A survey of RADIOSS features and performances for stamping simulation

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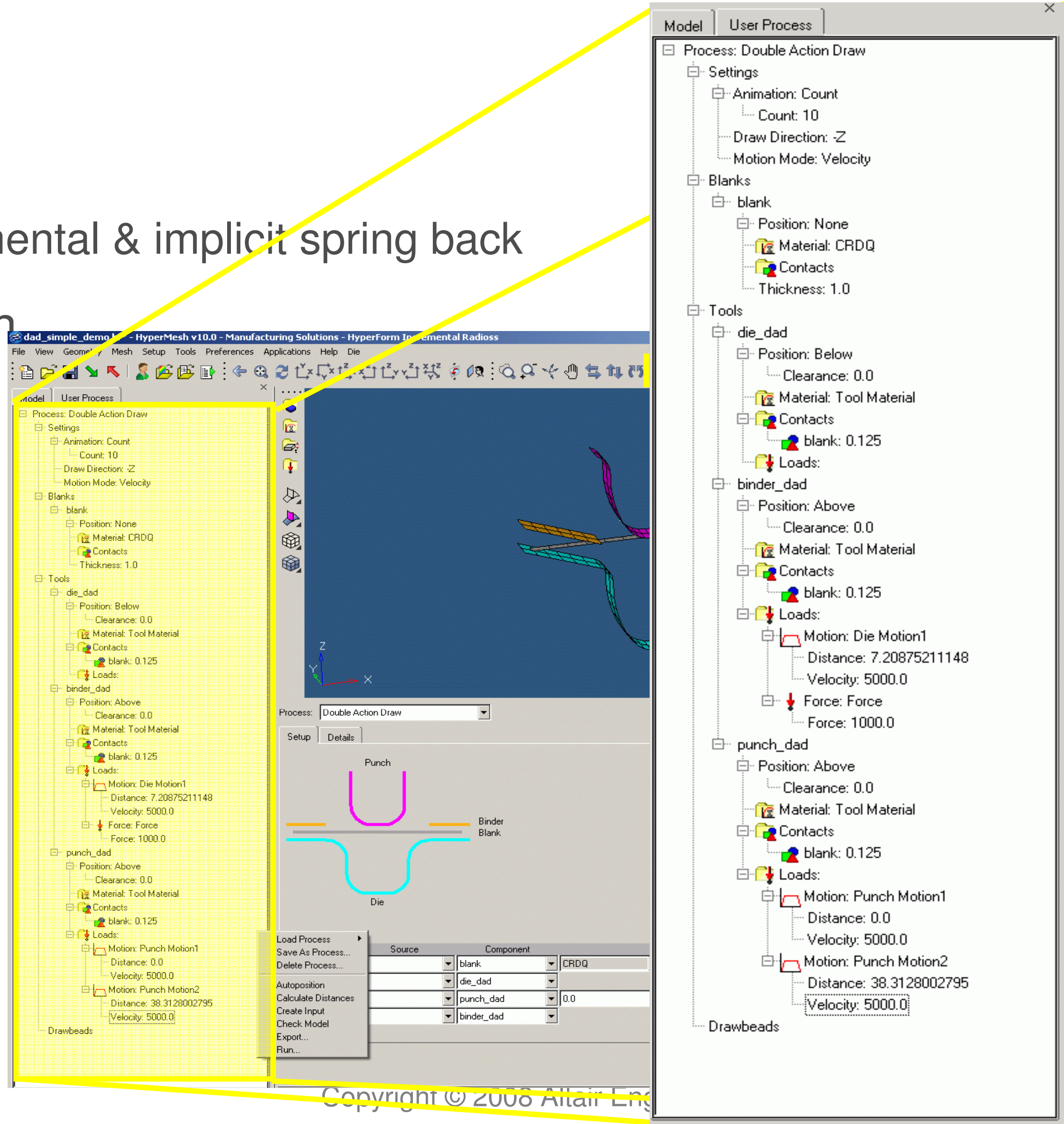
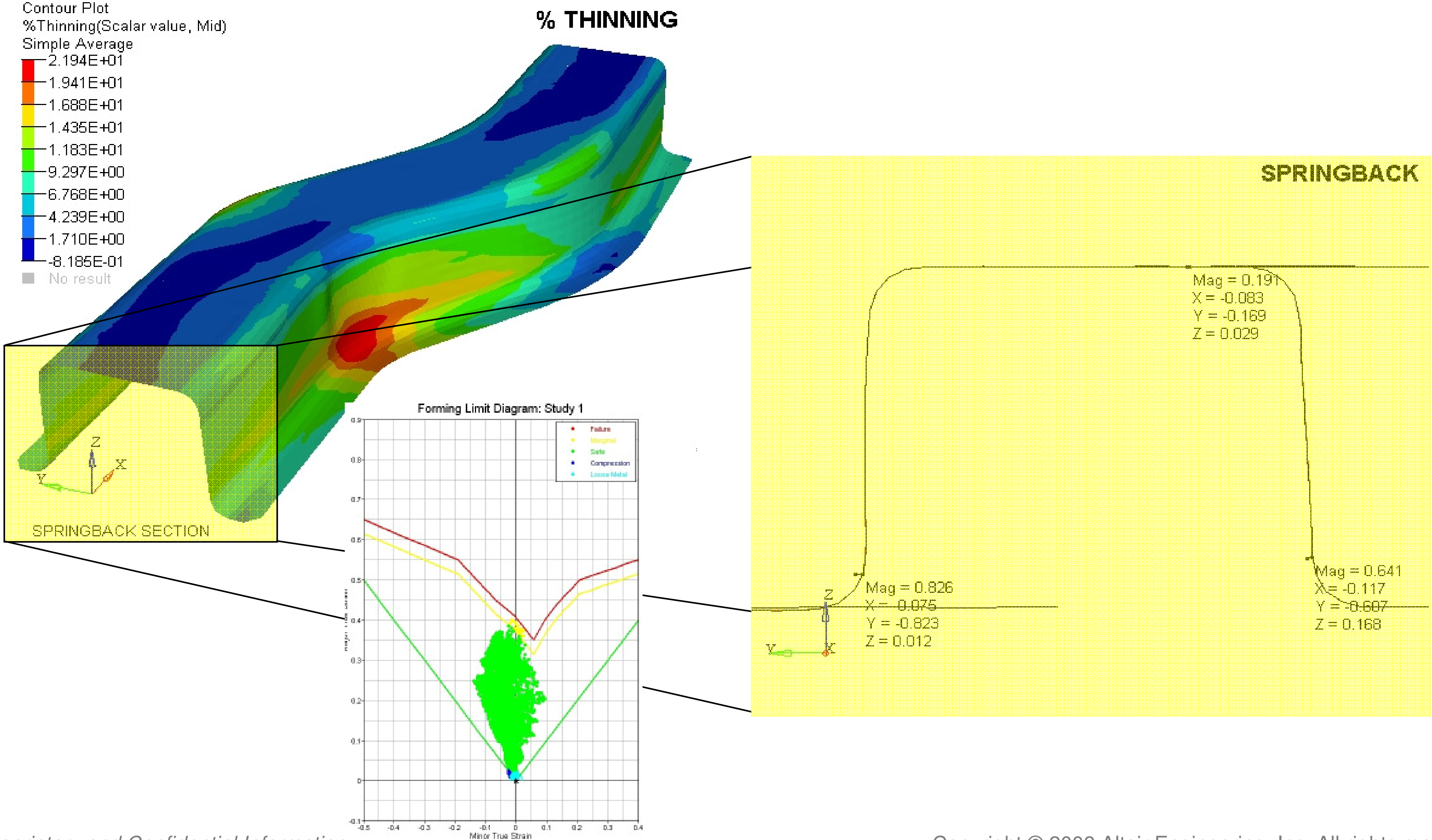
A survey of RADIOSS features and performances for stamping simulation

- HyperForm-RADIOSS
  - Feasability
    - RADIOSS One-Step
  - Process Validation
    - RADIOSS Large Displacement : incremental & implicit spring back
  - Unified interface for stamping simulation
  - Process driven GUI
  - Knowledge capture thru browser structure



- RADIOSS for Process Validation

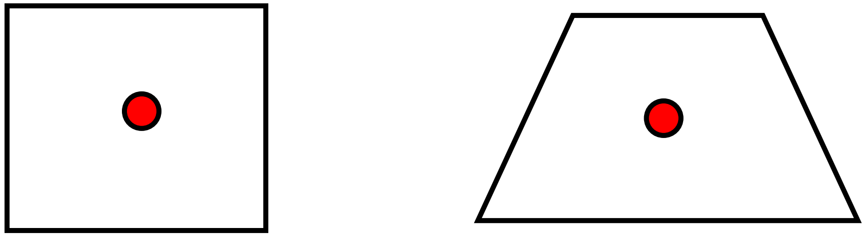


Summary

1. Shell formulations
2. Materials
3. Interfaces
4. Adaptive meshing
5. New Interface for stamping
6. Other features (Implicit spring back, Multi-stage analysis, hot forming, …)
7. Roadmap

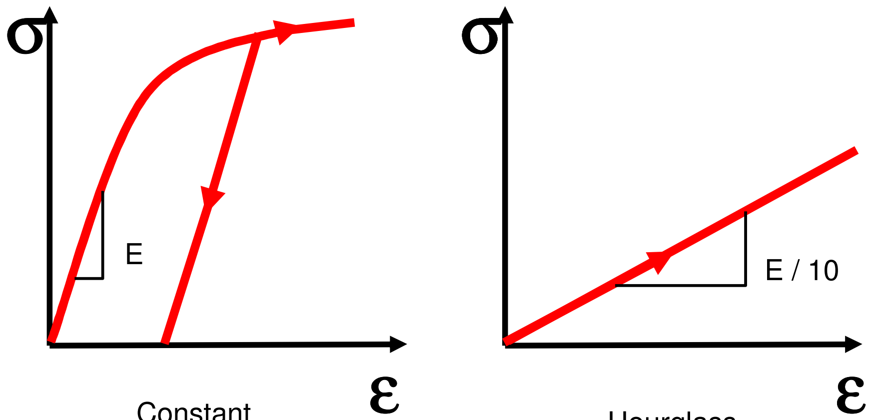
Q4BT element (Belytschko – Tsay)

- 1 integration point on the surface => Hourglass modes with a null strain energy must be stabilized



$E(\sigma, \varepsilon) = 0$ $\qquad$ $E(\sigma, \varepsilon) = 0$

- The hourglass stiffness is a linear function of the Young modulus.



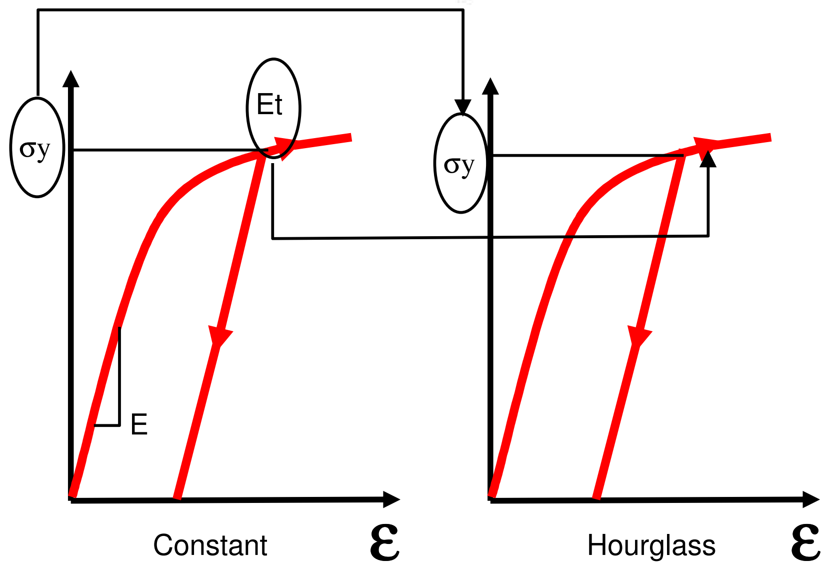
Constant $\qquad$ Hourglass

- Quasi-static simulation (low velocity) => Visco-elastic anti-hourglass forces are inefficient

- Elasto-plastic hourglass formulation Ishell=3
  - Elastic anti-hourglass forces are bounded depending on the current element mean yield stress

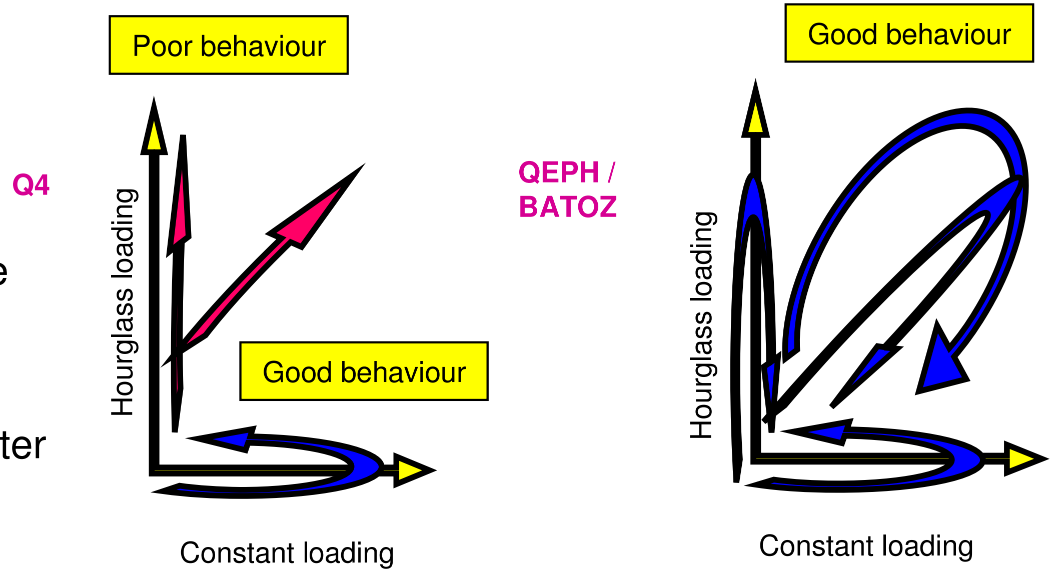
Shell formulations

- **QEPH element (…)**
  - Same element formulations as Q4BT.
  - Elastic - plastic Hourglass formulation.
  - Hourglass yield depends on constant yield.
  - Hourglass loading stiffness depends on constant tangent modulus



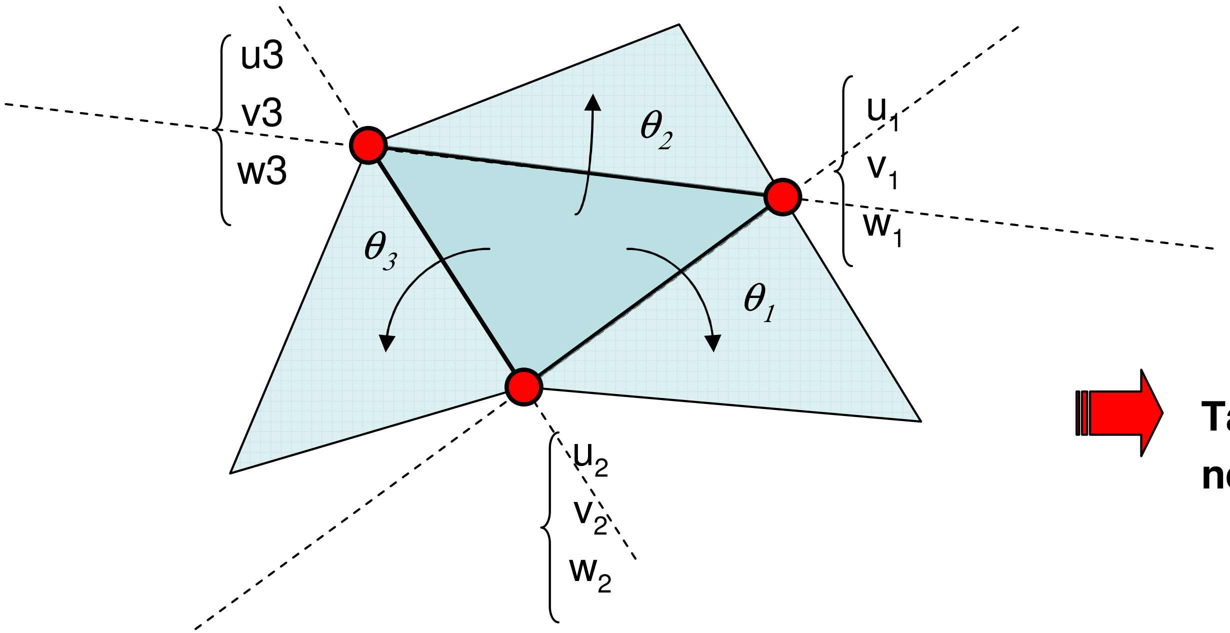
- **BATOZ element (Batoz-Dhatt)**
  - Similar to Dvorkin-Bathe MIT4 formulation
  - Full integration scheme : 4 Gauss points in shell surface
  - Does not need hourglass control
  - More expensive today

- **Formulations comparison**
  - The QEPH and Batoz elements give accurate results in case of loading and unloading even if there is hourglass mode deformation.
  - The QEPH and Batoz elements converge faster to the solution.



Use of QEPH ⇔ Best compromise quality/cost

- **3-node shell elements :**
  - **C0 formulation**
    - Membrane stiffness is too high
  - **S3N6** : Specific Triangular shell element



Take into account neighbouring elements

Materials

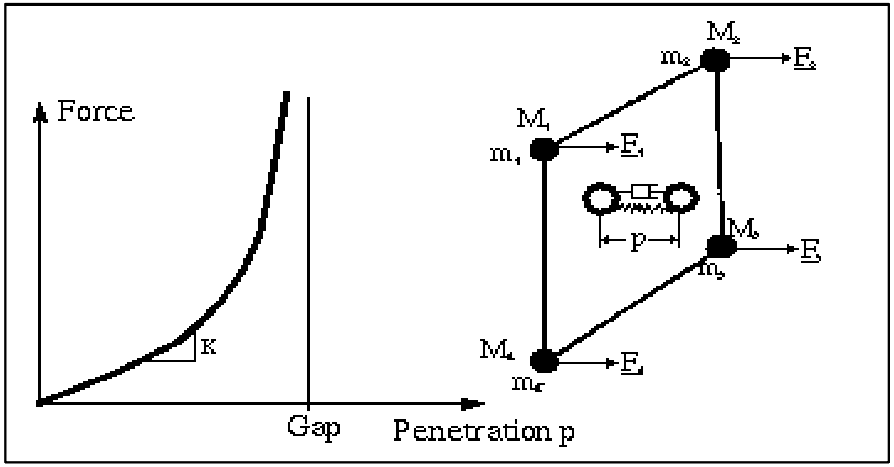
- **Metal**
  - Johnson Cook, Zerilli Armstrong (law 2)
    - Isotropic yeld criteria
    - Exponential criteria $\sigma = a + b\varepsilon_p^n$ & Temperature dependancy
  - Tabulated Elastic-Plastic law 36
    - Holomon law can be emulated with the tabulated law 36
  - Anisotropic yeld behavior
    - Hill (law 32, 43)
    - Barlat 89 (law 57)
  - Trip Steel (law 63, 64)
    - Transformation induced by plasticity
    - Martensite volumetric fraction
- **Kinematic Prager-Ziegler model for hardening**
  Available for laws 36, 43, 57
- **Fabric**
  - Elastic anisotropic material (law 58)
  - Elastic orthotropic material (law 19)
- **Composite**
  - Orthotropic plastic material (law 25)

Multi-purpose Interface Type 7

For the multi-purpose interface :

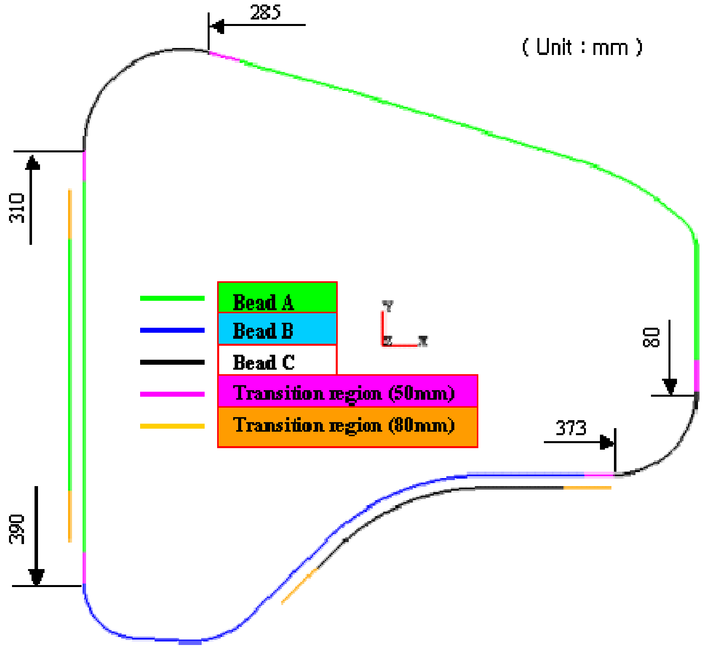
- Fast sorting method
- The force is defined with the penalty method (imposed forces).

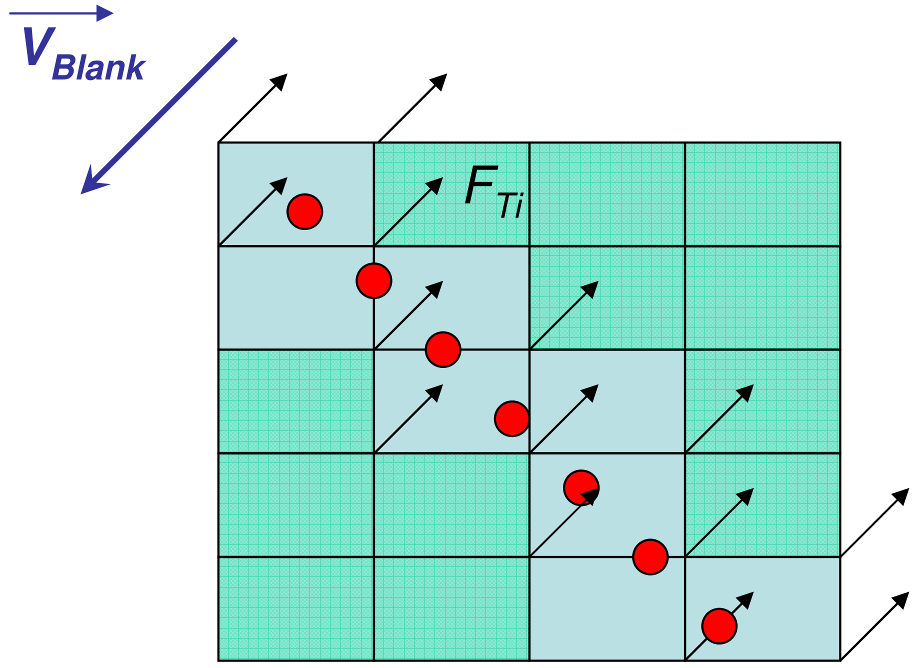
$$F = f(p) + C\frac{dp}{dt}$$

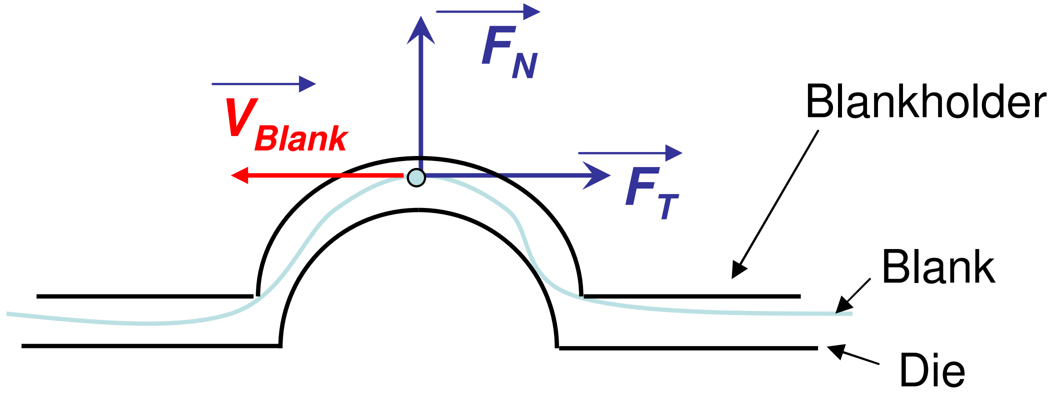


- Variable interface stiffness is used to avoid penetration larger than gap
- A nodal time step is computed to insure the stability
- Friction dependant on contact pressure is available

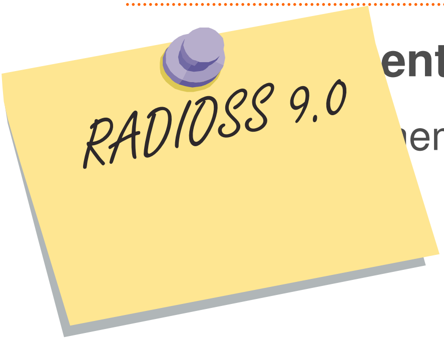
- **Contact interface dedicated to drawbead modelisation (Type 8)**





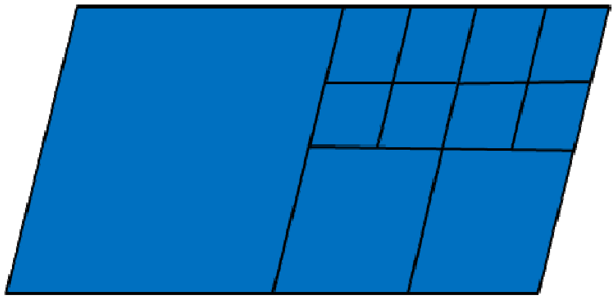


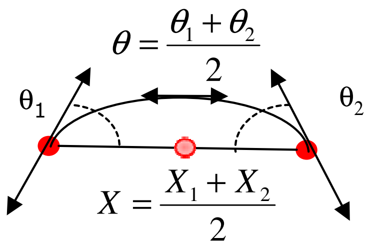
- ✓ Set of nodes as the bead line
- ✓ Blank
- ✓ F_{max} as the maximum force level



ents are built from RADIOSS Starter

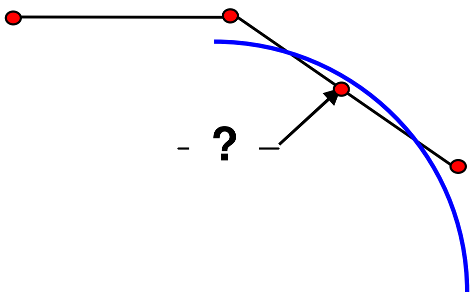
ematic conditions are applied at intermediary nodes where the mesh is non conform



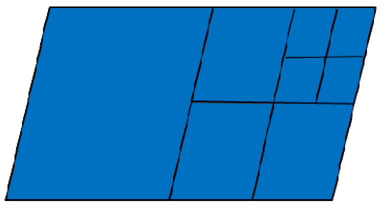


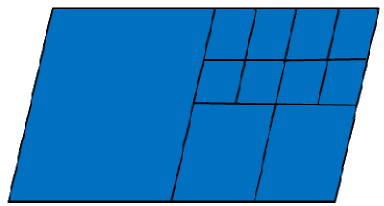
- The elements which are not active appear as eroded elements into Hyperview.

- **Contacts are computed for each node of the finest mesh**
  - Avoid to re-compute a position for the intermediate node when dividing



- **Rule 2 to 1**
  - 1 element and its neighbors get a difference level of maximum 1
  - Rule 2 to 1 may be enforced or not

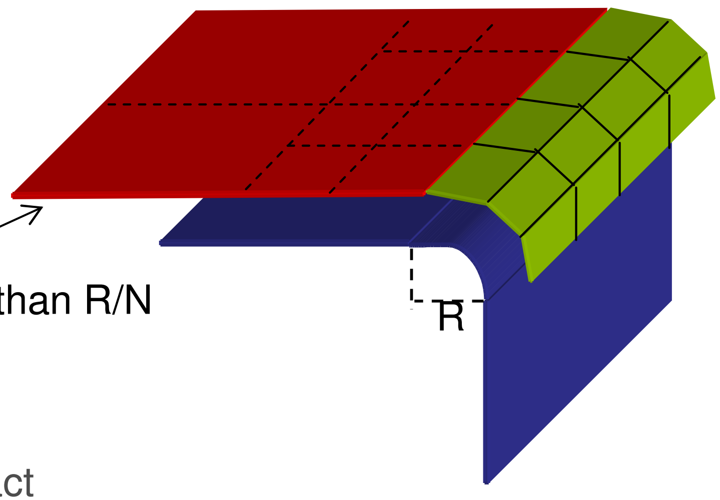

Yes


No

Refinement Criteria

- Curvature of the tool at the location of the impact

Element will be divided until the element's size is lower than R/N

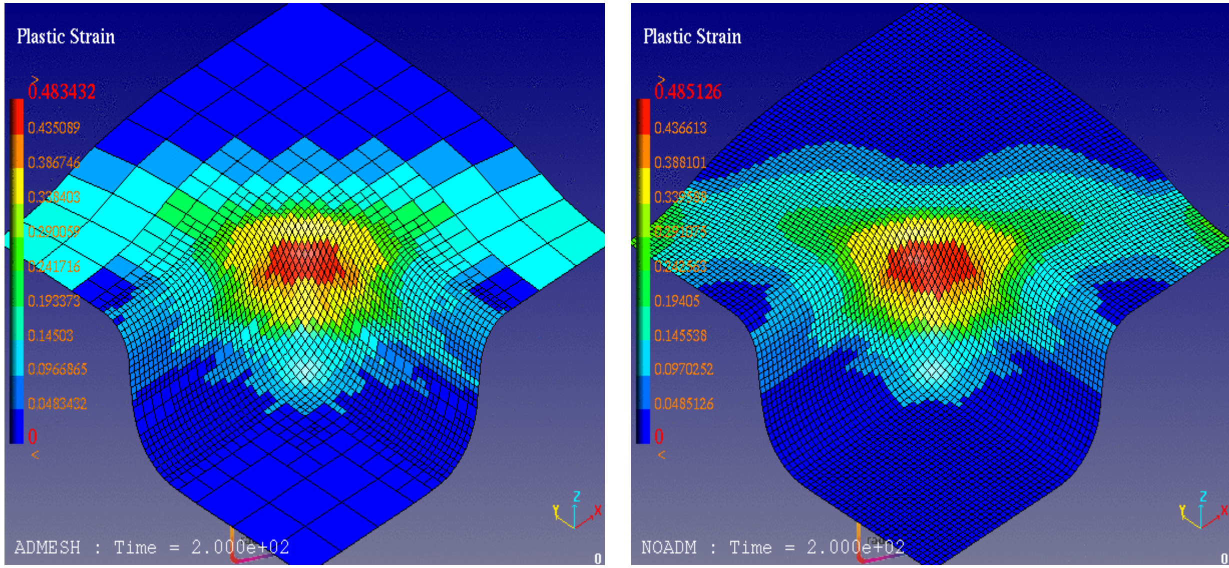


- Angle between the elements of the tool at the location of the impact
- Penetration into the gap of the impacted tool
- Angle between the elements of the blank
    - Get more degrees of freedom in areas where an angle is becoming
    - This check can be done at some given frequency

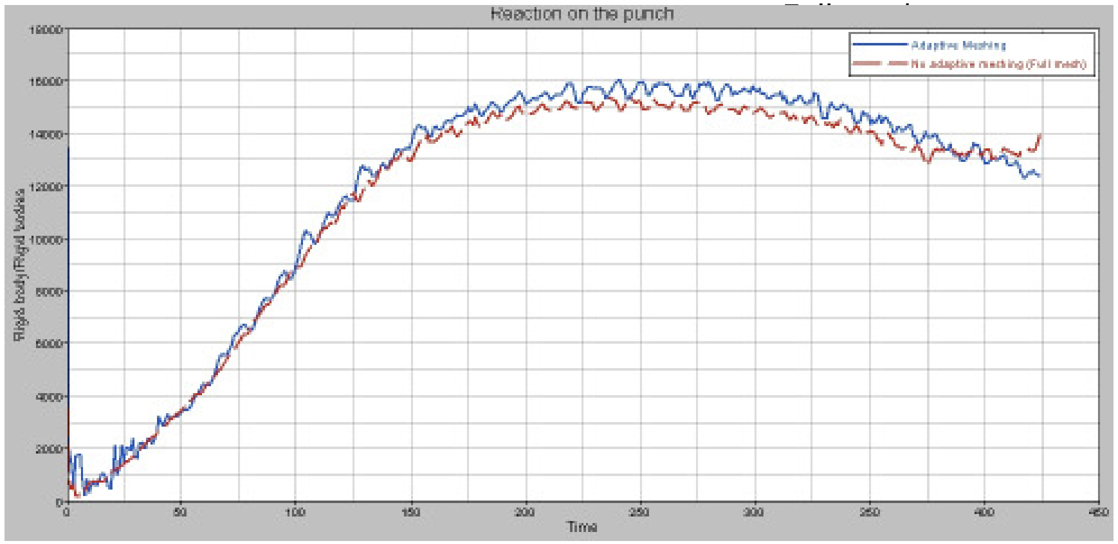
Adaptive Meshing

- **Cup drawing**

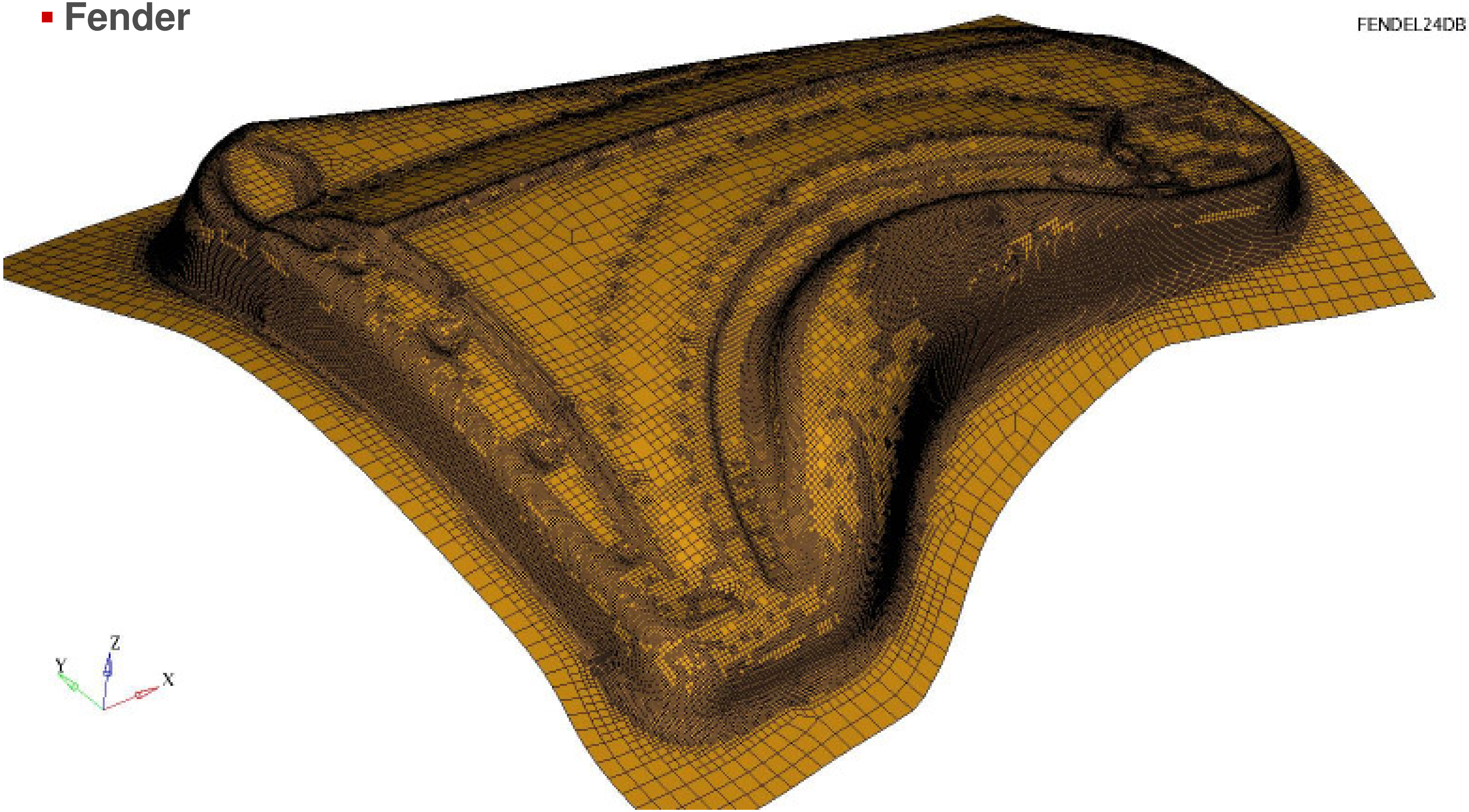
Plastic strain



Force on the punch



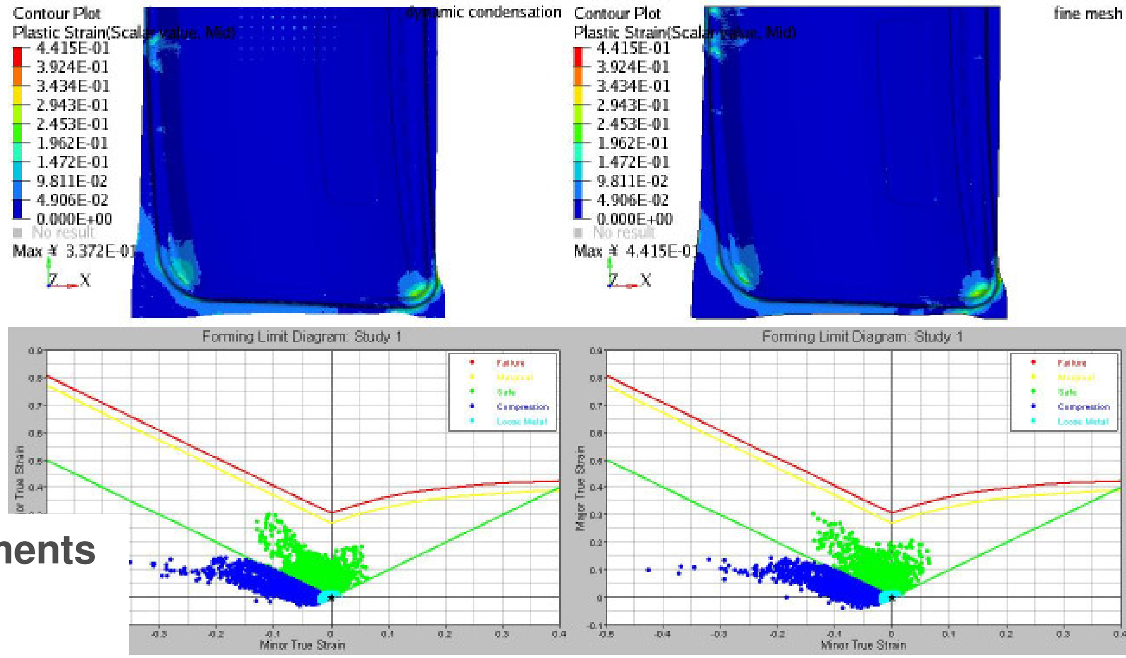
- **Fender**



Adaptive Meshing

RADIOSS 9.0 SA1
New

- C... tting the time step based on the
  - ... tiffness at nodes of the coarse mesh
  - ... e as with the only coarse mesh
  - Time step is the same as the one of the coarse mesh



Fine mesh is 3 levels down the coarse mesh : 1 to 64 elements

- **Time step ratio between coarse and fine mesh = 8**

AMD Opteron 2.4 GHz / 4 procs, Single precision	Number of cycles / Elapse Time	Speed up versus Fine mesh
Fine mesh	89127 cycles 9252 s	
Fine mesh w/ time step based on the coarse mesh	18324 cycles 1436 s	6.35
Adaptive mesh w/ time step based on the coarse mesh	20352 cycles 1148 s	8.05

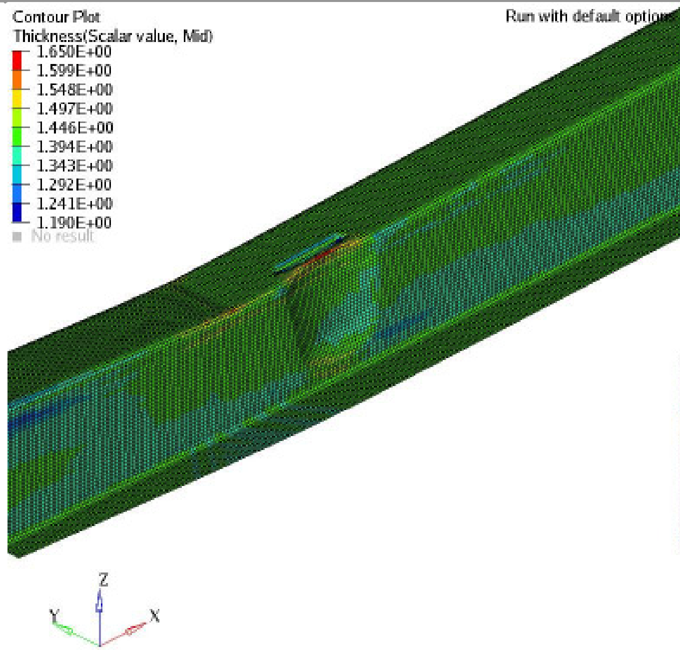
- **Rail**

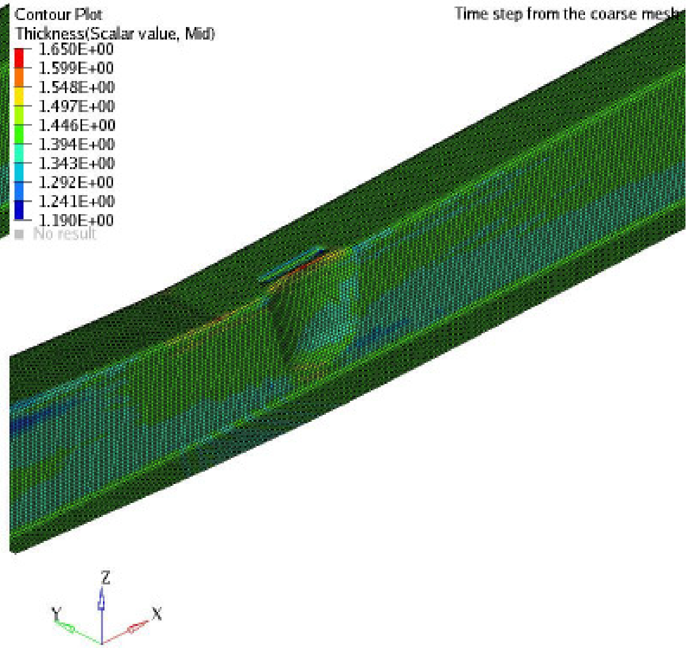
179610 nodes

Fine mesh is 2 levels down the coarse mesh : 1 to 16 elements

Time step ratio between coarse and fine mesh = 4

	Number of cycles / Elapse Time	Speed up versus Fine mesh
Fine mesh	243650 cycles 35690 s	
Fine mesh w/ time step based on the coarse mesh	63149 cycles 10790 s	3,3





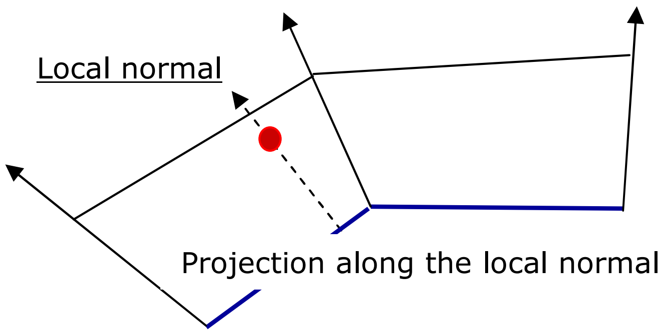
...ce Type 21 for Stamping — To be released in 10.0

...face between a rigid tool (master) and the blank (slave)

...ant Stiffness + Damping (Stiffness is taken from the slave surface)
=> No time step issue

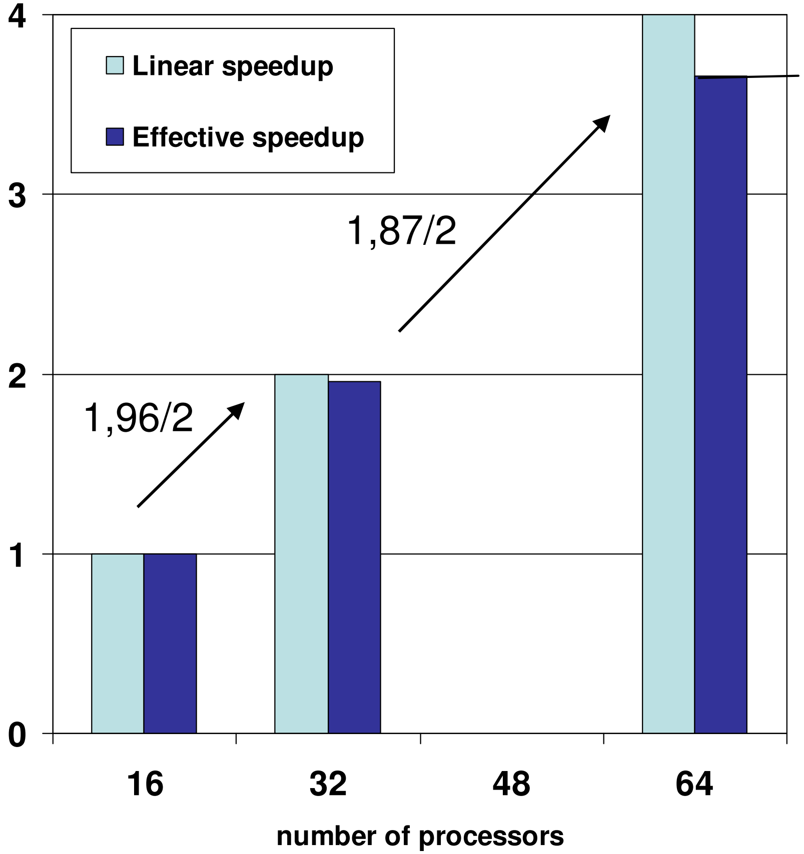
$$F = Kp + C\frac{dp}{dt}$$

- Allows crossing the master segment up to some depth
- Gap is taken from the blank thickness (tools are meshed on the outer surface)
  Takes into account thinning / thickening of the blank
- Continuity of the normal to the master side and of the force modulus
  Only 1 impact is considered for each slave node
  => Friction is better taken into account



- Friction dependant on contact pressure is available
- Designed for high speedup w/ SPMD : almost no communication is needed
  - Tool is rigid and only translates
  - All procs will know about the full initial geometry and prescribed motion of the tool
    – BCS, Imposed displacement, Loading
- Fast sort algorithm for sorting contacts

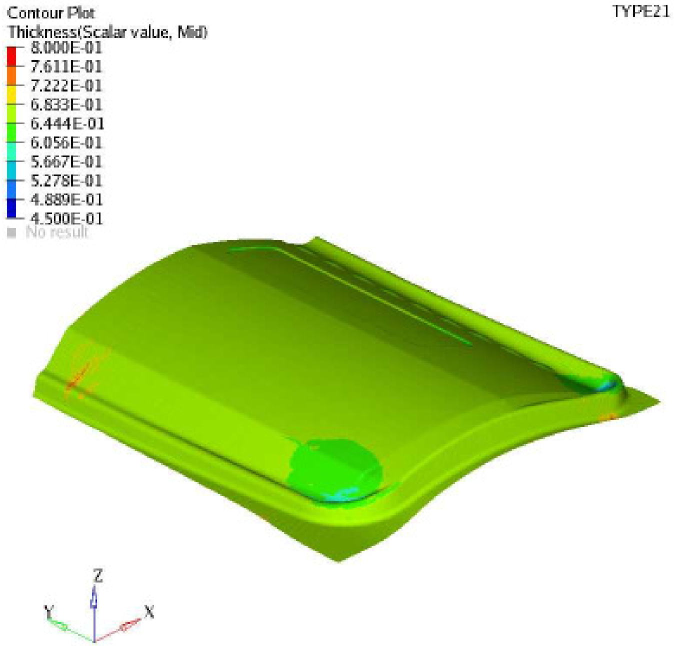
- **Hoodinner**

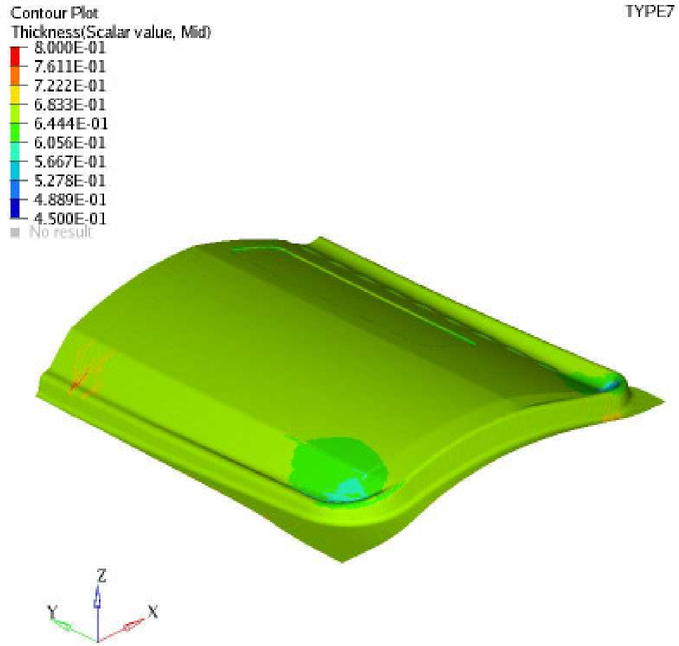


3,66/4

432500 nodes
345000 cycles

12h 07mn on 16 procs
3h 19mn on 64 procs



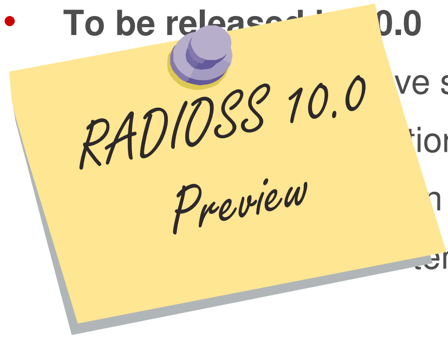


Other Features

- Implicit spring back analysis

- Multi-stage analysis
  - Trimming, …
  - From 1 stage to the other :
    - .sta files including the geometry of the blank and the stress, plastic strain, …

- Hot Forming
  - **Actually**
    - Conduction from master side to the slave side in Interface Type 7
      - Constant temperature for each tool
      - Conduction from the tools to the blank
    - FE formulation of thermics
  - **To be releas… 0.0**



    - …ve side ⇔ master side in Interface Type 7
    - …tions
    - …n (Imposed thermal flow)
    - …emperature

Roadmap

- Option for getting time step based on the coarse mesh
  - To be available with MPP version
- Thermics

  + adaptivity

  + Interface Type21

Accuracy, Robustness and Efficiency

Thank you!