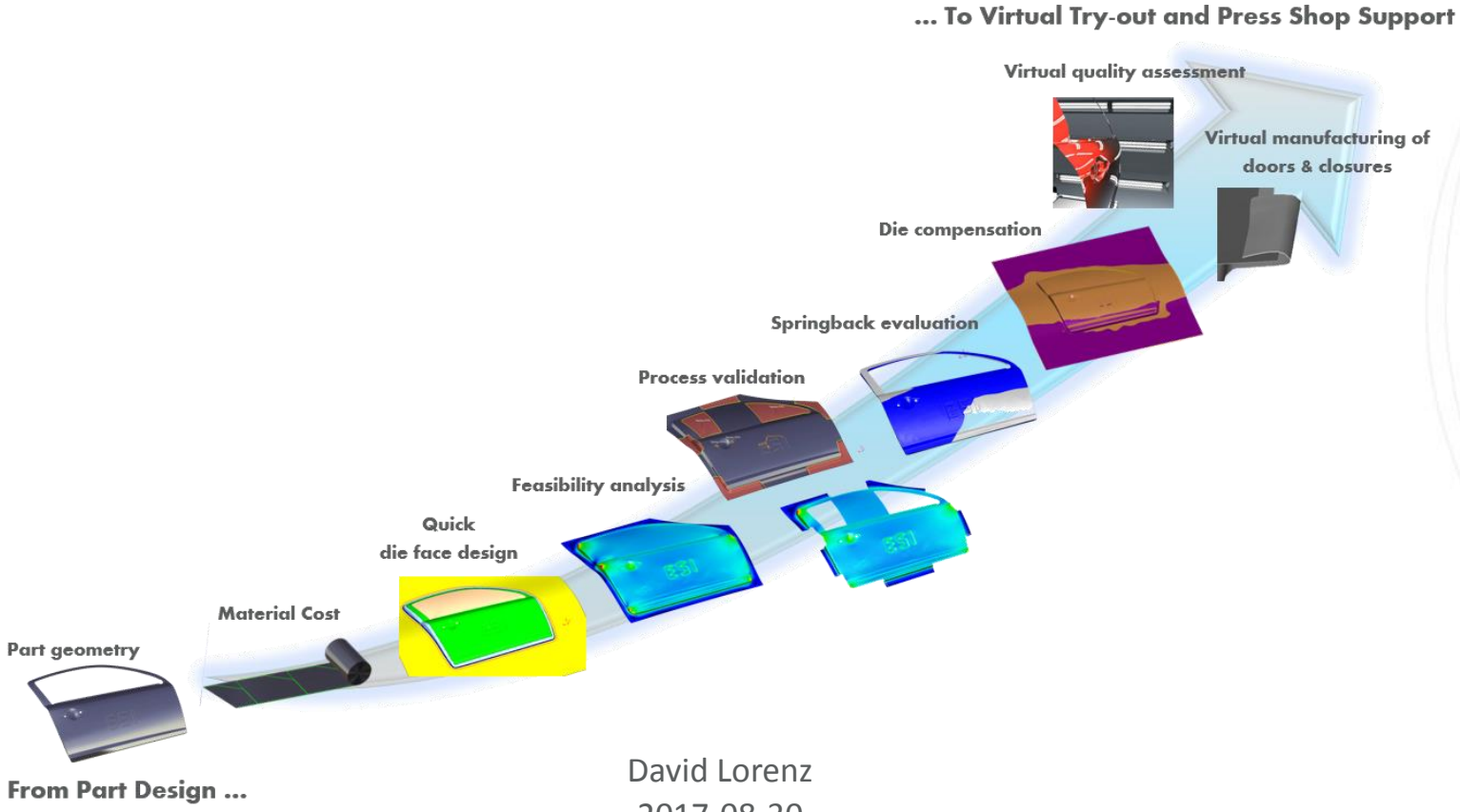
What's New in PAM-STAMP 2017.5

Webinar



David Lorenz

2017-08-30

get it right®

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Agenda

Available methodologies from concept to try-out

Reduce Try-Out Costs with Accurate Results

- Material
- Gravity fit between stages
- Uniform meshes
- HPC computing
- Deformable tools
- Surface defects

Robustness

Hotforming Update

Efficiency Improvements – GUI

Tips and Tricks

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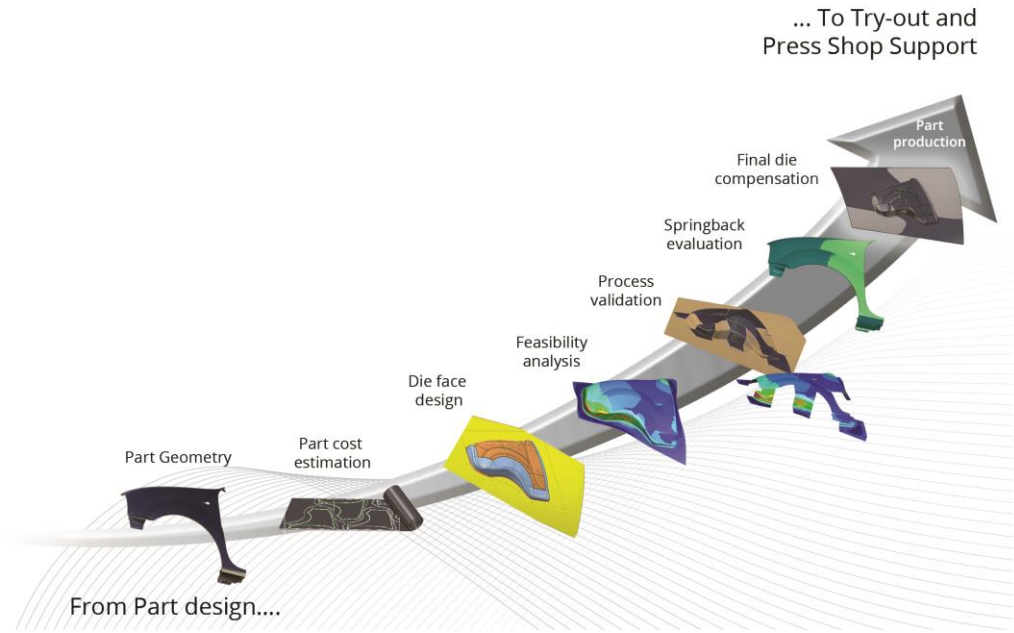
Available Methodologies

From Concept to Try-Out



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3 Methods to Go from Concept to Try-Out

For all options: Entire process with following operations

Concept feasibility

- On the nominal, only explicit in case of stress removal, else springback

Process validation

- As process feasibility, but conservative settings like tool speed etc. and refined mesh

Try-Out

- As process validation but no speed up anywhere and very low tool speeds

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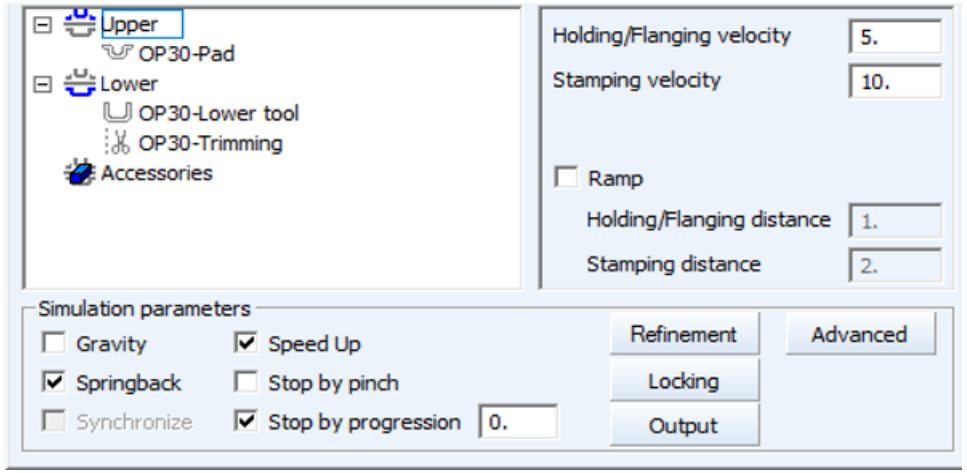
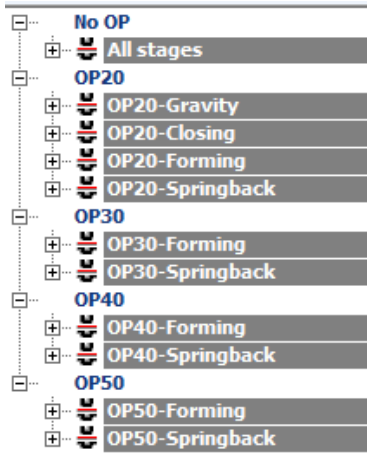
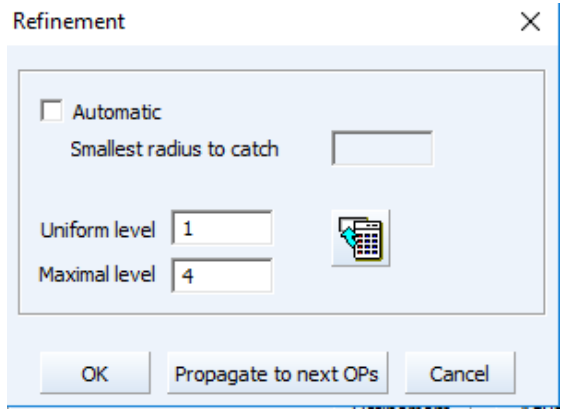
Available Methodologies in V2017.5, Concept & Validation / Try-Out

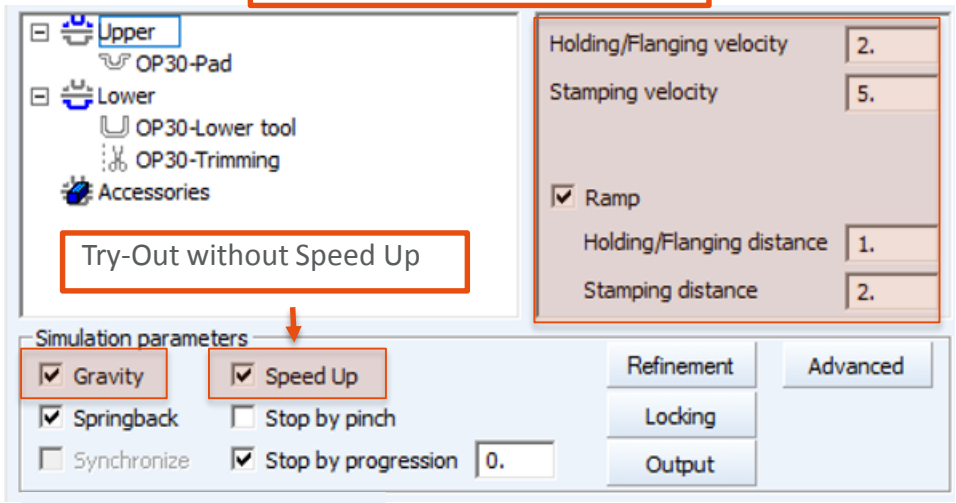
Concept feasibility

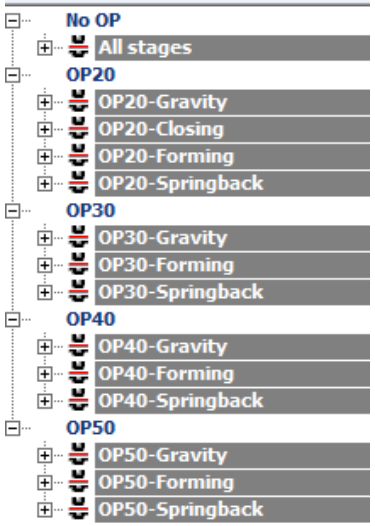


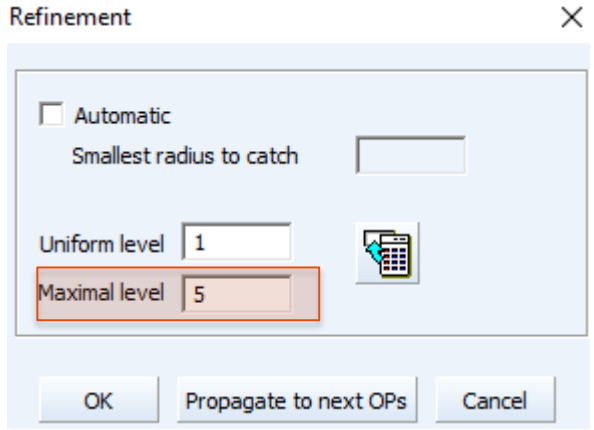




Process validation







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Available Methodologies in V2017.5, from Concept to Try-Out

	Concept Feasibility	Process Validation	Try-Out Quality	Availability
Description	Full process, fastest way doing it	Full process with high accuracy	Most conservative setup, all included	
Benefit	See if the process works OK, no springback quality	Try-out quality, fast, springback quality	Try-out quality, springback quality	
Stress removal	no / yes (*)	no	no	PE
Springback after each operation or during gravity fit	no / yes	yes	yes	PE
Locating	no	yes	yes	Macro, introduced for V2017.5
Gravity fit at the start of each operation	no	Yes, if needed	Yes, if needed	PE
Triple speed set in closing and stamping stage	yes	yes for closing, choice for stamping	no	PE
Element elimination, amount of plastic strain	Yes, 300% means 3	Yes, 300% means 3	Yes, 300% means 3	PE

(*) If no springback a separate trimming operation needs to be defined

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Available Methodologies in V2017.5, from Concept to Try-Out

	Concept Feasibility	Process Validation	Try-Out Quality	Availability
Description	Full process, fastest way doing it	Full process with high accuracy	Most conservative setup, all included	
Triple speed in flanging stages	yes	yes	no	PE
Tool speed closing	5m/s	2m/s	1-2 m/s	PE
Tool speed forming	10m/s	5m/s	2-5m/s	PE
Tool speed flanging*	2m/s (*)	2m/s (*)	2m/s (*)	PE
Tool speed ramps	no	yes	yes	PE

* Depends of the length of the flange

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Available Methodologies in V2017.5, from Concept to Try-Out

	Concept Feasibility	Process Validation	Try-Out Quality	Availability
Description	Full process, fastest way doing it	Full process with high accuracy	Most conservative setup, all included	PE
Mesh refinement	Min = 1-2 * blank thickness	Min = 0.5 - 1 * blank thickness	Min = 0.5 * blank thickness	PE
Mesh type	Adaptive mesh refinement	Adaptive mesh refinement or uniform	Adaptive mesh refinement or uniform	PE
Simulation time	Fastest	Moderate	Conservative	PE
Memory requirements	Minimum if only explicit, else what implicit springback and gravity fit requires	Minimum if only explicit, else what implicit springback and gravity fit requires	Minimum if only explicit, else what implicit springback and gravity fit requires	PE + Macro

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Available Methodologies in V2017.5, from Concept to Try-Out

	Concept Feasibility	Process Validation	Try-Out Quality	Availability
Description	Full process, fastest way doing it	Full process with high accuracy	Most conservative setup, all included	PE
Yield surface	Always use best possible	Always use best possible	Always use best possible	Material database
Hardening	Always use best possible fit, Yoshida if available	Always use best possible fit, Yoshida if available	Always use best possible fit, Yoshida if available	Material database
Hardening – Yoshida: Number of plastic increments	5	20	20	Attribute tree, in test for V2017.5
Friction	0.12 – 0.15 (*)	0.08 – 0.10 (*)	0.08 – 0.10 (*)	PE

* As a rule of thumb

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Reduce Try-Out Costs with Accurate Results

PAM-STAMP

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Keys to Get Accurate Results for Line Dies

Accurate material modelling

- Yield function and hardening
- Best to use from the beginning

Accurate tool meshes and blank meshes with no penetration

- A uniform mesh with small elements is best suited
- Concerns do exist on computation time

A good fit of the sprung blank on the next die

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Accurate Material Modelling

Advanced **Yield Functions –** so far based on **Expensive Tests**

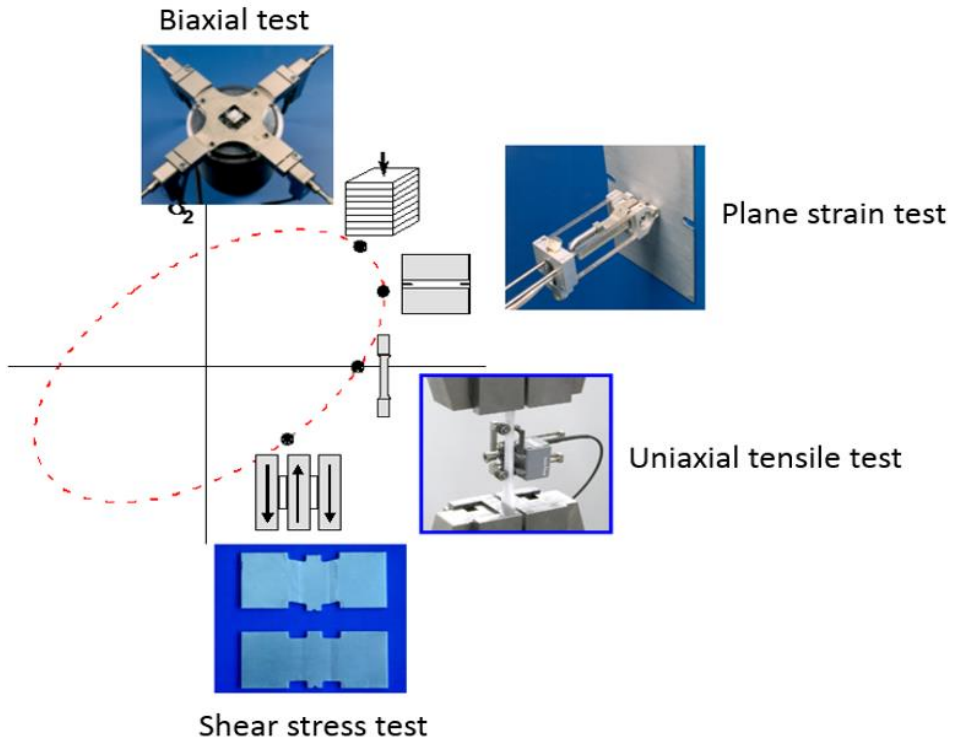
Four tests need to be done to model yield functions of advanced material

- Only the tensile test is cheap
- The other tests are expensive (up to 50 times of a tensile test) and partially difficult to conduct

Many model parameters need to be determined

Material changes all the time….

- Even per coil
- Per steel provider
- Per……



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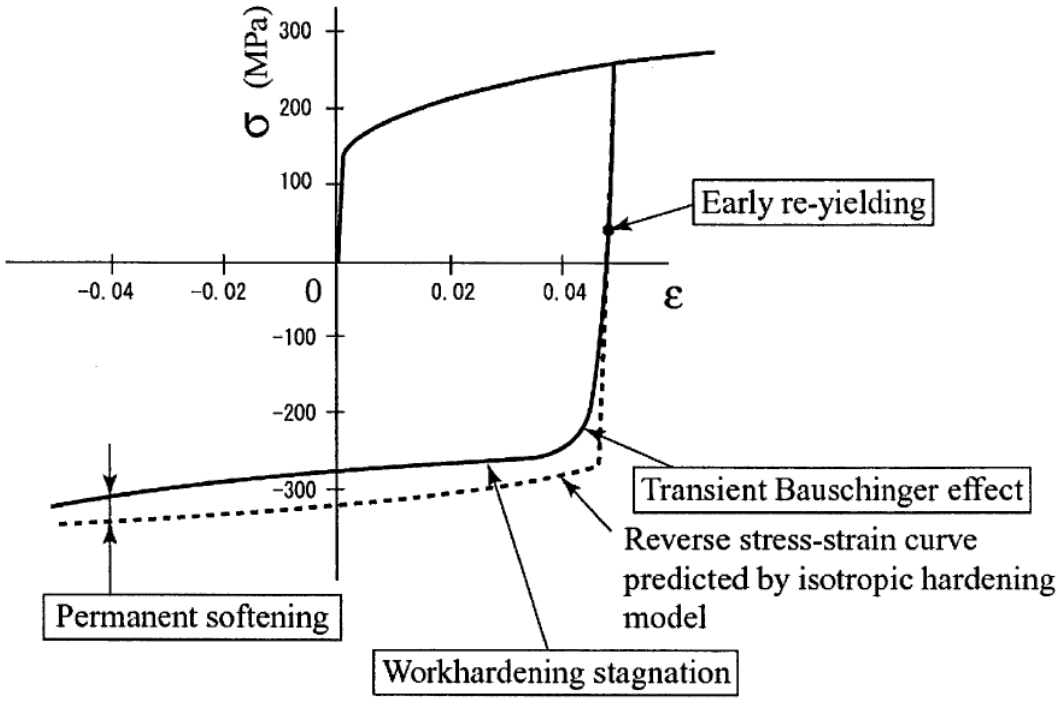
Accurate Material Modelling

Advanced **Hardening Models** – so far based on **Expensive Tests**

Kinematic hardening models require – so far – expensive and difficult tests to conduct in order to determine many parameters required for accurate modelling



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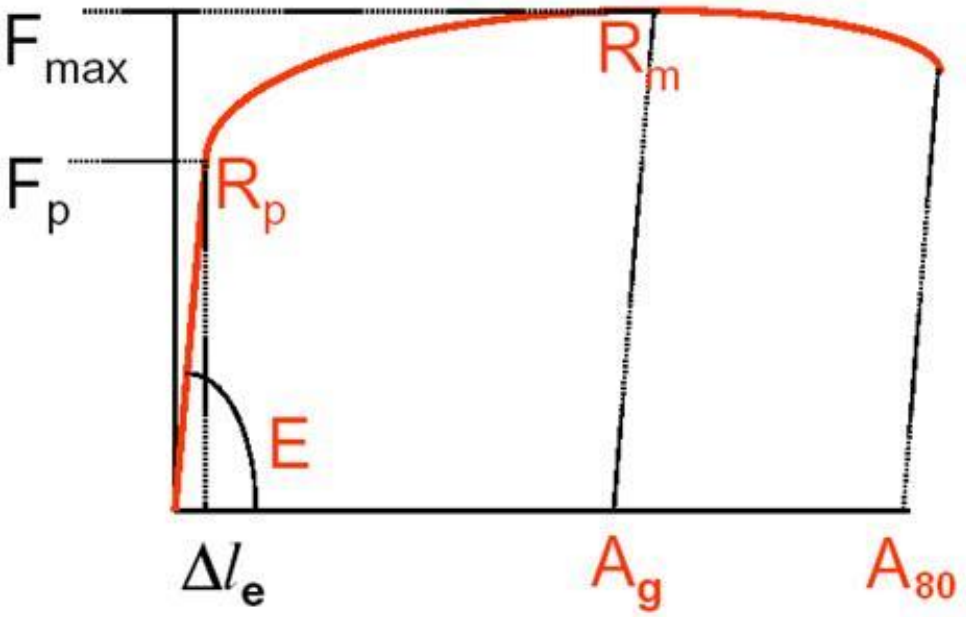
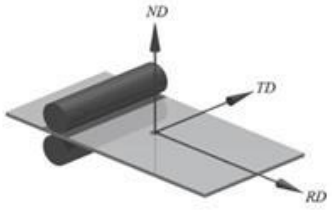
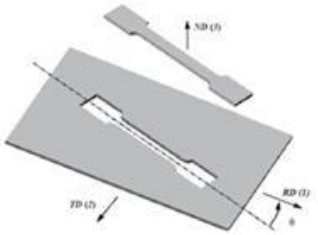
Extraction of All Required Data from Tensile Tests

Makes Accurate Material Modeling Available To Everybody!

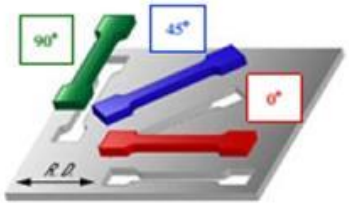




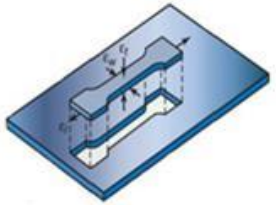
Axis of orthotropy: Rolling, transverse, normal directions



Tensile specimen at angle Θ from rolling direction



Measurements of tensile specimens at 0, 45, 90 degree (from rolling direction)



Lankford parameter (anisotropy coefficient or Strain ratio): $r=\frac{\varepsilon_w}{\varepsilon_t}$ for all 3 directions r_0, r_{45}, r_{90}

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Advanced Yield Function Based on **Tensile Tests only**

New Vegter 2017 Yield Locus Definition

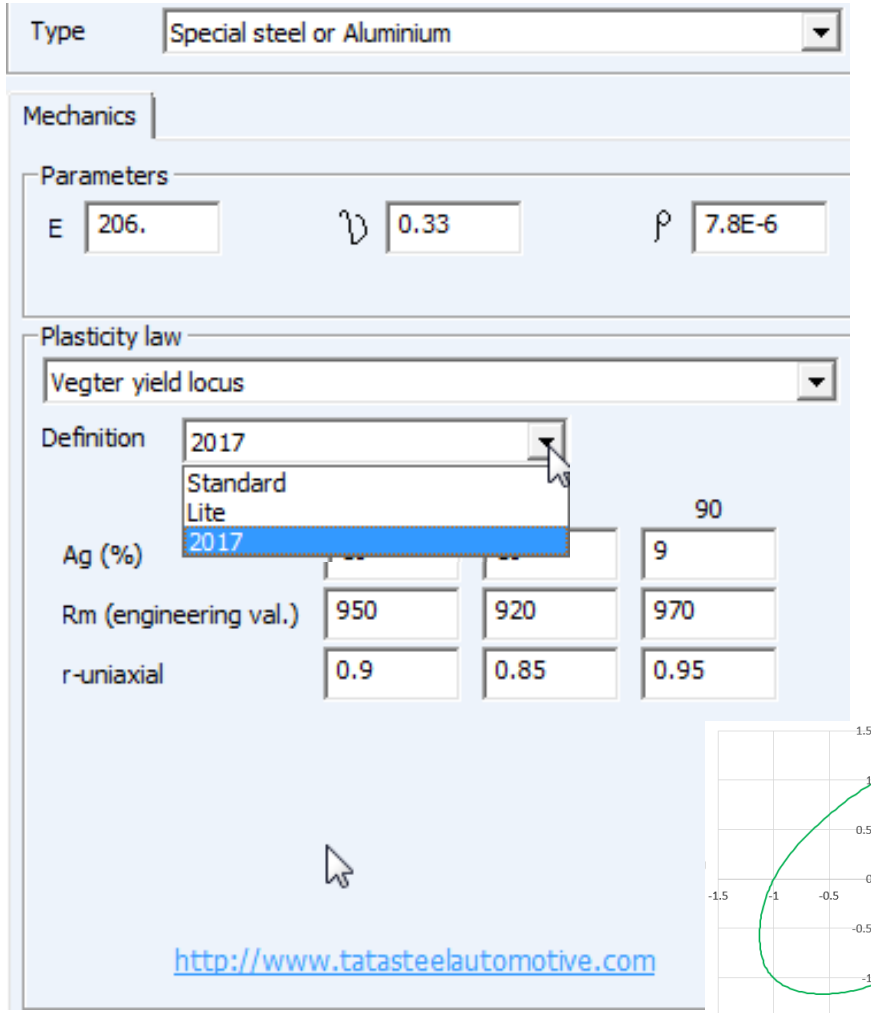
Relationships have been implemented between the stress points of the yield locus and the mechanical properties derived from standard uniaxial testing

- User enters easily-measured standard parameters of tensile strength, uniform elongation and Lankford coefficient
- Biaxial, plane strain and shear point are predicted with great accuracy

Developed and validated by TATA STEEL

- Tata Steel Vegter material decks available in database

Applicable for low carbon steel, aluminum alloys and stainless steel



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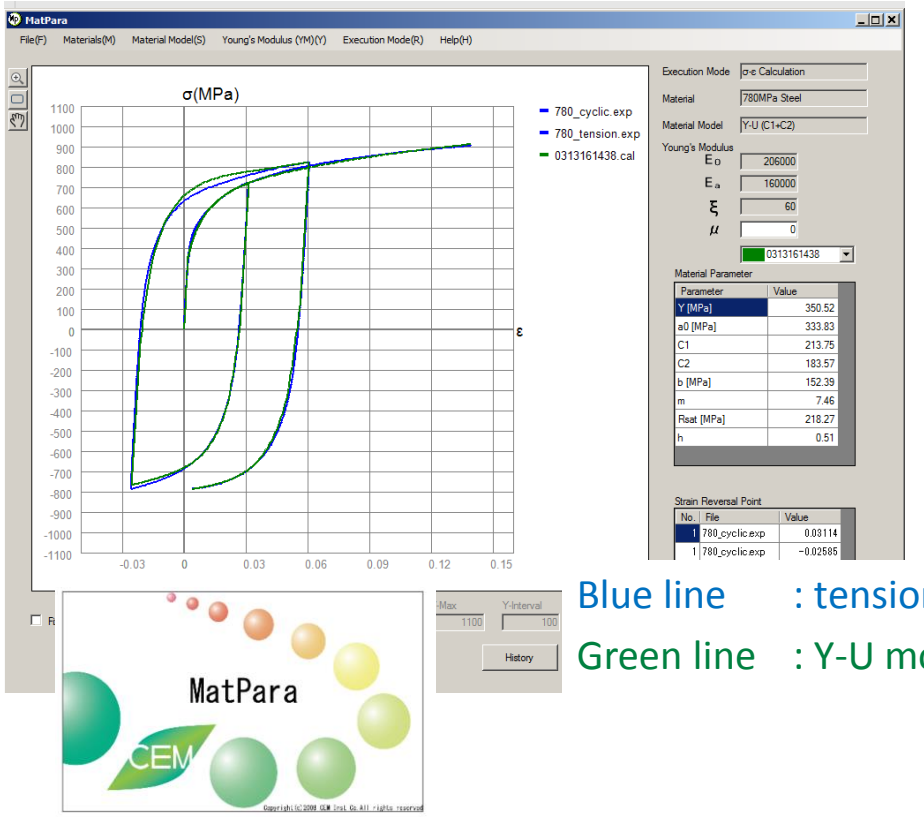
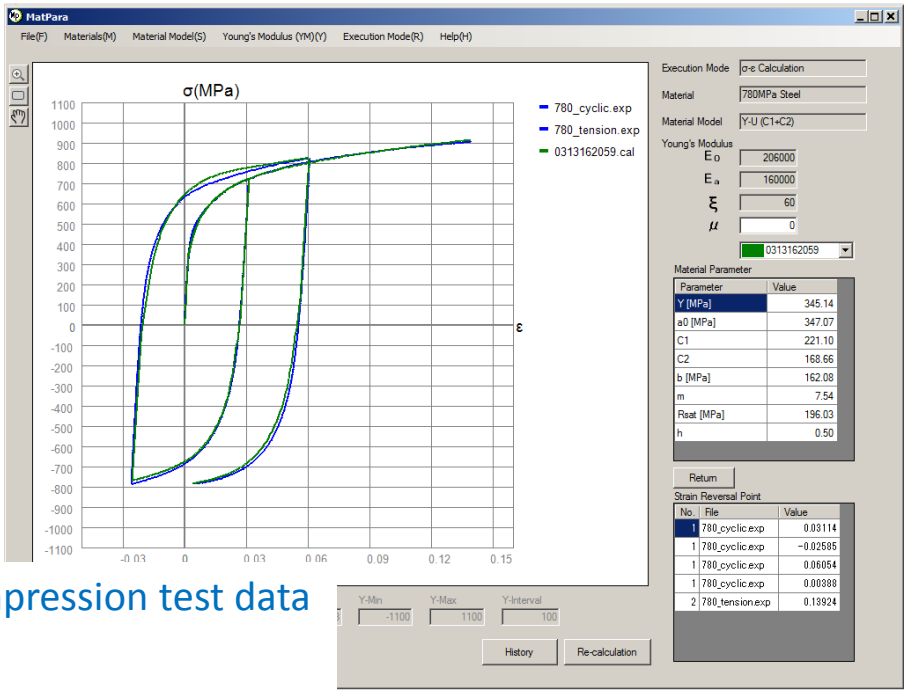
Y-U model's Stress-Strain Curves Estimated **from Tensile Tests only**

Similar to the one from Tension & Compression Test

Y-U parameters are estimated from tension and tension-compression test results



Y-U parameters are estimated from tension test result only



Blue line : tension-compression test data

Green line : Y-U model

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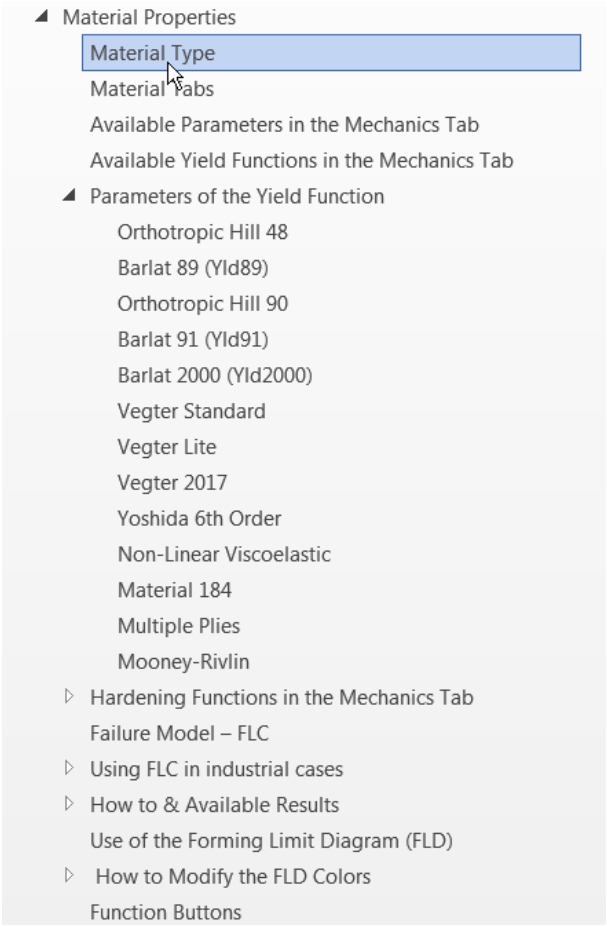
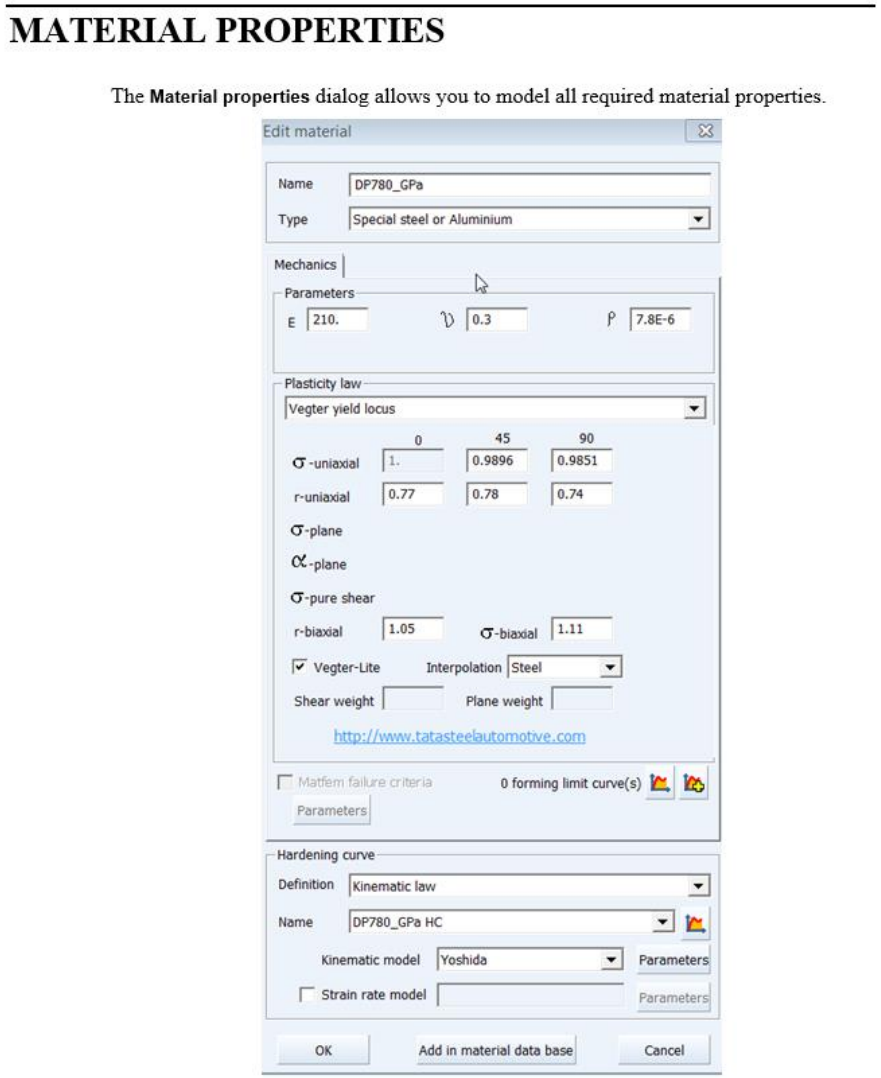
Material Online Help

- 84 pages to explain details





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Material Database – Also Strain Rate Dependent

Forming steels, conventional HSS steels, advanced HSS steels, MPa and GPa

- Tata_Steel
  - GPa
    - Advanced_HSS-GPa
      - StrainRate
    - Conventional_HSS-GPa
      - StrainRate
    - Forming_steels-GPa
      - StrainRate
  - MPa
    - Advanced_HSS_MPa
      - StrainRate
    - Conventional_HSS_MPa
      - StrainRate
    - Forming_steels_MPa
      - StrainRate

Name

DC01_0.8<=t<1.2_Vegter_Average
DC01_1.2<=t<1.6_Vegter_Average
DC03_0.4<=t<0.8_Vegter_Average
DC04_0.4<=t<0.8_Vegter_Average
DC04_0.8<=t<1.2_Vegter_Average
DC04_1.2<=t<1.6_Vegter_Average
DC04_1.6<=t<2.0_Vegter_Average
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CR_BH180-SemiStabilised-GI_1.6<=t<2.0_Vegter_Average
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HR_DP600-UC_3.0<=t<4.0_Vegter_Average
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HR_FB600-UC_3.0<=t<4.0_Vegter_Average
HR_XPF650-UC_3.0<=t<4.0_Vegter_Average
HR_XPF800-UC_3.0<=t<4.0_Vegter_Average

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CoE Services for Material Characterization – Find the Best Yield Function

EXPERIMENTAL DATA	
R0 =	0.78
R45 =	0.49
R90 =	0.68
SIG0 =	1
SIG45 =	1.02956
SIG90 =	0.961148
SIG_B =	0.96118
WPS =	0.4125
WSH =	0.75
m =	8
Rb =	Not Available

ACCURACY(%)	
Hill 48	87.9792
Hill 90	83.5083
Barlat 89	96.7763
Vegter Lite	99.9903
Vegter 2017	95.3501
Barlat 2000	97.3871
Barlat 91	92.7967

Final Biaxial Test:	
SIGB =	0.96118
Rb =	1.14706

Automatic Output Hill 90 Parameters

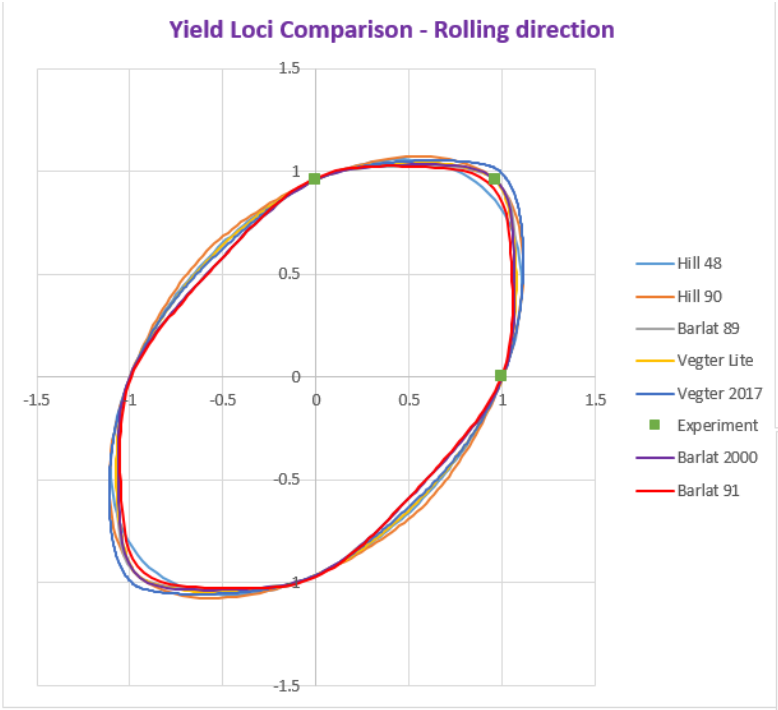
m =	1.74869427
alfa =	1.4779153
beta =	-0.1124988
gamma =	0.2682396

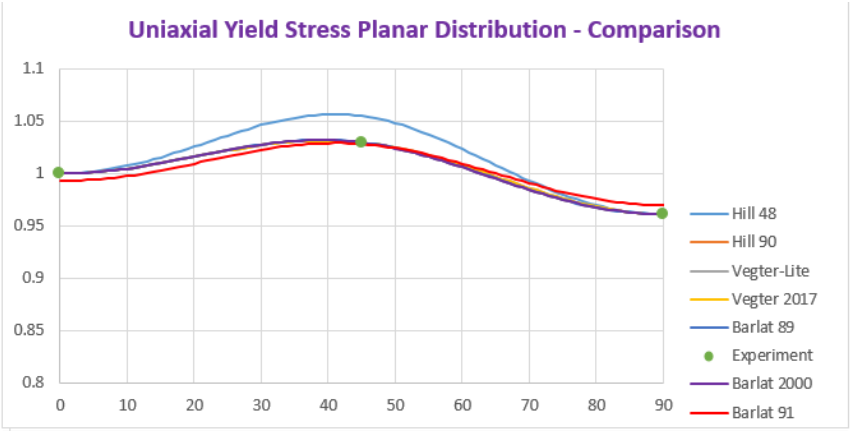
Automatic Output Barlat 89 Parameters

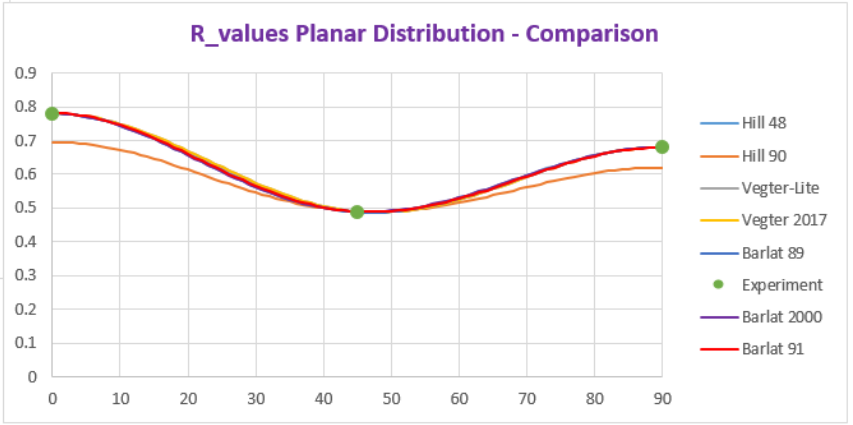
A =	1.1576994
C =	0.8423006
H =	1.04048898
m =	8
P =	0.94927756

Automatic output Vegter 2017 Parameters

R0 =	0.78
R45 =	0.49
R90 =	0.68
SIG0 =	1
SIG45 =	1.02956
SIG90 =	0.961148
SIG_B =	0.99399161
SIG_PS1_0 =	1.11161065







INPUT_DATA | Hill 48 | Hill 90 | Barlat 89 | Barlat_91 | Barlat_2000 | Vegter Lite | Vegter 2017 | Comparisons | Calcul_Ve ...

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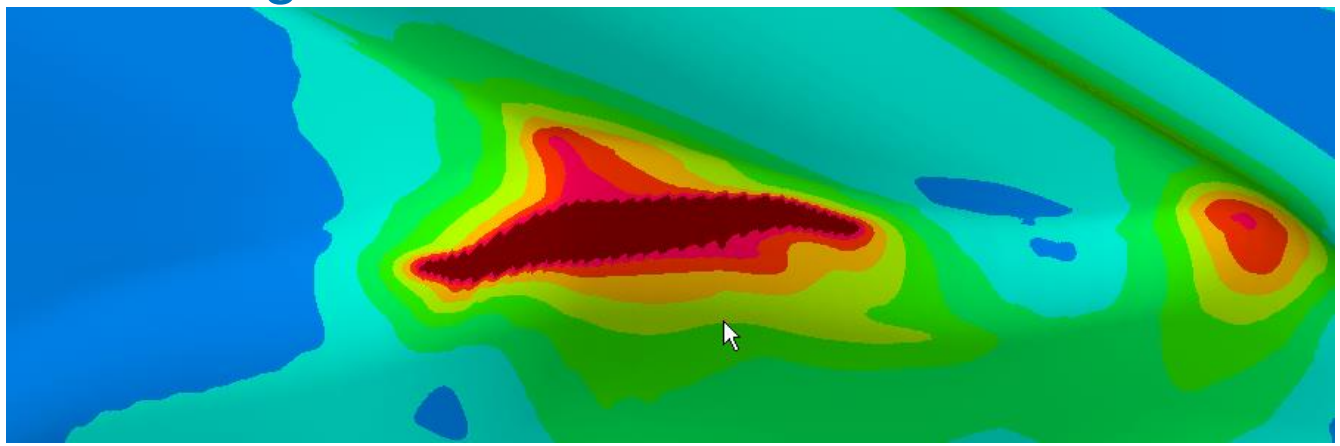
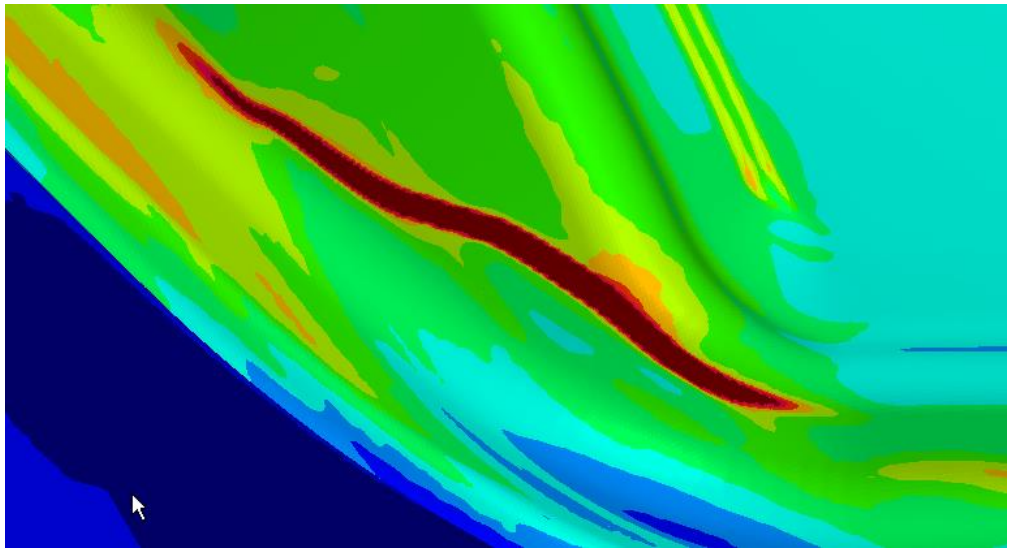
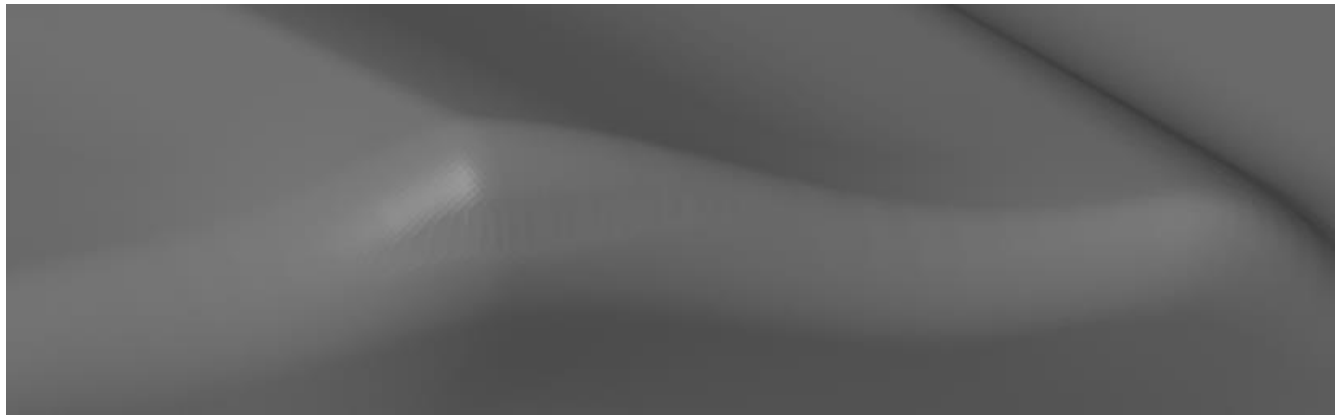
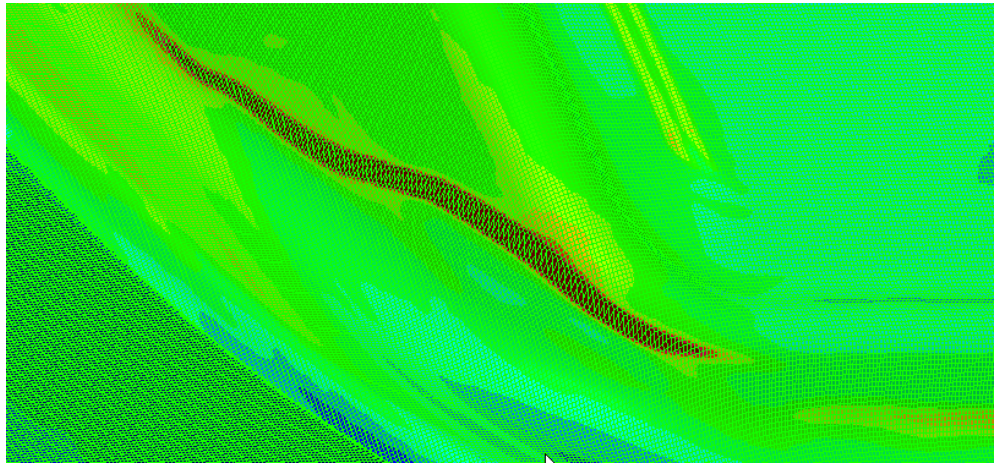
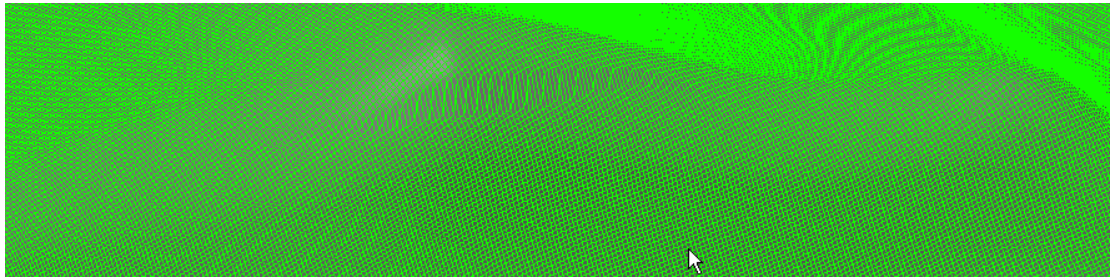
Uniform Meshes up to 10 Million Elements - Observe the Real Crack – Not Just Signs











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Fit of the Sprung Blank on the Next Die

Fit between stages

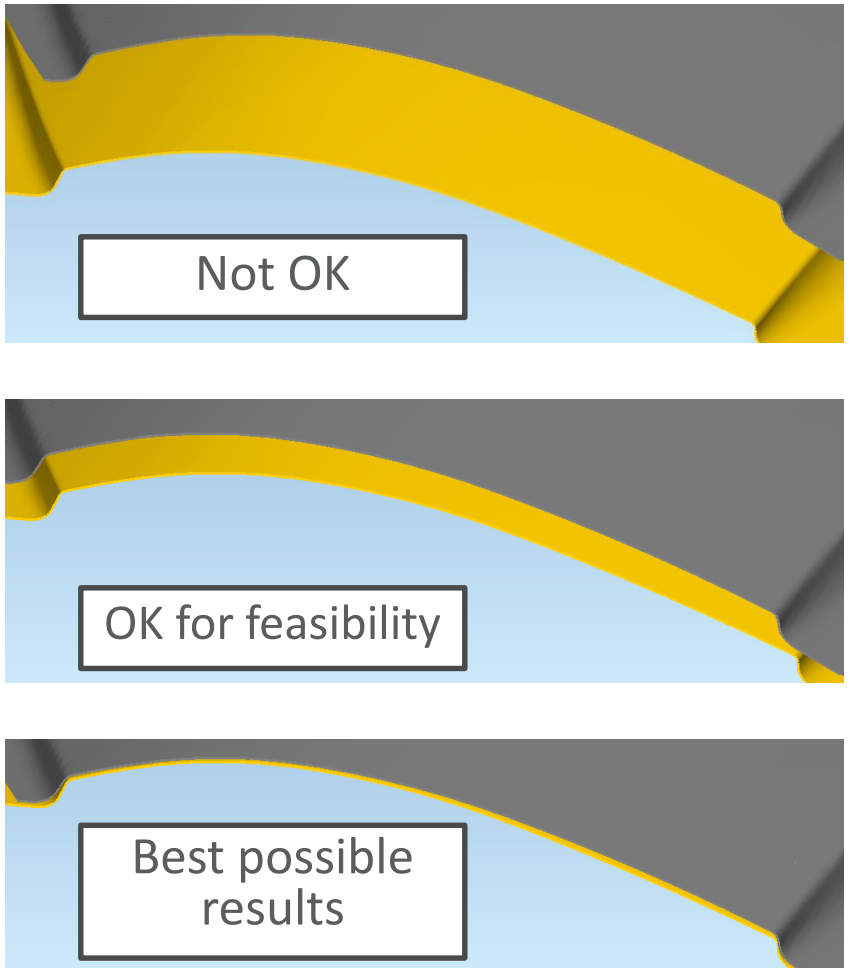
- Is key to accurate results
- As illustrated on the right side

Springback

- A springback needs to be done between each operation to get accurate results

The chosen simulation strategy depends on

- Accuracy expected
  - Feasibility
  - Validation
- Available time
- Available computer resources
  - Nb. of CPU's
  - Memory



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New Solution: ‘Locating Stage’

New method available from V2017.5

- Fits a rigid blank on a lower tool

Can improve the results of auto-positioning significantly

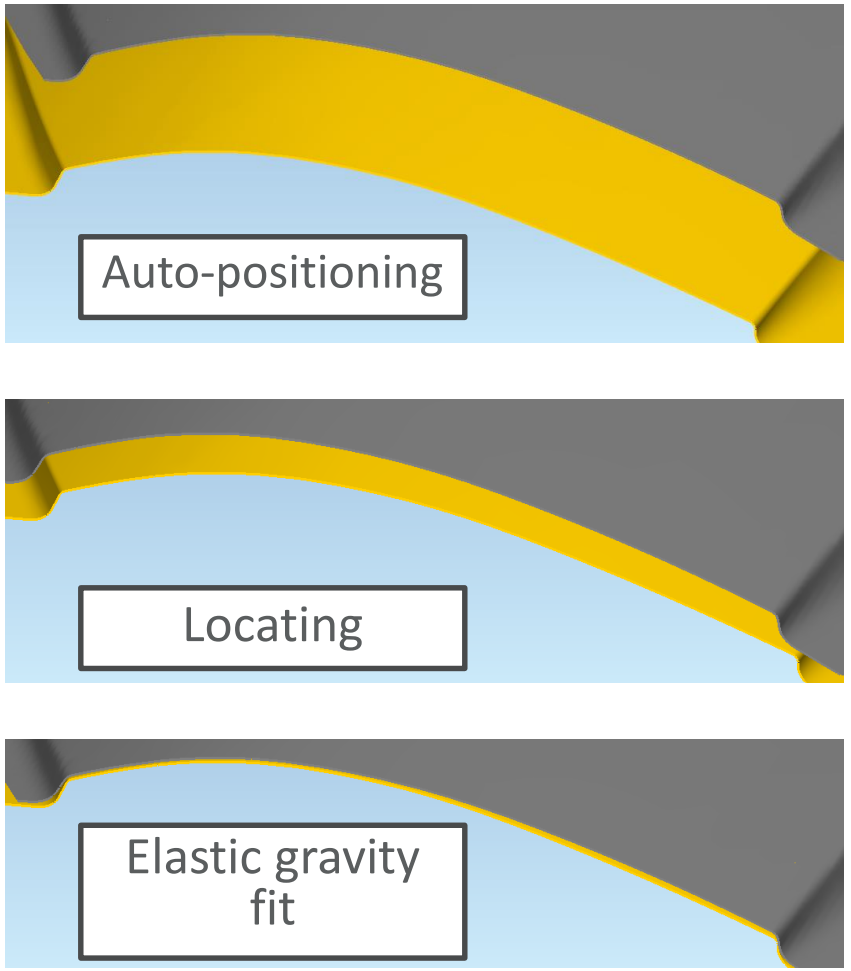
- Avoids the disadvantages of auto-positioning (see next slide)

Brings the rigid blank as close to the lower tool as it can get, in a good position

- After rigid body fit, auto-positioning will result in the same position and can be thus applied without problem in case a switch from explicit to implicit is required
  - An auto-positioning is required at the start of advanced implicit since explicit can have penetrations that need to be removed

In the body side example on the right side

- Initial distance after auto-positioning **47**mm
- After rigid body fit **12**mm
- After elastic gravity fit **2**mm



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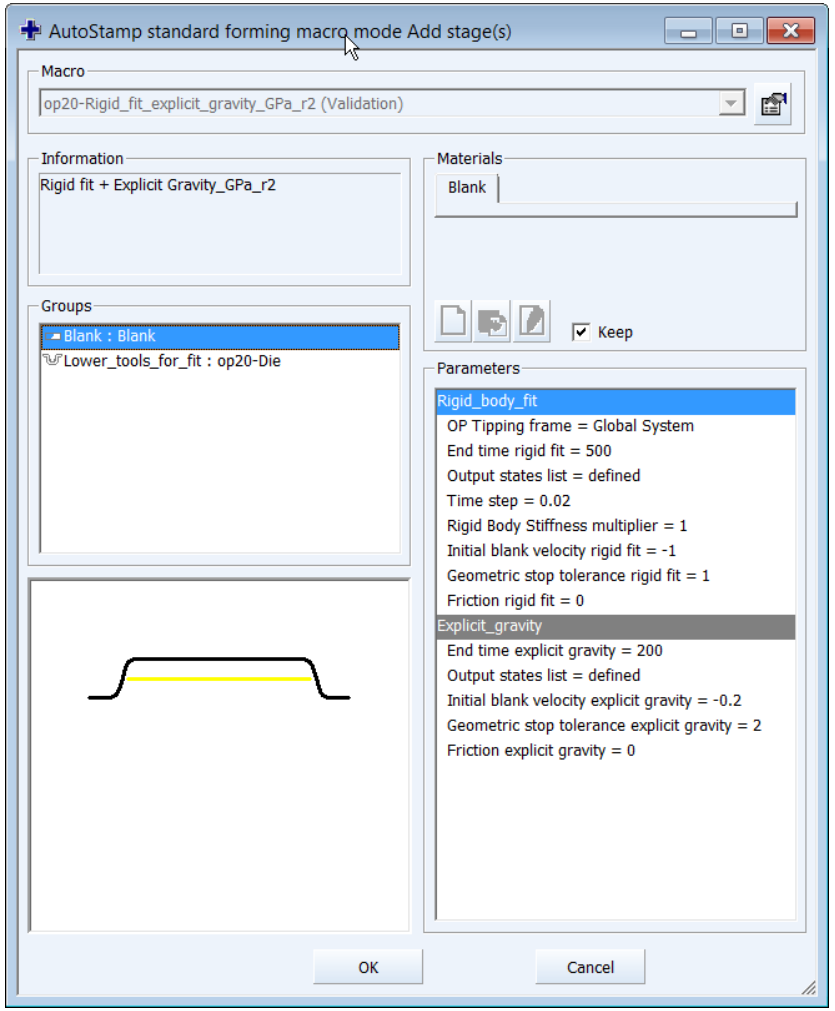
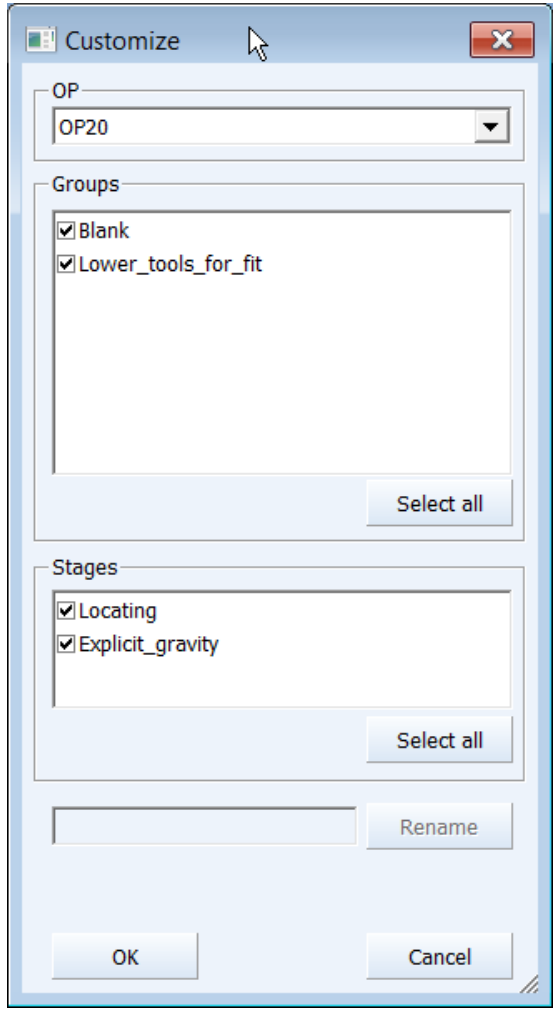
Locating and Gravity Fit – Including Springback

Accessible via Macro and Complementing Process Editor

- Locating
- Explicit gravity fit
- Implicit (Eulerian) gravity fit
- Advanced (Lagrangian) implicit gravity fit
- Explicit gravity fit and explicit springback at the same time





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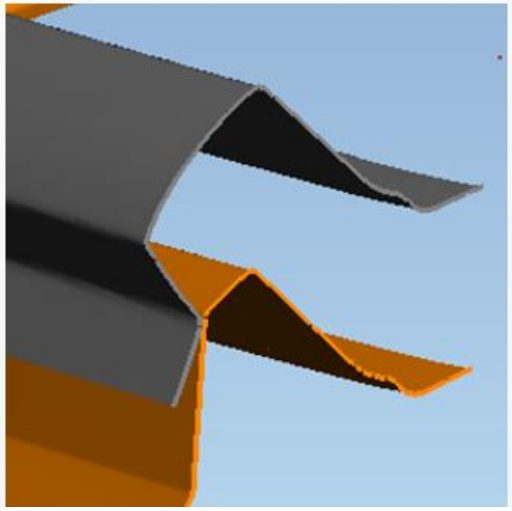
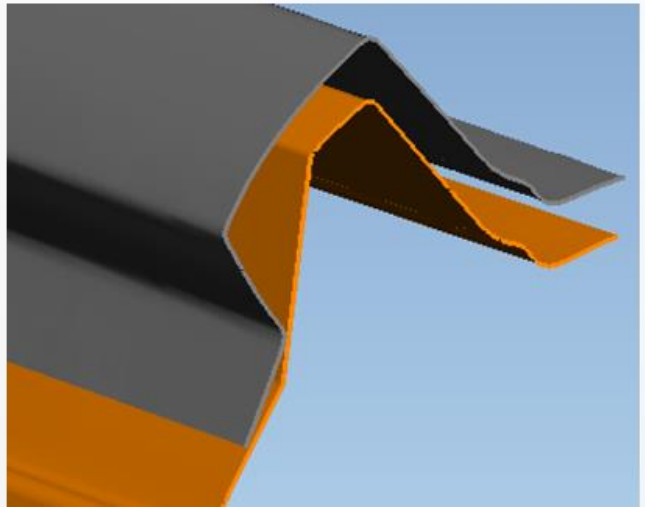
Auto-Positioning – Locating – Elastic Gravity Fit

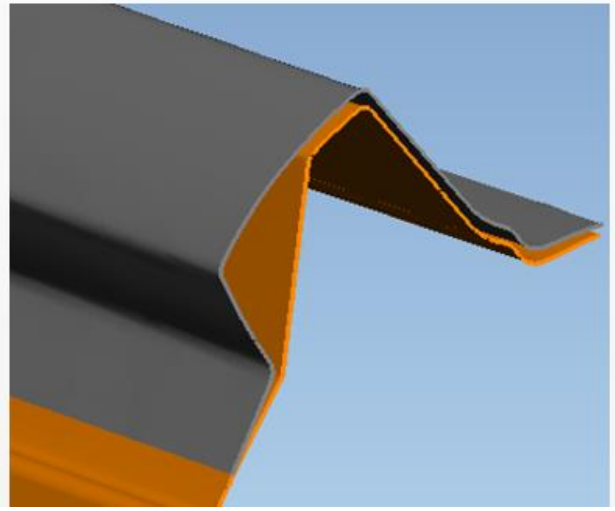
Auto-Positioning

Locating –
Rigid Body Fit

Elastic Gravity Fit







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Engineering Problems to Solve with This Capability

Check the Exact Fit between Stages – Also for Progressive Dies

Process

- OP
- Transport and fit
  - Springback
  - Locating
  - Gravity fit – if needed
    - Explicit or implicit
- Next OP

Benefit

- Check if the blank / stripe sits on the next die
- The locating will already show issues with positioning, so it might be good enough
- As the process happens in reality
- No simplification
- Specific recommendation
  - For explicit gravity fit a geometrical tolerance of 2 is sufficient since a sprung blank in equilibrium is used

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Engineering Problems to Solve with This Capability

Manage large blanks with limited memory and / or within limited time

Process

- OP
- **No** Springback
- Transport
  - Locating
  - Explicit gravity fit **including springback**
- Next OP

Benefit

- Only explicit
  - Uses minimum memory
- Locating will put the formed blank in the best position
- Explicit gravity fit will solve the springback and the fit problem at the same time, taking into account the contact to the lower tool
- Specific recommendation to safe time
  - For explicit gravity fit a geometrical tolerance of 0.2 is sufficient for a combined fit and springback
  - A geometrical tolerance of 0.01 is very costly and can cause 3 times the simulation time versus 0.2
  - In a gravity fit of a large panel +- 1mm do not matter in positioning vs. the lower tool
  - Use as many CPU as you have – there is no adaptive mesh refinement
- If you have neither memory nor time
  - Set the geometric tolerance to 1
  - Stop the explicit operation with an appropriate end time
    - Set points for printing result files and check
    - Make a dump during simulation and check
    - For outer panels between 50ms and 100ms is reasonable

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Conclusion – Minimize TRY-OUT Costs with Best Possible Accuracy

Most accurate modelling of material

- Procedure to evaluate the best possible yield function for measured data
- New yield function to give the best possible yield surface based on tensile tests only
- MatPara to determine kinematic hardening model data from tensile tests only

Most accurate modelling of contact

- No tool penetration of the blank due to accurate contact and a uniform mesh with small element sizes

Most accurate modelling of following operations

- Due to most accurate fit on the following die

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Conclusion – Minimize TRY-OUT Costs with Best Possible Accuracy

Most accurate modelling of geometrical beads (physical beads)

- With a uniform mesh

Most accurate modelling of splits and wrinkles

- With a uniform mesh

Most accurate modelling of springback

- With a uniform mesh
- With deformable tools

Results available in 24 hours for a body side with 8 million elements and a uniform mesh

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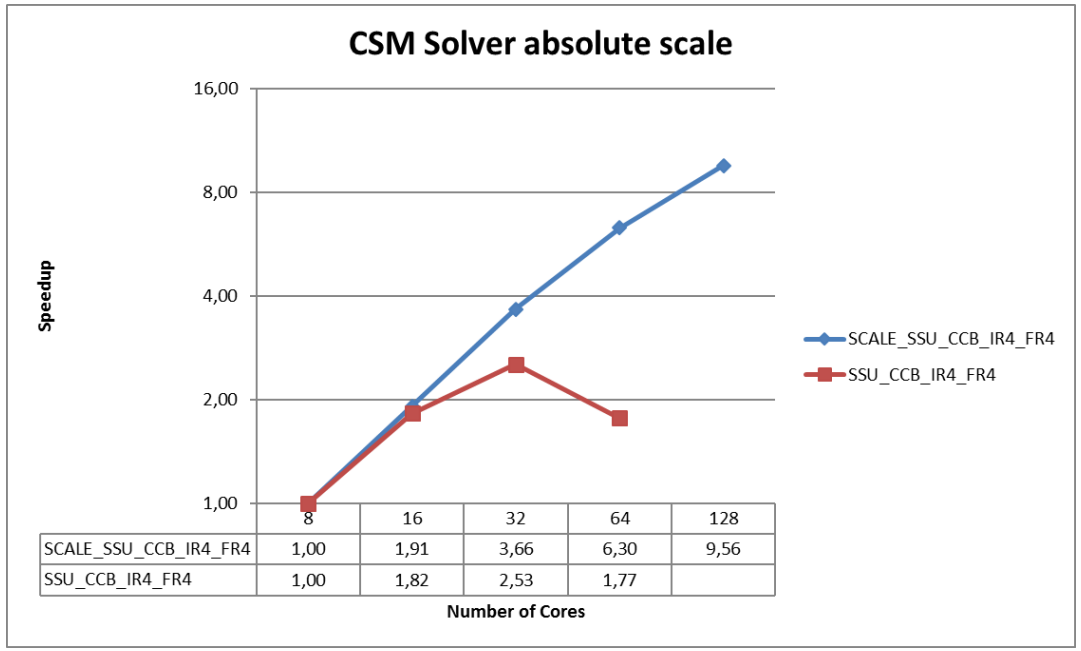
HPC Computing

Scalability & Solver Type



	8	16	32	64	128
SCALE_SSU_CCB_IR4_FR4	1,00	1,91	3,66	6,30	9,56
SSU_CCB_IR4_FR4	1,00	1,82	2,53	1,77	

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Solver Type

Now all can be done with one solver type - DMP

- DMP-DP – Double precision
  - For explicit and advanced implicit
  - Same Nb. of cores for all operations
- DMP-SP – Single precision
  - All stages explicit
  - Gravity fit done with locating and explicit gravity fit
  - Springback between operations within explicit gravity fit

Mix of single and double precision - DMP-SP / DMP-DP

- All stages explicit
- Springback at the end with advanced implicit

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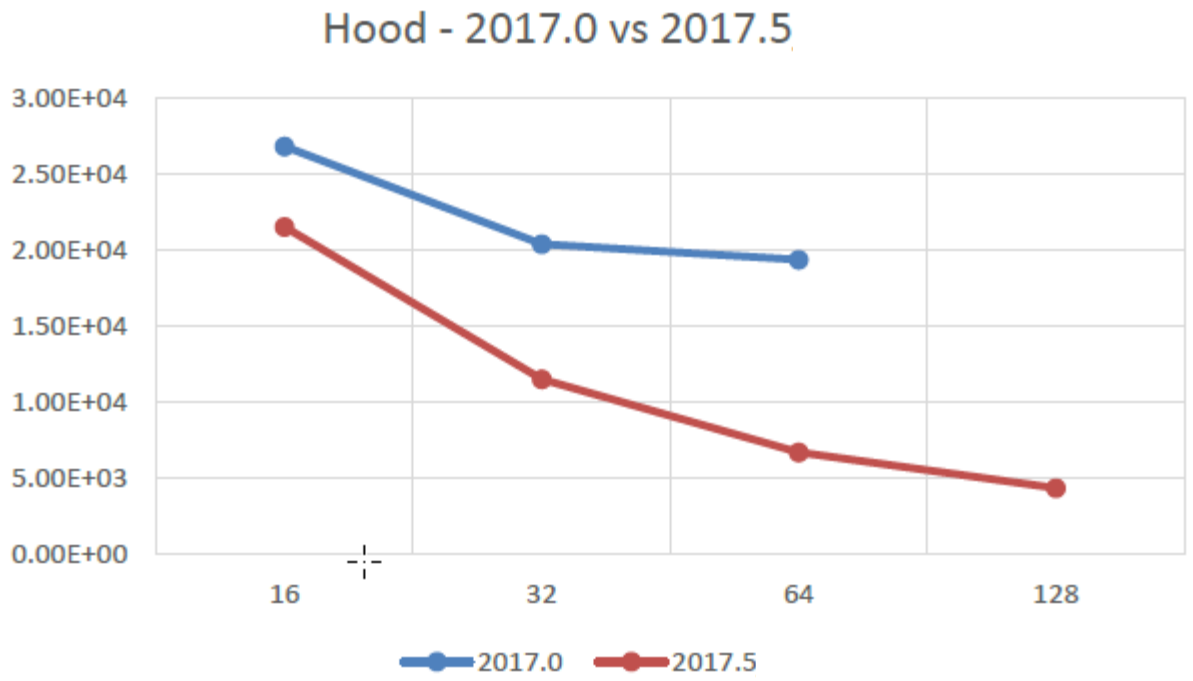
Scalability with a Uniform Mesh and SSU: 4 Times Faster Possible vs. V2017.0

Uniform mesh and triple speed

More examples

- Hood:
  - **4.82 million** deformable elements
  - Uniform mesh size: 0.8mm
  - Stroke: 110mm, velocity: 5 m/s
  - 1h12min

- B pillar :
  - **0.4 million** deformable elements
  - Uniform mesh size: 1,3mm
  - Stroke: 85mm, velocity: 5 ms
  - 5min



	8 CPUs	16 CPUs	32 CPUs	64 CPUs	128 CPUs
2017.0		7:27:41	5:40:07	5:23:08	x
2017.5		5:59:06	3:11:39	1:51:16	1:11:55

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Scalability with Adaptive Mesh Refinement

Door outer, geometrical draw beads, validation tool speeds with ramp, 12mm initial mesh size, 5 refinement levels, best accuracy, 64 x Xeon E5-2650 v2 @ 2.6 GHz

	NO SSU				SSU
Nodes	1		2	4	2
Cores	8	16	32	64	32
Gravity	0h, 3min, 37sec	0h, 2min, 54sec	0h, 2min, 57sec	0h, 2min, 53sec	0h, 2min, 57sec
Holding	1h, 27min, 17sec	1h, 1min, 50 sec	0h, 59min, 25sec	1h, 11min, 23sec	0h, 24min, 20sec
Stamping	6h, 13min, 10sec	3 h, 38min, 10sec (1.71 factor vs 8)	2h, 13min, 18sec (2.79 factor vs 8)	1 h, 40min, 21sec (3.72 factor vs 8)	0h, 38 min, 8sec (9.78 factor vs 8)
Springback	0h, 12min, 38sec	0h, 8min, 33sec (1.47 factor vs 8)	0h, 5min, 22sec (2.35 factor vs 8)	0h, 5min, 21sec (2.36 factor vs 8)	0h, 5min, 18sec (2.38 factor vs 8, no SSU active)

- Scalability in the holding stage is not as stamping because when geometrical drawbeads are closing, mesh refinement takes place on different regions
  - Some cores are overloaded up to a point when all the binder is fully closed
- Stamping stage is the one that takes normally 80% of the simulation time, and here scalability showed the above speedup factors up to 64 cores
- Implicit springback scales up to 32 cores

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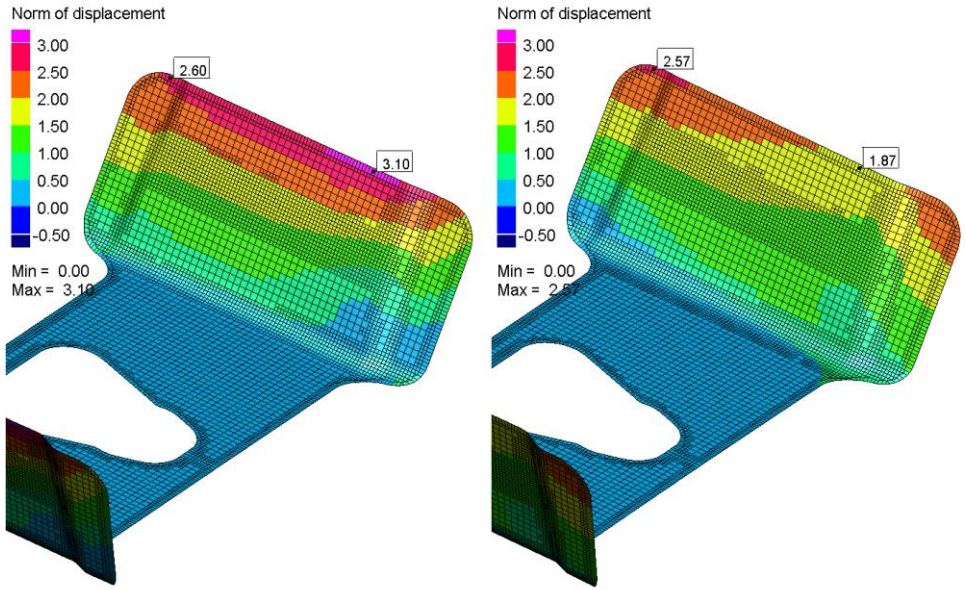
Deformable Tools

Get more accuracy into springback



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Improve Accuracy of Springback with Deformable Tools

Big improvement in PAM-STAMP V2017.0 and V2017.5: Solver coupling

Computational improvements in V2017.5

Benefit

- Improve springback results
- Evaluate fatigue issues on the die

How does it work

- Shell model in explicit (full stamping analysis)
- Solid model in implicit (linear analysis)
- Coupling:
  - Explicit sends contact forces, implicit sends displacements (and compute stresses, strains)
- Very fast
  - Not so much longer than normal explicit analysis

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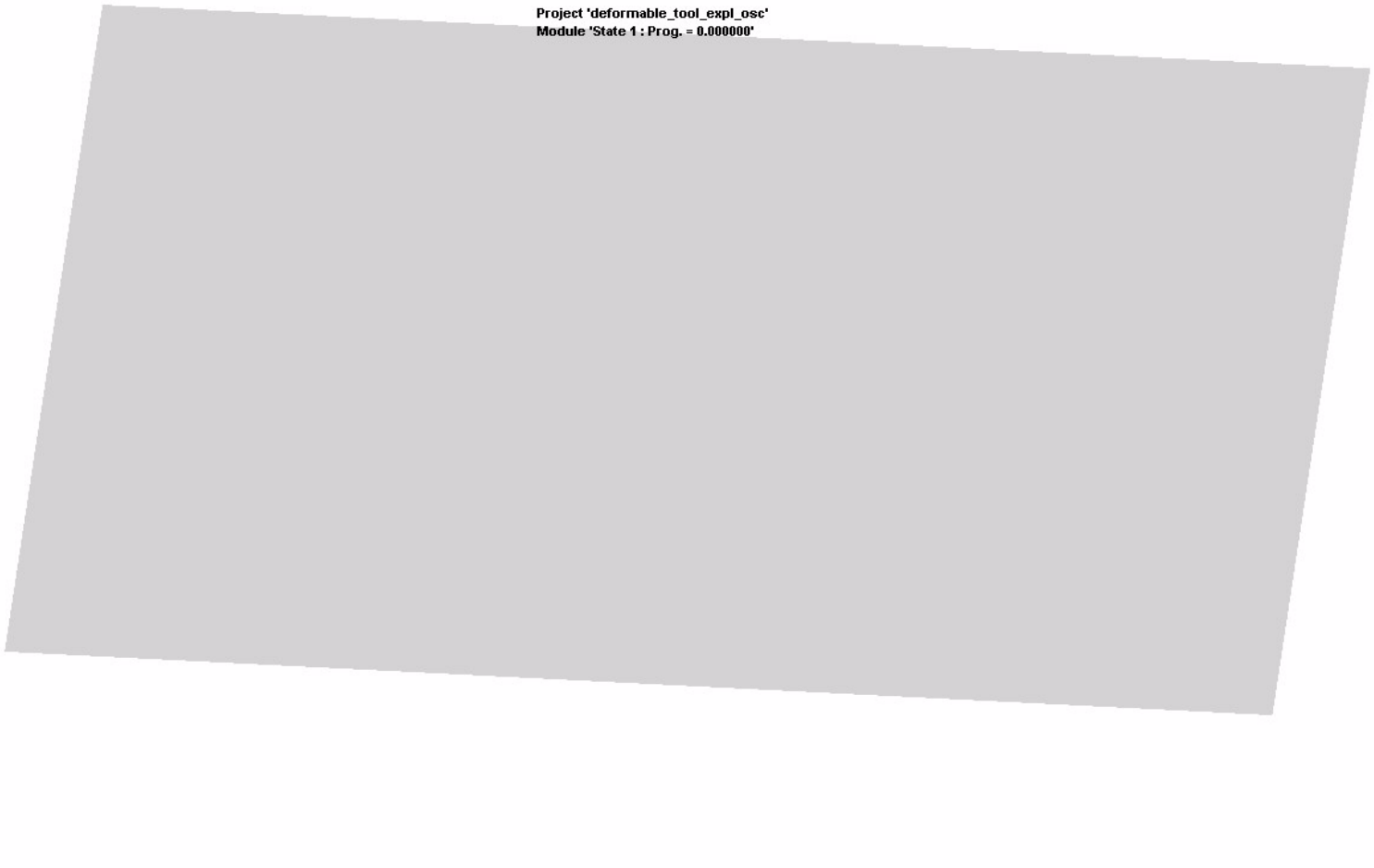
Real Stamping Tool – Forming Process



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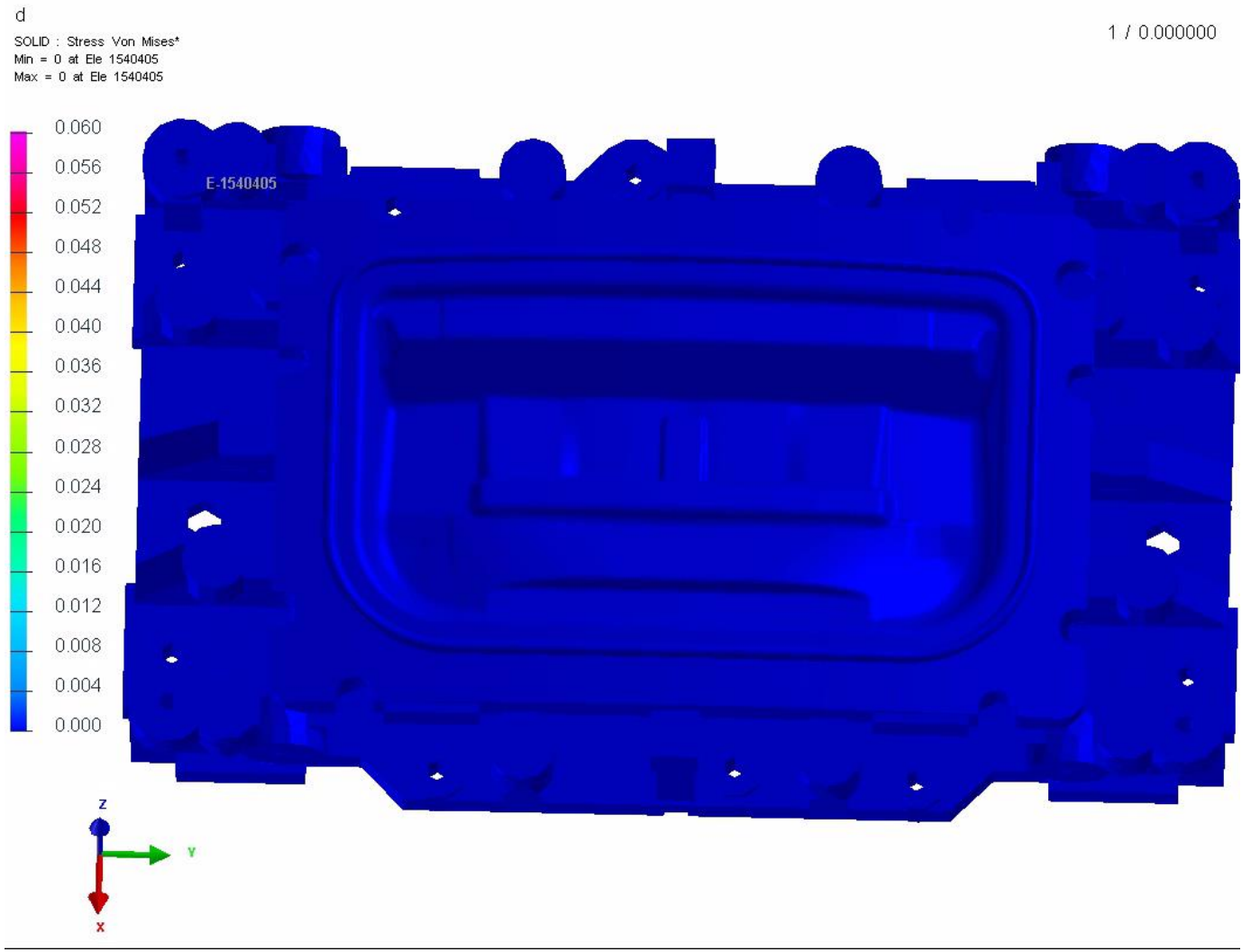
Deformable Stamping Tool – Die Stress Evolution During Forming



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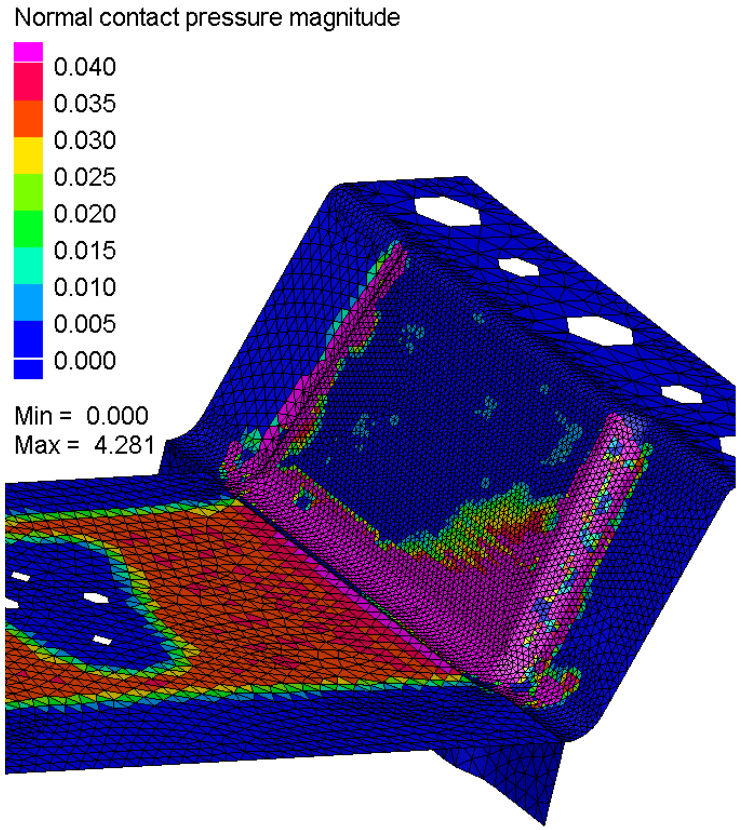
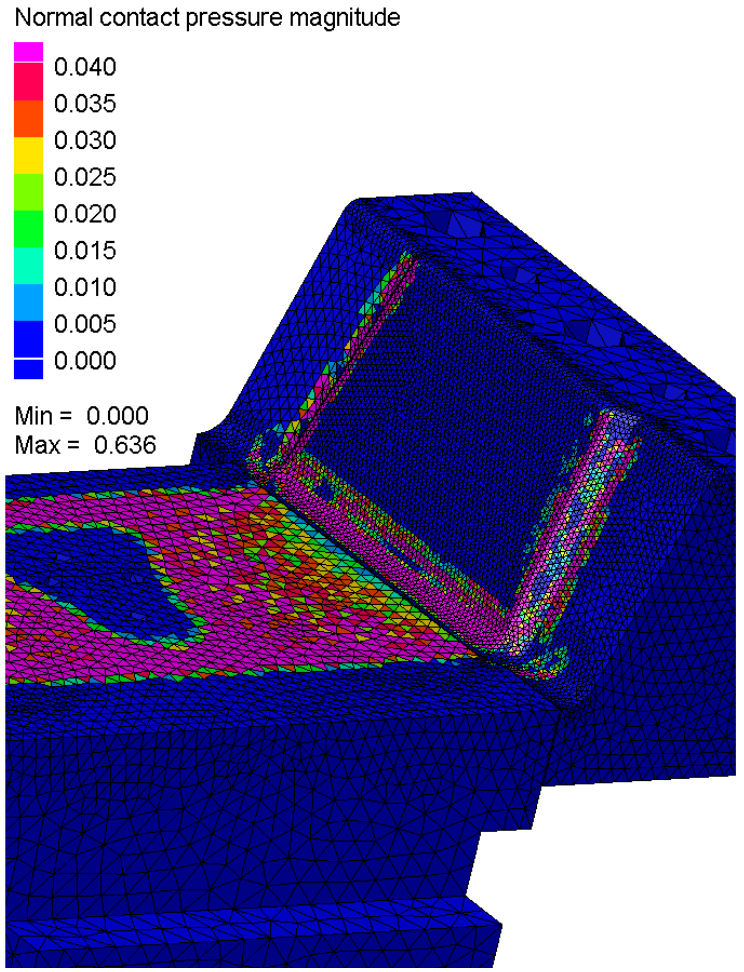
Contact Pressure Distribution – Deformable vs. Rigid Tool

Rigid tools - shell



Deformable tools - solid



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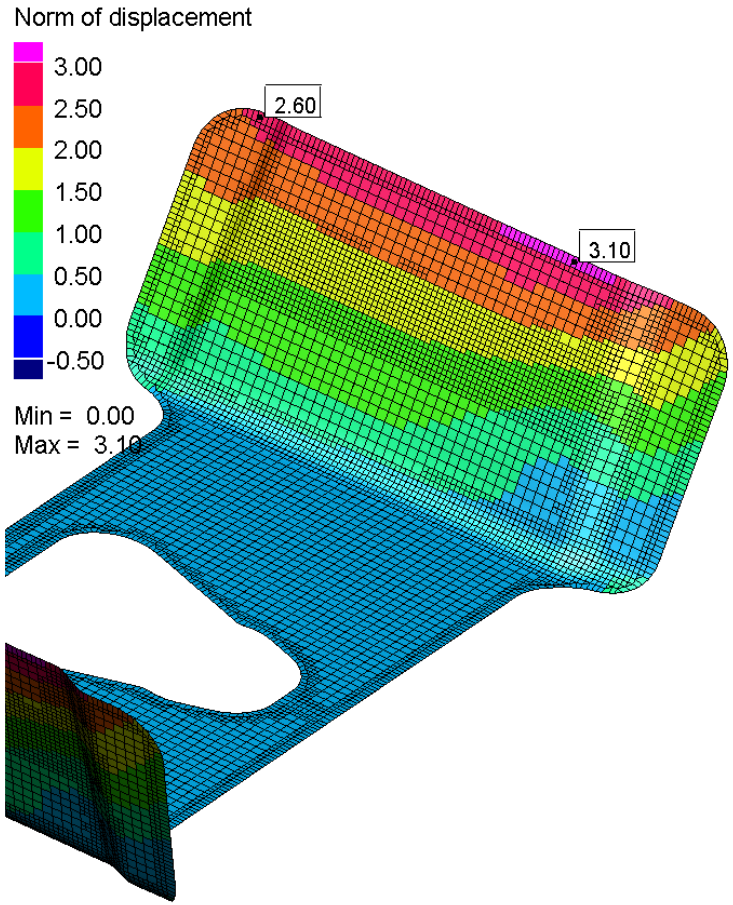
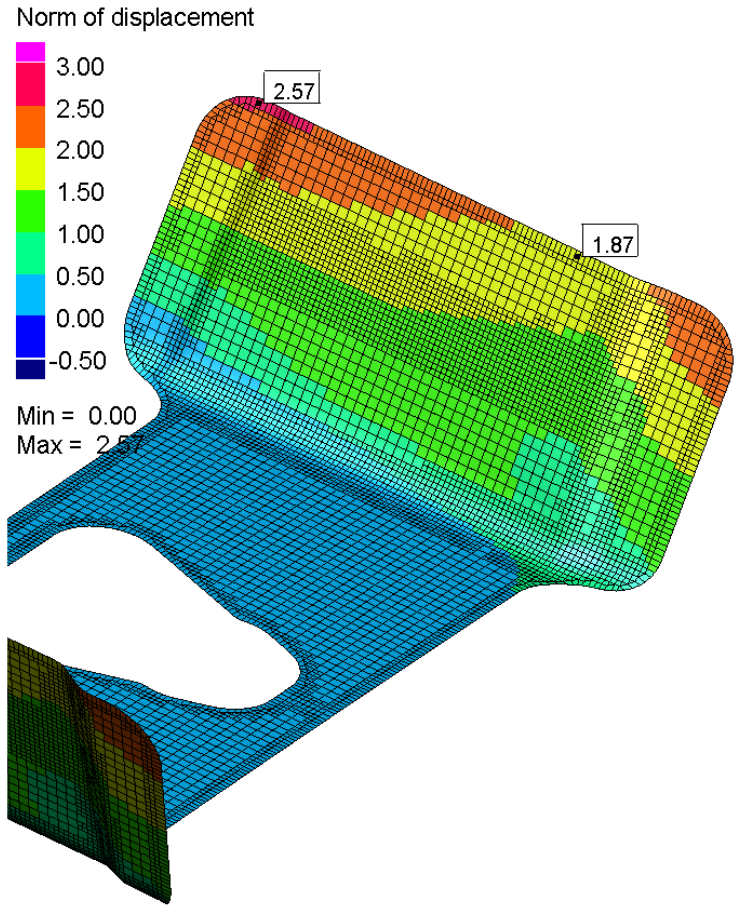
Comparison of Springback Magnitudes – Deformable vs. Rigid Tool

Rigid tools - shell



Deformable tools - solid



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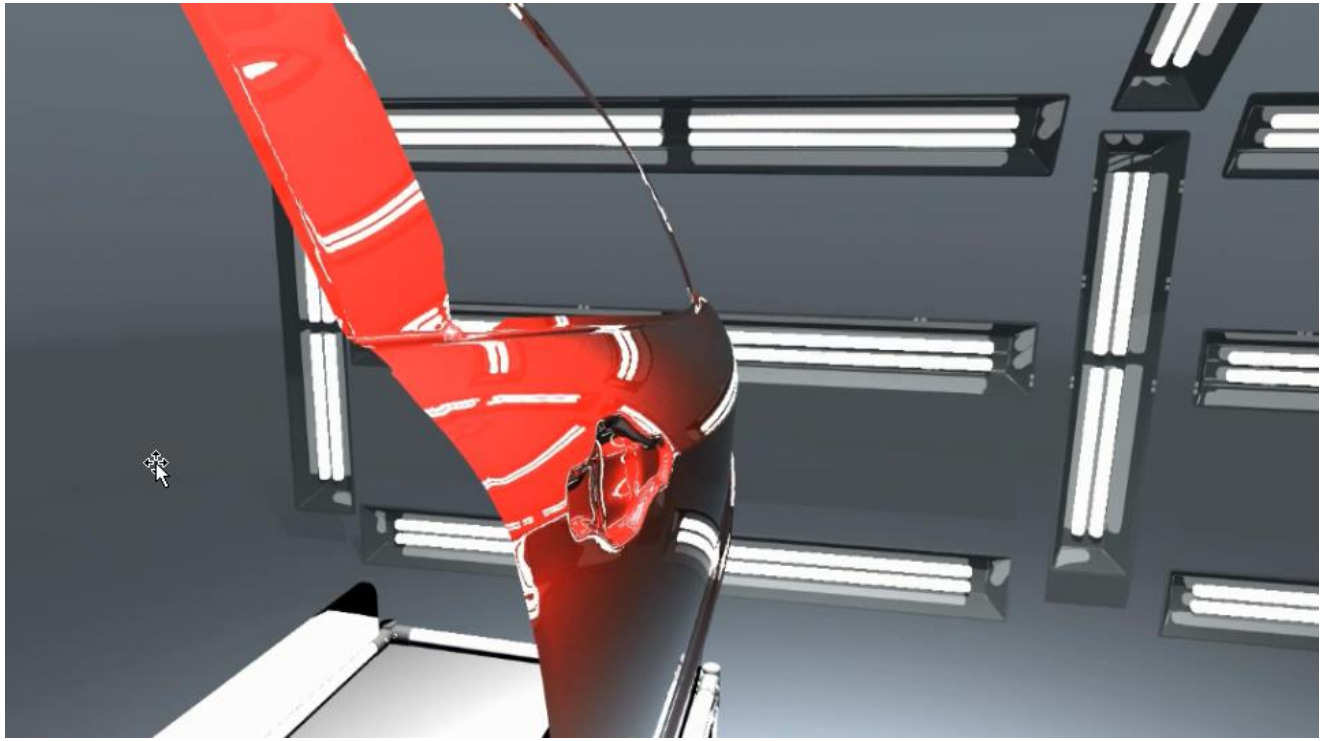
Surface Defects



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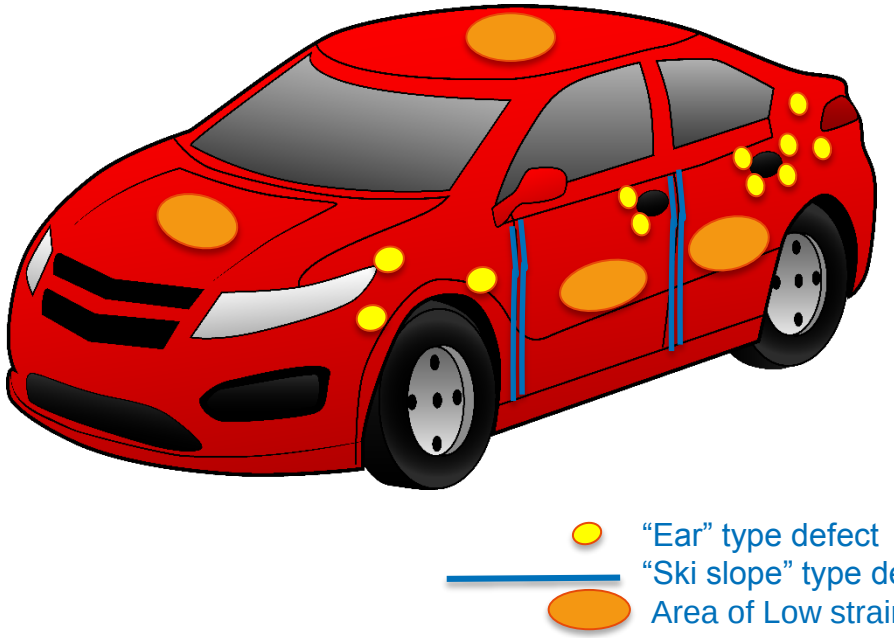
Surface Defects – Best to be Analyzed with a Very Fine Uniform Mesh

Based on accurate results

Skin Panels – Background

Visual Characteristics – Aesthetic
Manufacturing requirements – Retaining intended geometry



Surface defects are the result of elastic recovery of non-uniform strain distribution during forming

- CAD surface design – Analyze Reflect Lines
- Die making - Dirt, NC error, Die spotting, Tool bearing
- Skid marks due to Process / Part geometry.
- Surface defects due to spring-back
- Defects due to incomplete forming, Insufficient stretching
- Aesthetic for Skin Panels
  - Skid Lines
  - Shock Line
  - Surface Lows/Deformations
  - Ski Slopes near flange bends

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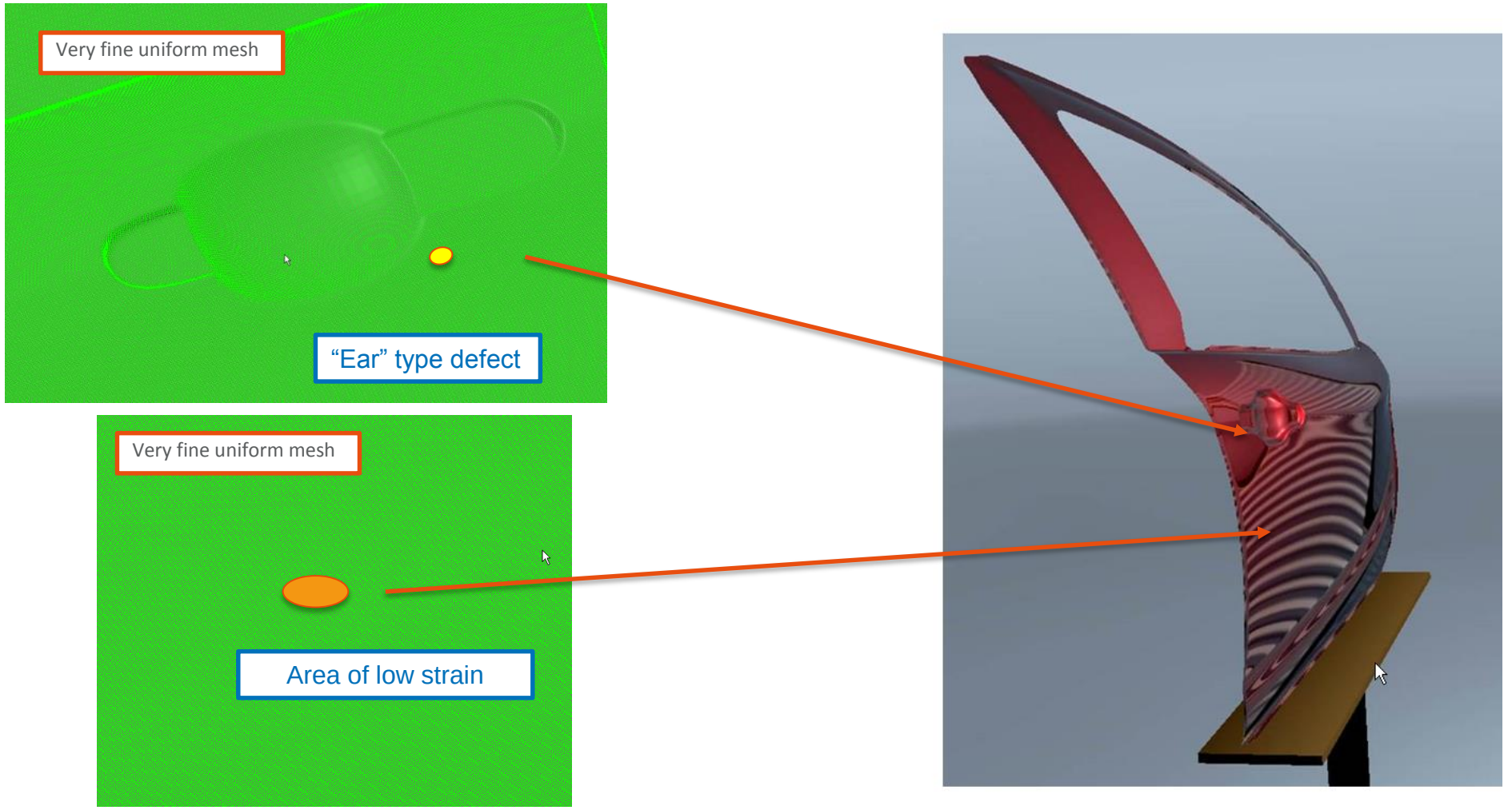
Realistic Rendering – Best Results with High Quality / Uniform Meshes



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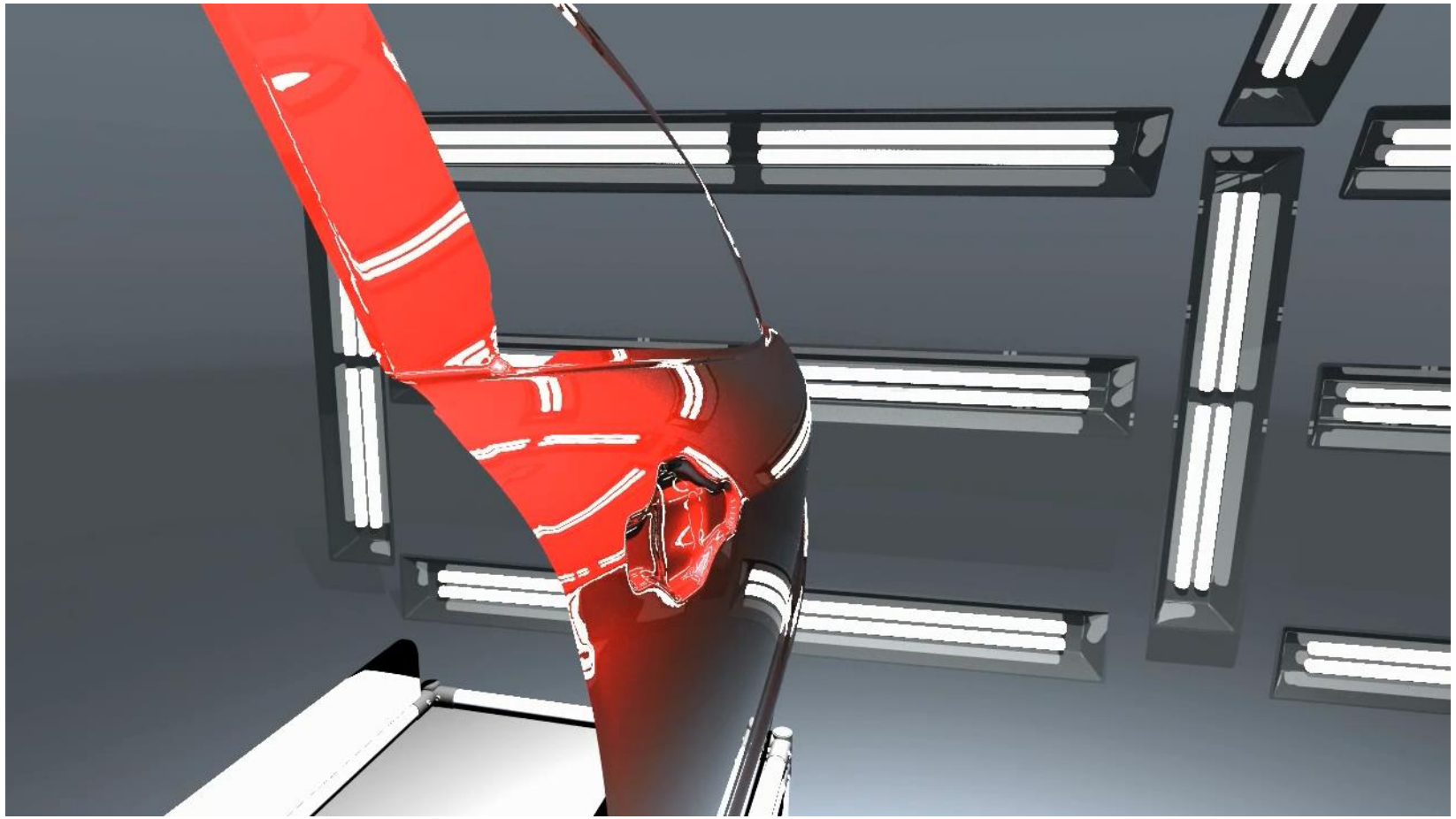
Realistic Rendering – Best Results with a Uniform Mesh

Dynamic Analysis



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Surface Defects – Digital stoning

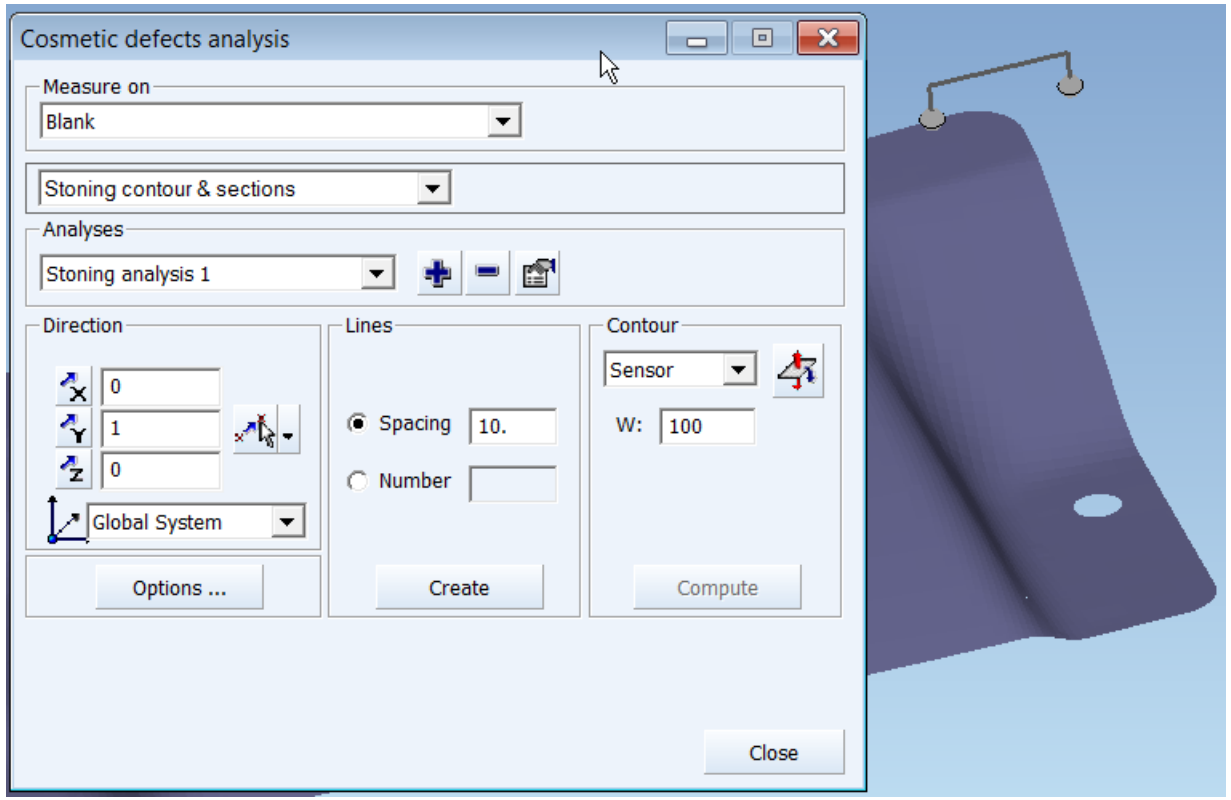
New concept of “Analysis” :

- All parameters and sections saved in each “analysis”.
- “Analysis” saved in the project.

Faster section creation (algorithm improved)

Dialog rearranged :

- Fewer buttons (but same capabilities thanks to sessions)
- Workflow clearer



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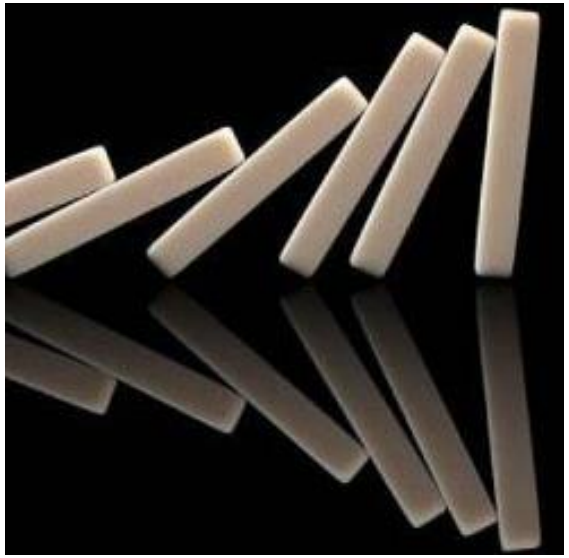
Robustness



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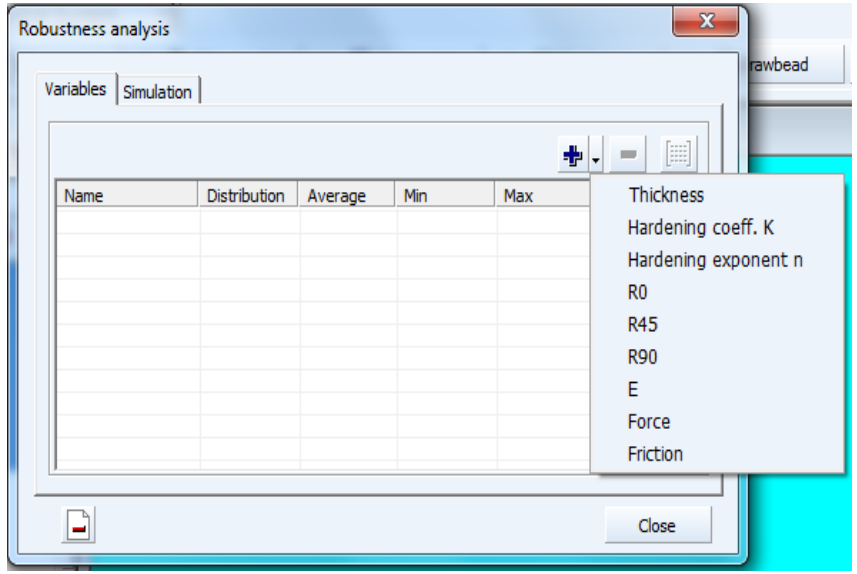
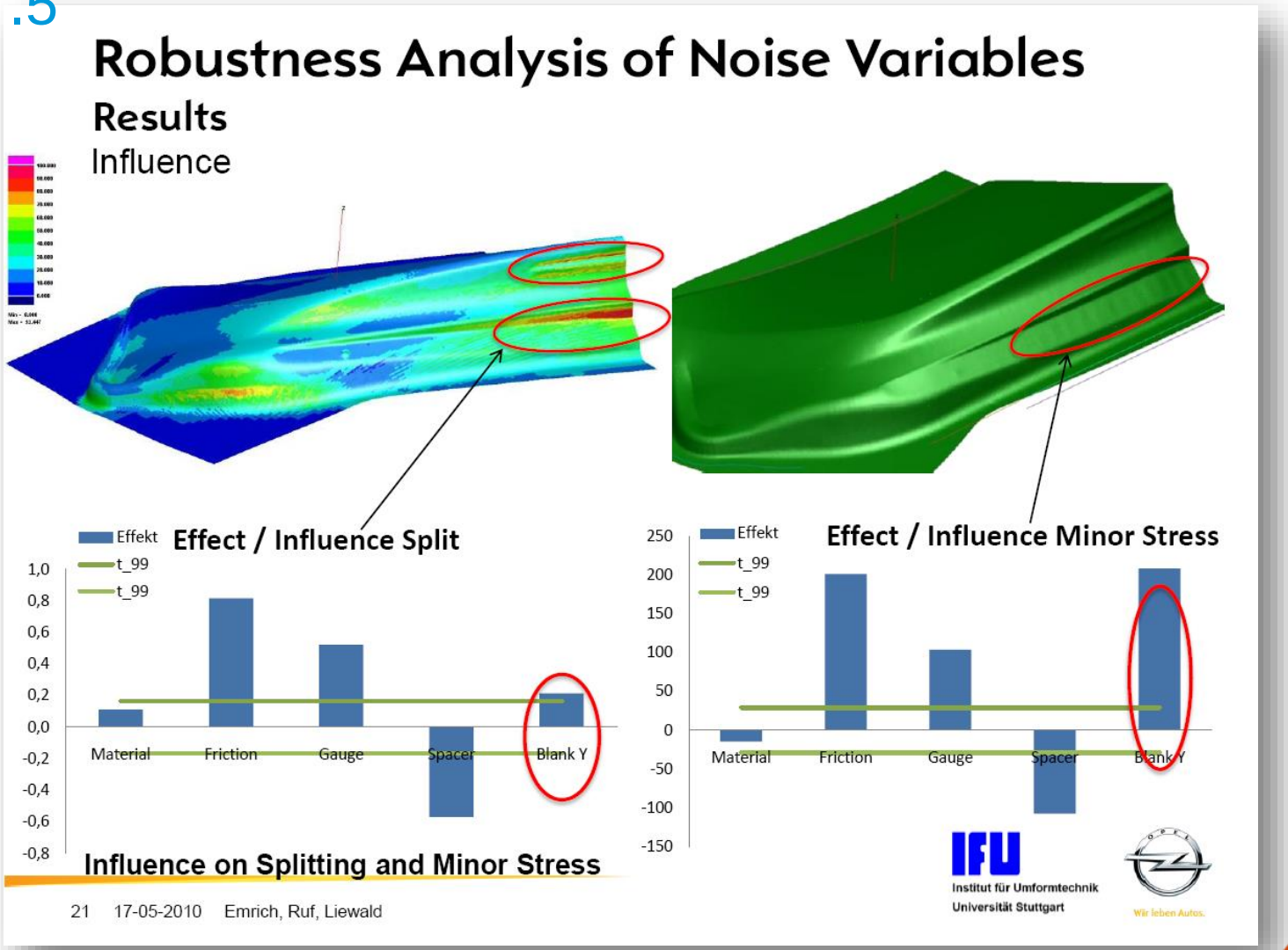
GM/ESI contract

Robustness Analysis

Setup now available in V2017.5

Presentation Mr. Emrich
ESI Global Forum 2010





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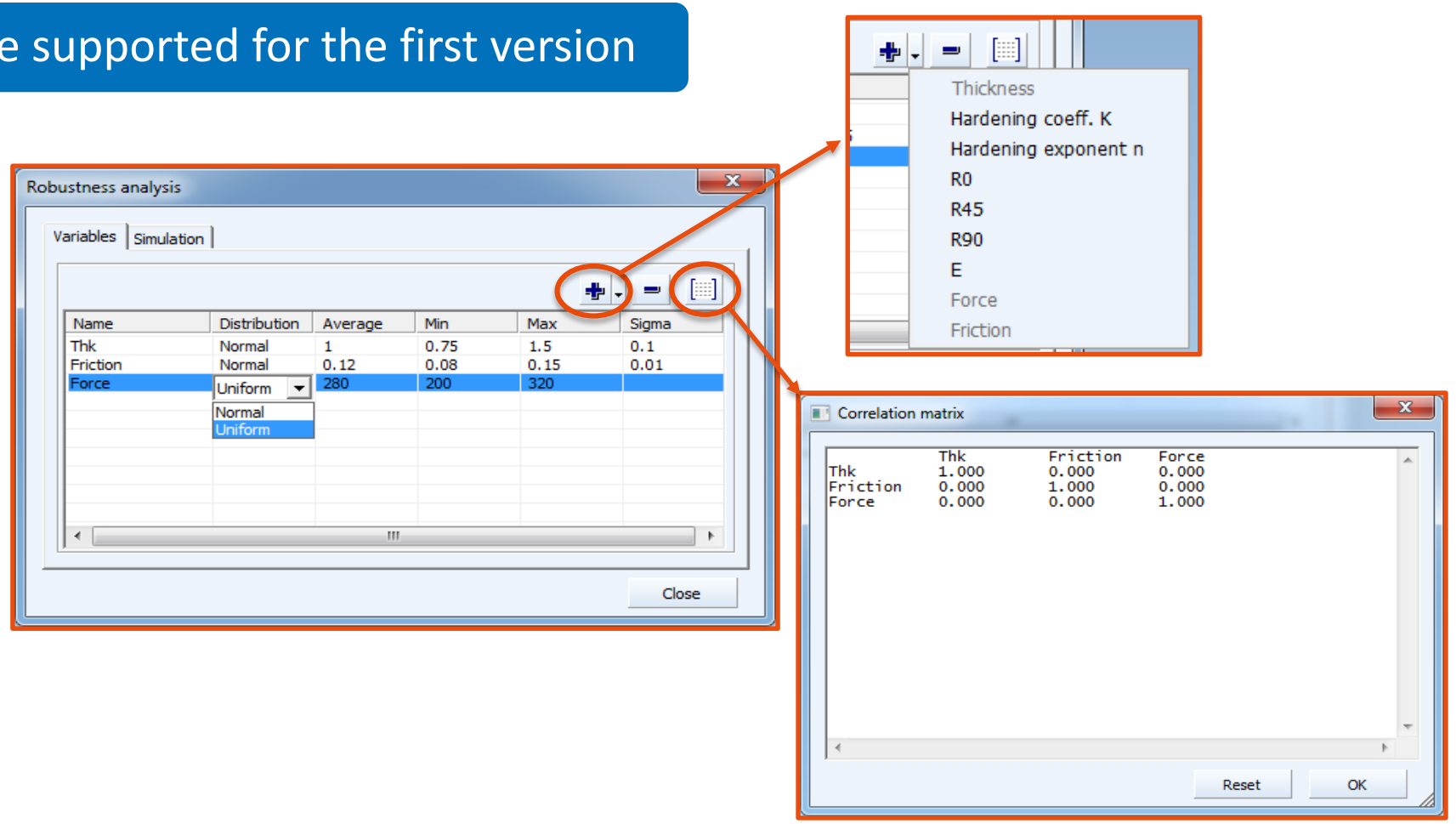
Robustness Analysis

Fully compatible with Krupkowsky Law

9 variables are supported for the first version



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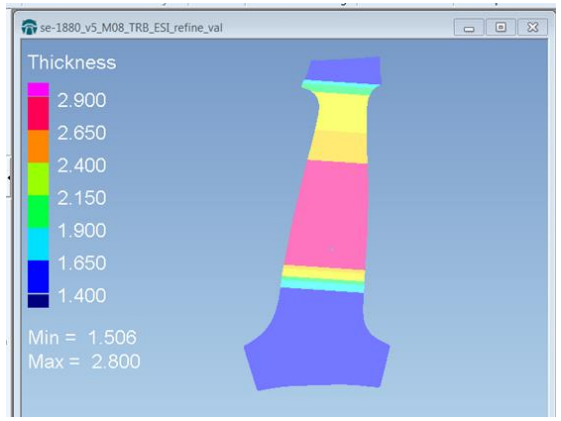
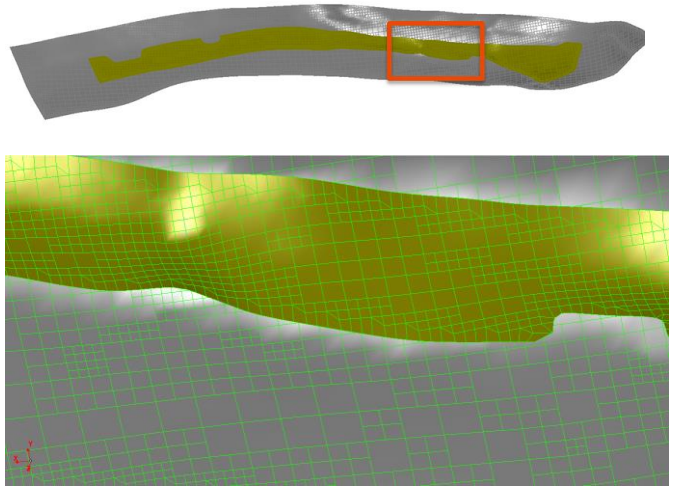
Hotforming Update

Full support of recent lightweight trends





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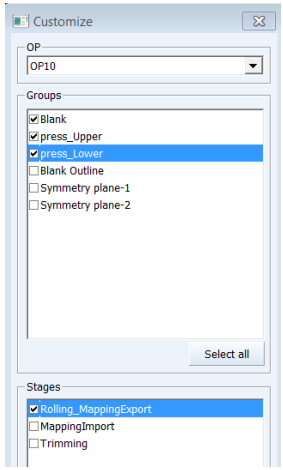
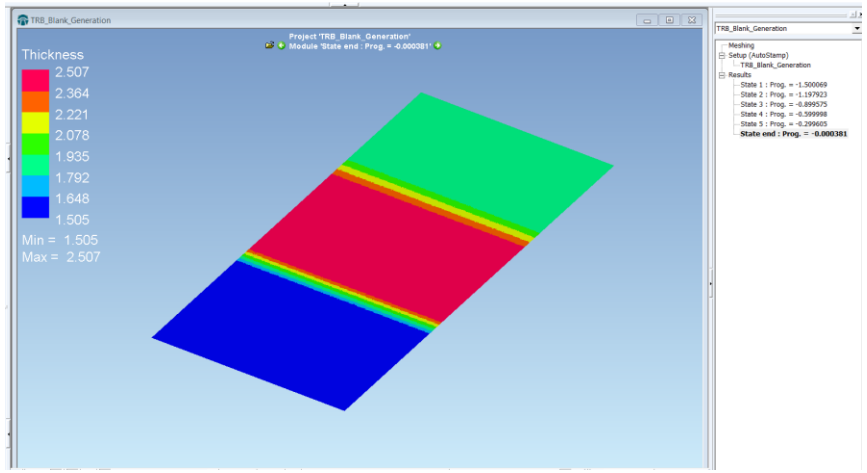
Tailor Rolled Blanks

Simplified Model for Rolling Process

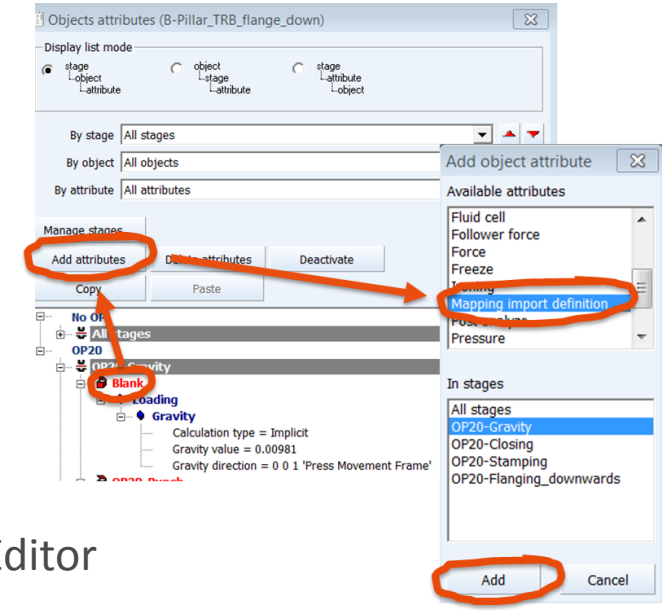
- Fully supported by Macro
- gives rectangular blank with thickness profile
- thickness is mapped to blank defined by outline

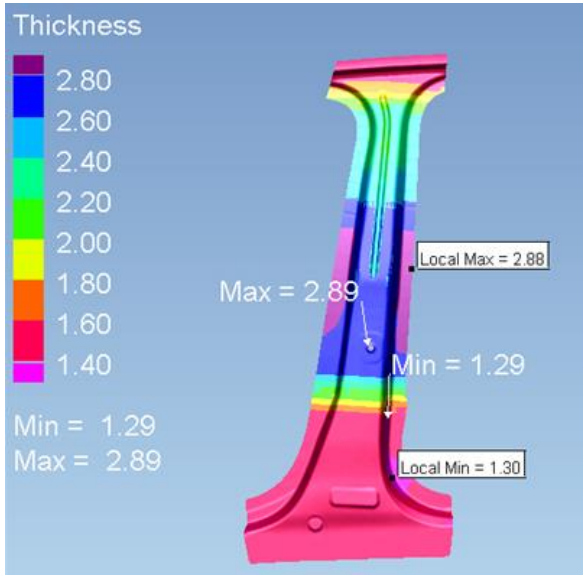




Thickness Mapping in Hotforming

- Typical first feasibility runs with uniform thickness
- Flattening gives transition zones on flat blank
- Adding mapping attribute to blank to make it a TRB





Diespotting for Tool Offset adjustment

- First run with TRB with a uniform tool offset
- Diespotting to adjust tool gap to TRB final thickness
- CAD Reconstruction of nominal Dieface in Visual CAD-Editor

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Patched Blanks

Powerfull Macro for all possible cases

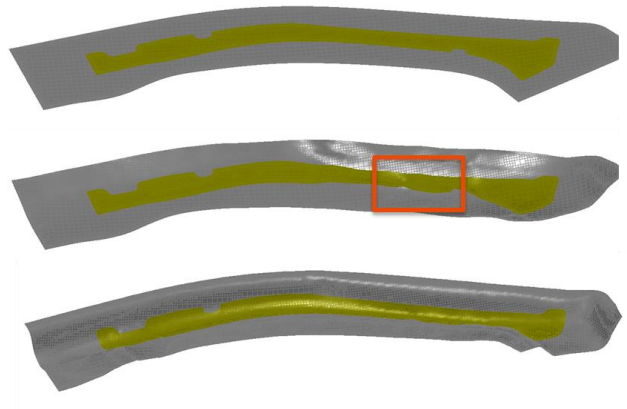
- single/multiple patch on top or bottom side
- Simple Spotweld definition by independent free nodes
- Contact and heat transfer between blanks

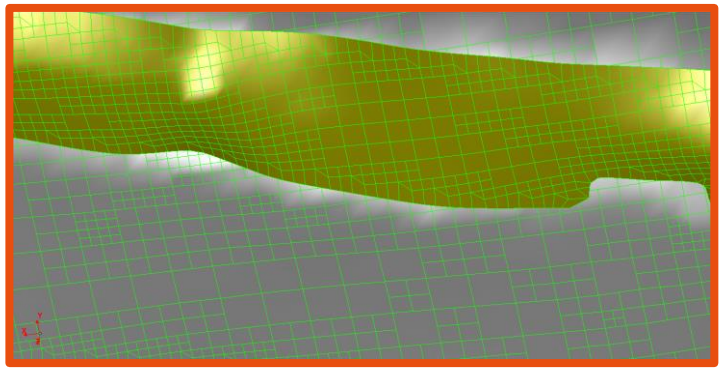
No special simulation settings

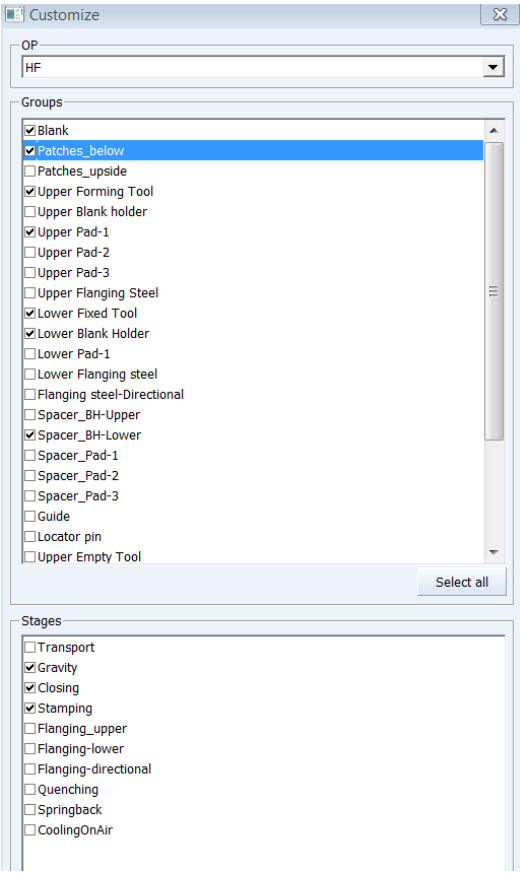
- Adaptive refinement works for both blank and patch
- Spotweld elements are created by the macro

Benefits

- Accurate representation of real physics
- Prediction of the real wrinkling behavior
- Spotweld failure models from VPS are available







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Warmforming and Hotforming of High Strength Aluminum

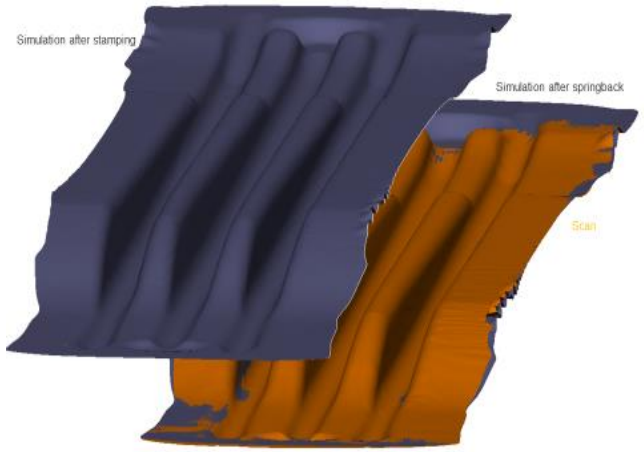
Participation in relevant research projects

- Material model is the key to high predictive accuracy
- Lack of available test data is currently the biggest issue
- Combination of test, literature data and valid assumptions is current best practice

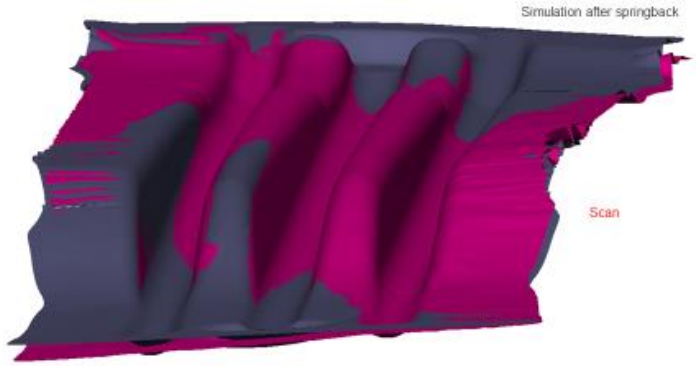
Close cooperation with customers

- Validation of models under real process conditions
- Facing real challenges in first implementation trials of new technology
- Win-win situation for both sides

Hotforming



Warmfoming 300°C



Warmfoming 200°C

Coloured is scanned part
Grey is PAM-STAMP result

AP&T
AUTOMATION · PRESSES · TOOLING

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Efficiency Improvements

GUI

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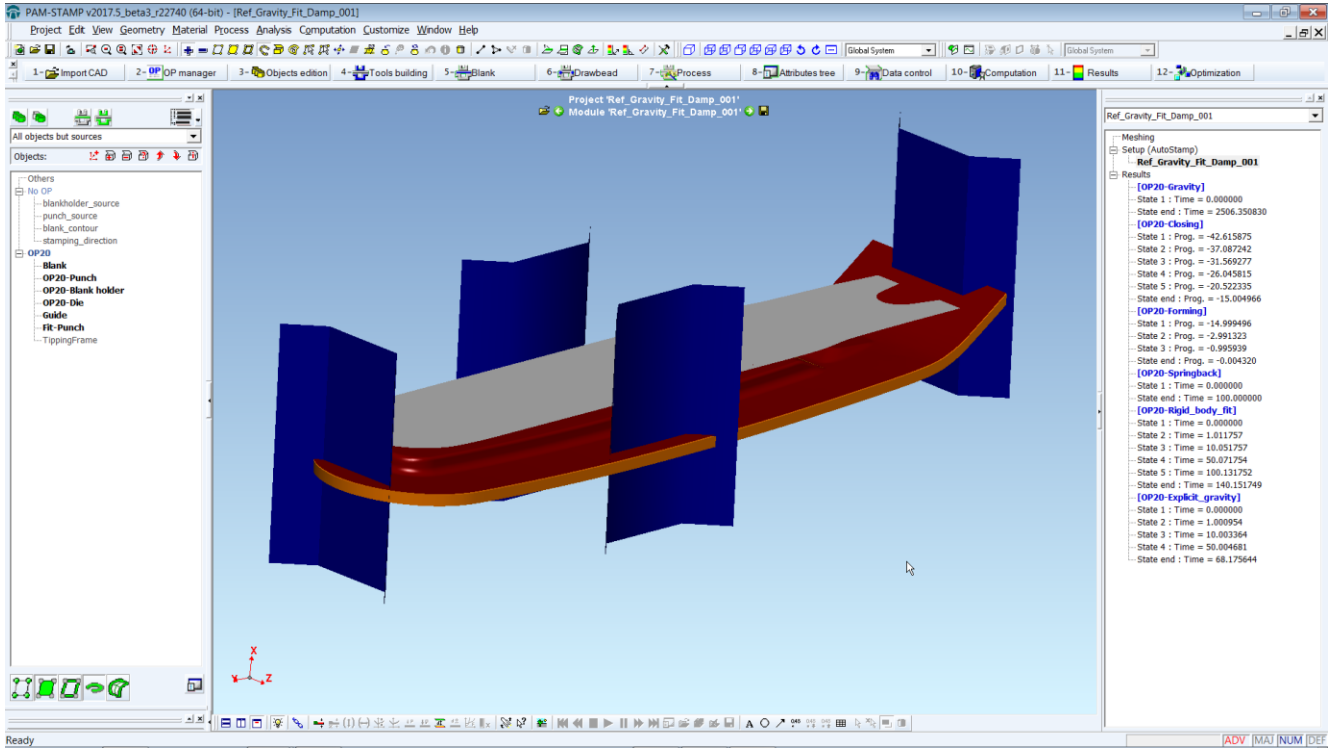
Improvements V2017.0

New GUI Layout

- GUI Pre/Post way more reactive
- Import simplified / improved
- New OP manager
- Objects and Frames – New user experience
- Tool editor simplified
- Geometrical drawbead
- New process editor
- Improved kinematic check
- Simplified solver setup and run



New solver architecture

Deformable tools

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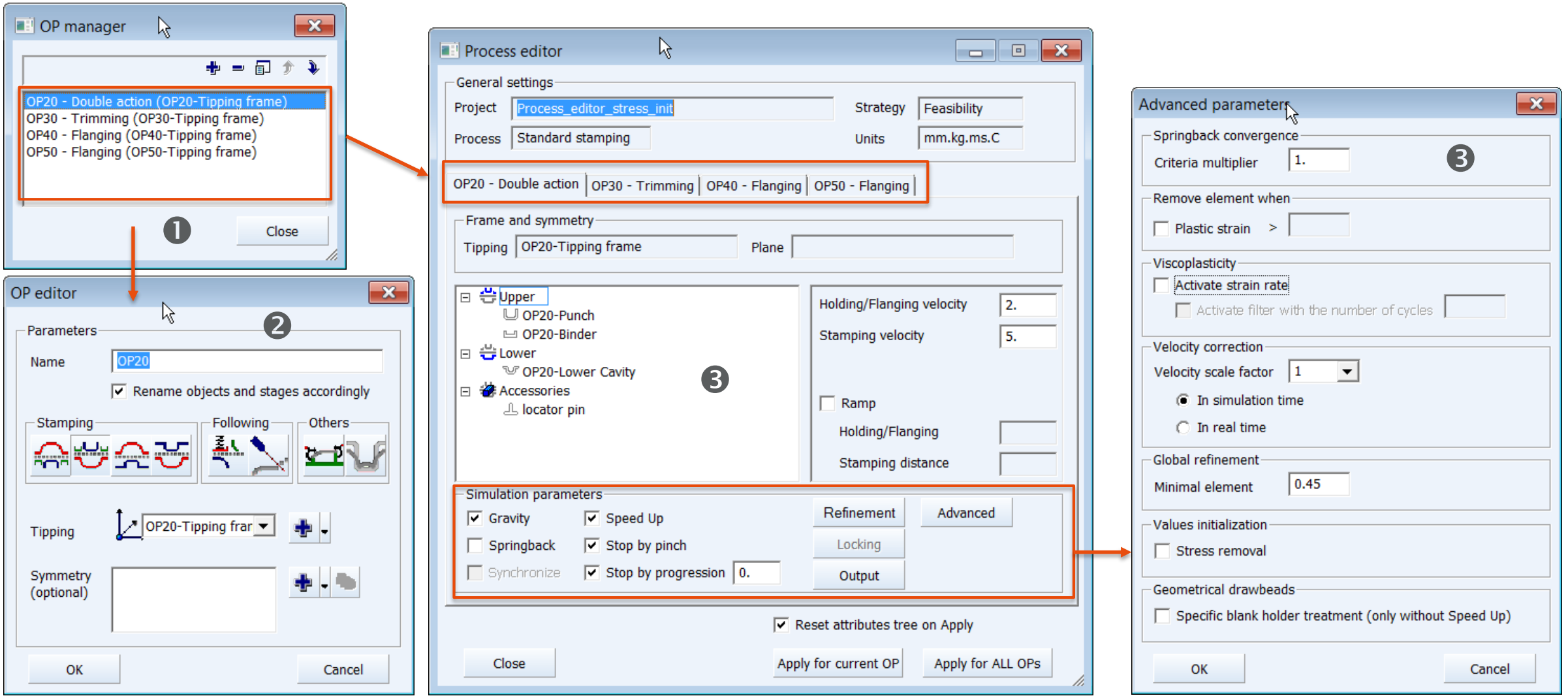
Ease of Use – Set up in a Few Minutes – Full Control



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GUI Improvement V2017.5

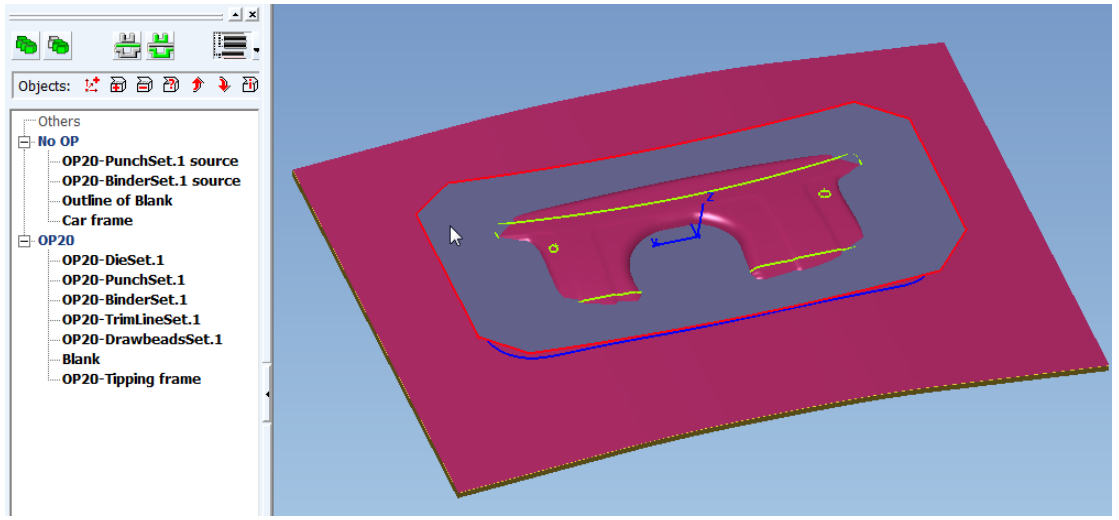
Display with and without sources

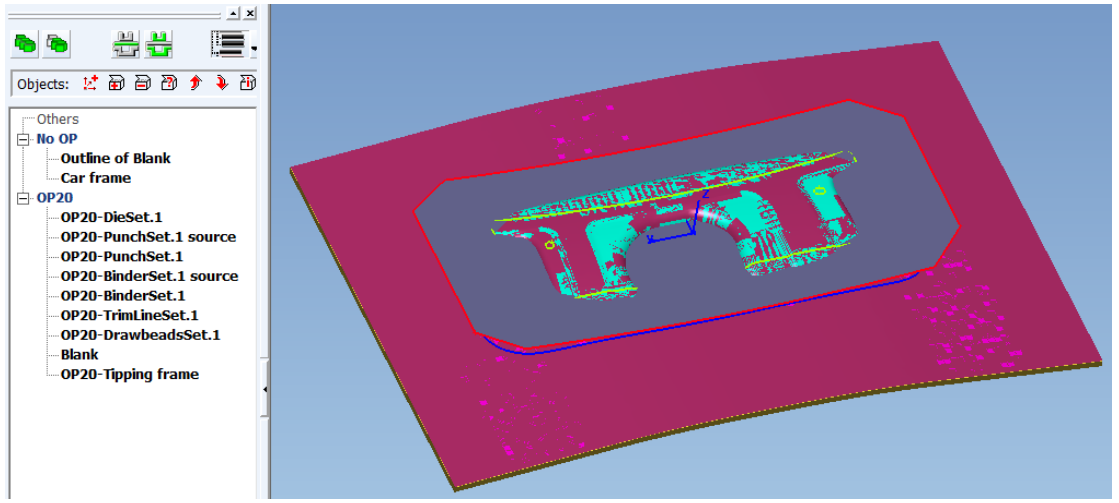
Hide and show blank buttons

Cross section toolbar

Improved mouse functionality

Keyboard buttons to scroll results





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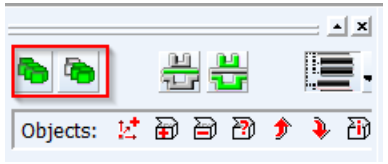
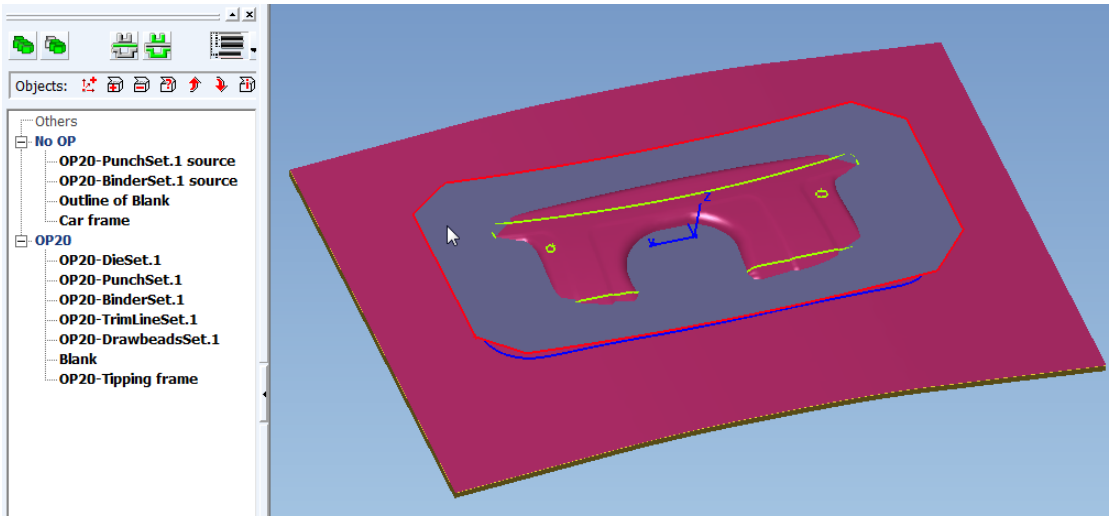
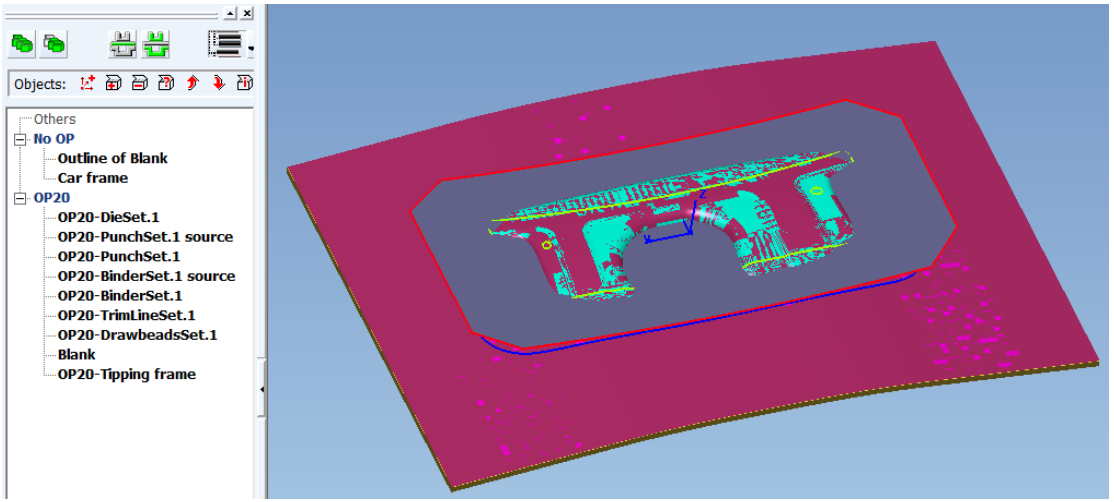
Buttons to Display and Hide Sources





Display without sources – one click



Display with sources – one click

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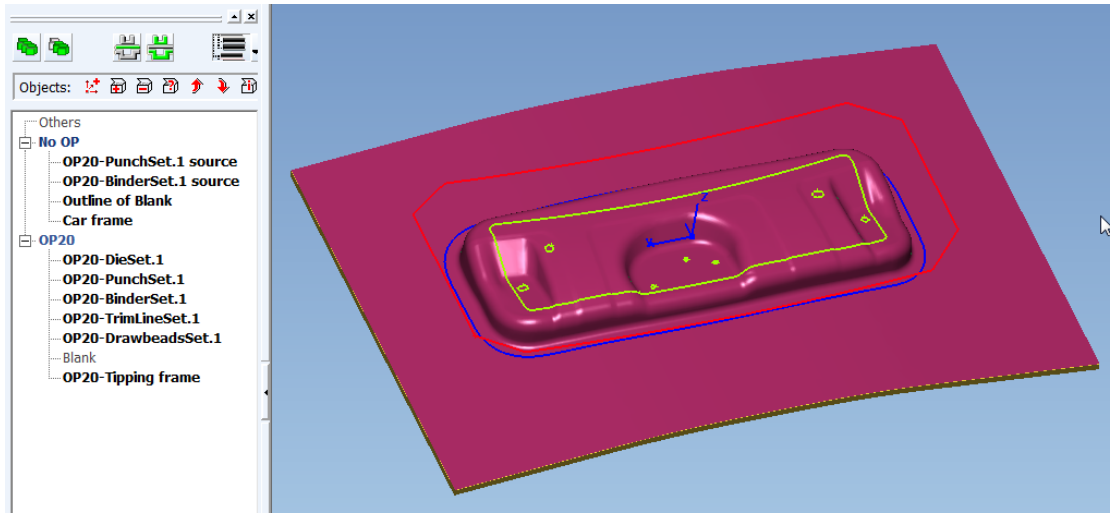
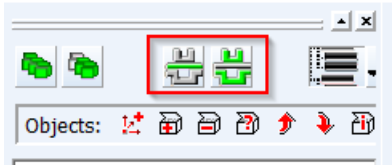
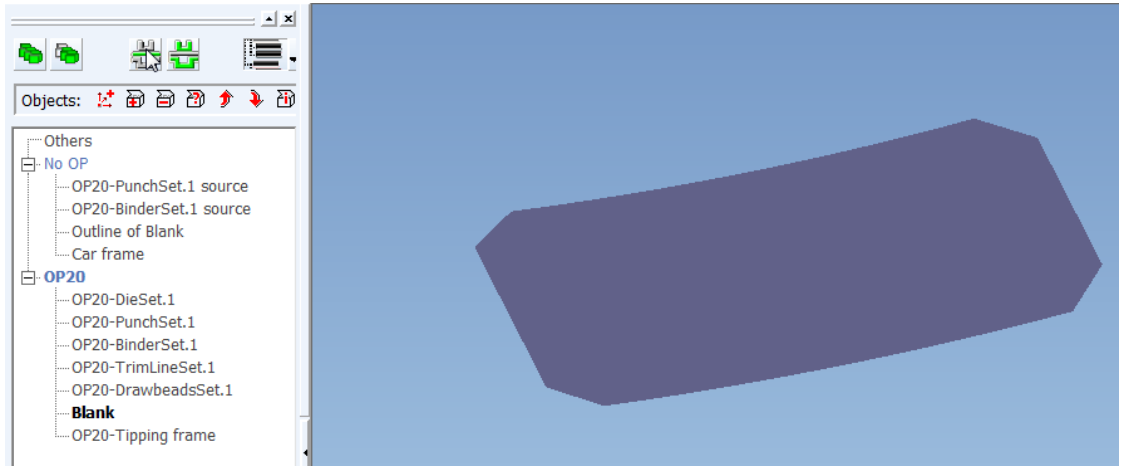
Buttons to Hide the Blank / Show only the Blank





Display without blank – one click



Display blank only – one click

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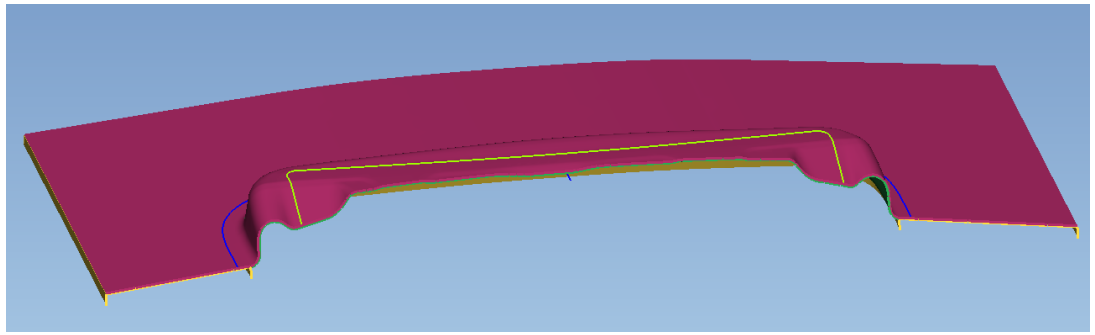
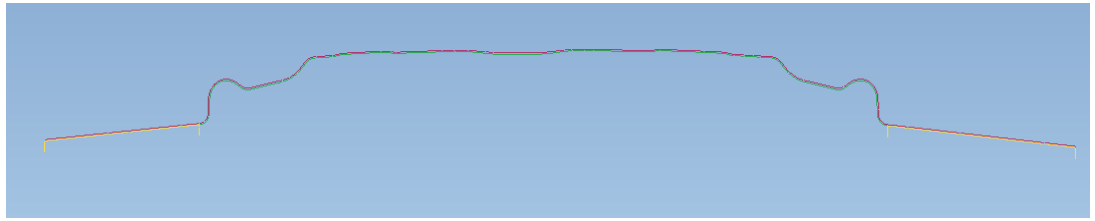
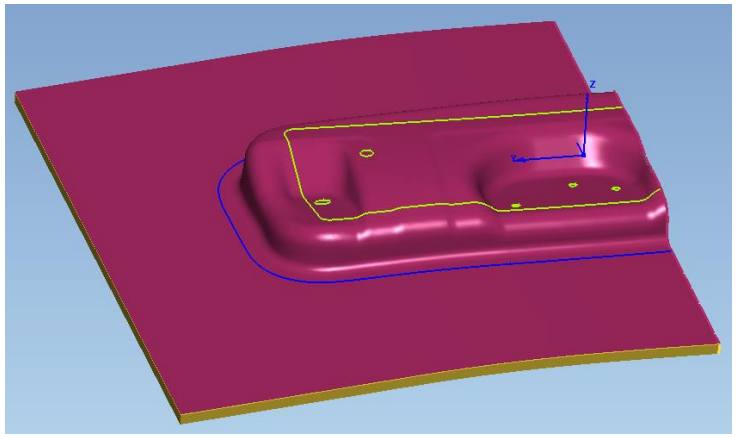
Cross Section Toolbar



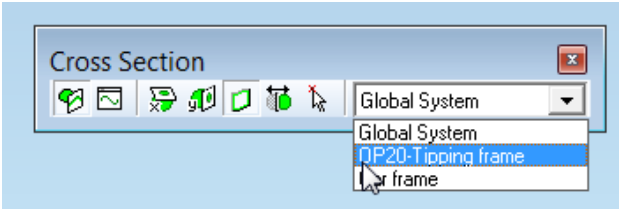
3D and behind



2D



Perpendicular to x or y



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Keyboard Buttons for Fast Post-Processing

Page up or down

- Scroll to the end of the actual or previous stage

Arrow up or down

- Scroll to the next or previous state within a stage

No additional click required to display the result again

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Miscellaneous

Pre-Processing

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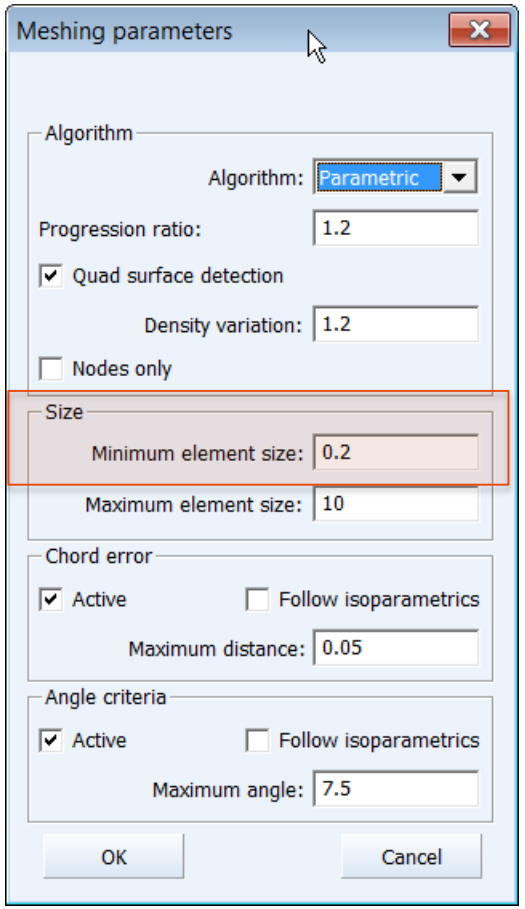
Tool Mesh – Improved Import

- When import, set the minimum mesh size in the meshing strategy to 0.2mm
- Improved in V2017.5, sticks exactly to the value, so offset will be OK



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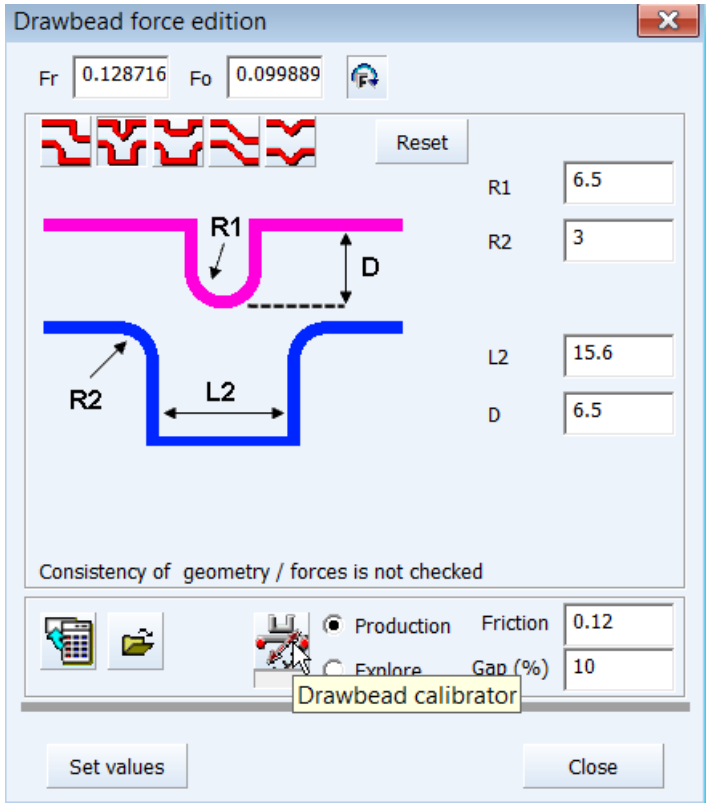
Drawbead Calibrator

Explore mode

- As it has been in the previous versions

Production mode

- All automatic in the background
- Values will be automatically given back
  - Restraining and uplift force



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Tips & Tricks

Save Disk Space & Speed Up

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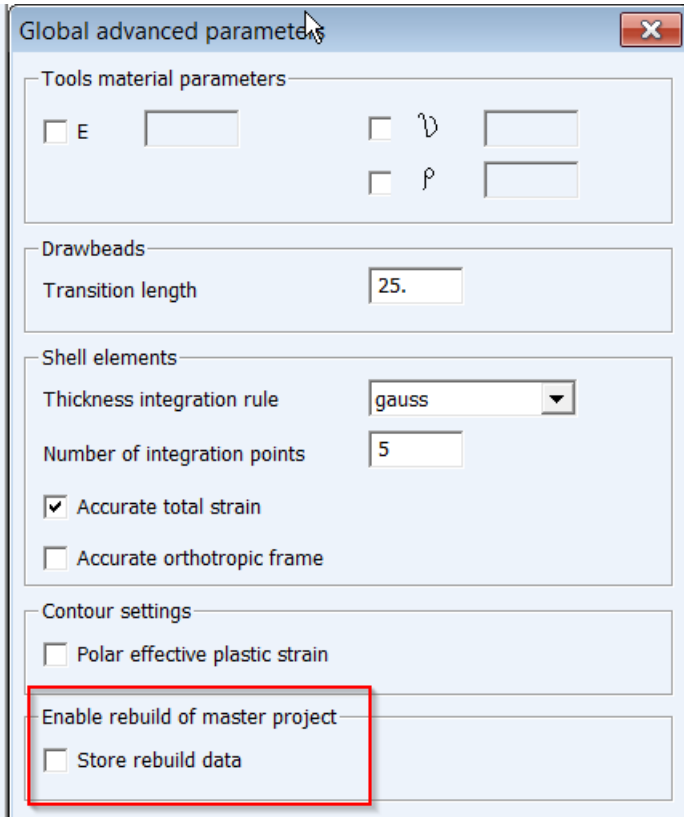
Switch off Store Rebuild Data

Reduces file size of .pic and .erfh5 significantly for line die projects

History is accumulated in .pic files if switched on

Attribute: Global advanced parameters



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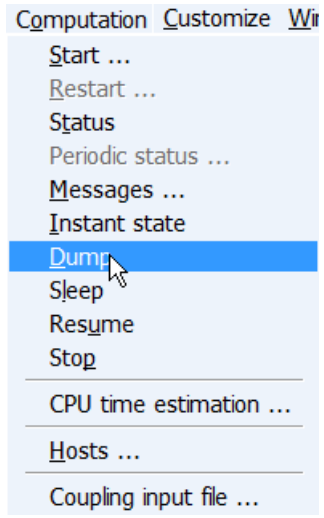
Set no Restart Files *.rst

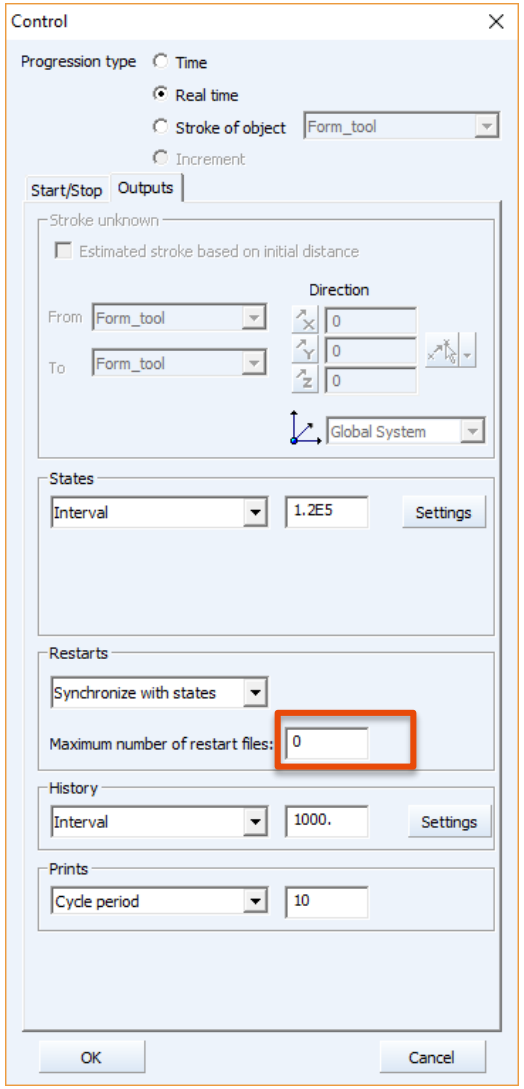
Since 2017 version it is possible to define 0 as number of restart files

- This will not create any restart file during the stage

Good to know

- There is then no possibility to restart from the middle of a stage
- However you can request a DUMP restart file interactively during the run, stop the calculation and restart afterwards





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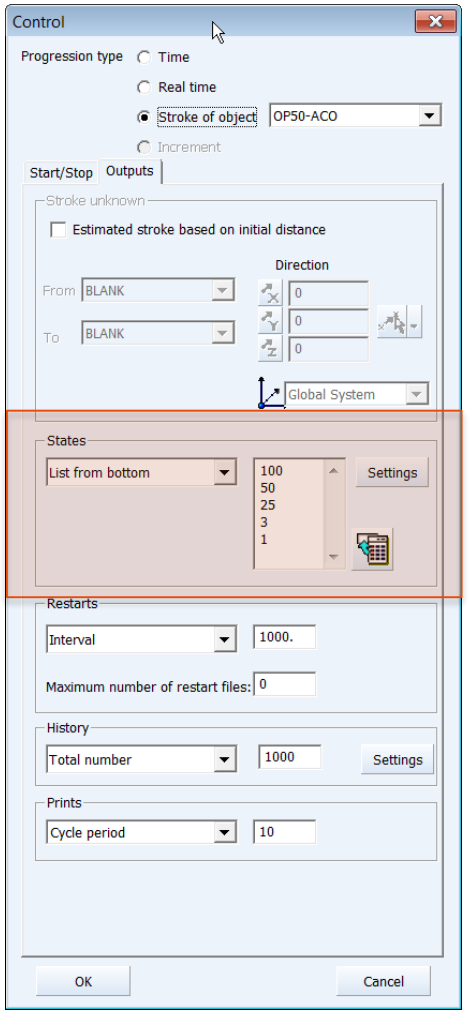
Control / Minimize the Number of Output Files

Define an output list from top / bottom

100, 50, 25, 3, 1 – only five result *.res files

- Attribute: Control

Ten result *.res files can extend the computational time by ~5% on a body side case



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Tips & Tricks

Speed Up

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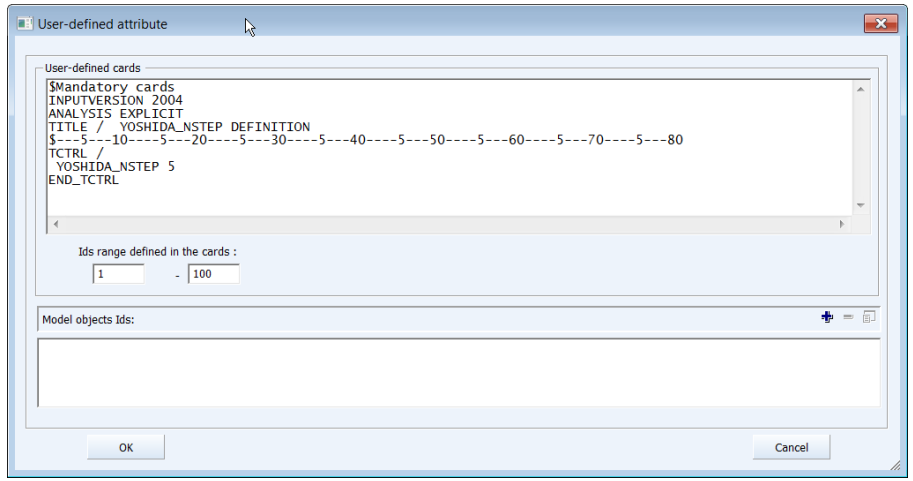
Number of Effective Plastic Strain Increments Using the Yoshida Model

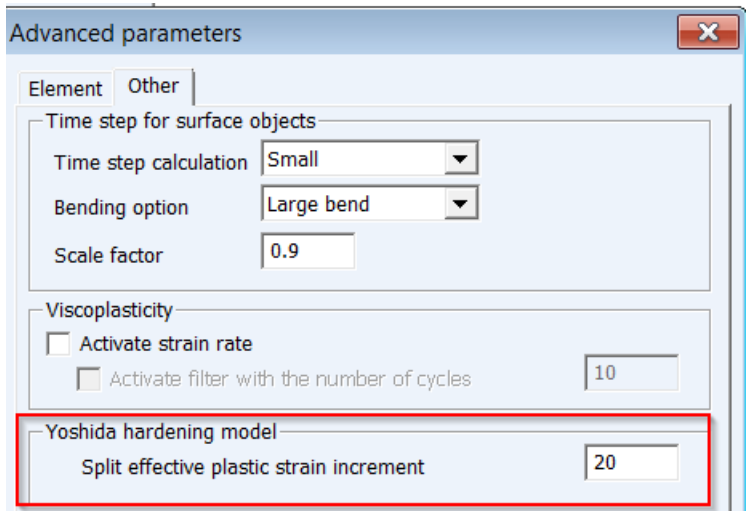
Reduces the number of effective plastic strain increments when using the Yoshida model

- Default: 20 (conservative)
- Recommended: 5
  - Via UDA
  - From V2017.5 in Advanced parameters

in 2017.0



in 2017.5



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Minimum Element Size for Adaptive Mesh Refinement

The minimum element size is defined to half the size of the blank thickness

Attribute

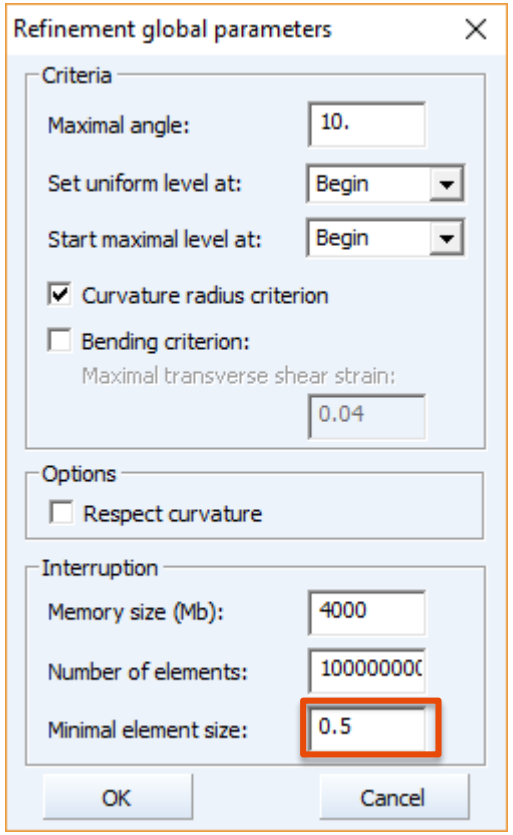
- Refinement global parameters

When adaptive mesh refinement happens, the following is checked:

- All elements that would have a characteristic length smaller then this parameter are not refined further

Good to know

- This does not prevent elements from becoming smaller as the given value due to plastic strains



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Improve Simulation Speed of Explicit Gravity Fit

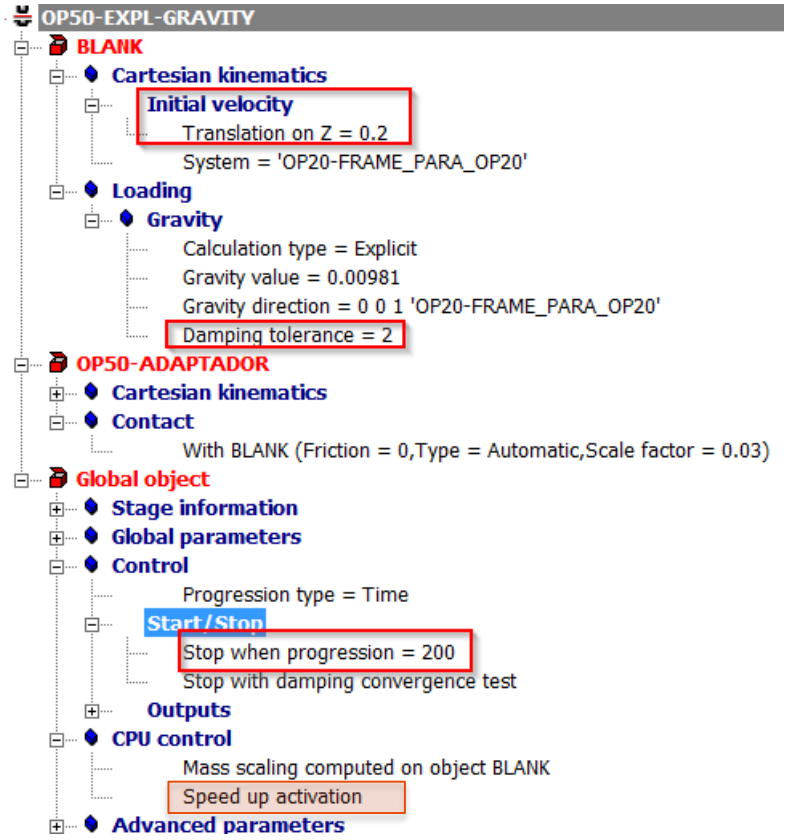
In case of any problem with implicit – use explicit

Maximize the time step

- Decrease simulation time by a factor of 3
  - Activate triple speed
  - Attribute: CPU control
- Improve speed by 25%
  - Time step calculation: Large
  - Scale factor: 1.0
  - Attribute: Advanced parameters
  - Use wih care

Set a stop criteria that makes sense

- 2.0 mm is good enough for gravity fit between operations
  - Not for springback or initial gravity



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Tips & Tricks

Avoid Stop on Error

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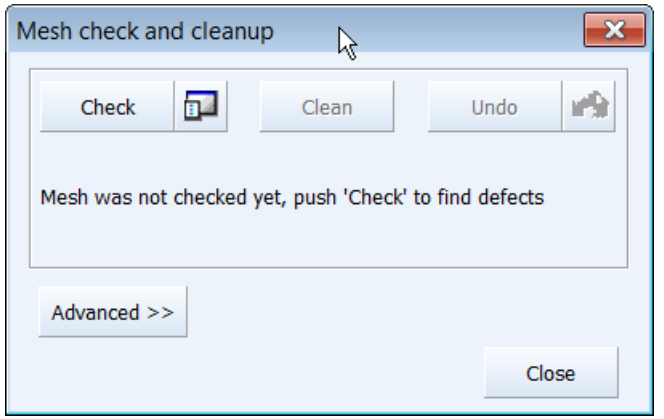
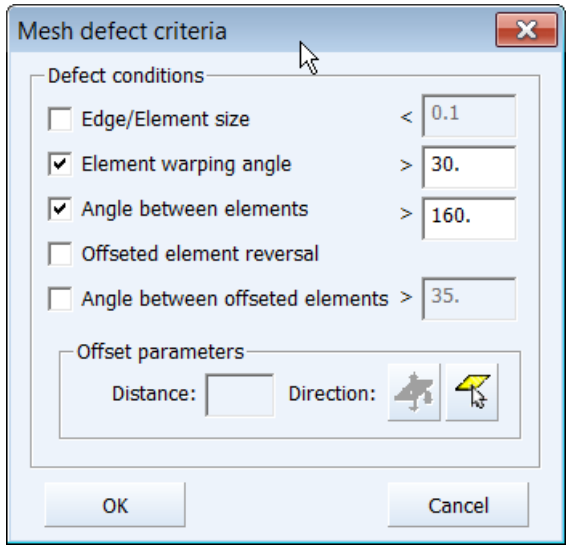
Tool Mesh – Avoid Stop on Error

- Avoid elements with warping > 30°
- Avoid elements with an angle > 160°
- Use mesh check and cleanup to fix it if necessary





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Manage Spring Back Simulations that Stop on Error

Criteria Multiplier

Occurs in tricky cases that show many modes close to each other

- Use advanced implicit

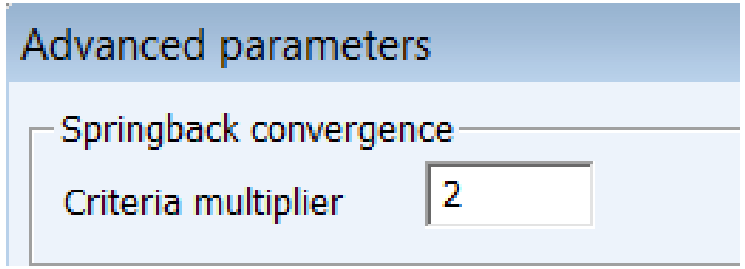
Check the .out file and display the convergence behavior of FORCE and DISP

- A tool to do this is available on myESI

Set DISP to a value that makes sense in case FORCE is converged

How

- See following slides



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How Does it Work – Springback with 100% Stress Load

All the residual stress field is “loaded” in one pseudo time step

- In PAM-STAMP usually “100”

The initial maximum residual force and displacement computed in iteration 1

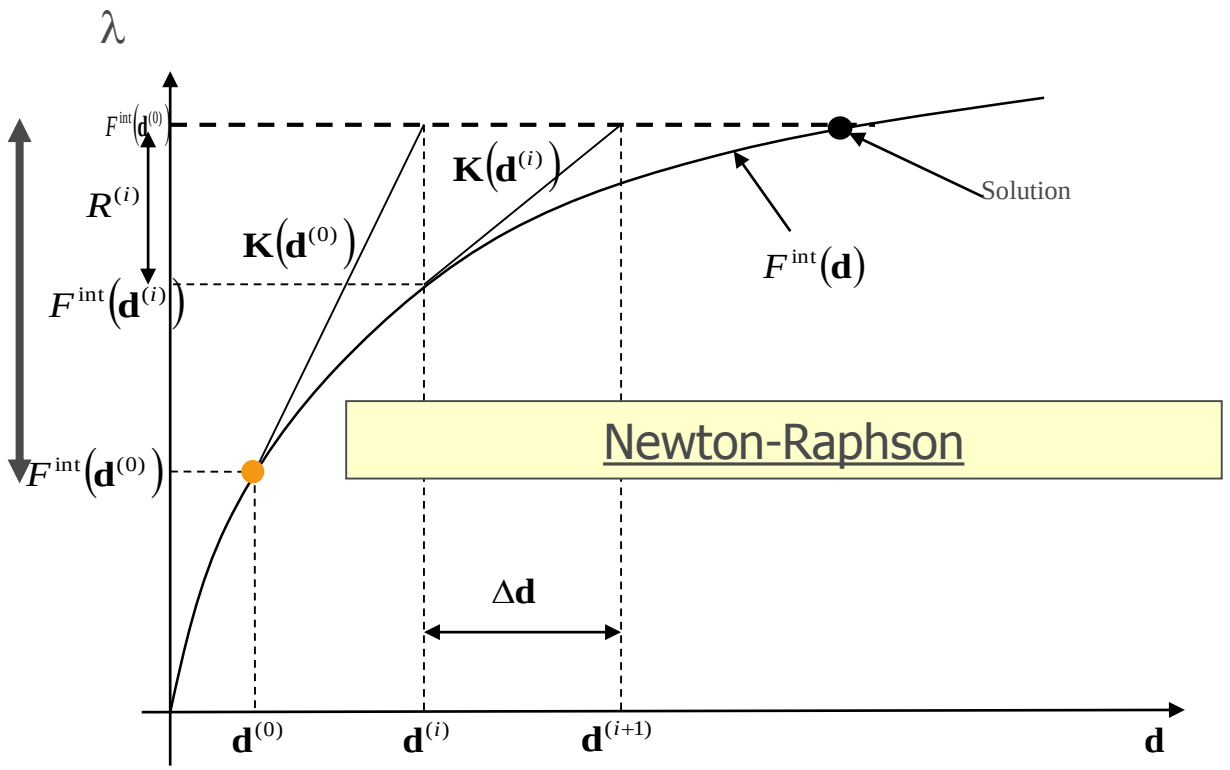
The displacement and force increments are computed for the iteration 2 (di, i=2 in graph)

The relative convergence is computed for iteration 2: Increment in iteration 2 / maximum value from iteration 1

This is done for n iterations

Converged in case increment is less then set convergence criteria:

- FORCE: % of initial maximum force
- DISP: % of initial maximum displacement



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Default Values Set in PAM-STAMP

DISP convergence

- 0.01

FORCE convergence

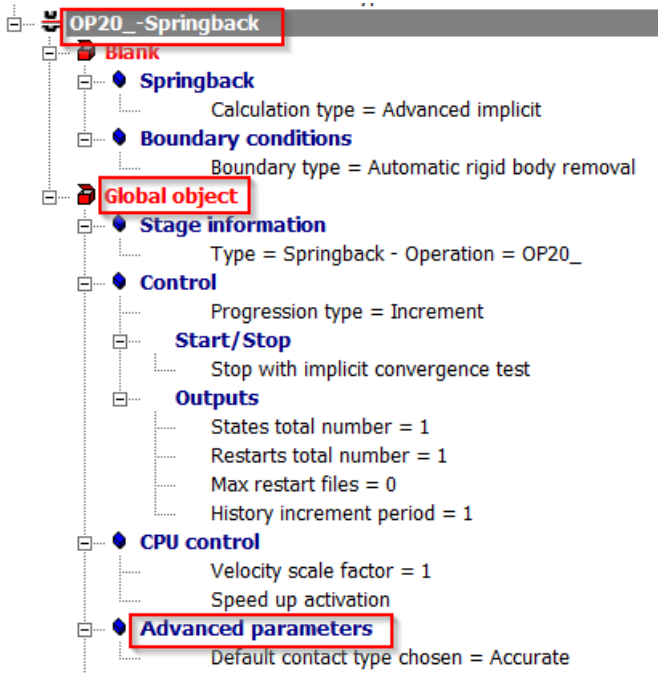
- 0.005

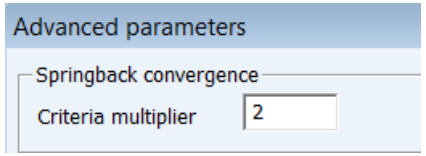
Maximum number of iterations

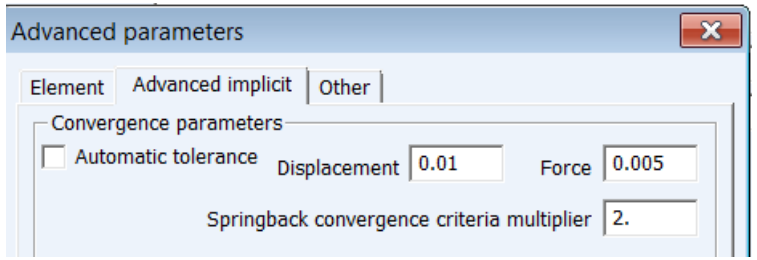
- 50

V2017.5

- Process Editor
  - Advanced parameters
  - Convergence multiplier
- Attribute
  - Advanced parameters







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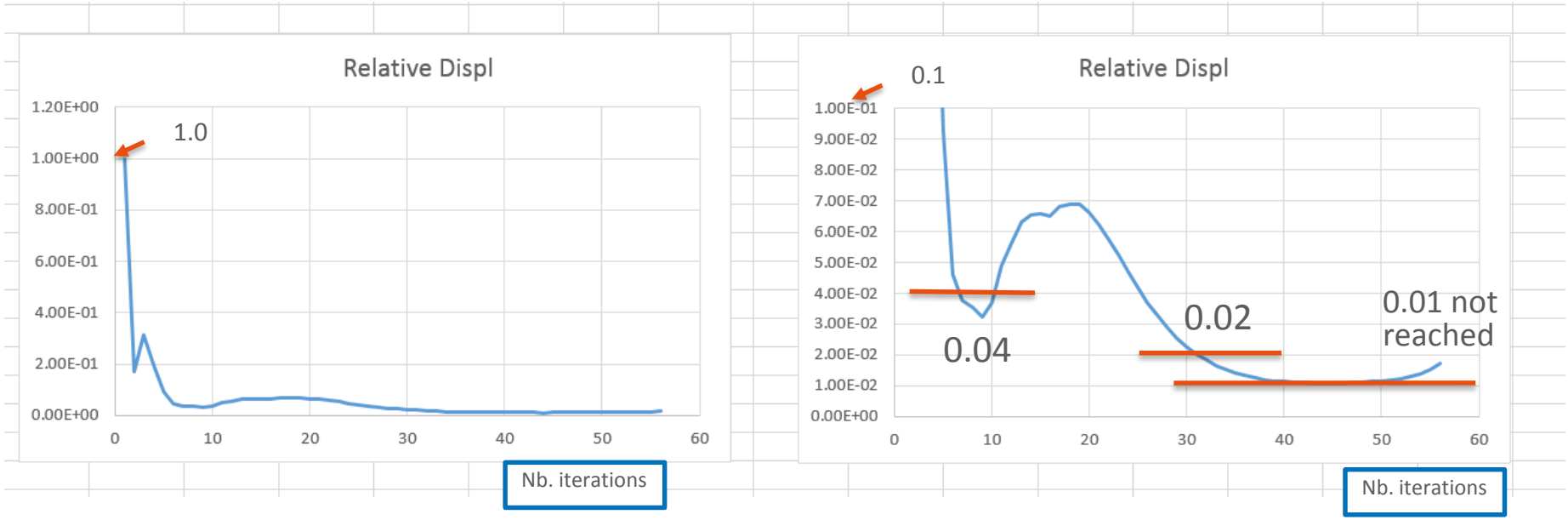
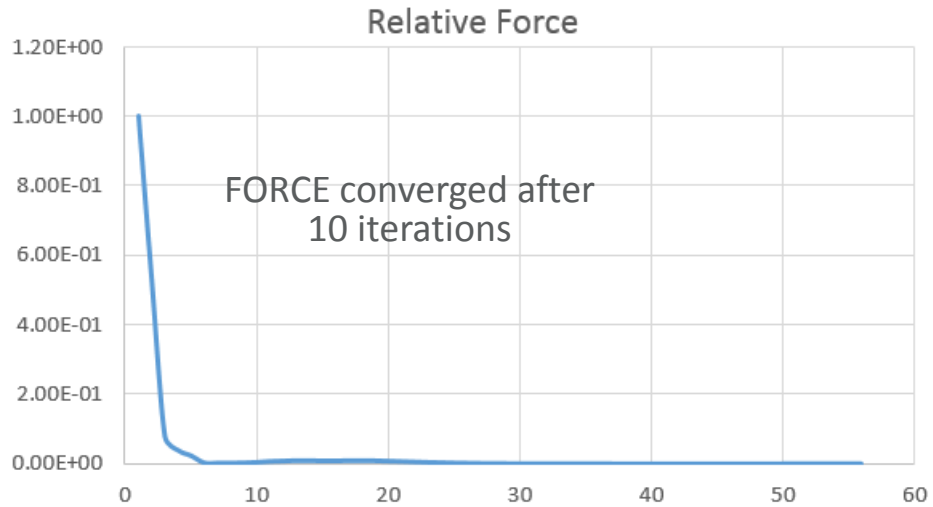
Example for an Application with Many Similar Modes



- FORCE is converged after 10 iterations
- DISP
  - Will not converge with 0.01
  - Gives results with 0.02 or 0.04
  - All OK



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Engineering Problem to Solve with this

Get the best possible springback result and judge the quality of the computation or resolve stop on error

Best possible results

- Multiply the criteria with 0.1 and compute
  - DISP will be 0.001 and FORCE 0.0005

Resolve Stop on Error

- Multiply the criteria with 5 and compute
- Or display the convergence graph and find a good tolerance, then set the multiplier

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Product Availability

Copyright © ESI Group, 2017. All rights reserved.

Supported Platforms

Windows 7

Windows 10

A good selection of Linux

- Solver only

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Thank You