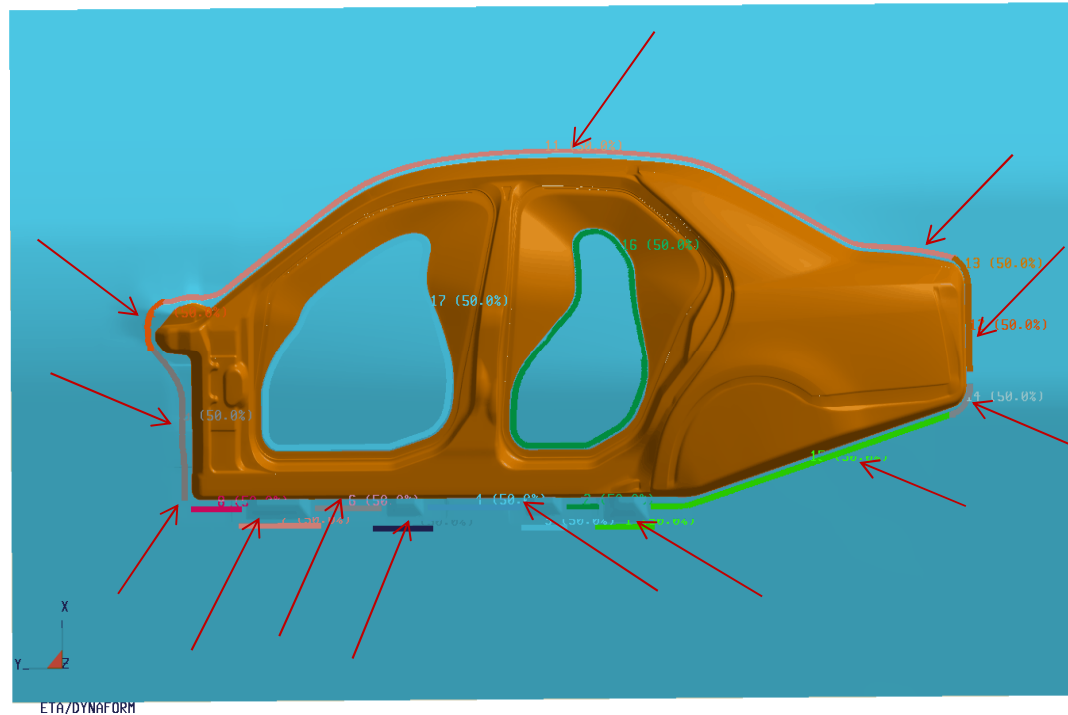
- Schachtelung
- Blechzuschnitt
- Modellaufbereitung
- Kostenkontrolle
- Machbarkeitsstudien im Einschrittverfahren

- Werkzeugkonstruktion



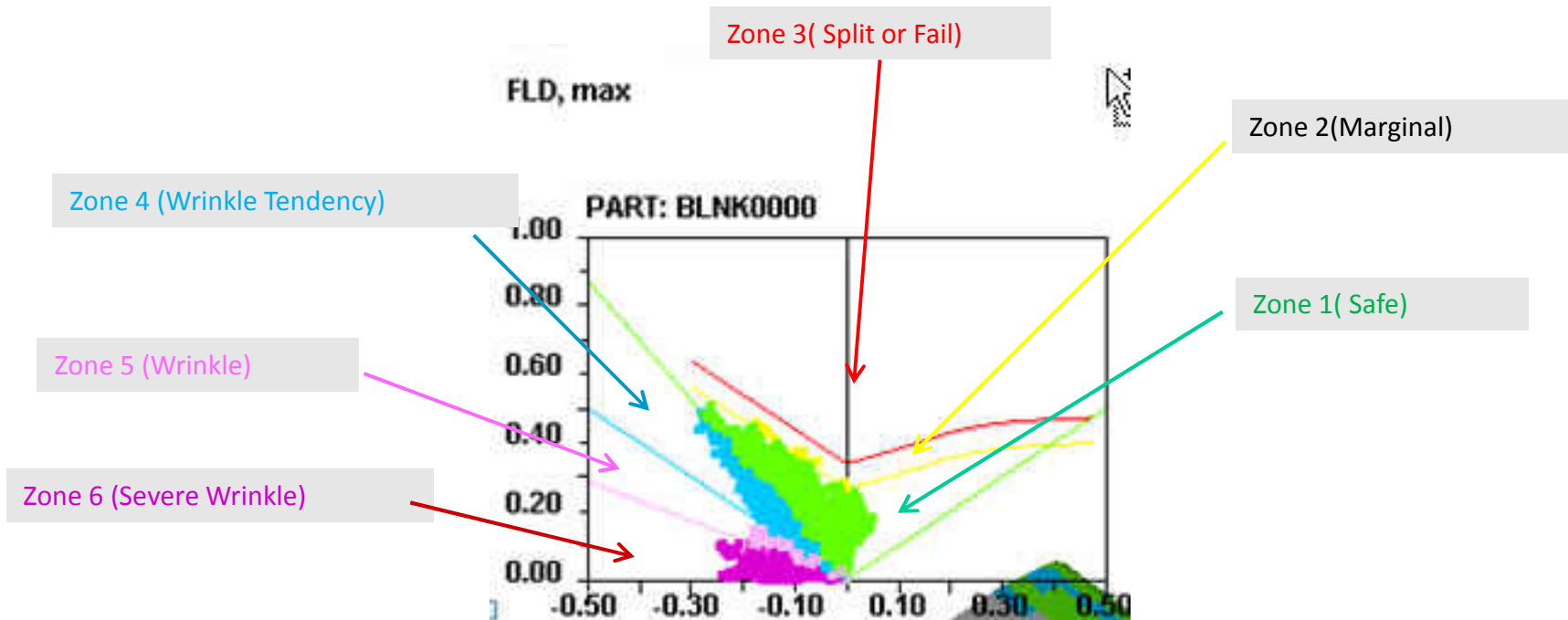


Optimization



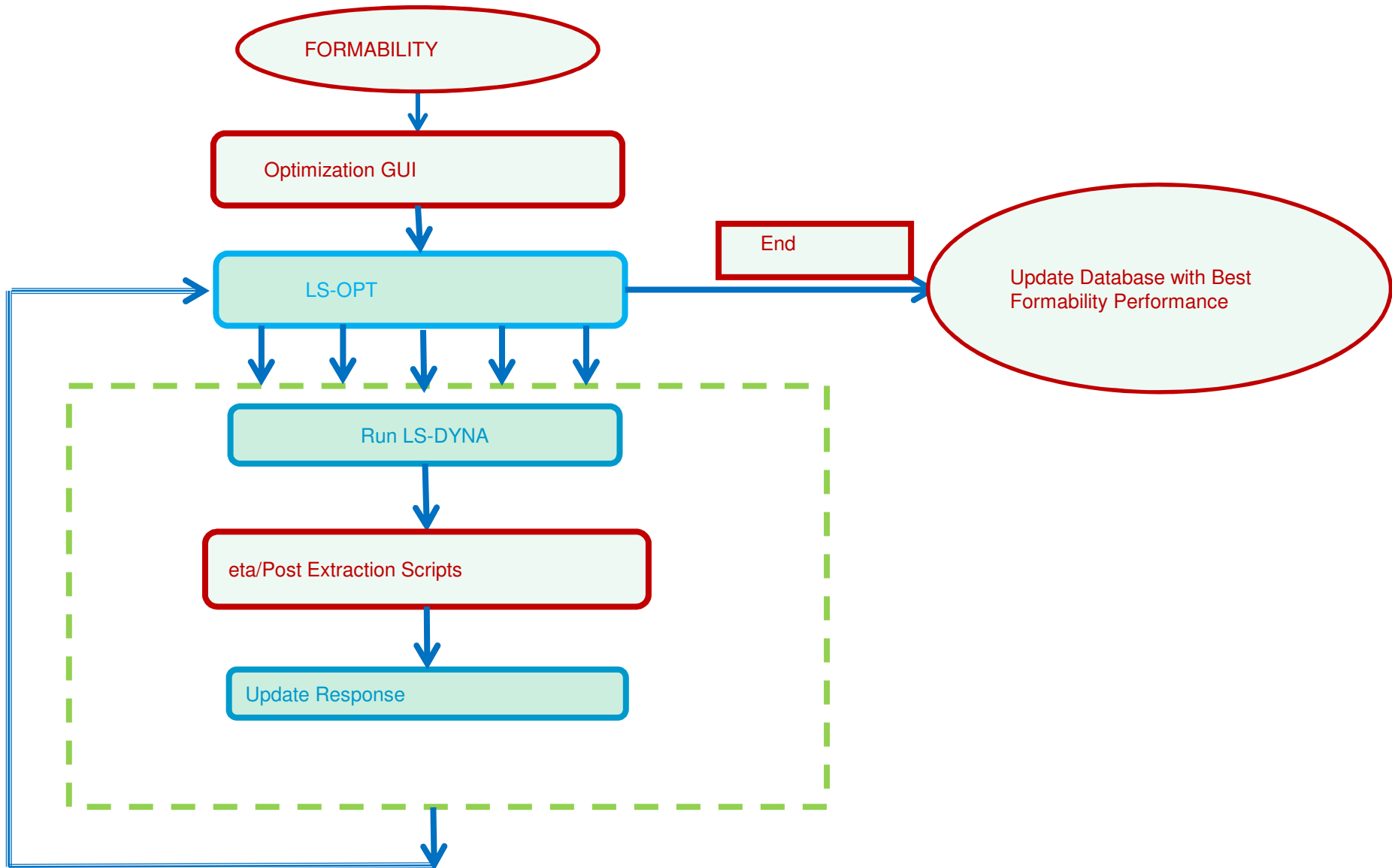
- Drawbeads are designed to restrict the blank from wrinkling & splitting in a forming process
- Adjusting Drawbead Forces of a large/complicated Drawbead setup can be very challenging, very time consuming to achieve a formable panel/part, take weeks
- Efficiently utilize the optimization technology with modern computing power for Drawbead Forces optimization is practical to achieve a optimum configuration in a reasonable time frame, take days

Forming Limited Diagram (FLD)

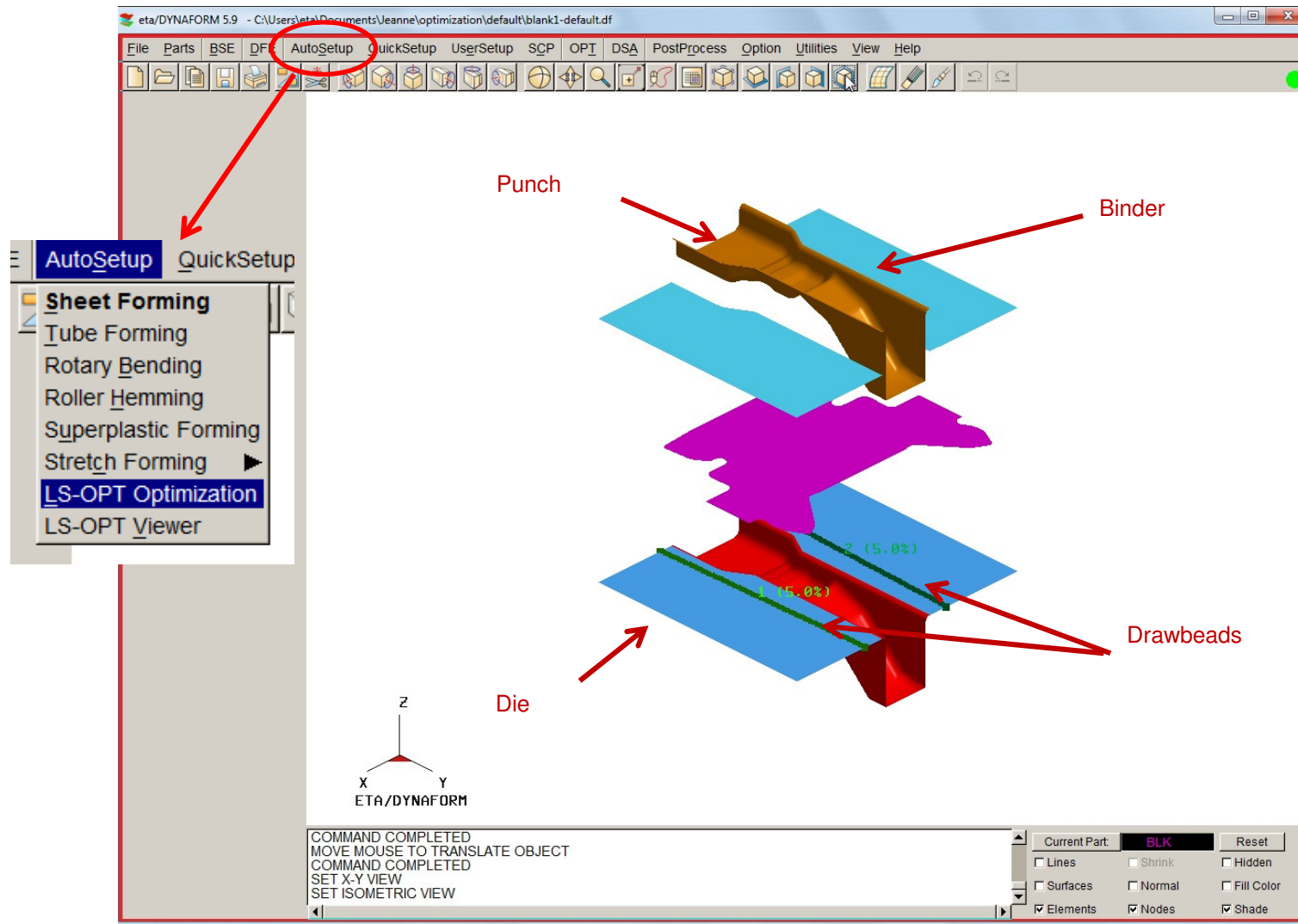


Define Constrain/Objective function as the ratio of elements in a particular Zone # / total elements

Optimization Flow Chart



Test Case 1: Tooling Setup



GUI of Optimization Overview

Design Variables

- > % Restraining Force
- > Friction Coefficient
- > Binder Force

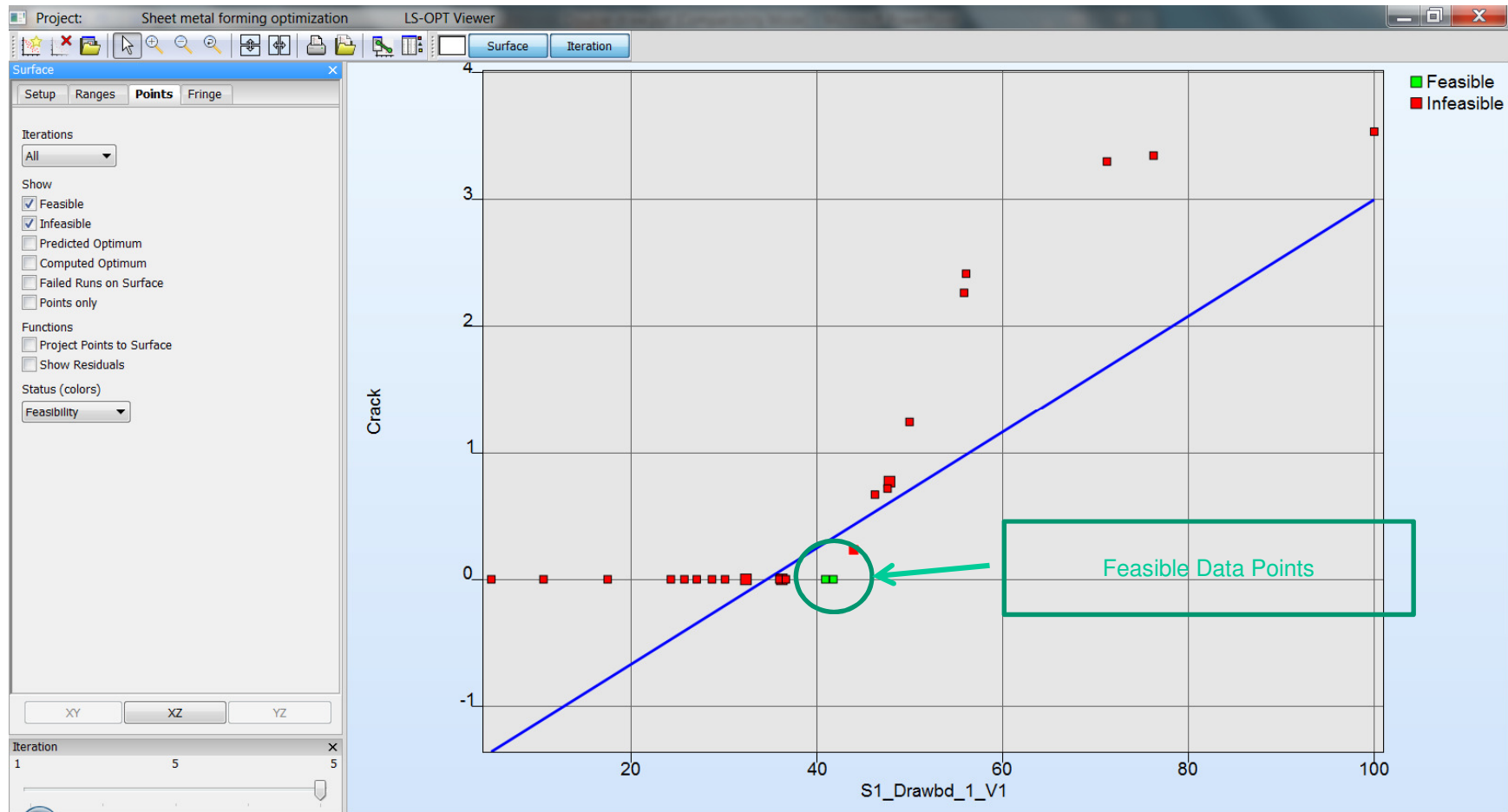
Define Objectives and Constraints

Optimization Methods options

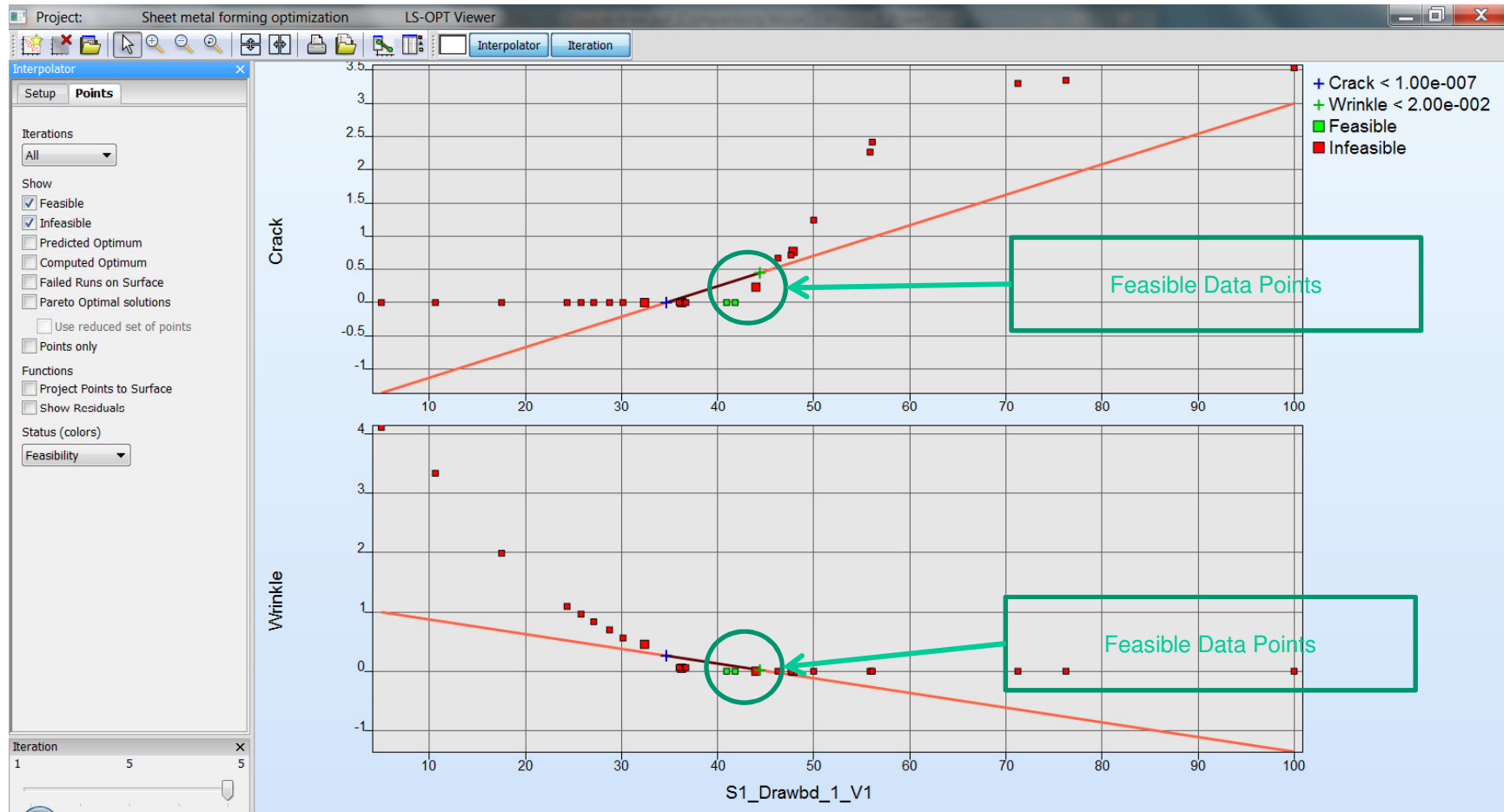
The screenshot displays the 'Sheet Forming Optimization' dialog box, divided into three main sections:

- Source:** A tree view on the left shows the hierarchy: Stages_(1_stages) > forming_<single_action > Friction (die, punch, binder) > Drawbead > Drawbd_1. A table on the right lists seven design variables (S1_Drawbd_1_V1 to S1_Drawbd_7_V1) with 'Contir' type and a range of 5 to 100. A baseline of 50.0 is set for each.
- Responses:** A list on the left includes Crack, Wrinkle, Thinning, InsufficientStretch, and BendingStrain. The 'Objective' table shows 'Crack' and 'Wrinkle' to be minimized with normalizing factors of 0.8 and 0.2. The 'Constraint' table shows 'C-Crack' and 'C-Wrinkle' with limits of 0 and 0.02. Below are input fields for 'Allowable Thinning(%)' (20.0) and 'Allowable Bending Strain' (0.500).
- Optimization Methods options:** Includes 'Number of Iteration' (9), 'Number in Parallel' (4), 'Strategy' (Sequential with Domai), 'Metamodel' (Polynomial), 'Point' (D-Optimal), 'Algorithm' (GA), and 'Solver' (Setting). It also features checkboxes for 'Advanced' and 'Global', and input fields for '10000', 'Order' (Linear), 'Number of Simulation Points' (13), 'Population' (100), and 'Generation' (250).

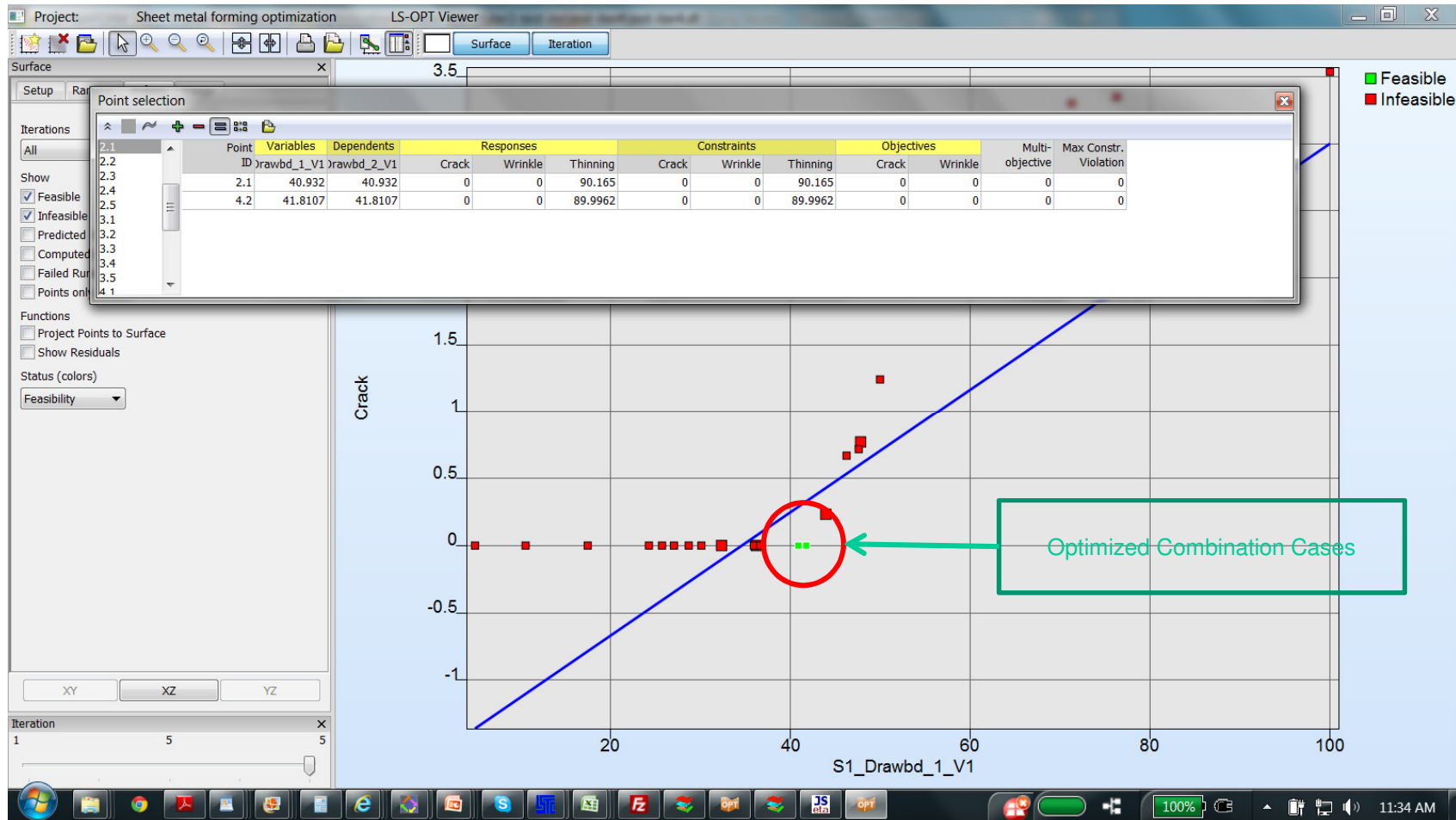
Test Case 1: Splits Response



Test Case 1: Splits and Wrinkle Responses

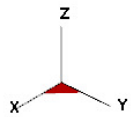
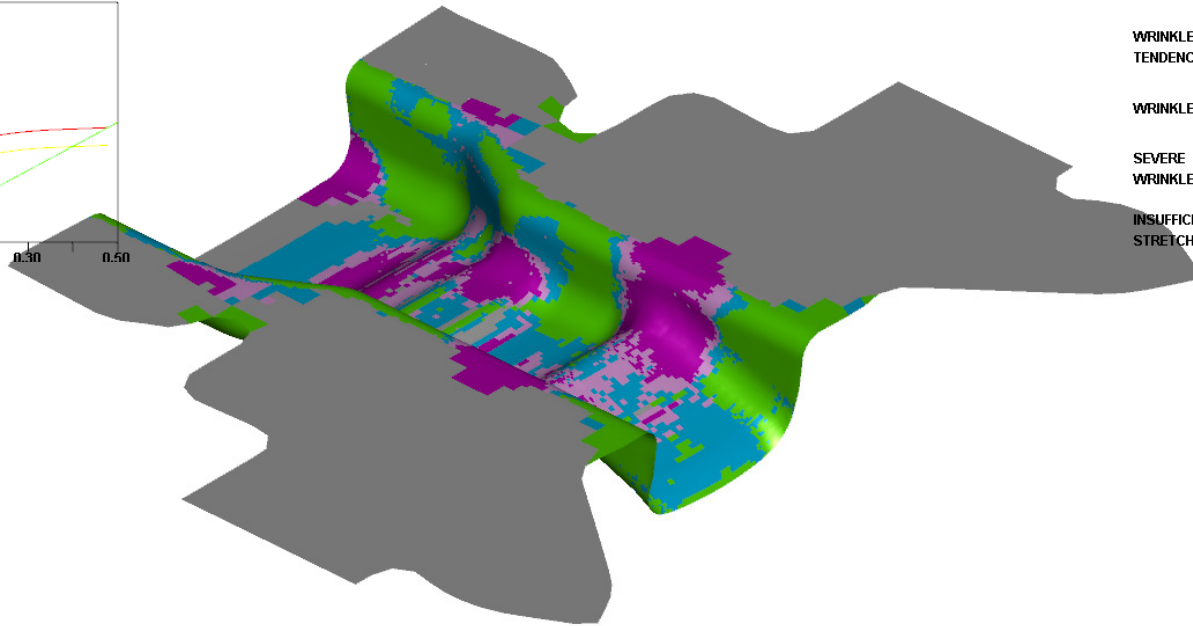
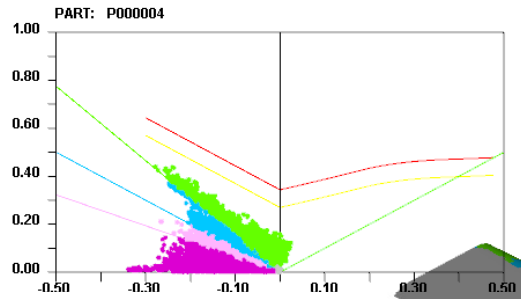


Test Case1: Feasible Designs



Test Case1 - Baseline

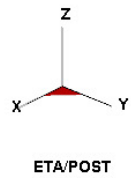
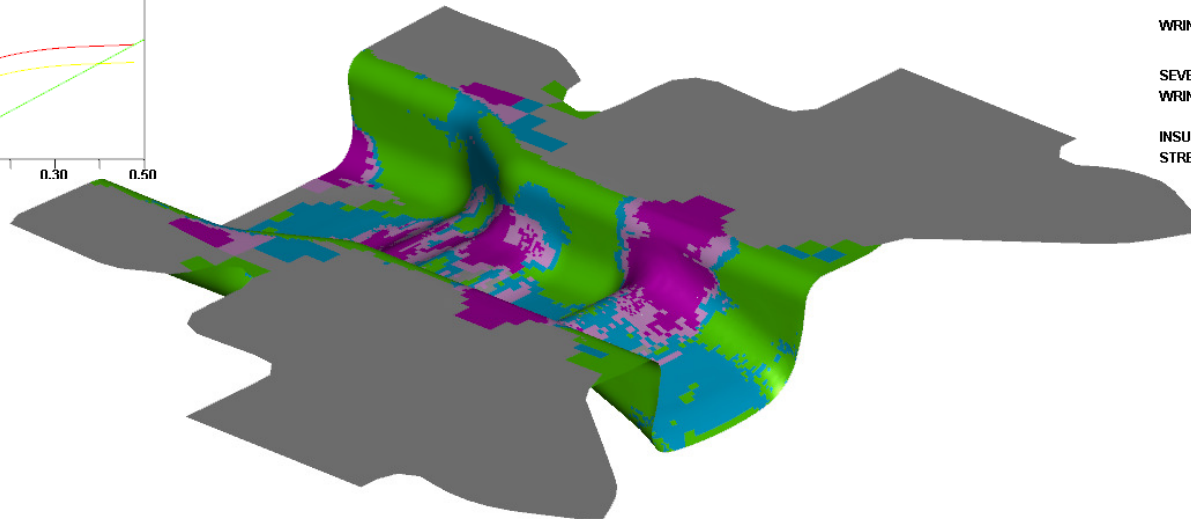
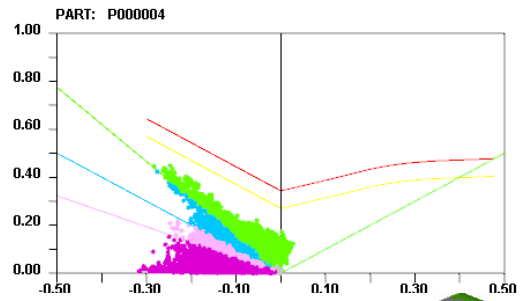
blank1_bead
STEP 17 TIME: 0.015871
FLD, max



ETA/POST

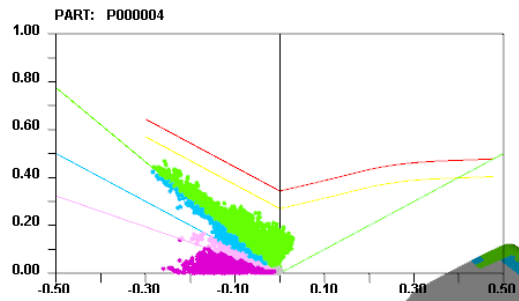
Test Case1- Feasible Iteration

blank1_bead
STEP 17 TIME: 0.015871
FLD, max

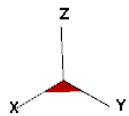


Test Case1- Feasible Iteration

blank1_bead
STEP 17 TIME: 0.015871
FLD, max



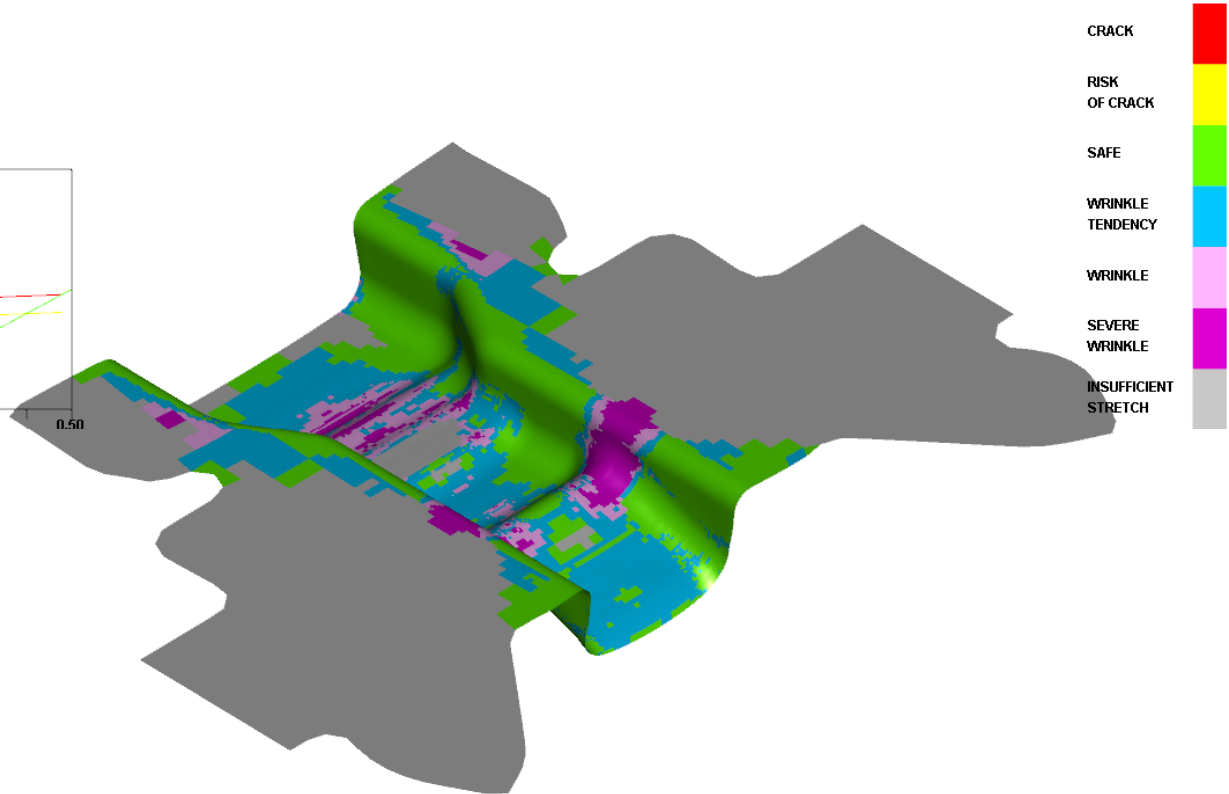
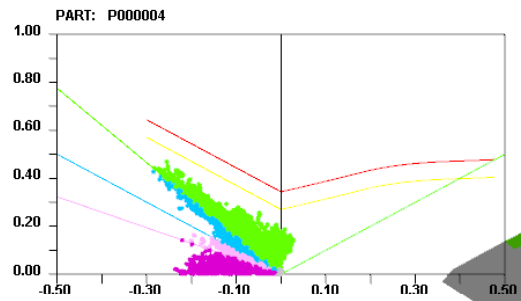
- CRACK
- RISK OF CRACK
- SAFE
- WRINKLE TENDENCY
- WRINKLE
- SEVERE WRINKLE
- INSUFFICIENT STRETCH



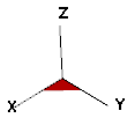
ETA/POST

Test Case1- Feasible Iteration

blank1_bead
STEP 17 TIME: 0.015871
FLD, max



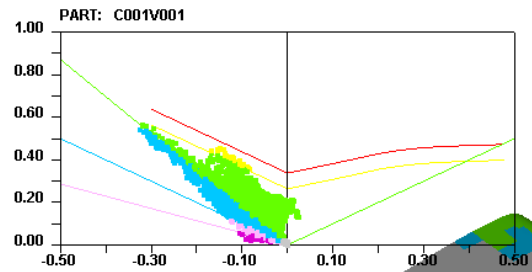
CRACK
RISK OF CRACK
SAFE
WRINKLE TENDENCY
WRINKLE
SEVERE WRINKLE
INSUFFICIENT STRETCH



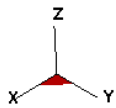
ETA/POST

Test Case1- Feasible Iterations

untitled
STEP 18 TIME: 0.014481
FLD, max



CRACK
RISK OF CRACK
SAFE
WRINKLE TENDENCY
WRINKLE
SEVERE WRINKLE
INSUFFICIENT STRETCH



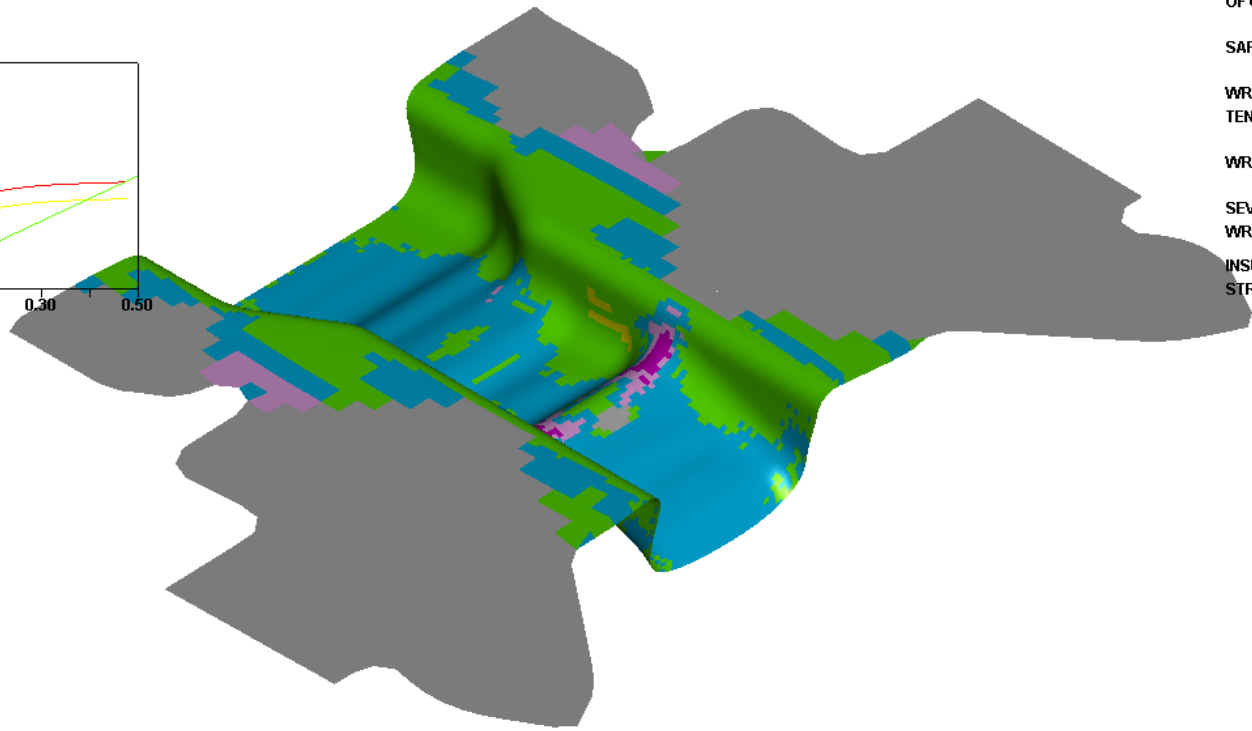
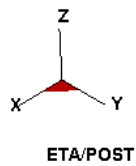
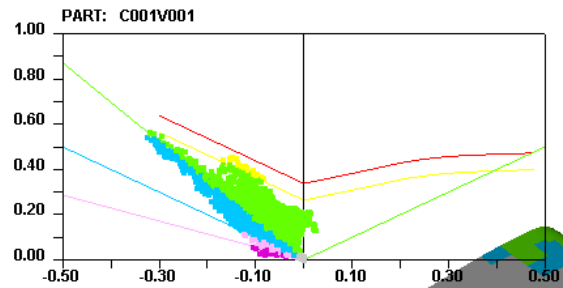
ETA/POST

Test Case1 - "Optimized" Drawbead Rates

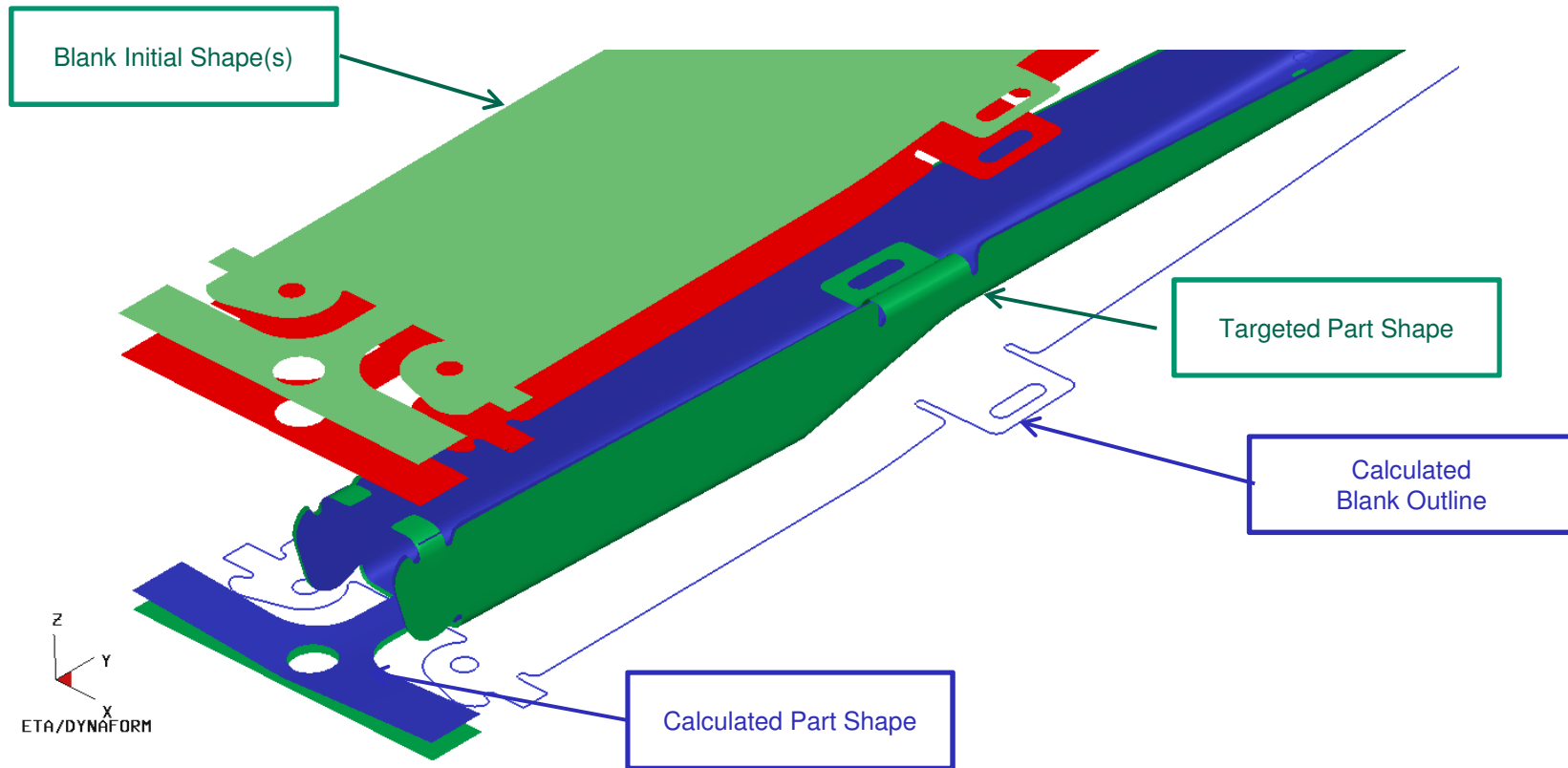
untitled

STEP 18 TIME: 0.014481

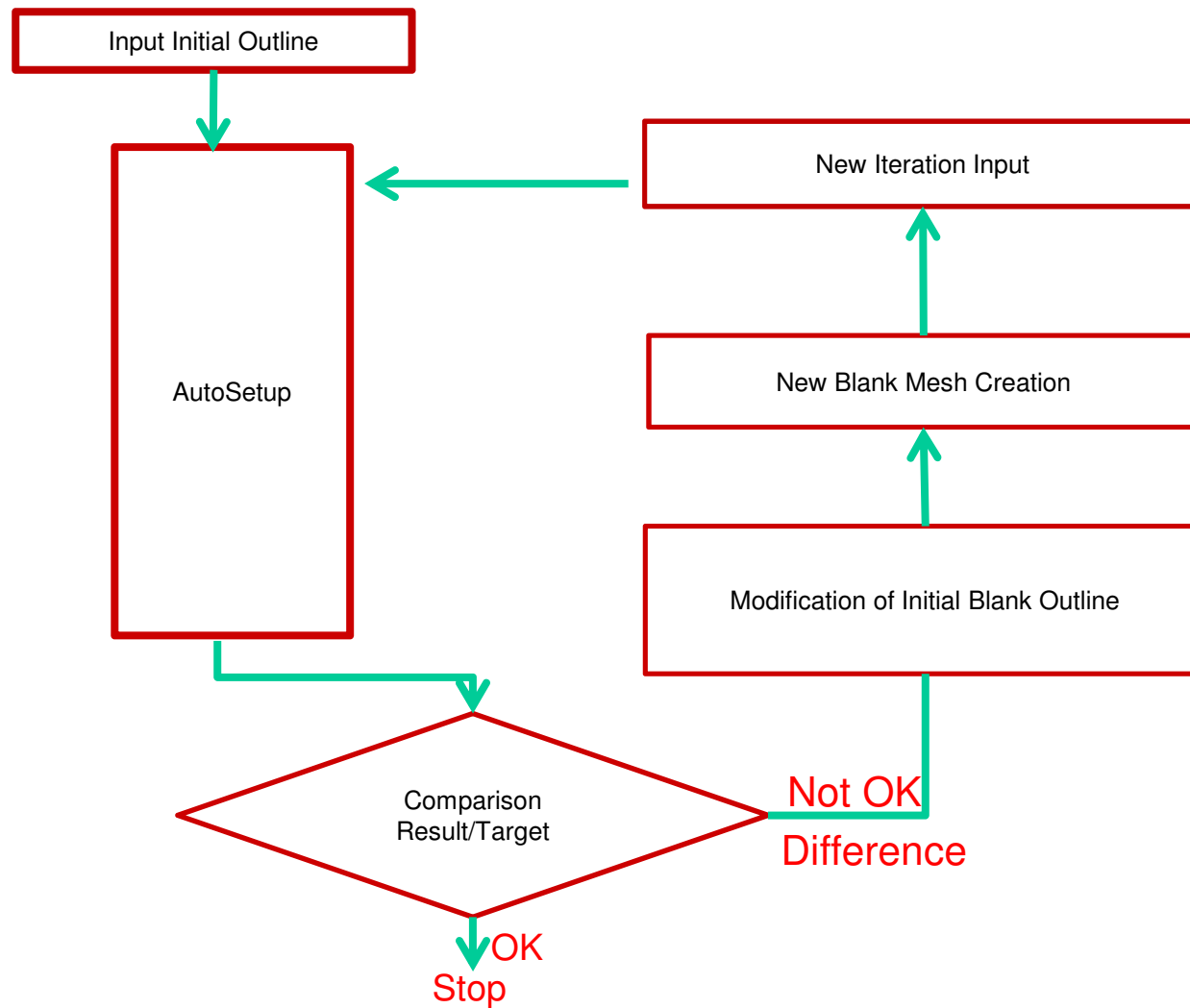
FLD, max



Blank Outline Optimization

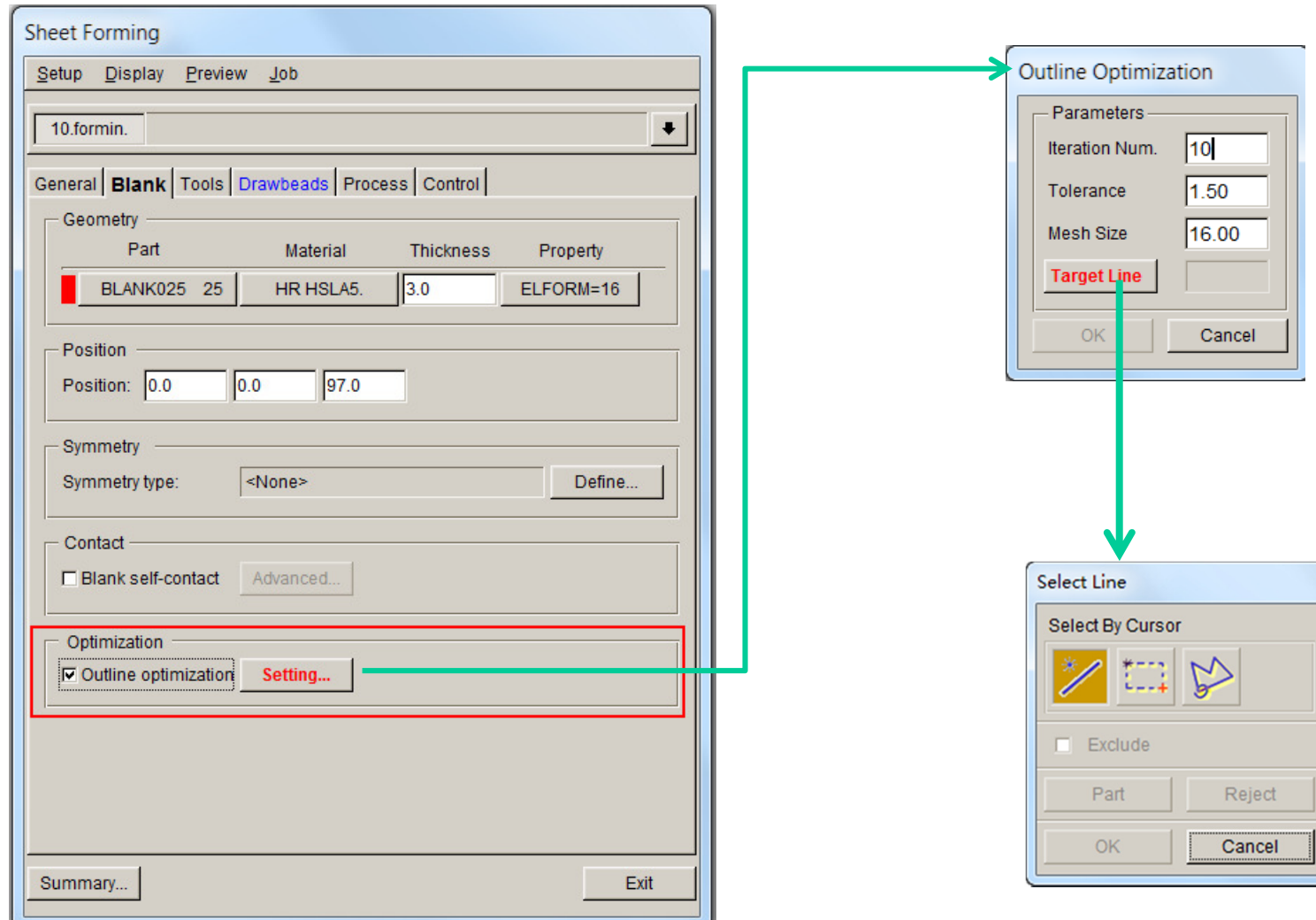


Workflow of Blank Outline Optimization





The Optimization function is integrated in Blank of AutoSetup.



Parameters:

① **Iteration Num:** Define the Iteration number.

② **Tolerance:** Define the allowable maximum gap between Target line and the simulation result boundary line of optimized Blank outline.

③ **Mesh Size:** This parameter controls the element size. (Same as Blank Generator)

④ **Target Line:** Select Trim Line, or part boundary line, or bead line as target line.

Outline Optimization

Parameters

Iteration Num. 10

Tolerance 1.50

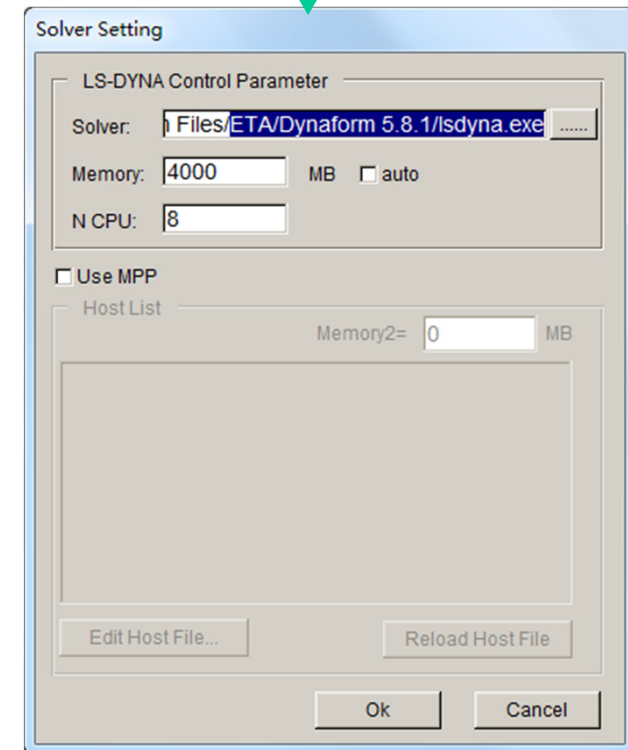
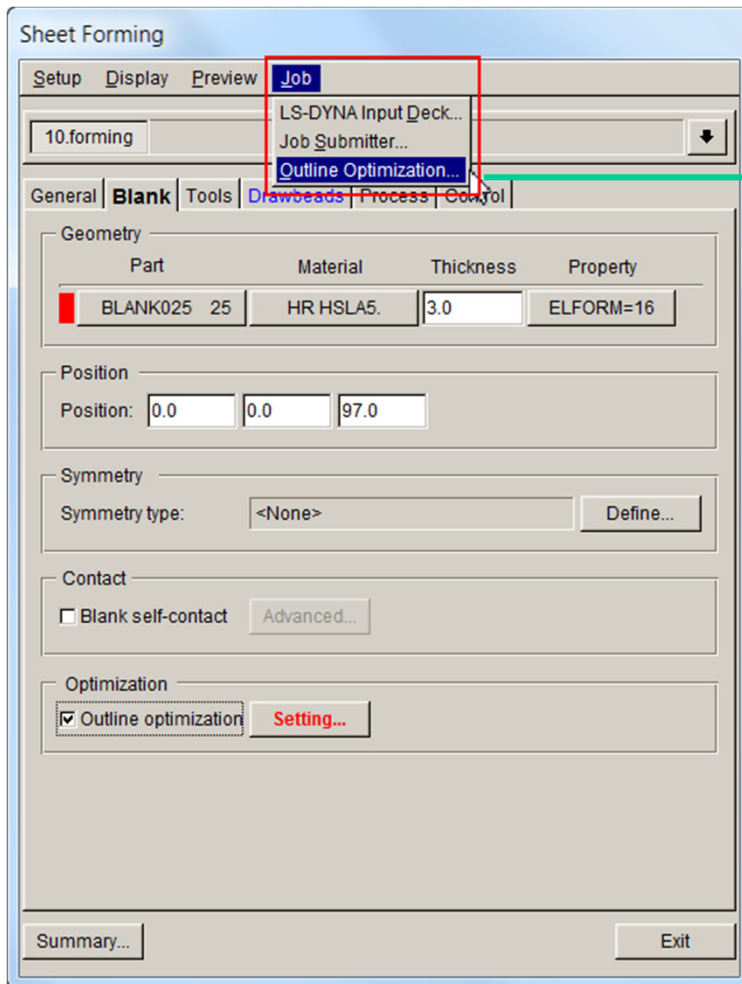
Mesh Size 16.00

Target Line

OK Cancel

Blank Outline Optimization

New option “*Outline Optimize*” is added in the Job menu, which is used to run blank optimization.



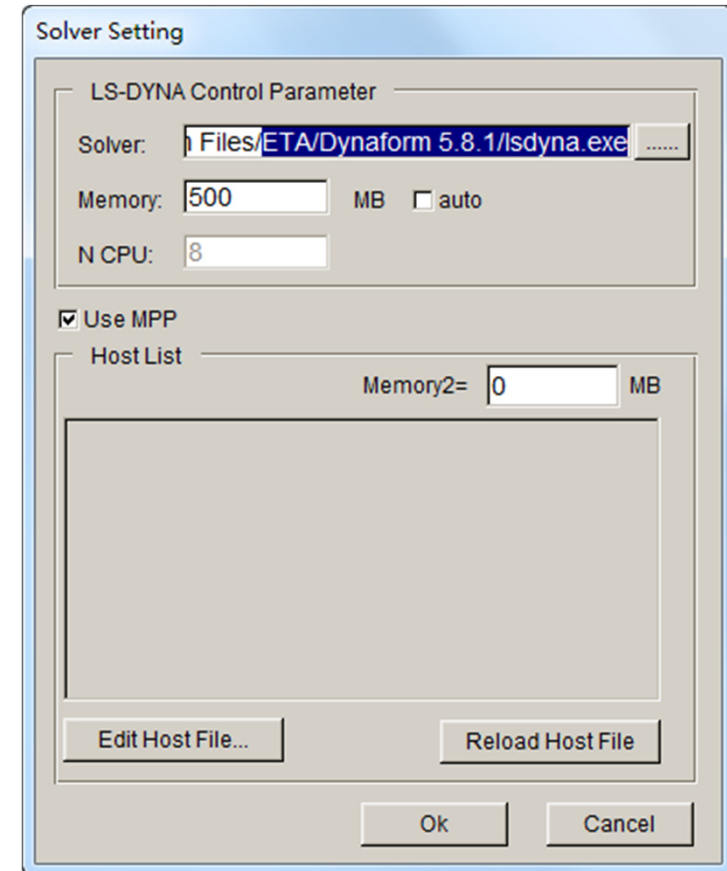
This optimization tool is independent of the solver; it works with LSDYNA_s.exe as well as LSDYNA_d.exe.

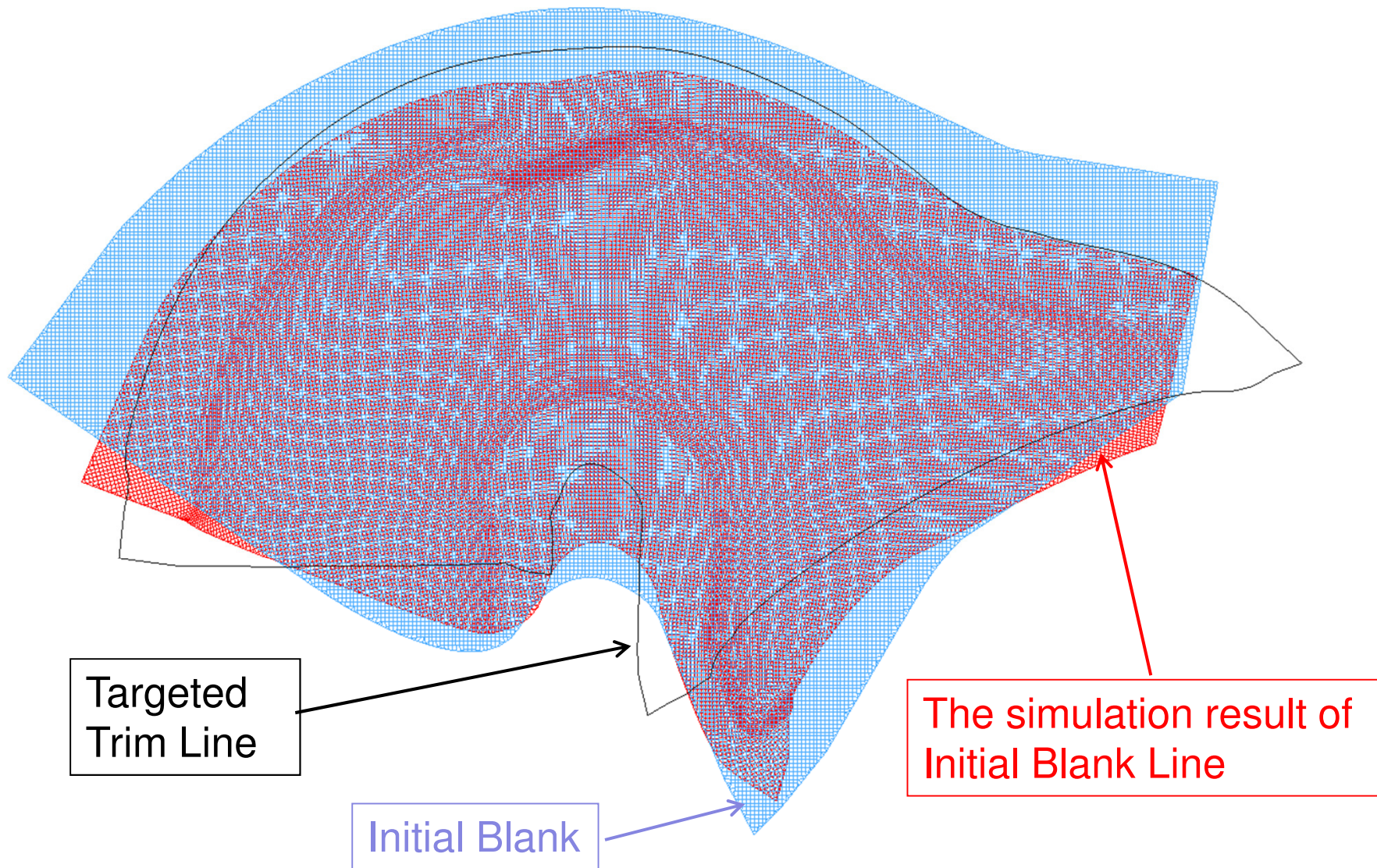
LS-DYNA Control Parameter:

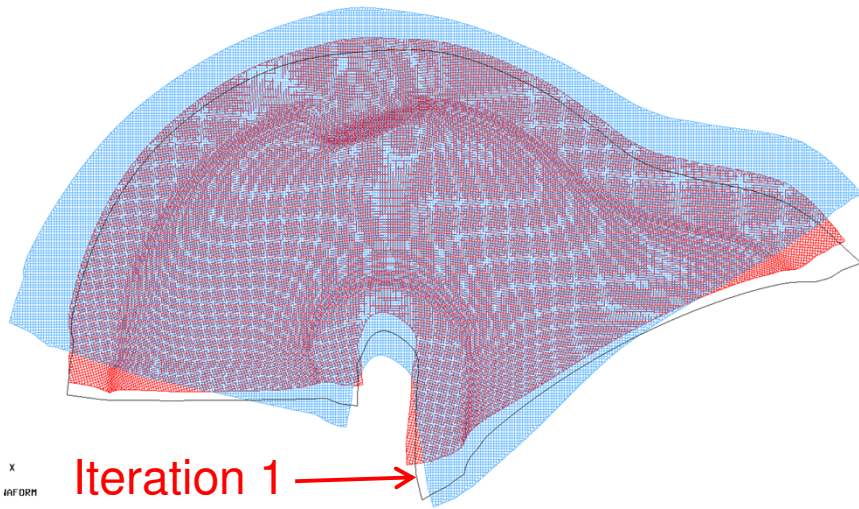
- **Solver:** Set the type of Solver.
- **Memory:** Set memory size for different stages.
- **N CPU:** Set CPU number.

Use MPP:

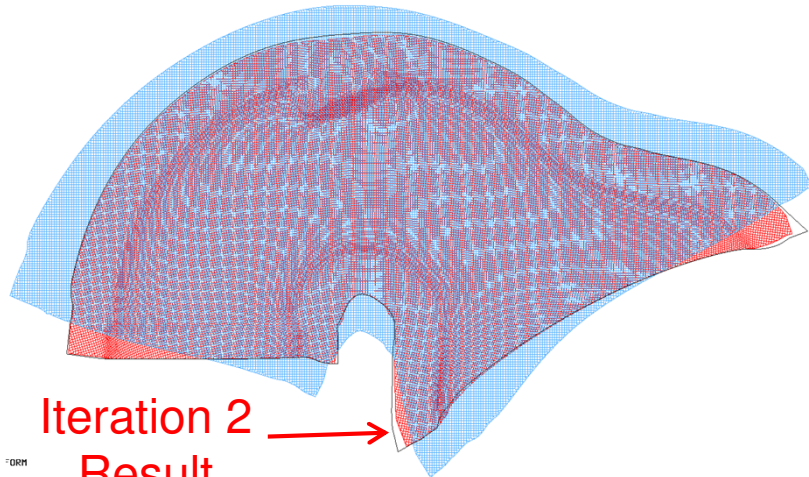
- **Memory2:** Set memory size for MPP.
- **Edit Host File:** Edit CPU config file.
- **Reload Host File:** Reload CPU config file.



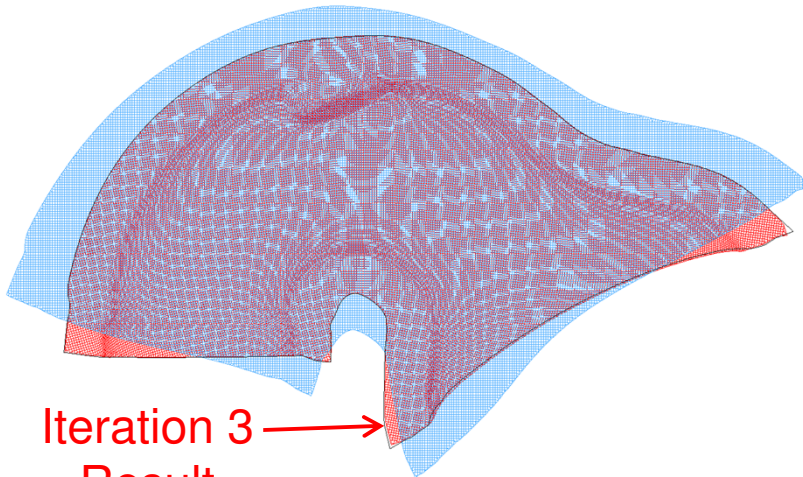




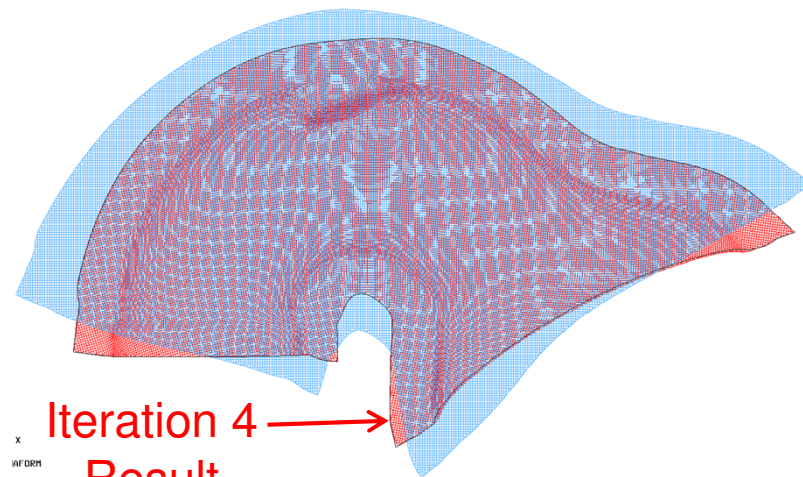
Iteration 1
Result



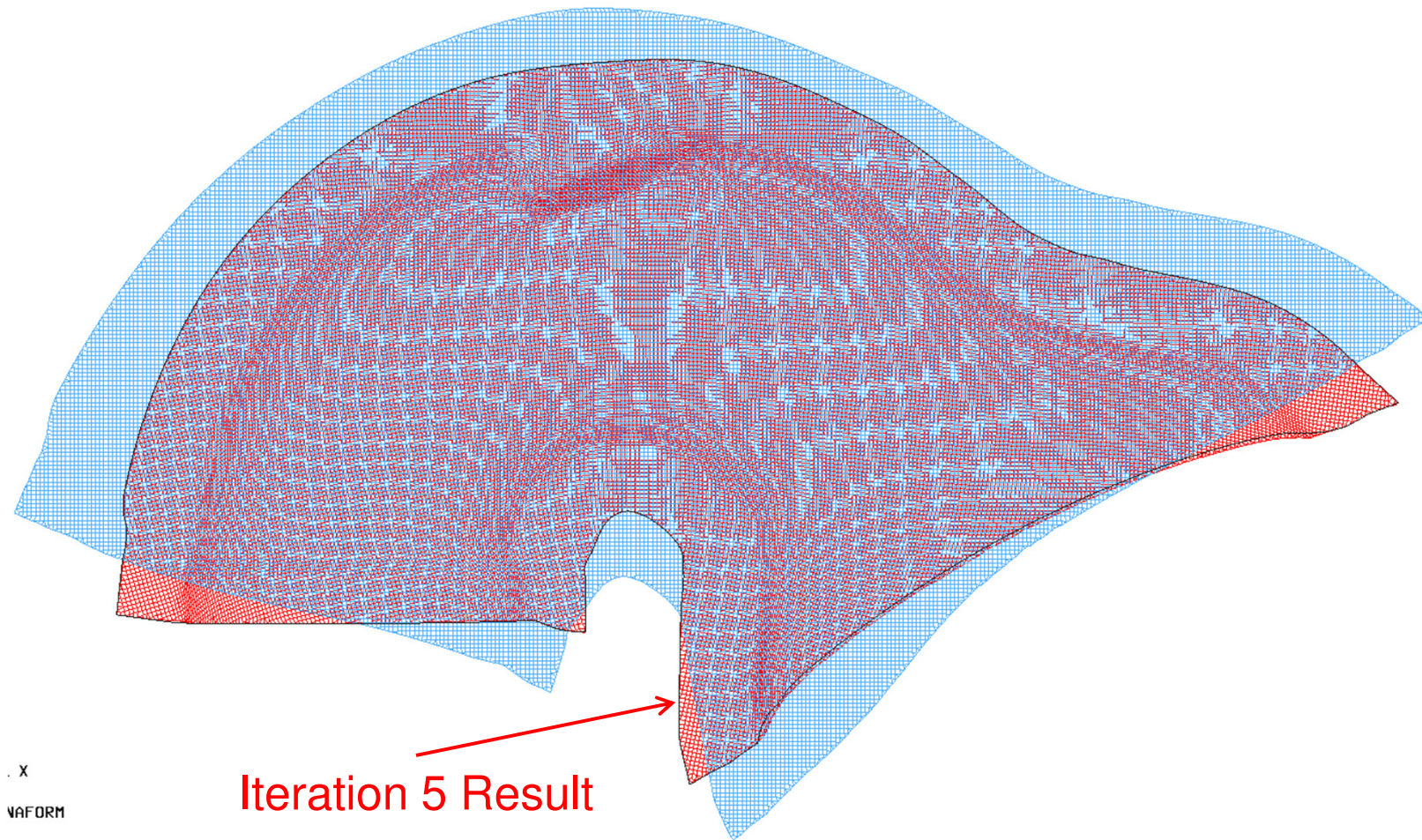
Iteration 2
Result



Iteration 3
Result



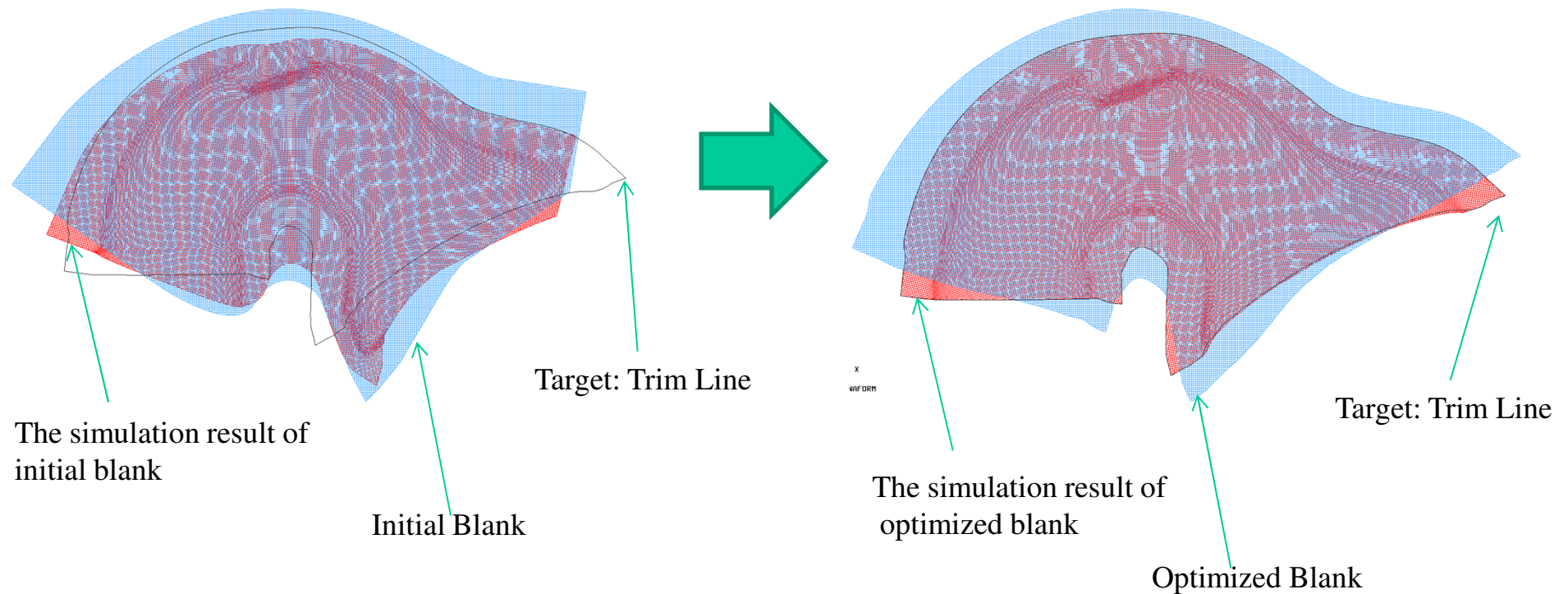
Iteration 4
Result

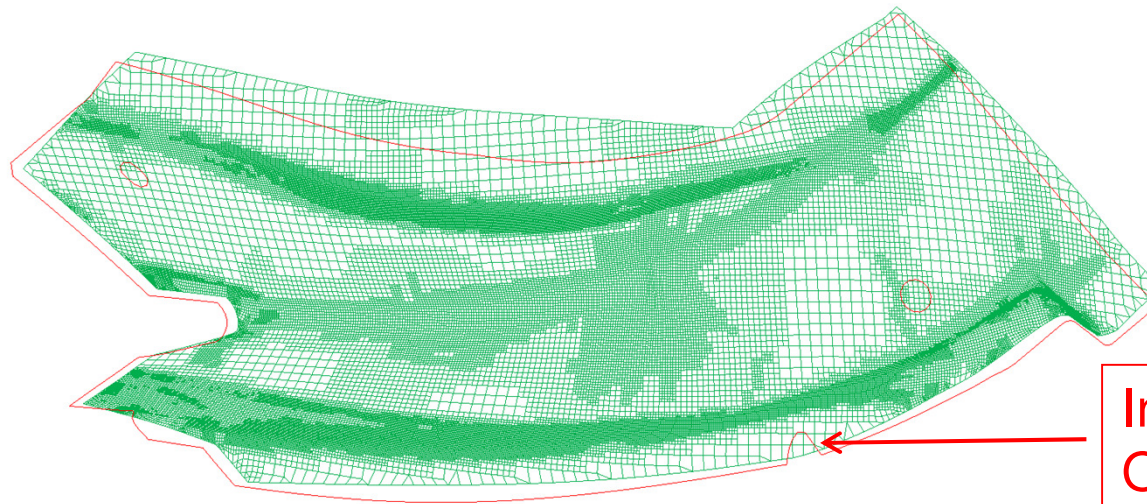


. X
NAFORM

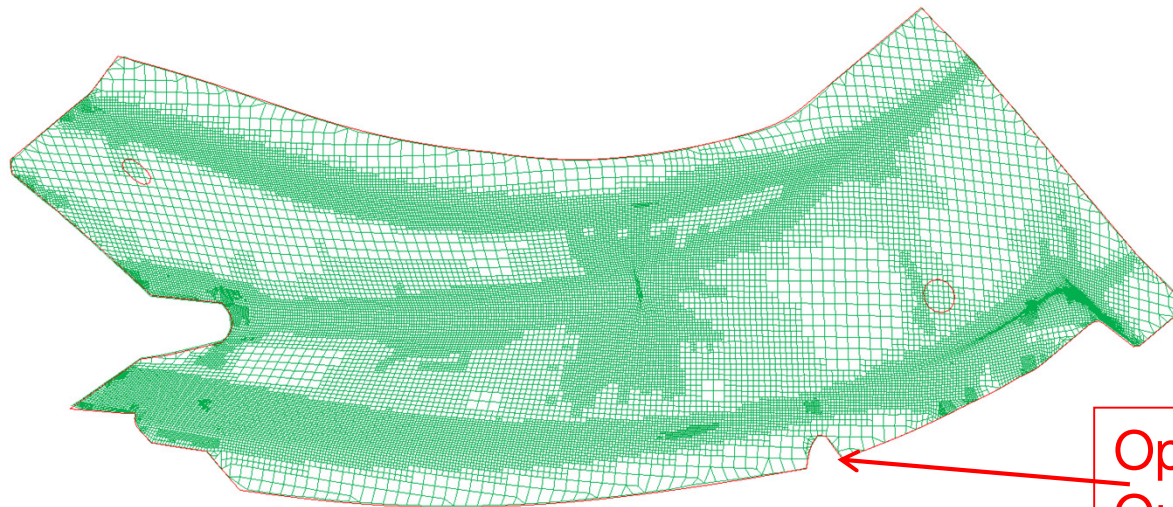
Iteration 5 Result
Simulation & Targeted
Blank Outlines Converged

Blank optimization provides an automatic method of modifying the blank outline in order that final blank matches the target.






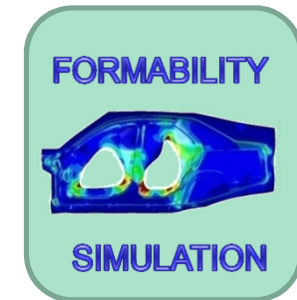
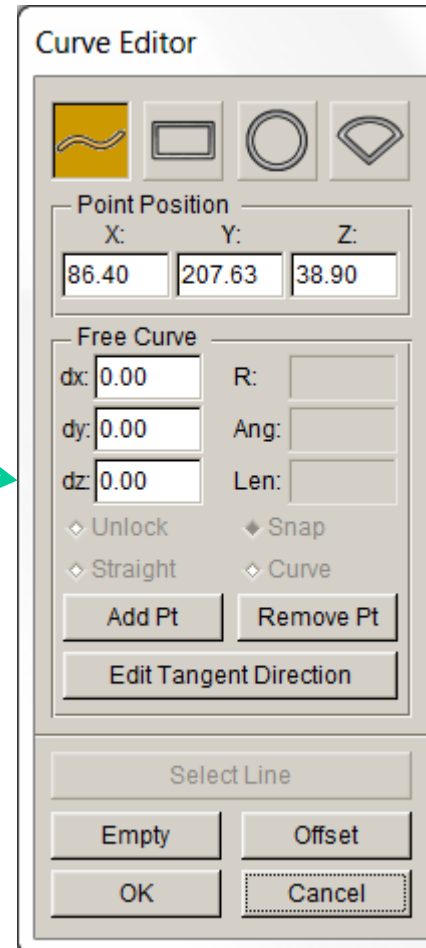
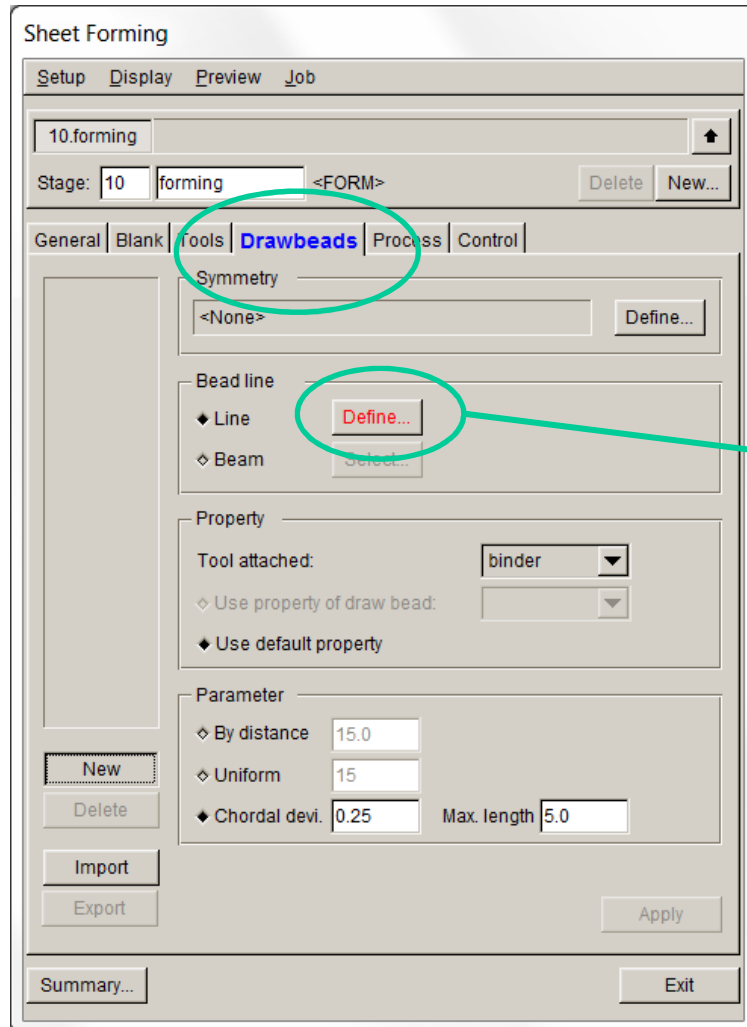
Initial Blank
Outline Result

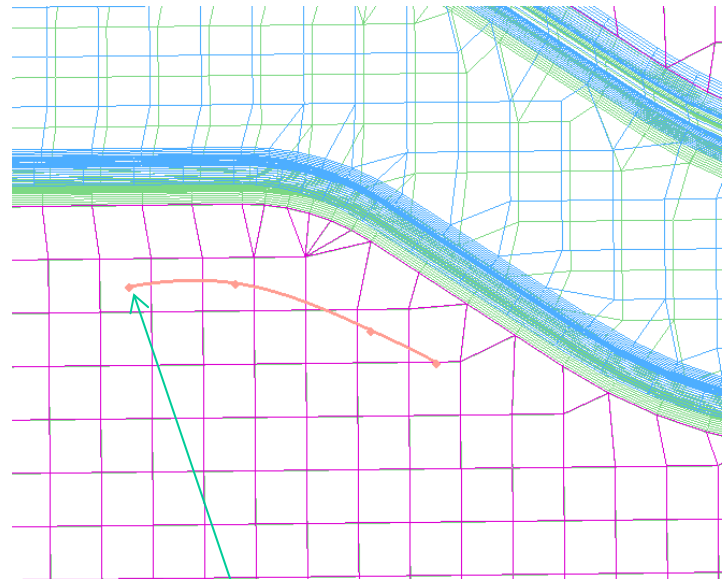
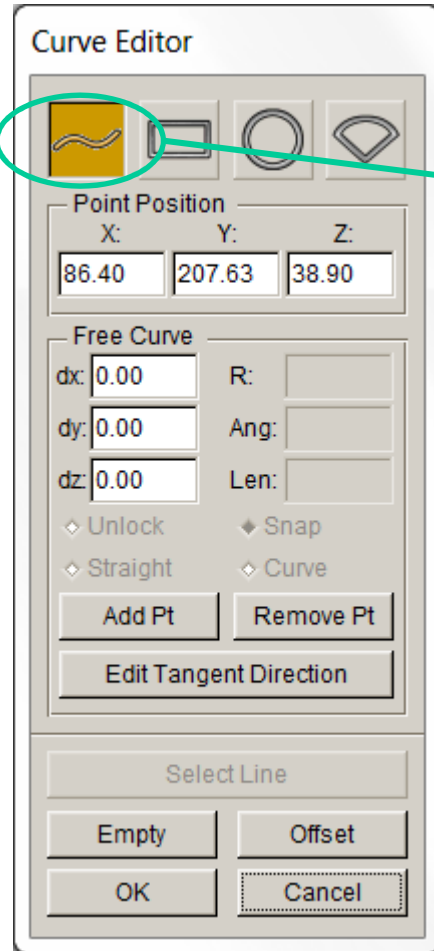


Optimized Blank
Outline Result

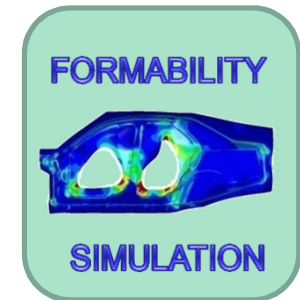


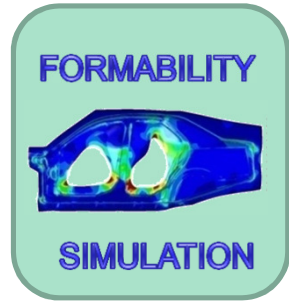
AutoSetup – Drawbeads





Free Selection





Property

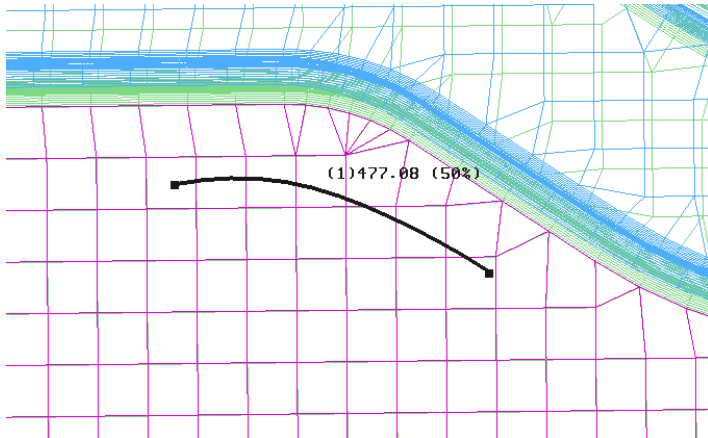
V1

Type: **Bead force**

Restraining force: 477.08 50.0 %

Uplift force: 0.0 0.0 %

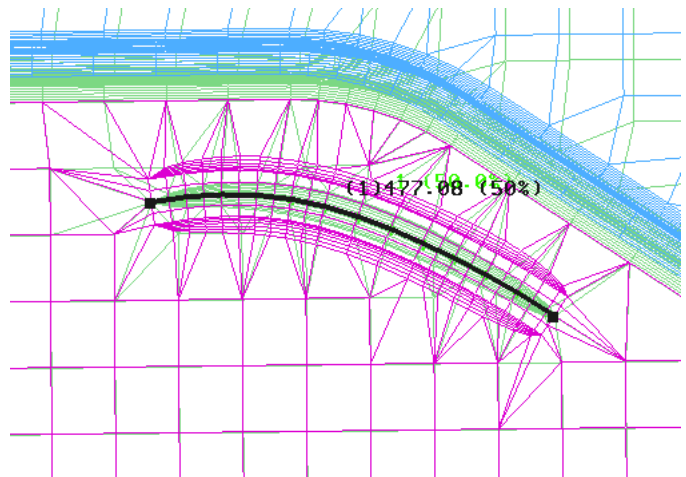
Variable... Delete Advanced...



>> Geometry bead



Drawbead Shape Library



GUI of Draw Bead Shape Library

Material type

Thickness level

Shape type

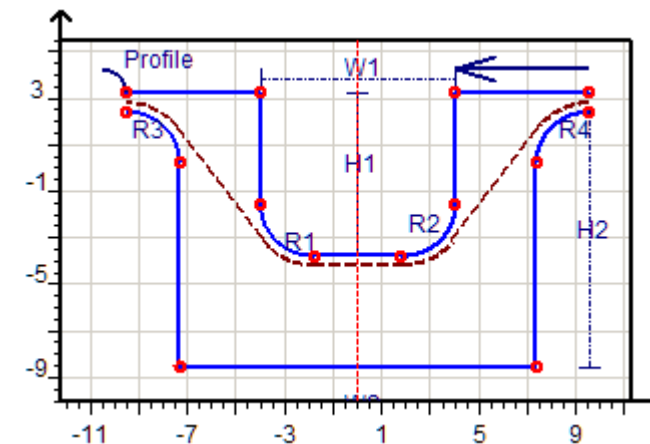
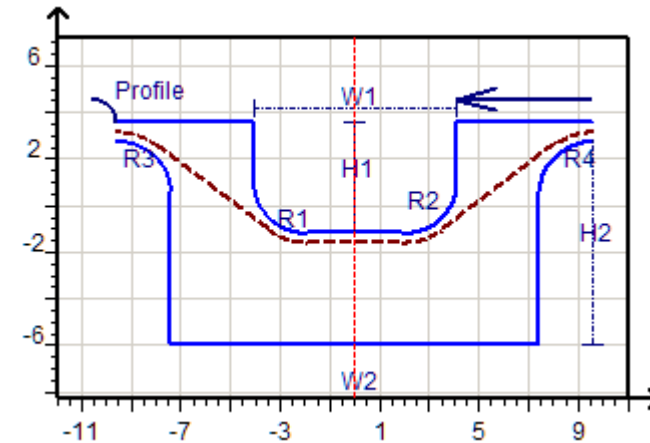
Force percentage

The screenshot shows the 'Draw Bead Shape Library' window. On the left, a tree view shows the hierarchy: 'Bead Shape Library' (expanded) contains 'Steel' (selected), 'T<=0.9' (expanded), and '0.9<T<=1.2' (expanded). Under 'T<=0.9', there is a 'Rectangle' folder containing a list of values: 10.0 (highlighted), 20.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0, and 100.0. Under '0.9<T<=1.2', there is another 'Rectangle' folder containing 10.0 and 20.0. On the right, the 'Shape' section has two icons of a draw bead profile. Below them are input fields for R1 (3.500), R2 (3.500), R3 (3.500), R4 (3.500), H1 (3.800), W1 (9.000), CL (-1.104), TH (0.800), W2 (8.393), and H2 (11.000). A graph shows the 'Profile' of the draw bead with dimensions W1, H1, H2, and radii R1, R2, R3, R4. The x-axis ranges from -9 to 11, and the y-axis ranges from 0 to -12. At the bottom, there are fields for 'Material: Steel', 'Thickness: T<=0.9', and 'Force Percentage(%) 10.0'. Buttons for 'Add', 'Modify', 'Delete', 'Default', 'Import', 'Export', 'OK', and 'Cancel' are also present.

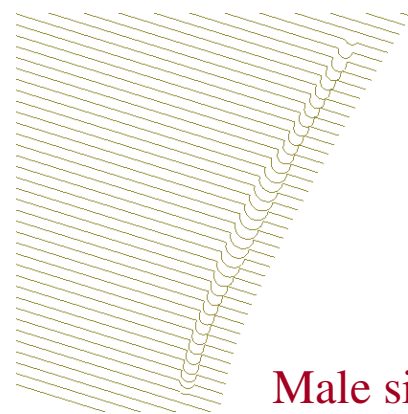
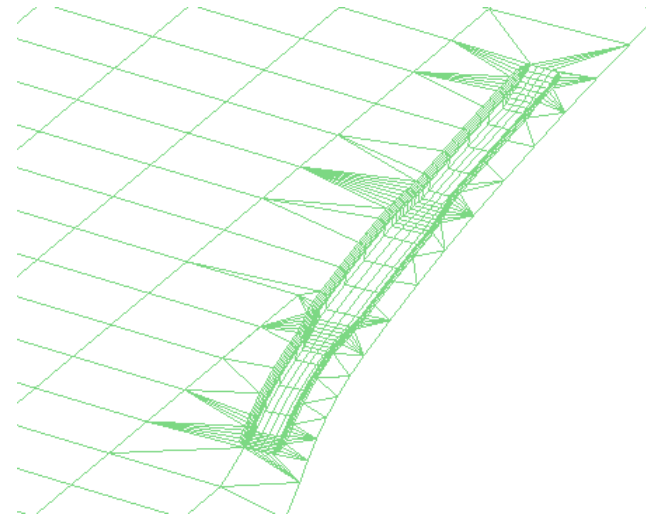
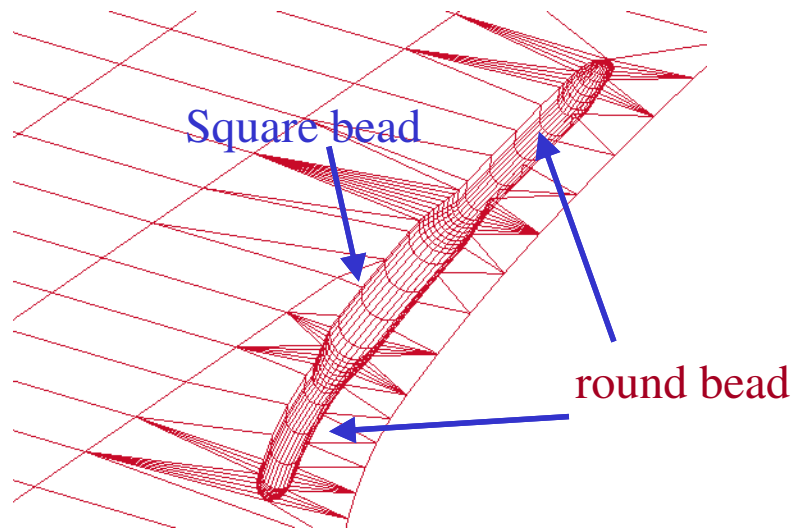
Diagram operation:

- ZOOM - Press the right mouse button and move up/down
- MOVE - Press the middle mouse button and move
- Fit screen - double click the diagram area with left mouse button
- Modify the parameters dynamically

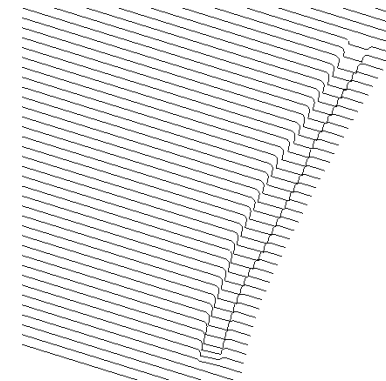
Double click the diagram area with middle mouse button, then drag the control point or the shape edge



Transition bead shape



Male side



Female side

Sheet Forming

Setup Display Preview Job

10.forming 25.springba. ↓

General **Blank** Tools Drawbeads Process Control

Geometry

Part	Material	Thickness	Property
BLANK.LI 1	DC04	1.0	ELFORM=16

Position

Position: 0.0 0.0 39.4003

Symmetry

Symmetry type: <None> Define...

Contact

Blank self-contact Advanced...

Optimization

Outline OPT Setting...

Summary... Exit

New Control Page



Sheet Forming

Setup Display Preview Job

10.formin. 25.spring. ↓

General Blank Tools Drawbeads Process **Control**

General

Refining meshes Accuracy:

Selective mass scaling

Time step size (DT2MS): ...

Refining meshes

Time steps (ENDTIM/ADPFREQ): ...

Minimum element size (ADPSIZE):

Max. refinement levels (MAXLVL):

Output ascii file

Tool interface forces Interval

Material energies Interval

Global data Interval

Sliding interface energy Interval

Adaptivity Duration

S1: drawing

Adaptivity Boxes

Boxes

BOX1 LEVEL=3

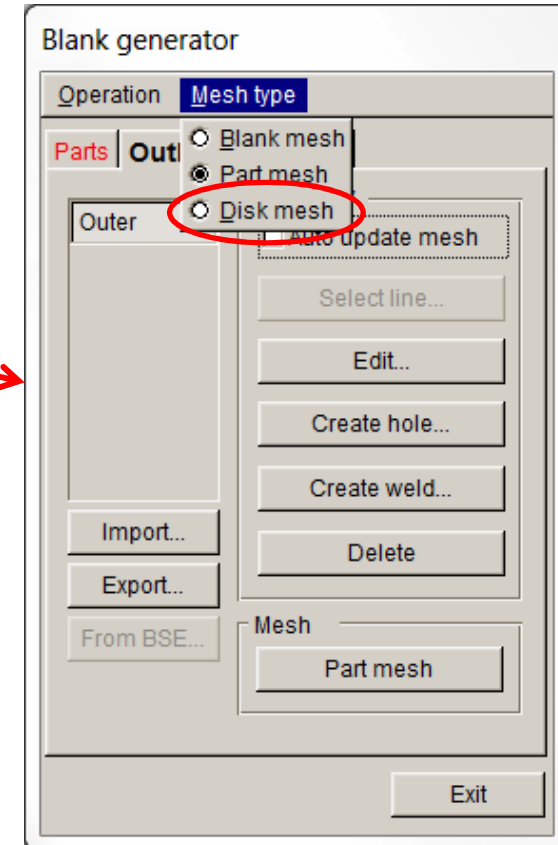
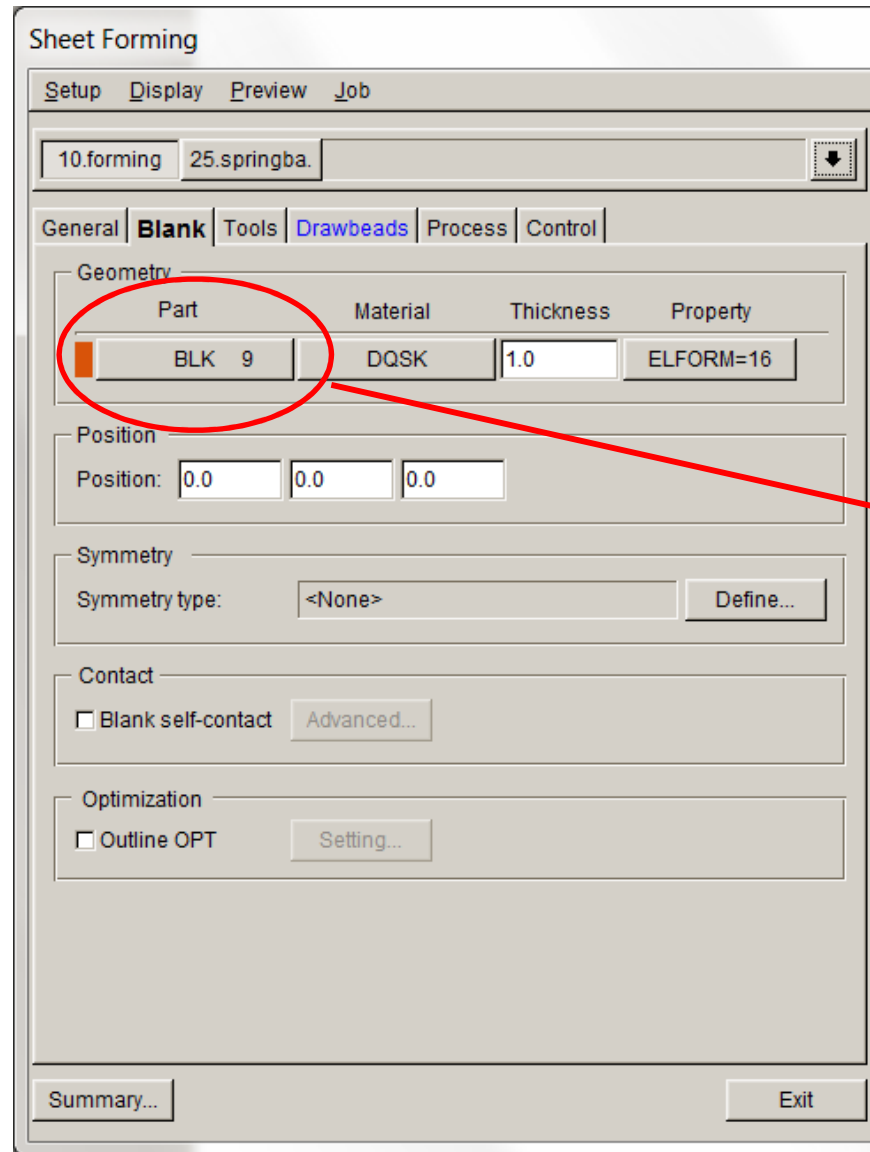
Max. level:

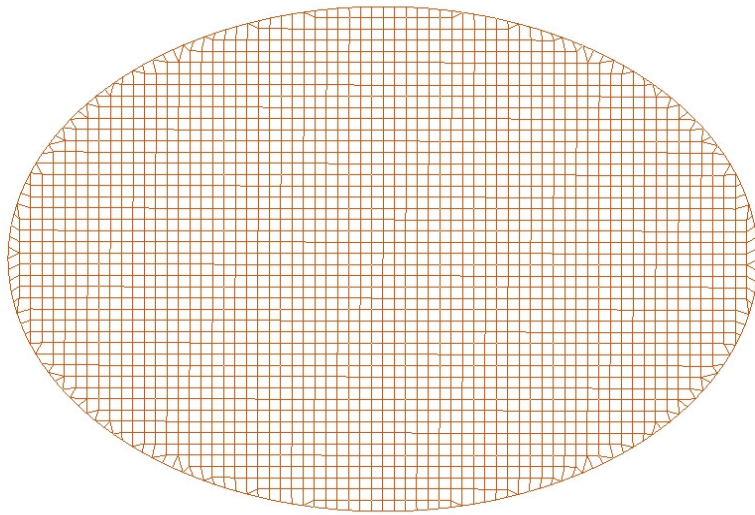
X:

Y:

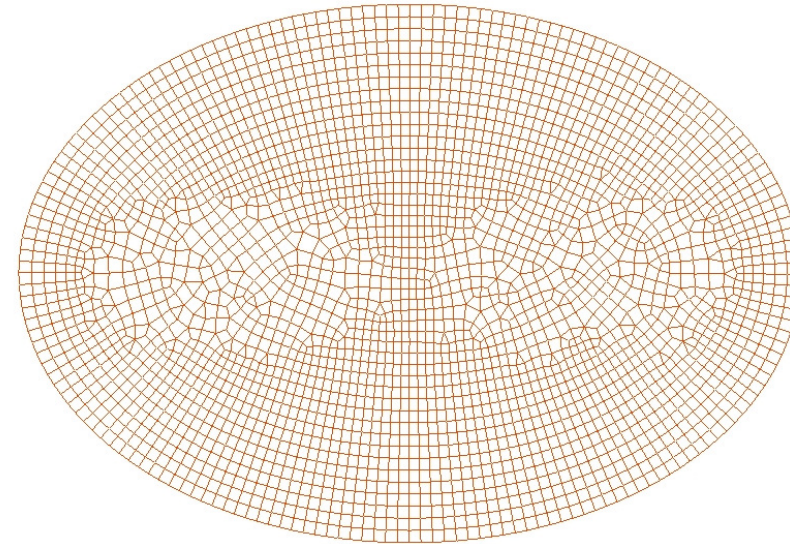
Z:

Blank Generator – New Mesher

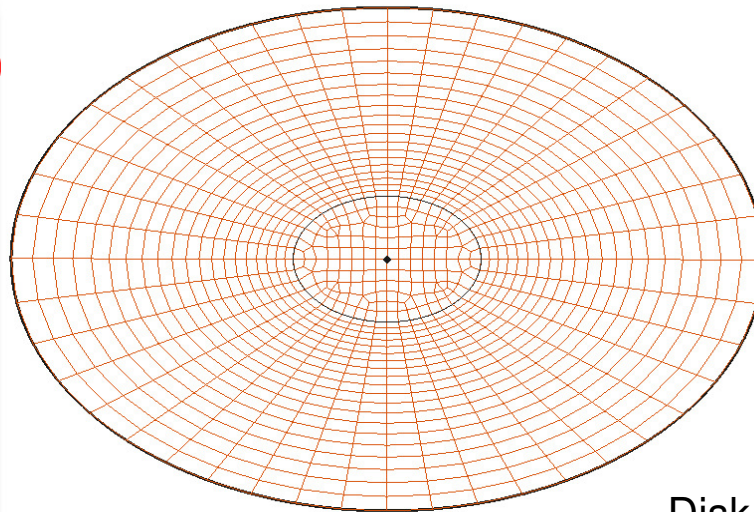
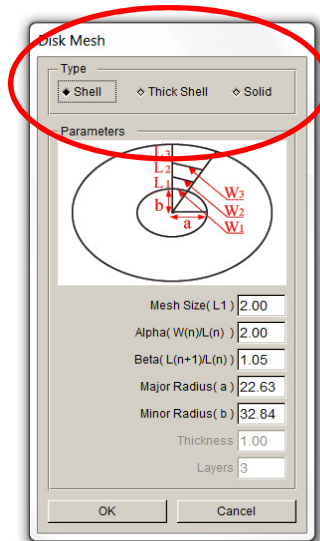




Blank Mesher



Part Mesher



Disk Mesher



The screenshot shows the 'Job Submitter 2012 R1' application window. The interface includes a 'Solver:' section with fields for LS-DYNA (S), LS-DYNA (D), UTILITY BATCH, MSTEP, and INC SOLVER. To the right, the 'LS-DYNA Control Parameter:' section contains fields for Memory (500 MB), CPU Number(ncpu=) (1), Pause between Jobs (2 Sec), and MPP (Not use MPP). A toolbar below the solver settings contains icons for adding, deleting, and refreshing jobs, as well as buttons for 'DYN', 'MSTEP', and 'INC'. A table with columns for Job Name, In Folder, Solver, MStages, Memory, Status, Message, Summary, I Force, and Other Param is visible. A 'License Settings' dialog box is open in the foreground, featuring a 'Network' checkbox and a 'Server IP' field with four input boxes. Two red circles and arrows point from the 'License' icon in the toolbar to the 'License Settings' dialog box.

eta/POSTverwaltung

License Settings

Network

Server IP

OK Cancel



Ausblick

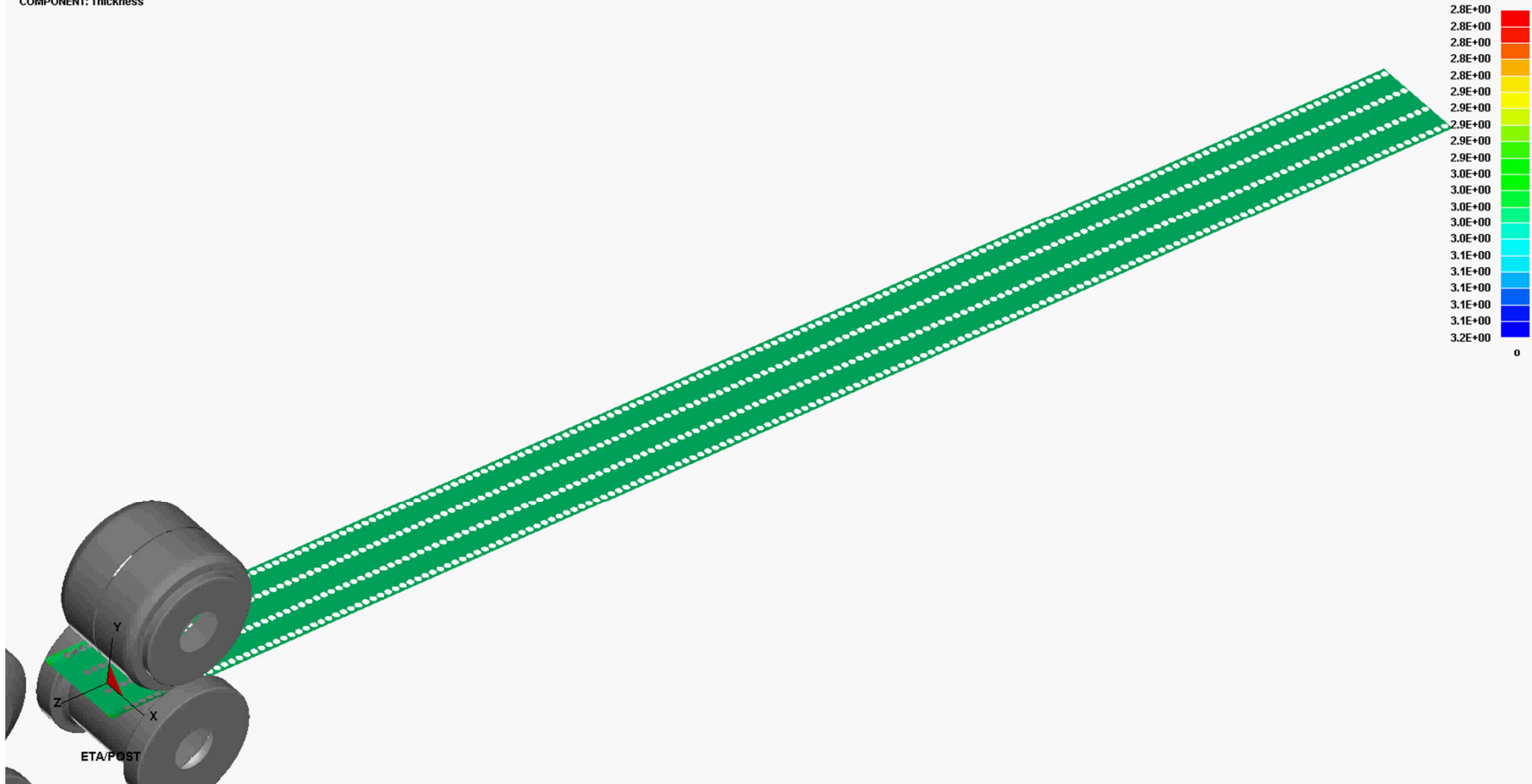
Walzprofilieren – Dickenverteilung gelocht



Walzprofilieren

STEP 7 TIME: 0.022203

COMPONENT: Thickness



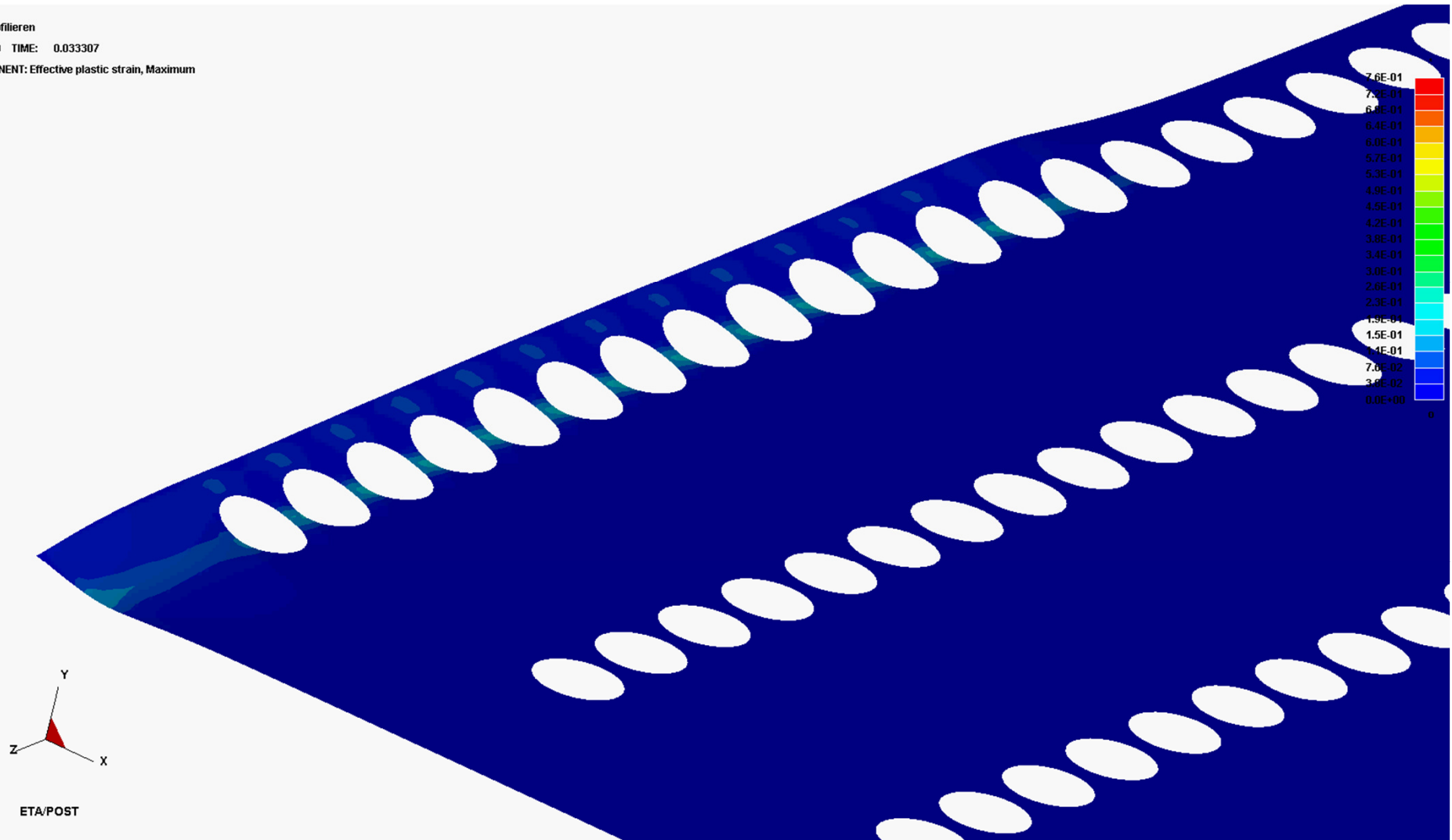
Walzprofilieren – Plastische Dehnungen gelocht (Detail)



Walzprofilieren

STEP 10 TIME: 0.033307

COMPONENT: Effective plastic strain, Maximum



EADS INNOVATION WORKS

Superplastic forming @ EADS Innovation Works

Joachim Zettler, IW-MS

30.10.2012

EADS INNOVATION WORKS

A hand is shown pointing towards a glowing blue target with concentric circles, symbolizing innovation or technology. The target is centered on the word 'WORKS' in the 'EADS INNOVATION WORKS' logo. The background is dark blue with a subtle gradient.

EADS

The EADS logo is located in the bottom right corner of the slide. It consists of the letters 'EADS' in a bold, sans-serif font. The background of the slide features a hand pointing at a glowing blue target with concentric circles, symbolizing innovation or technology.

Superplastic forming - Introduction

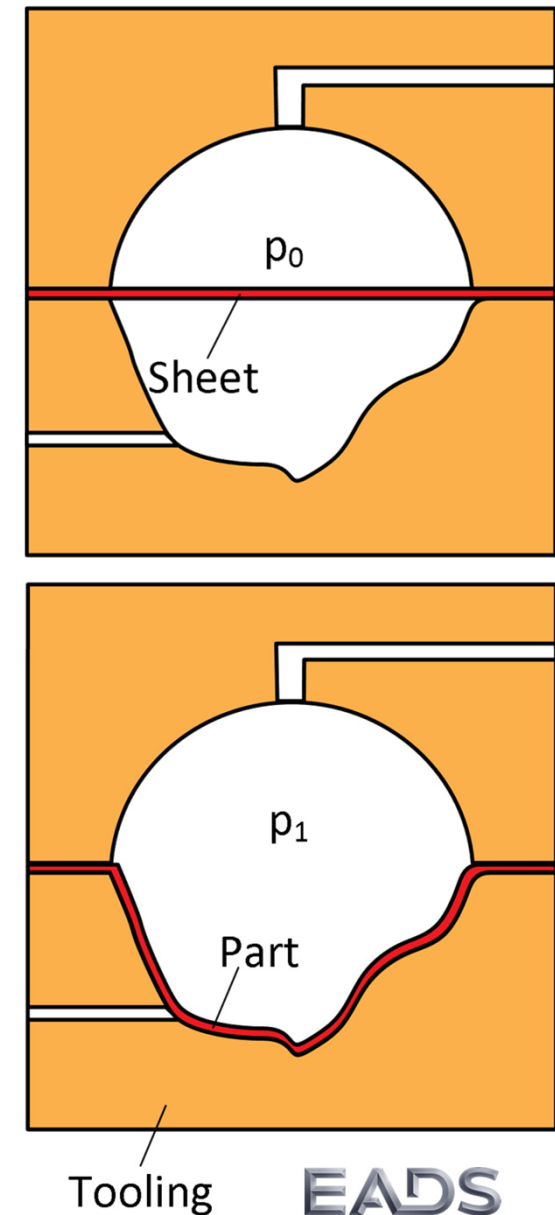
- Mainly used to form Ti6Al4V parts
- Yield stress is reduced at elevated temperatures ($\sim 900^{\circ}\text{C}$)
- Very high part accuracy is possible due to low residual stresses induced during forming
- High strain values for SPF (theoretically up to 1000% but practically around 300 – 400%)
- SPF state only at very low strain rates $1.E-5 < \dot{\epsilon} < 1.E-3$
→ Very long process time

Superplastic forming - Principle

- Position sheet in tooling and fix it
- Heat up to desired SPF temperature
- Apply optimized gas pressure to reach strain rates in the desired range

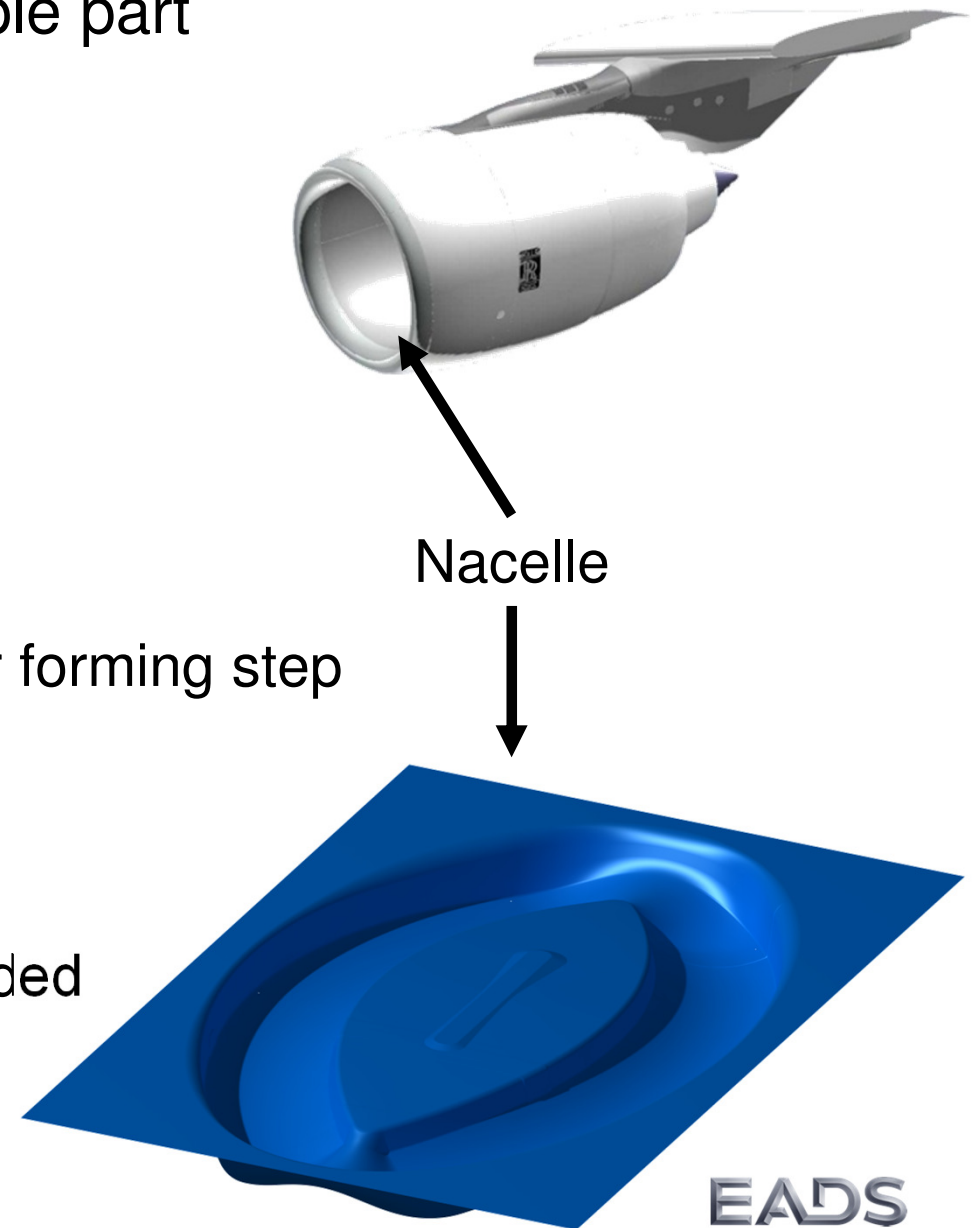
.....wait a long time.....

- Apply calibration pressure if necessary



Superplastic forming – Example part

- Part named “Nacelle”
- Material Ti6Al4V
- Thickness 3mm
- Due to symmetry, 2 parts per forming step
- Part size 2000mm*400mm
- 4 parts per A380 engine needed



Superplastic forming – Simulation setup with LSDYNA

- Rigid die
- Blank modeled with shell elements type 2
- Contact between blank and die can efficiently only be modeled with constraint contact formulations. Proposed choice is surface to surface option

*CONTACT_CONSTRAINT_SURFACE_TO_SURFACE

- Constitutive law used is

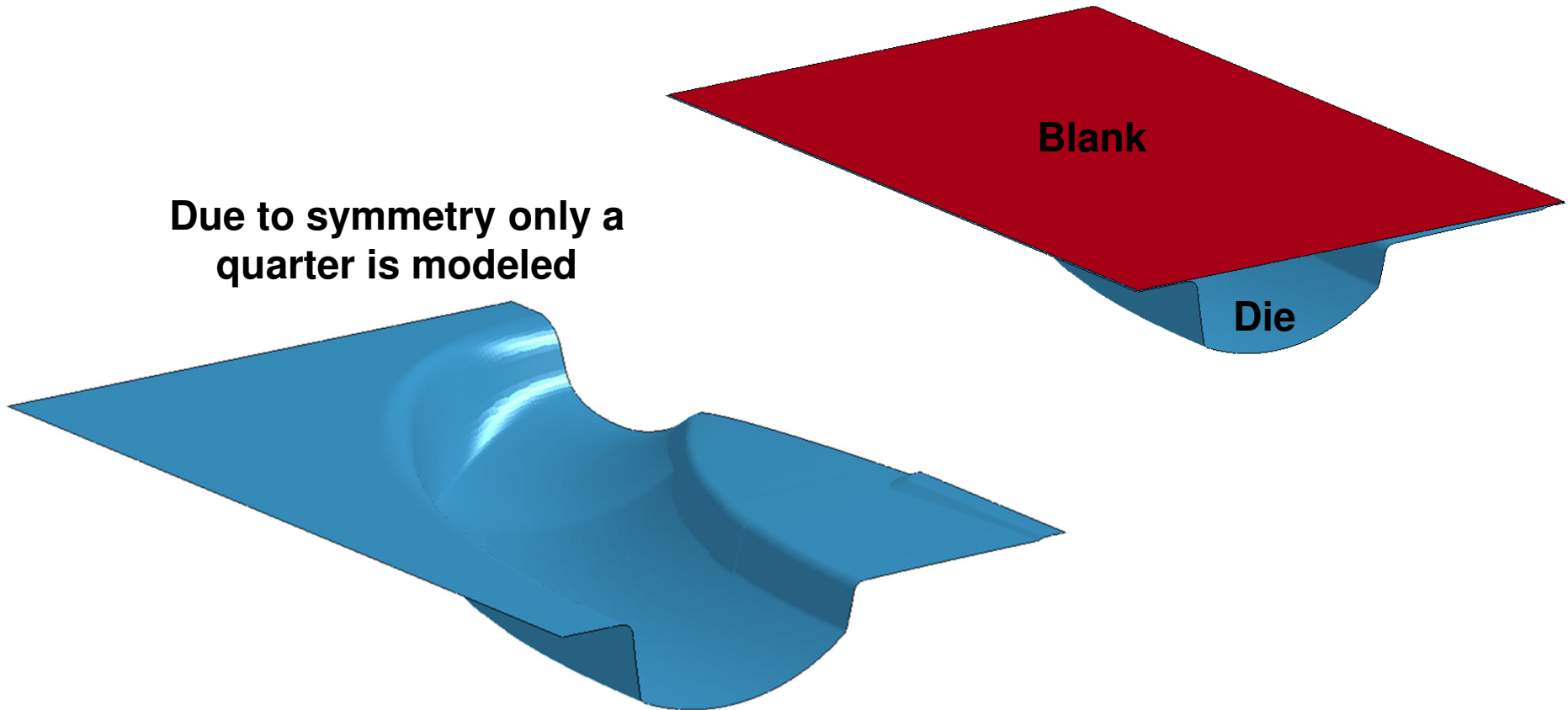
*MAT_RATE_SENSITIVE_POWERLAW_PLASTICITY

- Loading pressure control to account for a desired forming strain rate can be used with the keyword

*LOAD_SUPERPLASTIC_FORMING

Superplastic forming – Simulation setup with Dynaform

Due to symmetry only a quarter is modeled



Superplastic forming – Simulation setup with Dynaform

Superplastic Forming

Setup Display Preview Job

General Blank Tools **Process** Control

Phases

◆ One phase ◇ Two phases

Phase I

Pressure curve: 11 pnts Percent to terminate: 80.0

Contact tool: die ▼

Common

Desired strain rate (ERATE): 0.002 Advanced...

Termination time: 1e+006 Interval for d3plot: 10.0

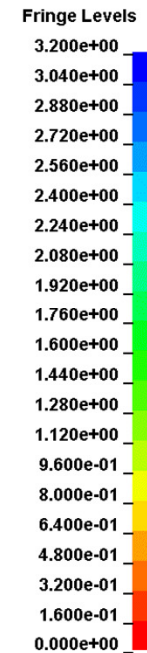
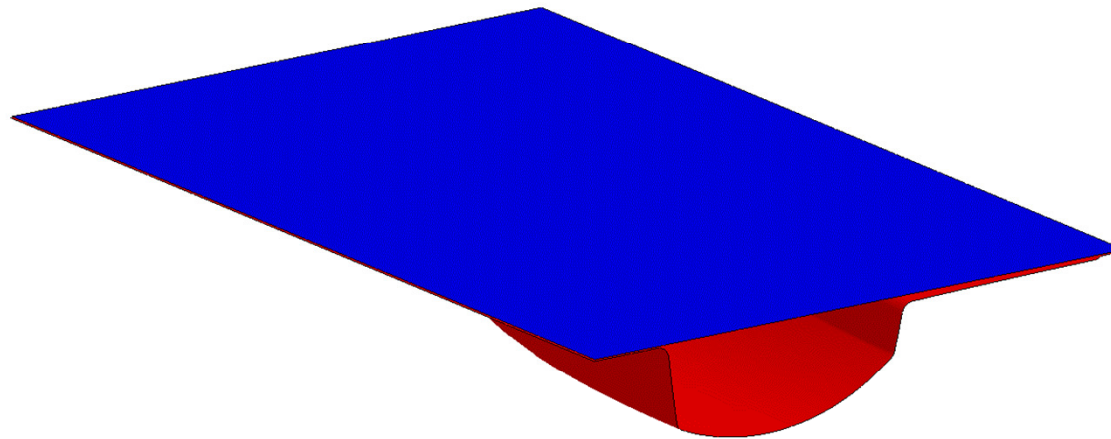
Constraints

Single point constraints (SPCs): <None> Define...

Summary... Exit

Superplastic forming – Nacelle simulation result

LS-DYNA keyword deck by LS-PrePost
Time = 0, #nodes=43296, #elem=44757
Contours of Shell Thickness
min=0, at elem# 39170
max=3.2, at elem# 75177



Superplastic forming – Nacelle simulation result for target strain rate of $2.5E-4$

- The simulation is mainly used to derive a strain-rate controlled pressure amplitude and a realistic thinning prediction

