DRD TECHNOLOGY

Metal Forming Simulation using Ansys LS-DYNA and Ansys Forming

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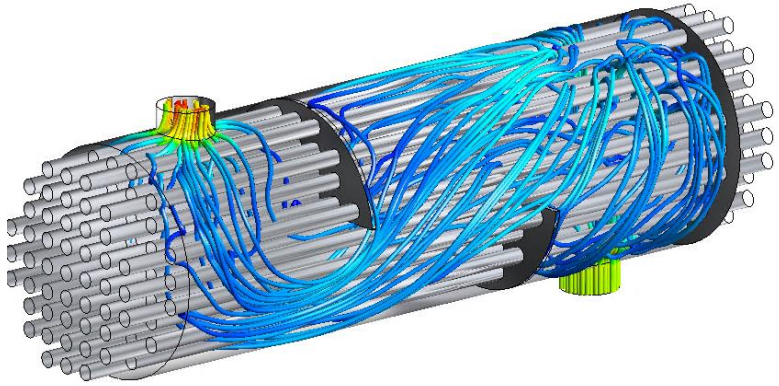
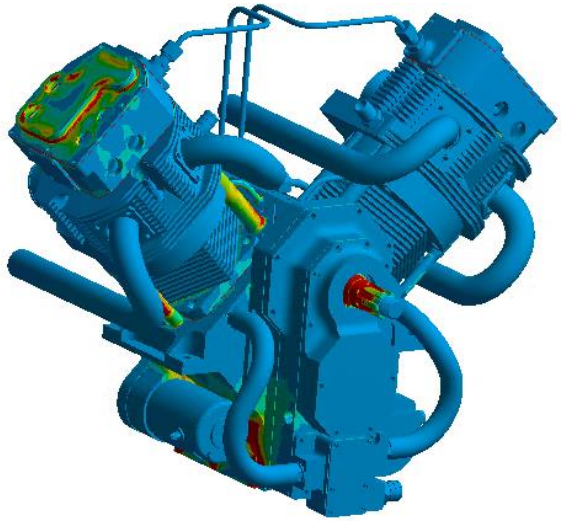
Agenda

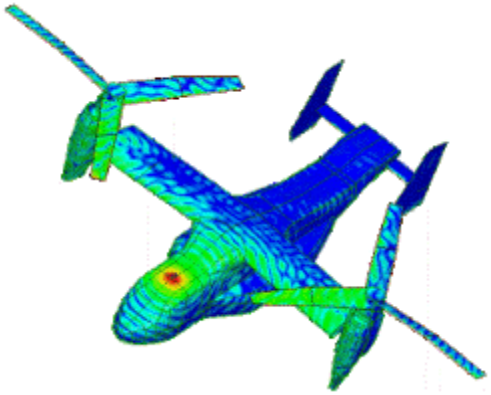
- DRD Mission Statement and Support Options
- Brief History Review of LS-DYNA in Stamping Simulations
- Typical Applications Related to Stamping Processes and different types of Forming
- Ansys Forming in Metal Forming Simulation
- Summary
- Questions

Mission Statement

DRD Technology helps engineering teams accelerate product development. With in-house expertise spanning the entire range of physics, we ensure customers succeed when using Ansys simulation tools for virtual prototyping and design verification.







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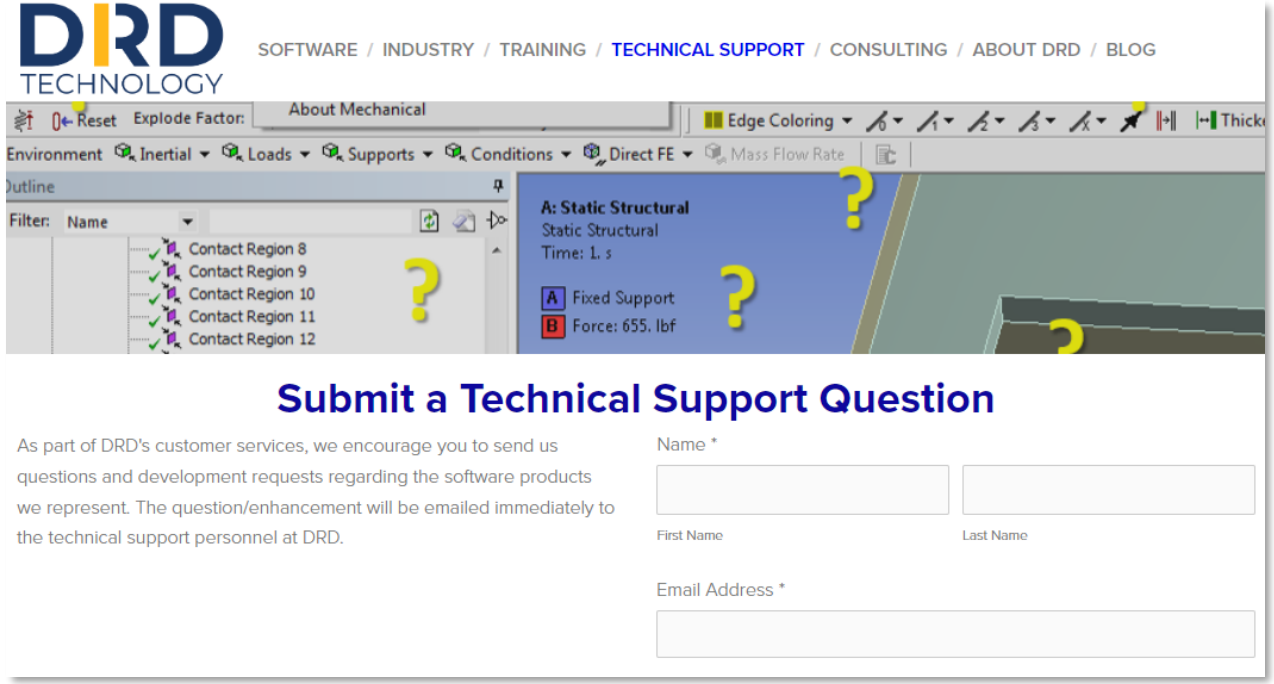
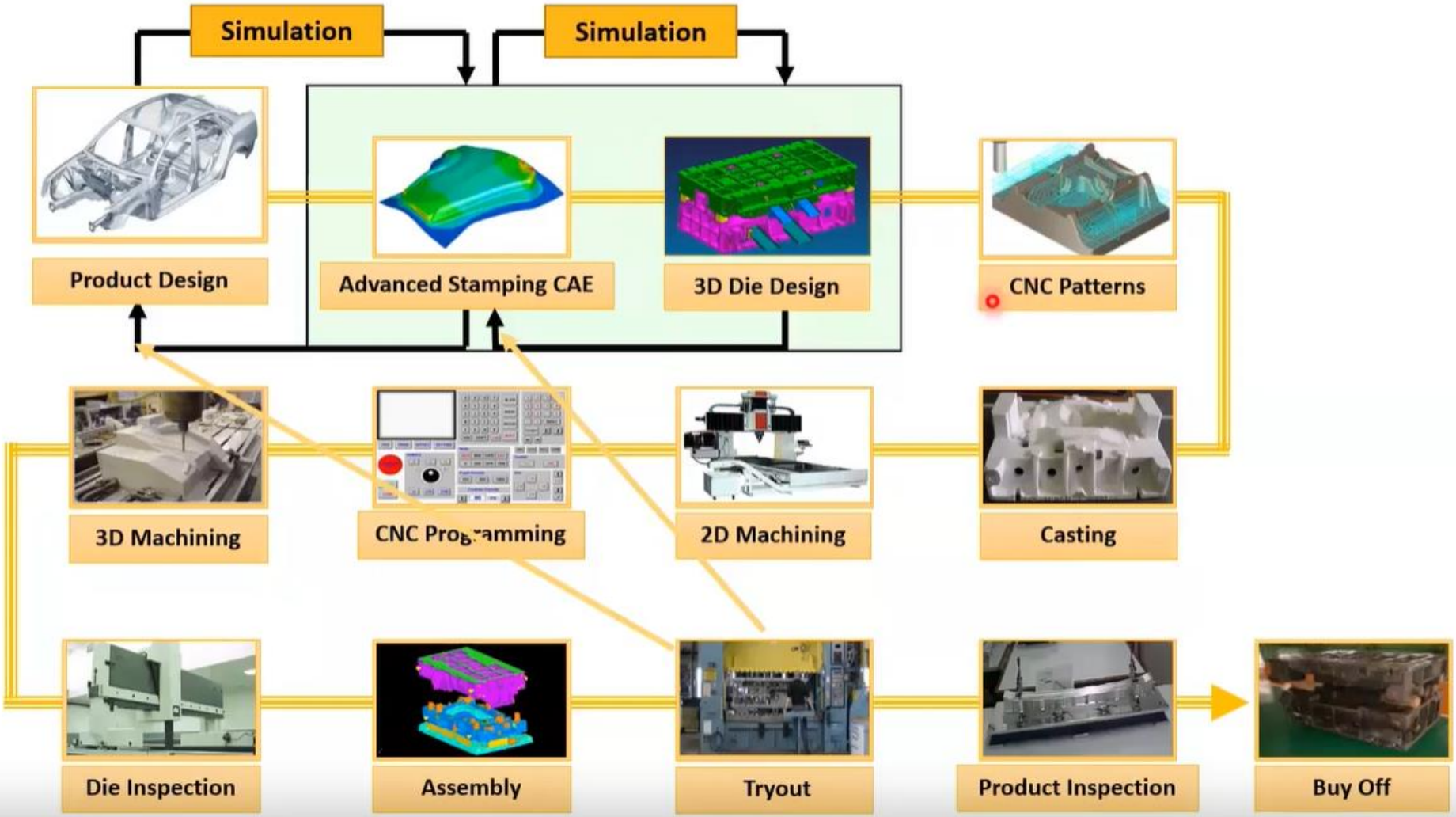


For more than five years, I have worked closely with DRD Technology to execute tactical and strategic initiatives here at EaglePicher due to our unprecedented growth. We've been very happy with DRD and will continue to work with them as our business partner for using Ansys tools effectively and efficiently.

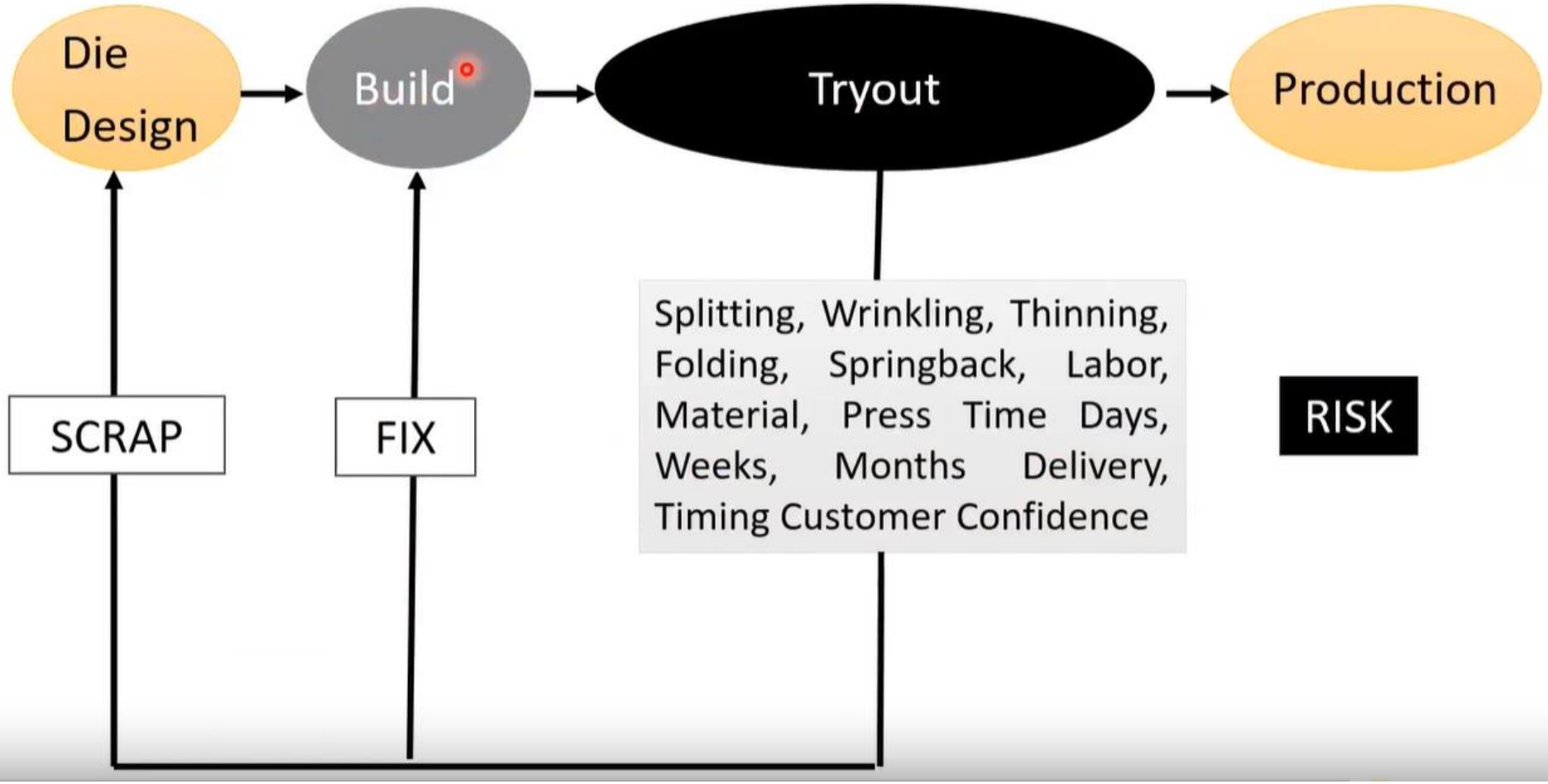
- Doug Austin
Director of Research and Development
EaglePicher™ Technologies, LLC

Stamping Process

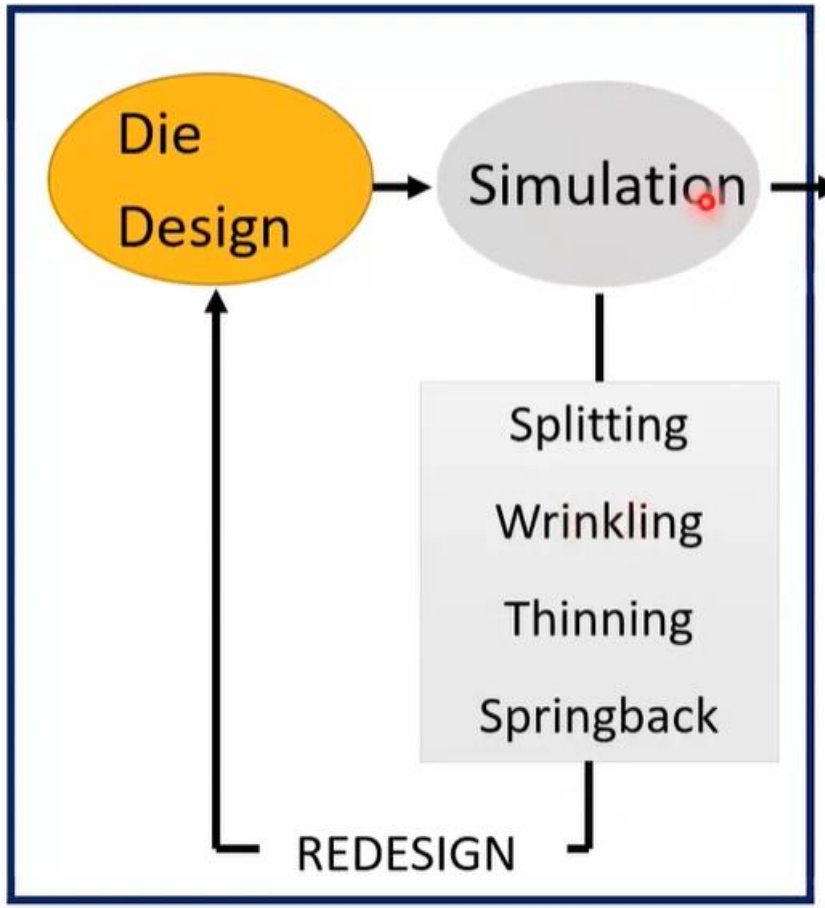
Die-Manufacturing and Simulations



Stamping Process | Traditional Tooling Process



Stamping Process | Tooling Design Process with Simulation

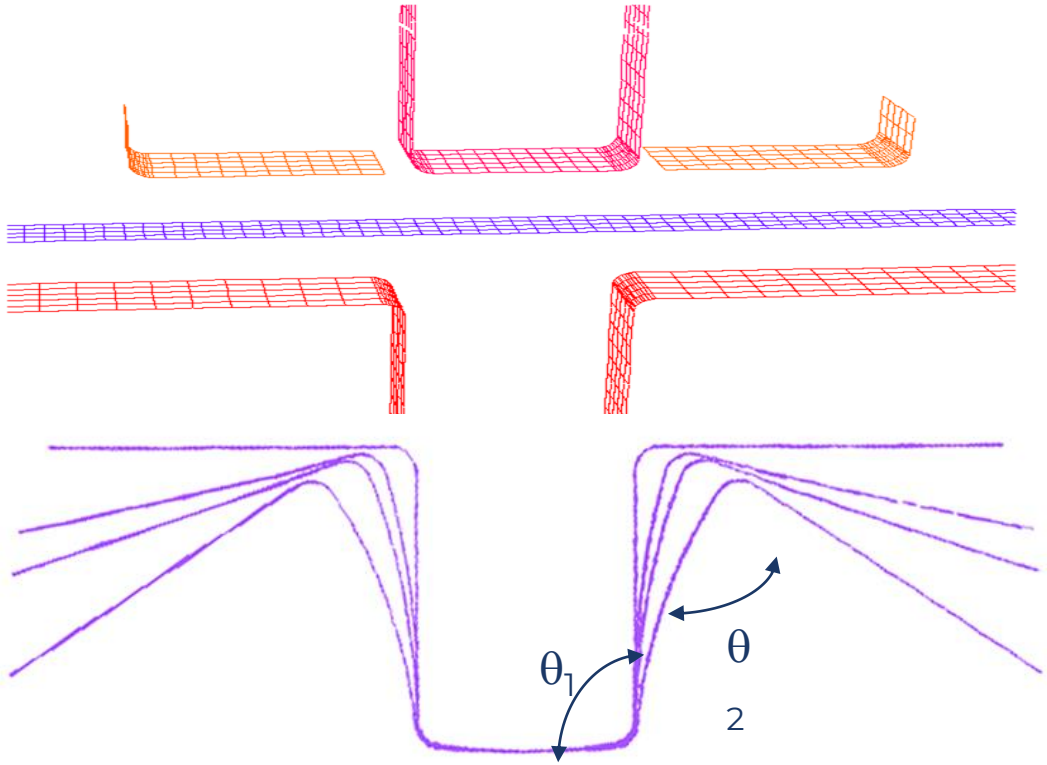


Build → Tryout → Production

Brief History Review of LS-DYNA in Stamping Simulations

- **Initial use of LS-DYNA in stamping simulations started from early 1990s**
  - **Early application mainly focused on formability analysis**
  - **Required expert knowledge, especially in springback predictions**
  - **Customer base was limited: Chrysler was the only OEM of using LS-DYNA in stamping analysis before 1999**

- **LS-DYNA underwent significant improvement in later 1990s**
  - **More OEMs began to use LS-DYNA in stamping simulation after 2000**
    - **Ford, GM, TOYOTA, HONDA, BMW….**



	Ms. 2.45	MS. 19.6	Al. 2.45	Al. 19.6	Hs. 2.45	Hs. 19.6
LSTC-ZL	17	8	31	17	23	16
LSTC-yh	11	4	40	2	12	10

Springback angle predictions
For the same problem, different user got different predictions for Numisheet 1993 benchmark

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Typical Applications Related to Stamping Processes and Different types of Forming

LS-DYNA is a powerful FEA software and has been applied (but not limited) to the following areas :

- Sheet metal gravity loading, binder closing
- Deep-Drawing,
- Springback and springback compensation
- Flanging and hemming (press/roller)
- Panel transfer (transfer press line)
- Clamping
- Denting or oil-canning simulation
- Tube-bending and hydro-forming
- Stamping scrap shedding
- Stamping subassembly
- Incremental forming
- Thermal forming and magnetic forming
- superplastic forming
- Die-wear prediction
- Die structure analysis

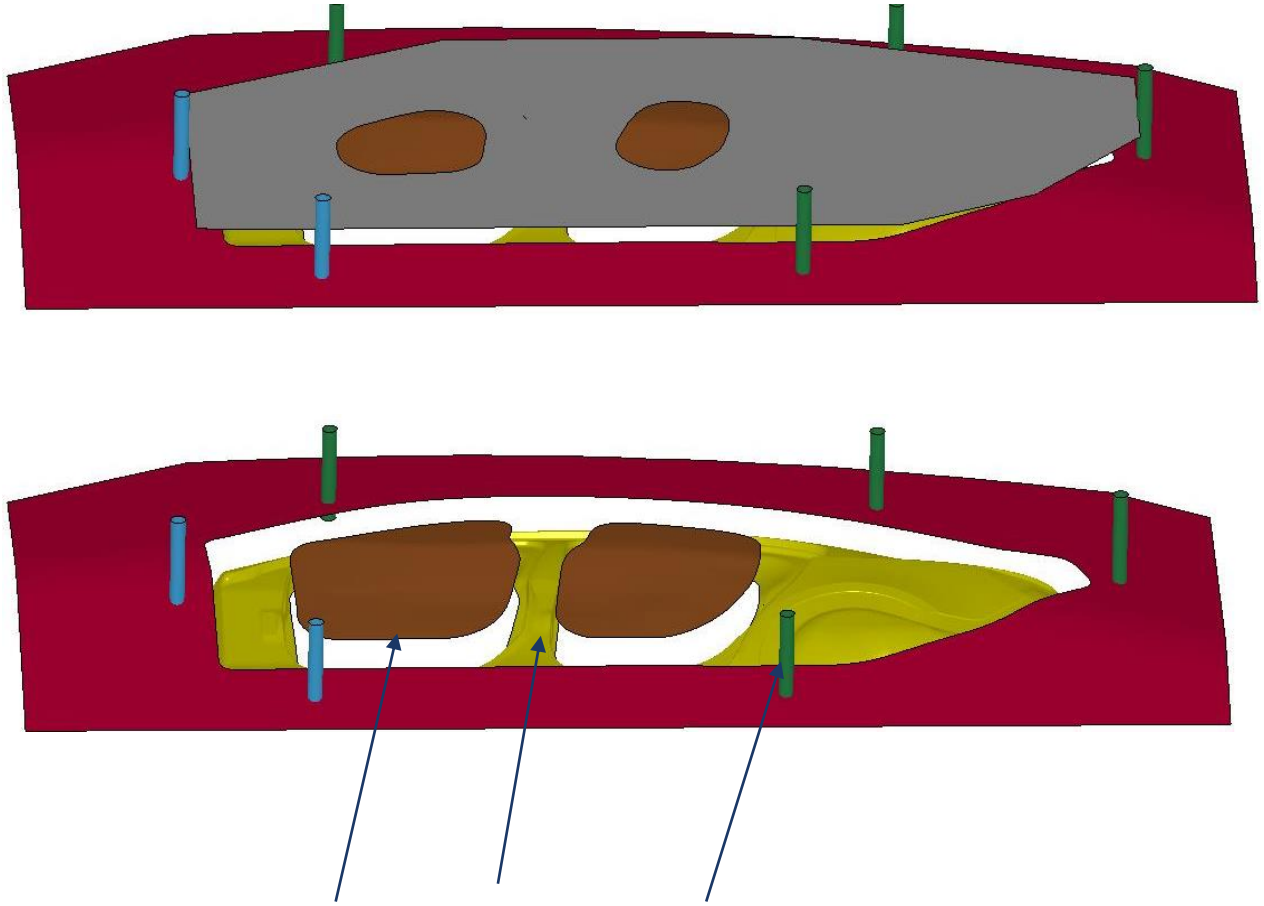
Typical Applications: Gravity loading simulation

- **Why it is needed?**
  - **Reduce punch travel and dynamic effect**
  - **Different modes affect surface quality**

- **Challenges :**
  - **Explicit method will take too much time to finish, and the result depends on damping and termination**
  - **Implicit method might have singularity problem:**

  the initial blank has no contact with the rigid tools

- **LS-DYNA strategy:**
  - **Implicit method with a patented technology to**
  - **ensure convergence**
  - **One simple keyword for implicit control**
  - **Efficient and robust, and also easy to use**



Support from pad, punch and guide pins increase difficulty

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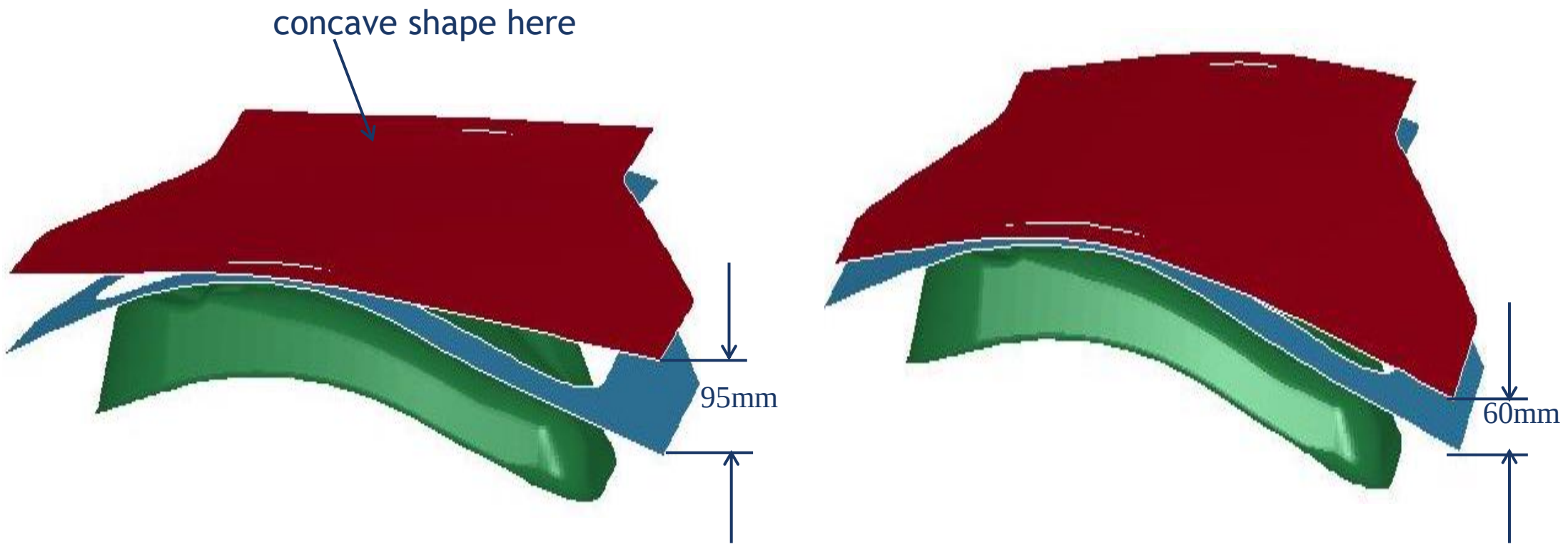
Typical Applications: Gravity loading simulation

Effect of pre-bending on gravity loading



Sometimes, two modes can be true after gravity loading
Pre-bending is used to get rid of the unfavorable mode

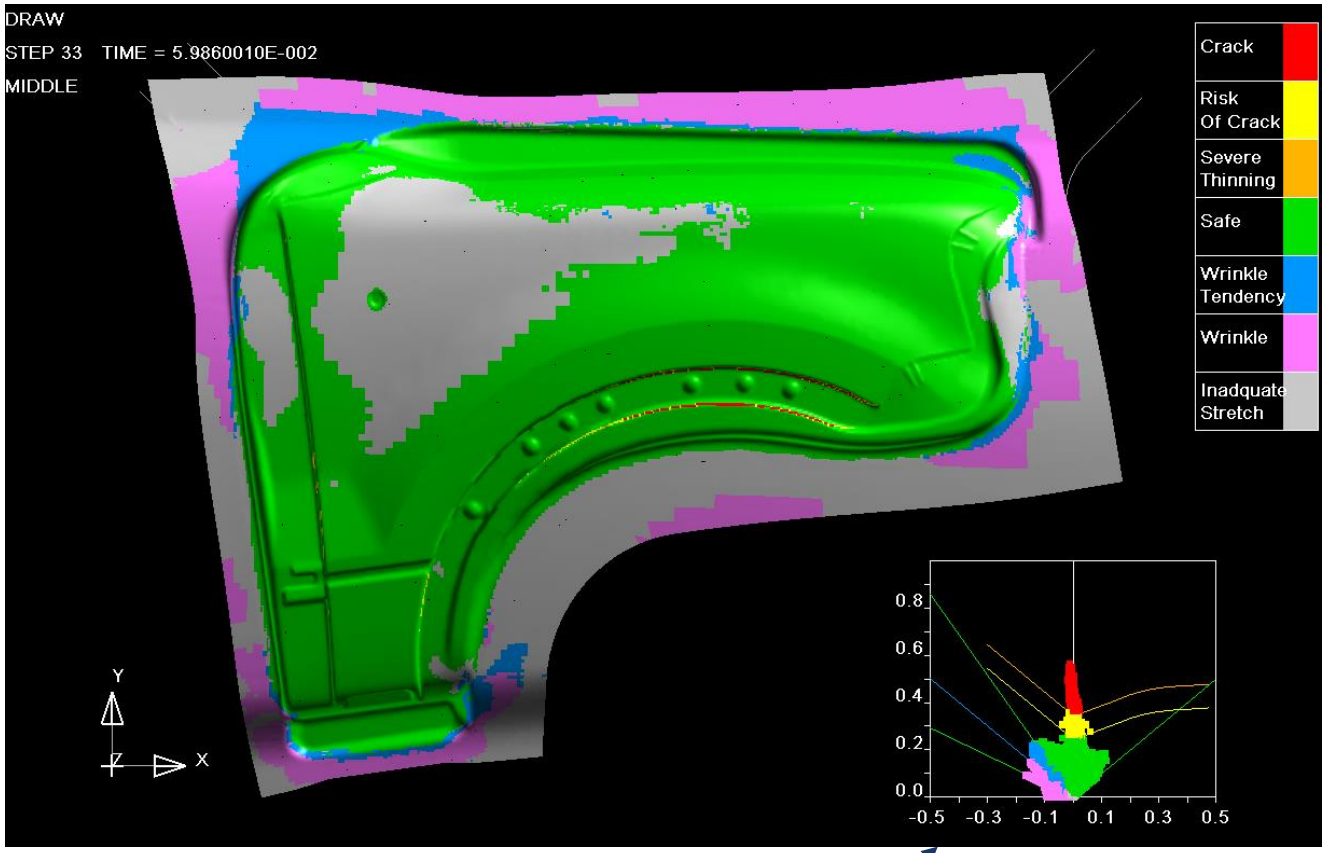
Typical Applications: Formability Analysis

- **Purpose:**
  - **Detect material formability**

- **The challenges :**

  - **Computing efficiency.**
    - **MPP, in-core adaptivity, etc are the solution.**

  - **Accuracy in formability prediction, especially for non-linear strain path problems.**
    - **Formability Index (FI) was proposed to address this issue.**



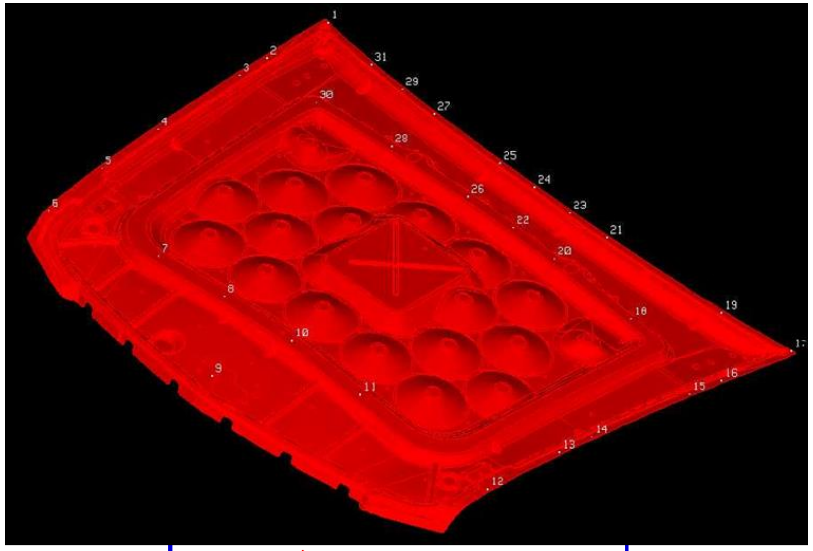
FLD is commonly used to evaluate formability, wrinkling tendency
FLD is derived from linear strain path, can have large error when strain path is not linear

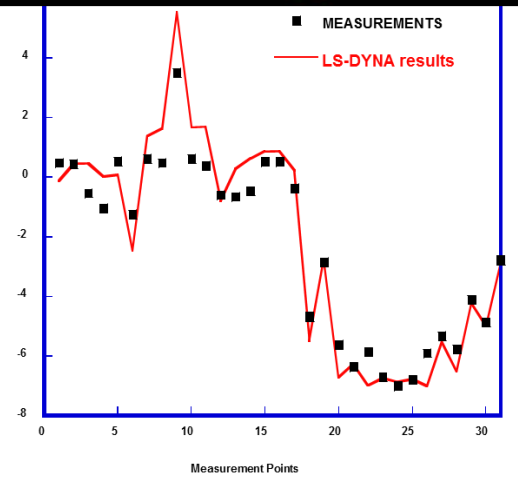
Typical Applications: Springback prediction

- Why springback prediction?
  - It causes dimensional inaccuracy
  - Many of the die – recut results from springback problem.

- Challenges
  - Higher requirement on forming simulation
  - Most of the more advanced high strength steel tends to have significant kinematic hardening effect

- LS-DYNA's strategy
  - More advanced material models
  - Smooth contact
  - A set of recommended procedure from a systematic study





Aluminum hood inner from GM

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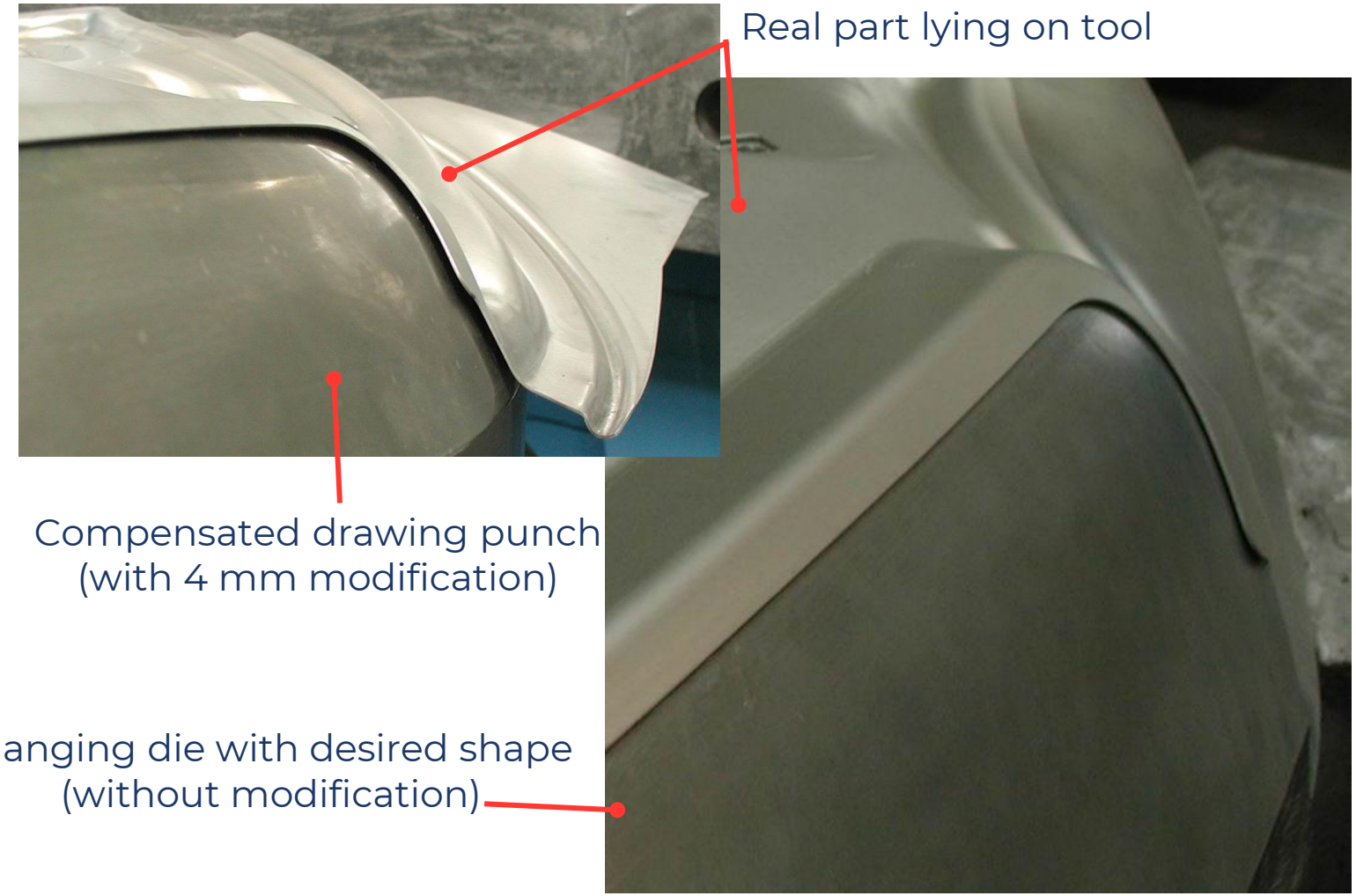
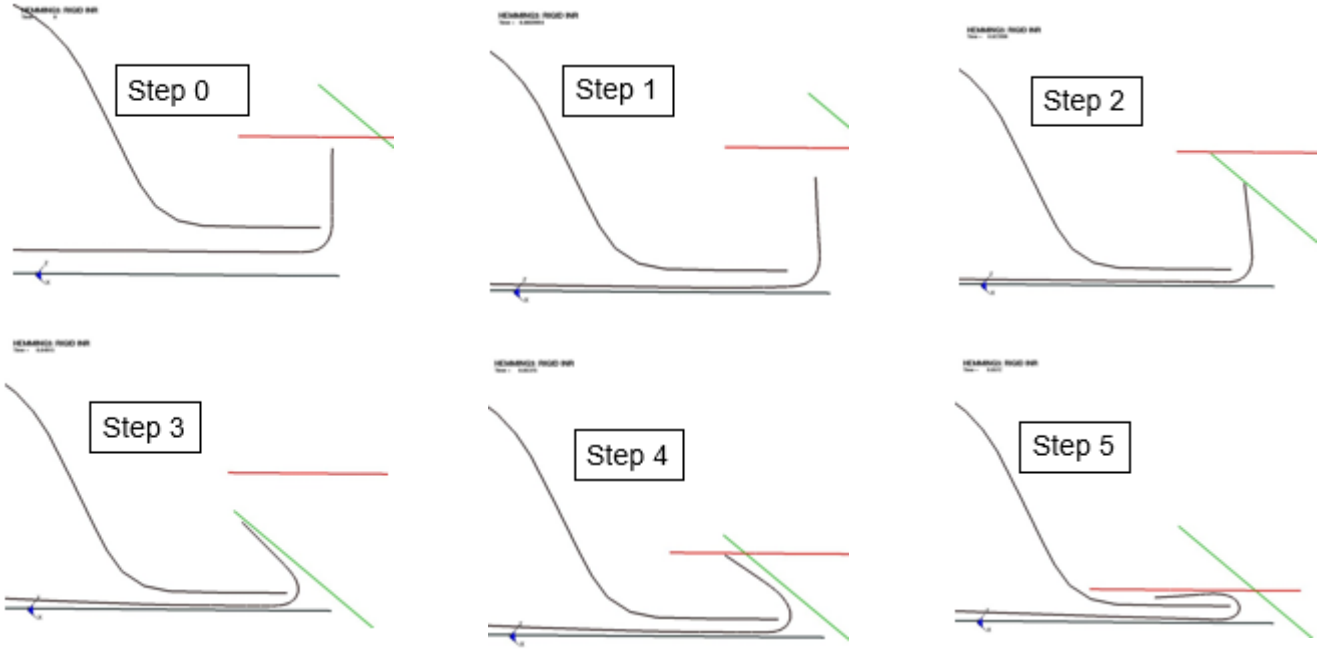
Typical Applications: Springback Compensations

- **Example showing springback compensation (from Daimler)**
- **First, perform draw simulation and prediction springback**
- **Second, compensated the draw die based on the predicted springback**
- **Then use the compensated draw die to manufacture the part. After springback, it fit the following flanging tool nicely**



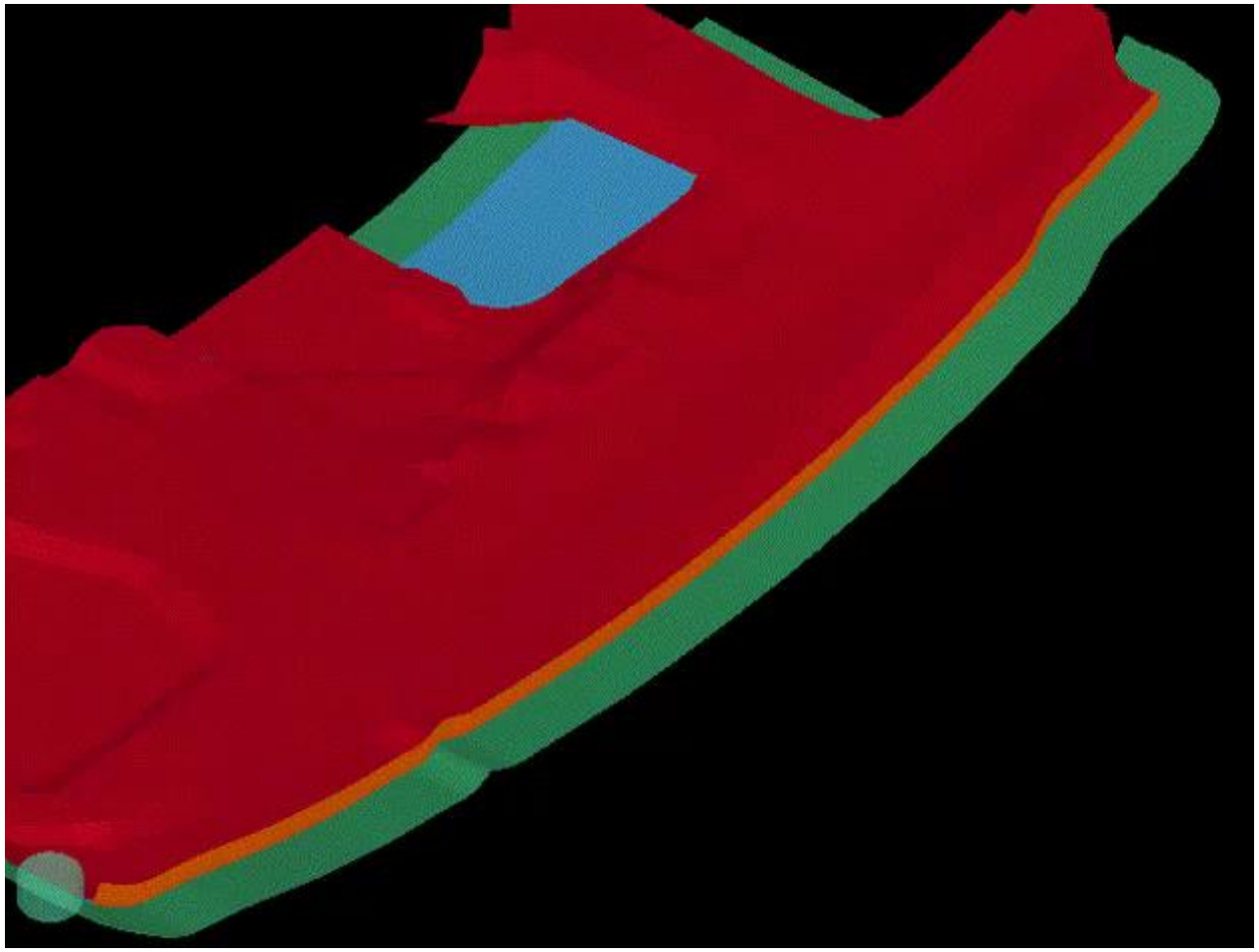
Typical Applications: Press- Hemming

- **Why perform hemming simulation?**
  - **Formability**
  - **Surface quality**
- **The challenges**
  - **Contact between deformable parts, and edge contact**
  - **Small element size and model size can be huge**
  - **Dynamic effect can be large**
- **LS-DYNA's strategy**
  - **Refine element along hemming edge**
  - **Different contact types**



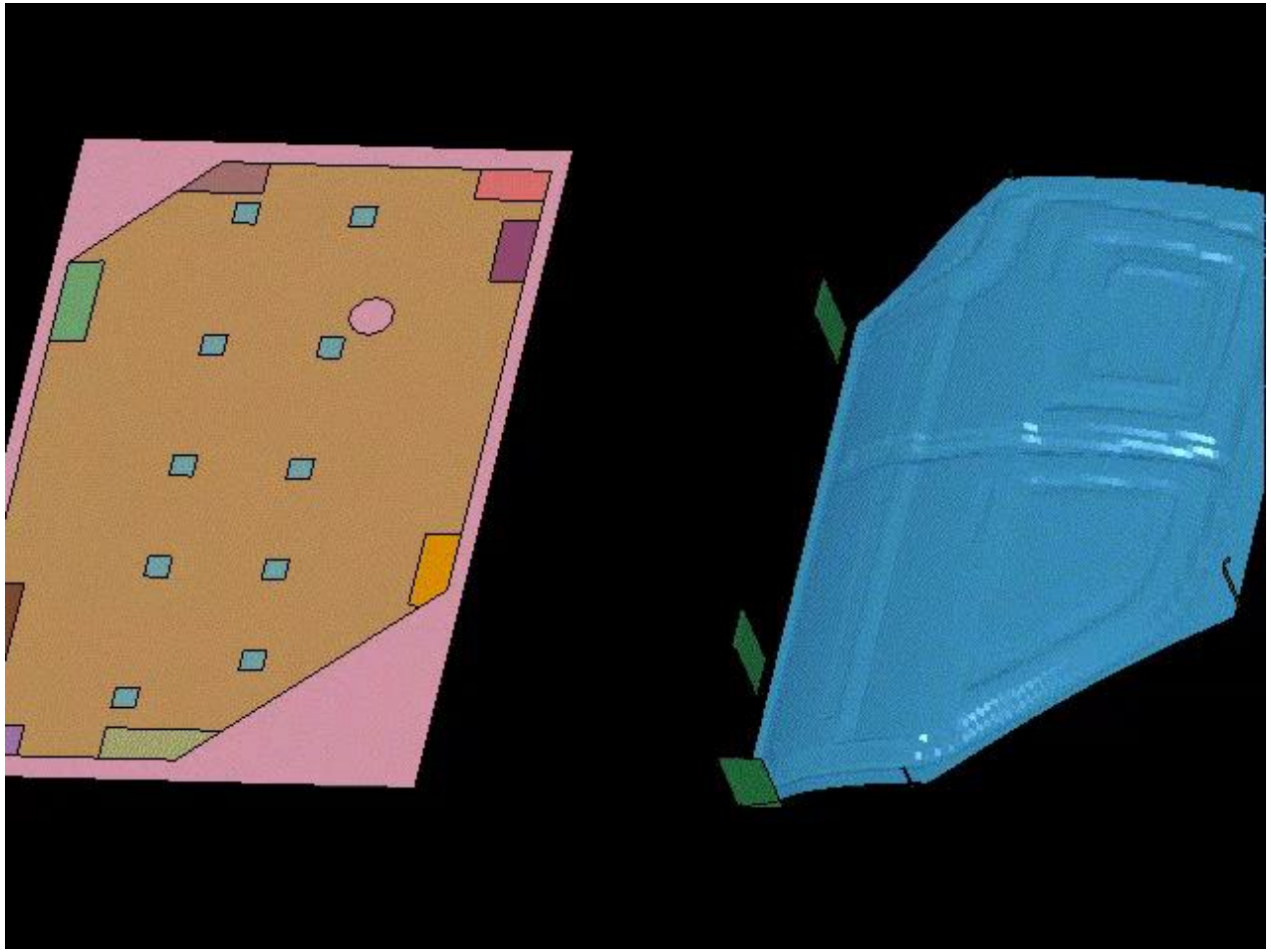
Typical Applications: Roller Hemming

- **Why need perform roller hemming?**
  - Check material formability
  - Check if the surface quality is affected
- **Challenging**
  - Tool path is much more complicated
  - Termination is too long and the CPU time is also very long
- **LS-DYNA's strategy**
  - Special mesh refinement along tool path and mesh fusion technique to speed up the simulation
  - A user-friendly interface to design the tool path



Typical Applications: Part Transfer

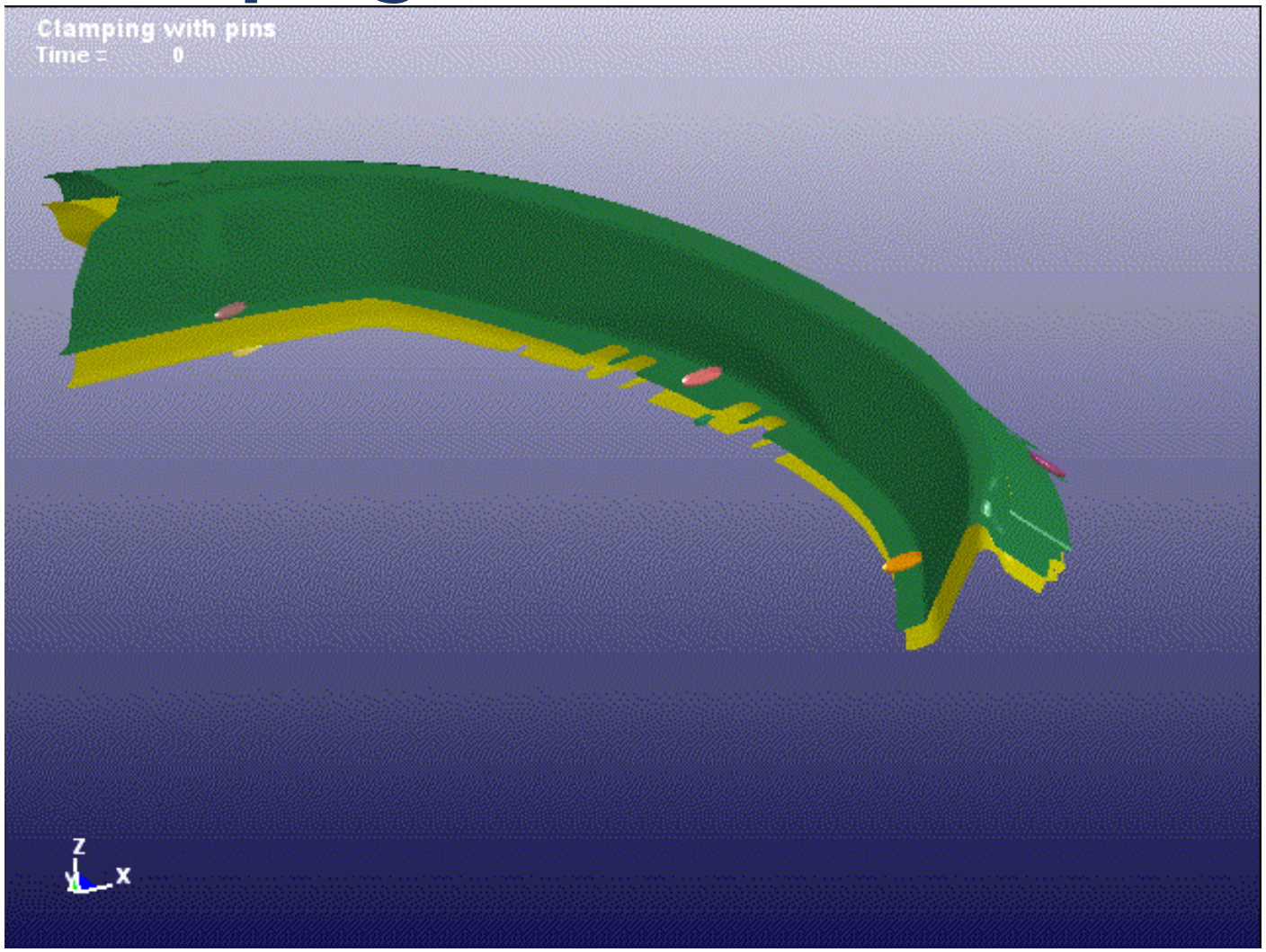
- **Why need to perform part transfer simulation?**
  - The maximum allowed speed to transfer the part is critical to obtain the manufacturing efficiency
  - Large dynamic effect will happen
  - Interface with the rigid tools during transfer
- **LS-DYNA's strategy**
  - Dynamic implicit method



Typical Applications: Clamping simulation

- Why clamping simulation?
  - After springback, the inner and outer will deviate from its target geometry, and need to be pushed back
  - There are many clamping pairs
  - Different clamping sequence can affect the final distortion of the assembly

- LS-DYNA's strategy
  - One keyword: *CONTACT_FORMING_CLAMP,
    - to define all the contacts,
    - set all the implicit control
    - Easy to use



Typical Applications: oil canning simulation

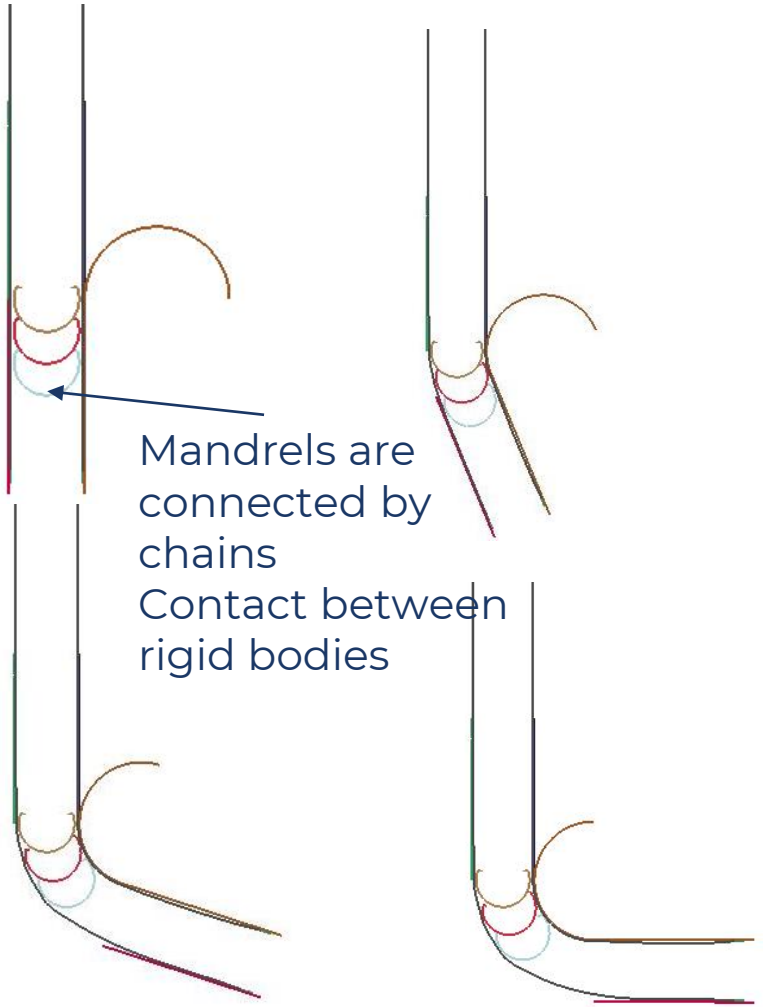
- Why perform oil canning simulation?
  - check the stiffness of the formed part
  - (one of the function of stamping is to sufficiently deform the blank so as to make the material work-hardened and increase the part stiffness)
- Difficulty in the simulation
  - Real time has to be used and termination is long. So implicit method has to be used
  - Buckling mode might happen and may cause convergence issue
- LS-DYNA's strategy: *control_implicit_forming, one keyword, simply and robust

Typical Applications: Tube bending

- **In hydro-forming simulation, the initial straight tube needs to be bent into different shape before applying internal pressure**

- **Challenges in performing simulation:**
  - **Internal mandrel is commonly used to maintain the shape of the tube as it go into the arc of the bend.**
  - **Mandrels are rigid tools and are connected by chains**
  - **The dynamic effect is also significant and implicit method is preferred.**

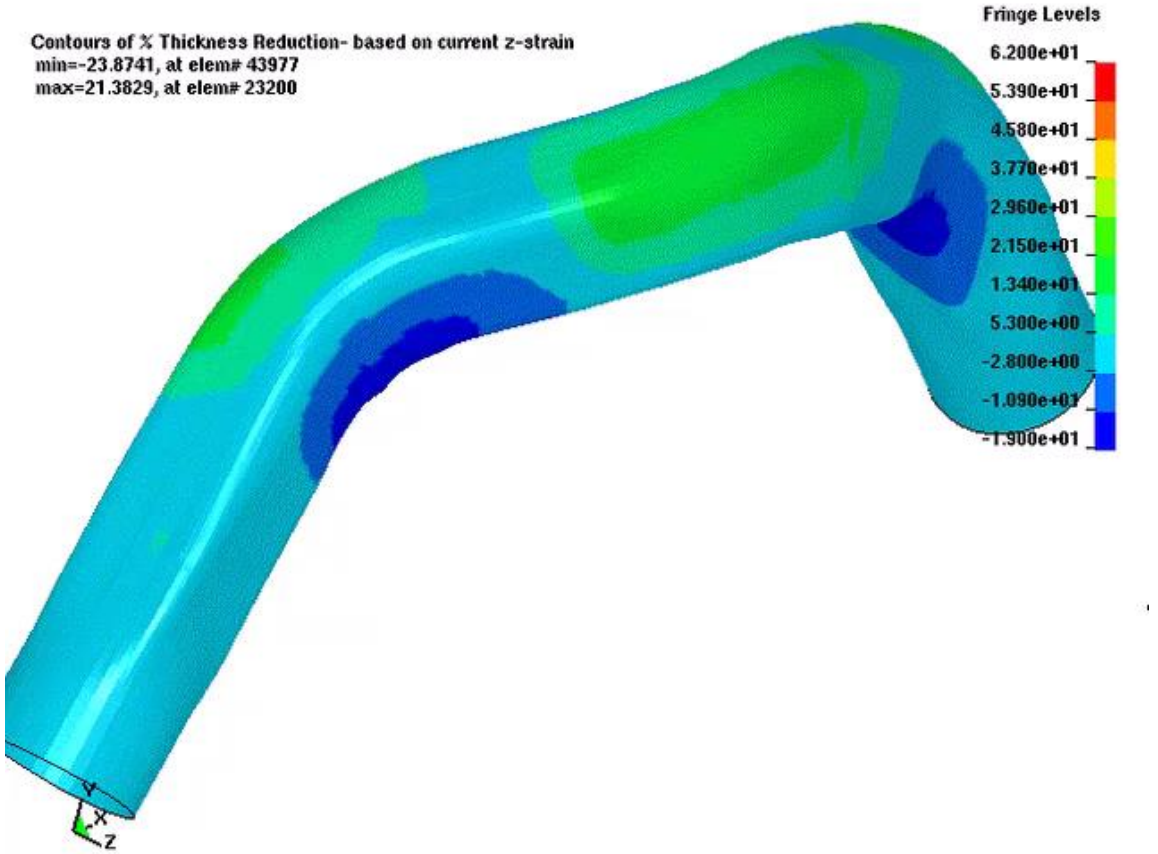
- **LS-DYNA's strategy**
  - **LSDYNA offer different contact types to meet different requirement**
  - **Joints can be used to connect the internal mandrel**



Typical Applications: Hydro Forming

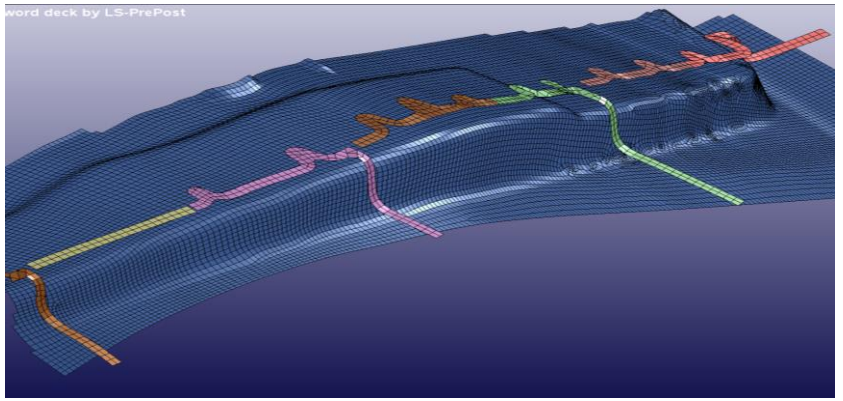
- **Purpose of performing hydro-forming simulation**
  - **Obtain proper hydro-pressure**
  - **Obtain other process parameters, such as end-feed speed based on each pressure**
  - **Detect split or wrinkling problems.**

- **LS-DYNA in hydro-forming simulation**
  - **Several loading methods allow user to easily define the loading condition**

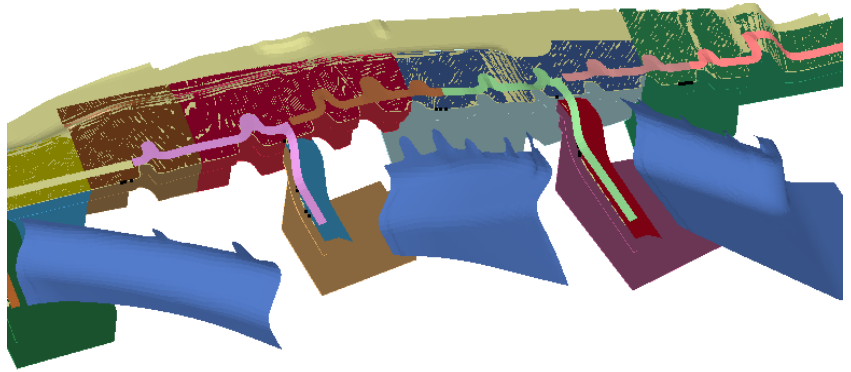


Typical Applications: Scrap Fall

- Why Scrap Fall simulation?
  - Scrap removal is the main cause of delays in production
  - Scrap fall simulation can find the potential problem areas to help stamping plants find design changes to alleviate and eliminate the bottlenecks of scrap being stuck in the chute or in the die



- Challenges:
  - During the simulation, scrap has to be cut or separated from the original part
  - The scrap move is driven by cam steel and gravity



- LS-DYNA's strategy
  - A user friendly keyword to handle all of problems

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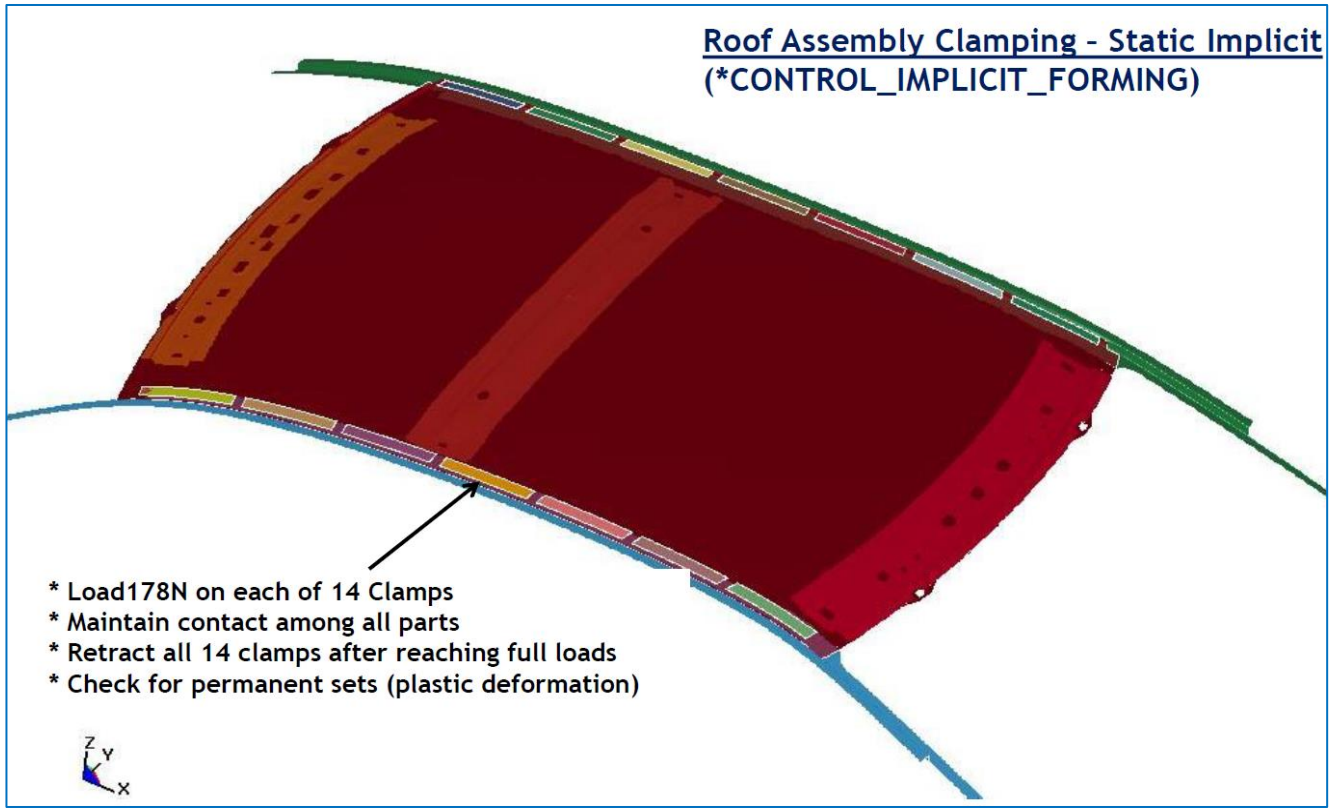
Typical Applications: Scrap Fall

Trimming speed is too fast
Scrap fall outside of the channel

With reduced trimming speed

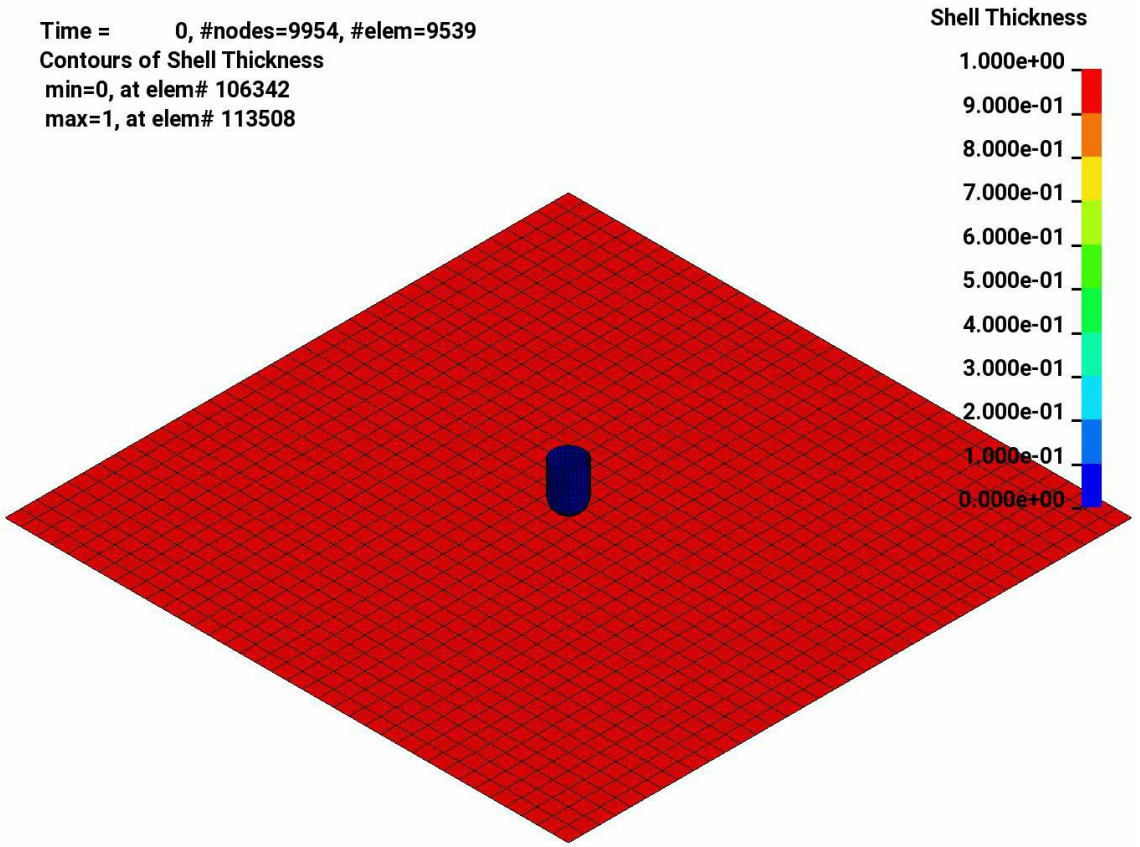
Assembly

- Why assembly simulation?
  - Predict the final distortion
- Challenges
  - It is multi-physics nature: welding, reverting, clamping, springback
  - A complete process chain has to be simulated
  - Material has thermal expansion
- LS-DYNA provides all the necessary functionalities
  - Explicit for draw, flanging, and hemming
  - Implicit for welding, gravity loading, final distortion analysis



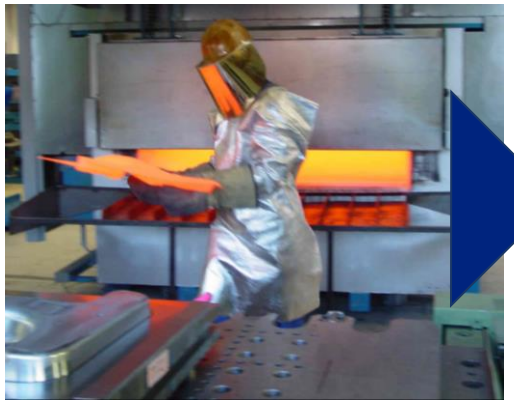
Incremental Forming Simulation

- Why incremental forming simulation?
  - Predict formability
  - Distortion
- Challenges
  - The CPU cost is very long
- LSDYNA's strategy
  - Adaptive the mesh along the tool path, rather than based on the curvature
  - Mesh fusion after forming



Thermal Analysis

- LS-DYNA can be used to analyze all the stages in hot forming process
  - Heating
  - Part transfer
  - Forming
  - quench

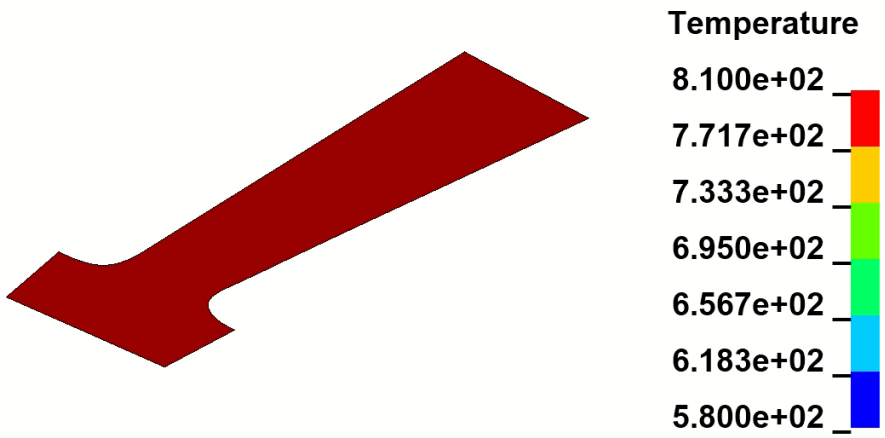


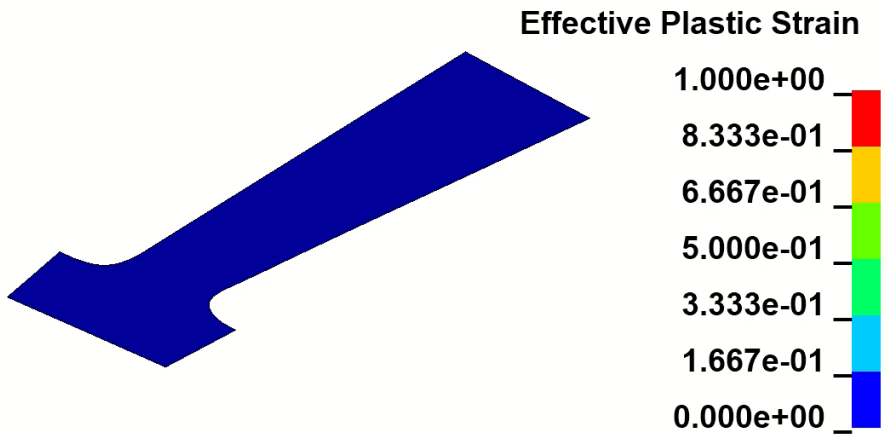
2. Transfer

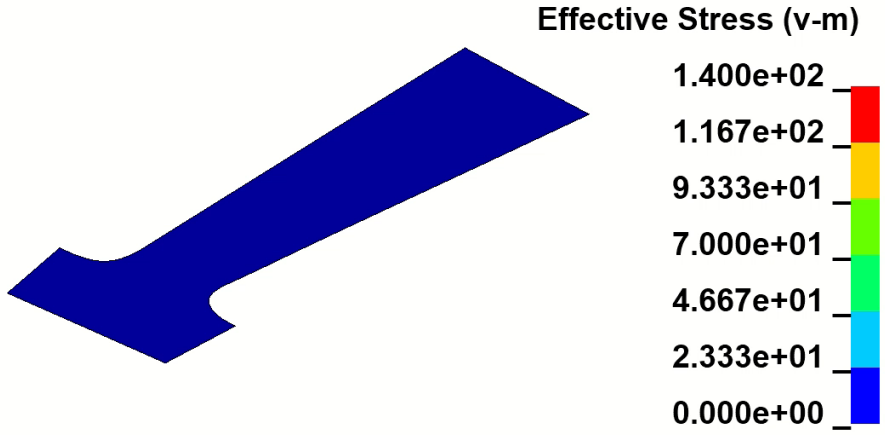
3. Form

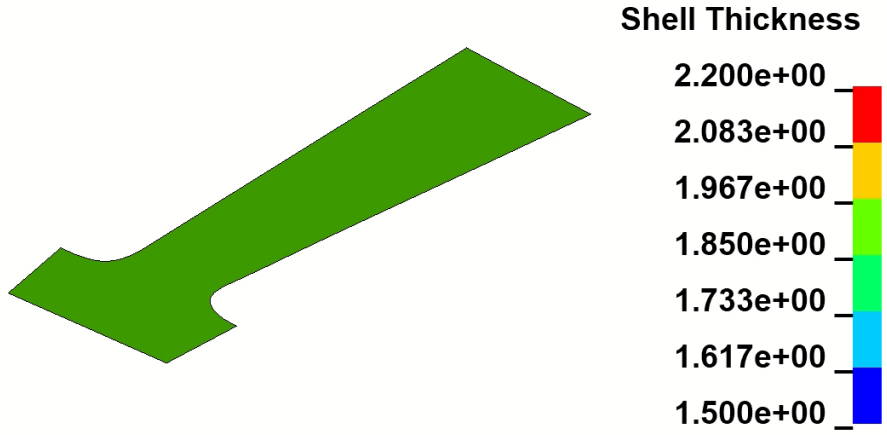
4. Quench

Hot forming simulation example









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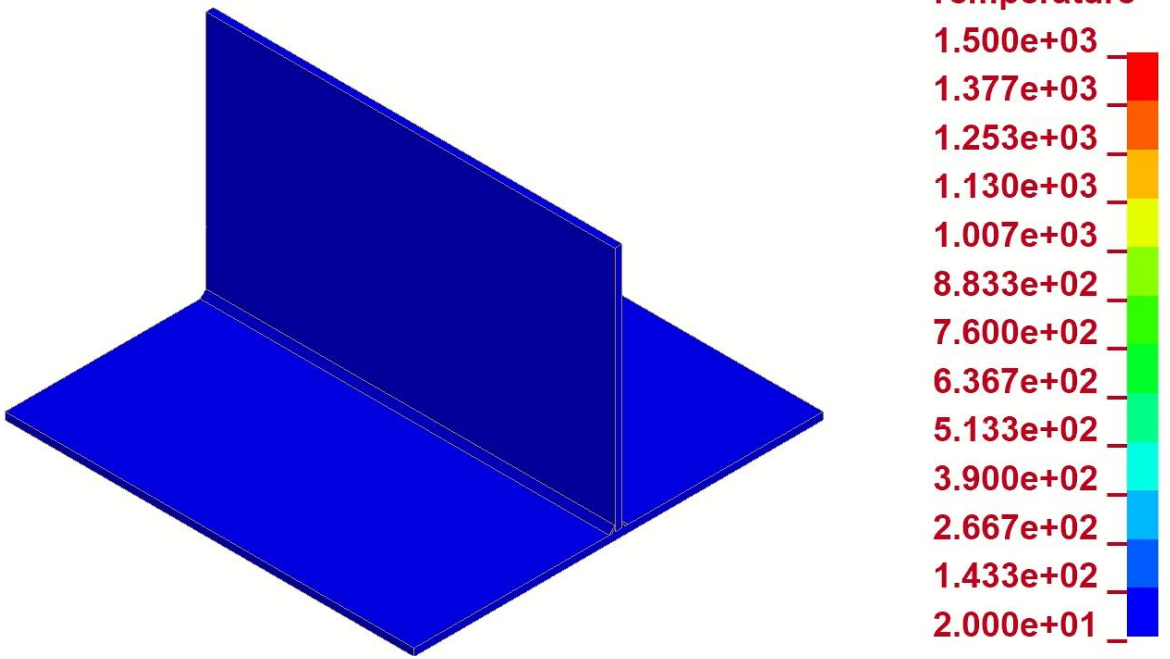
Thermal Forming Technology For Welding Simulation

- The functions developed for thermal forming analysis can be extended to other application
  - The most common one is welding simulation
  - It can consider material phase transformation
  - Material property predictions



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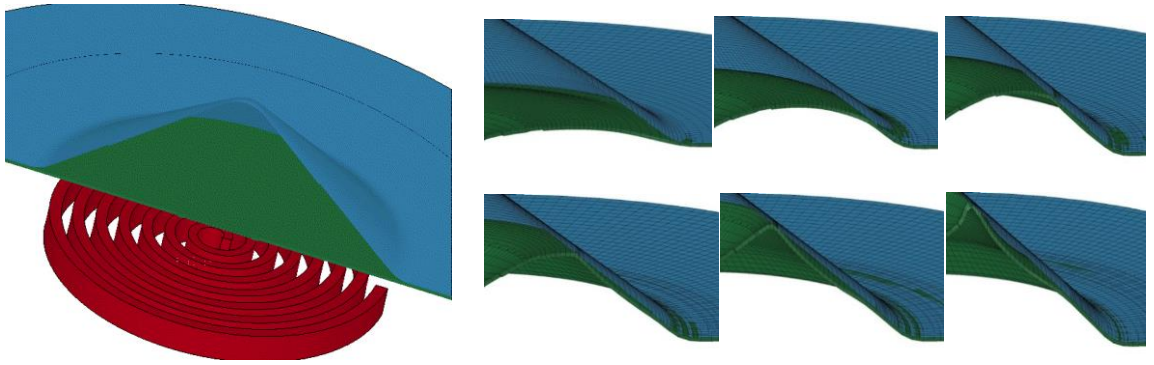
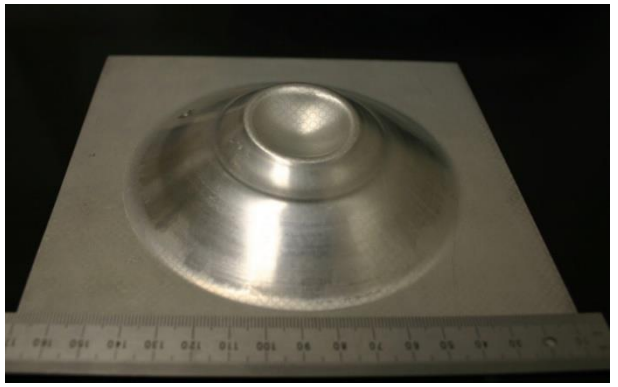
Magnetic Pulse Forming (MPF)

- **Why magnetic pulse forming?**
  - **Achieve higher formability**
  - **Produce sharp corner and fine details**
  - **Reduce springback**
  - **Use one side of die**
  - **Can be combined with other forming technology**

- **LS-DYNA EM solver**
  - **Coupled with mechanics and thermal solver**
  - **Boundary element method in the air and coupled with finite elements to avoid meshing the air**



Conducting coil induces electrical currents, which creates an electromagnetic force pushing the workpiece against the die



Sheet forming on conical die

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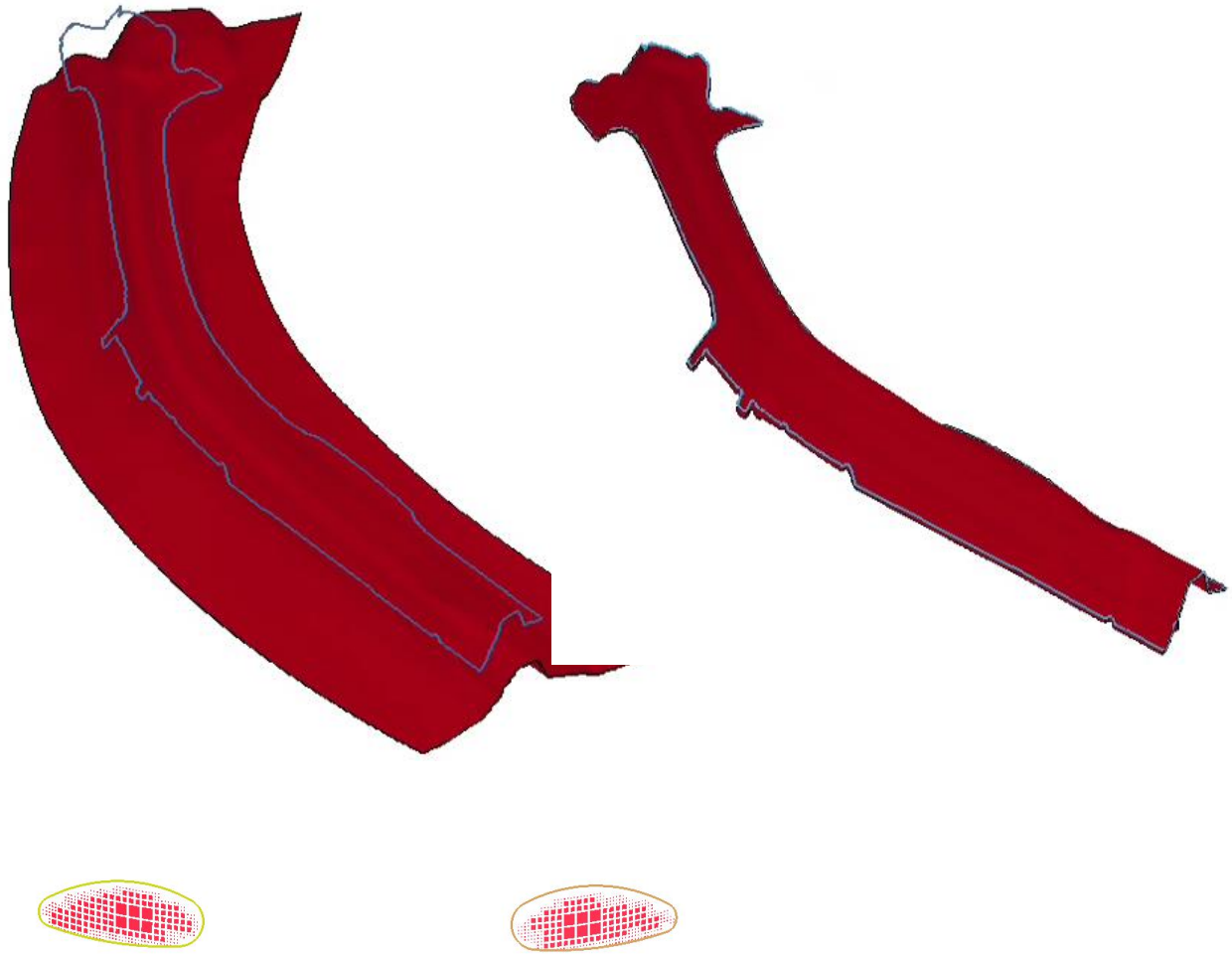
Some Important Features: Trimming & Blanking

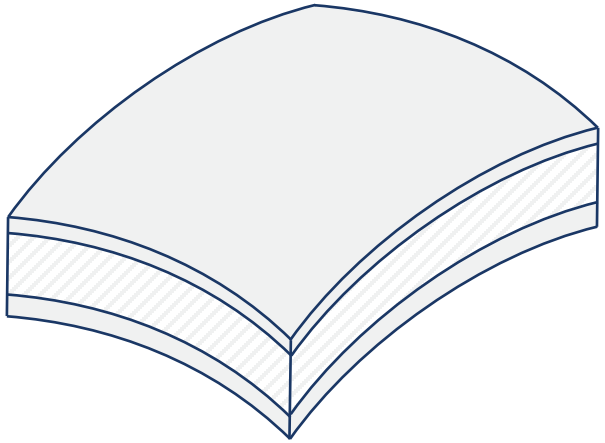
- Two trimming algorithms
  - Cam trim, trim the part along one direction
  - Laser trimming, no fixed trimming vector. LS-DYNA allow user to trim the part by using the nearest element normal to trim
    - The trimming curve should be close to the part
  - Allow double-attached parts to be trimmed



Some Important Features: Trimming

- Trimming can be applied to solid, thick shell and sandwich elements

Sandwich part is made up of three layers
Top and bottom layter: think sheet metal
Middle layer: composite



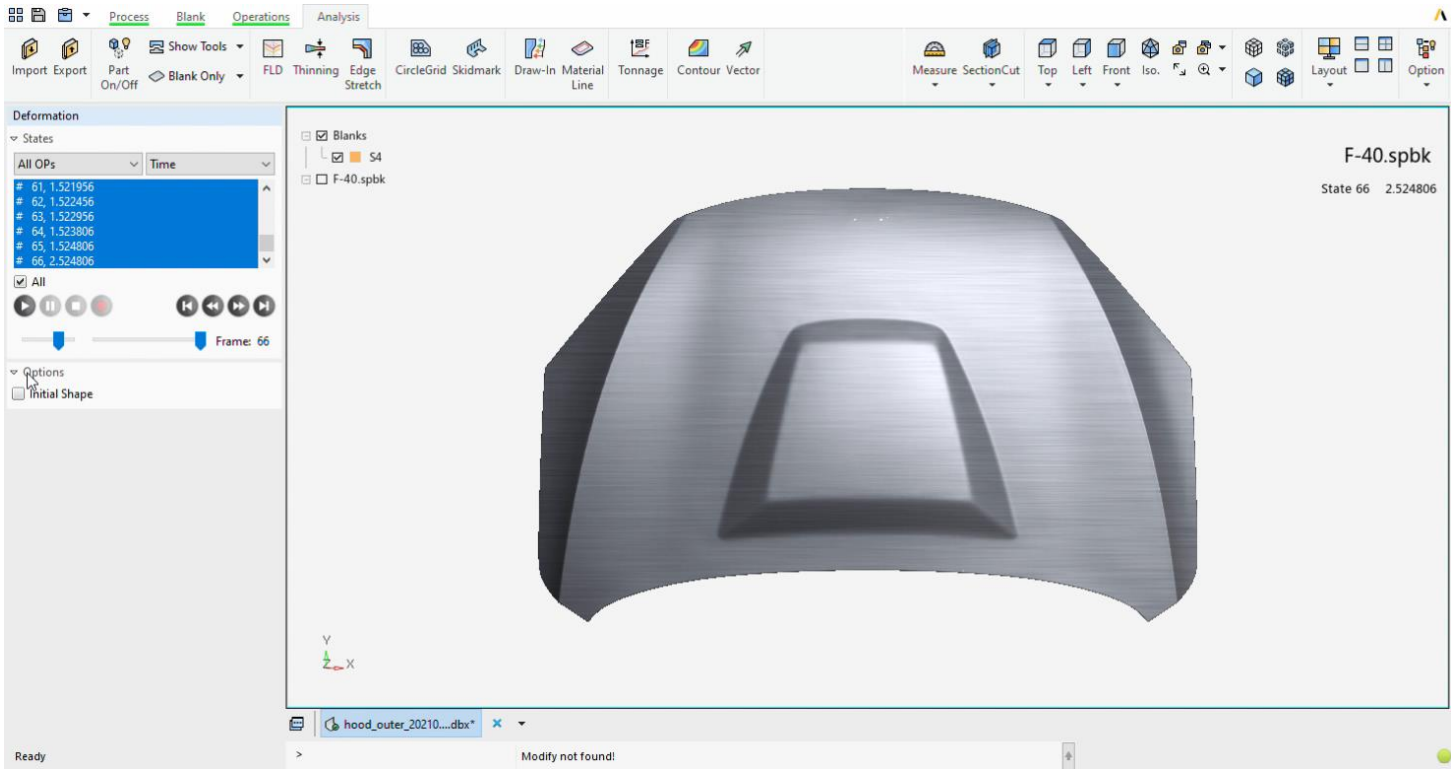
Control Parameter Selections

- LS-DYNA is a general purpose code
  - Different applications require different control parameters
- Inappropriate parameters affect predictions
- For forming simulation, critical control parameters have been found
  - Many benchmarks have been done
  - Improved consistency has been found with the new parameters
- Standard procedure has been suggested to improve accuracy , as well as efficiency

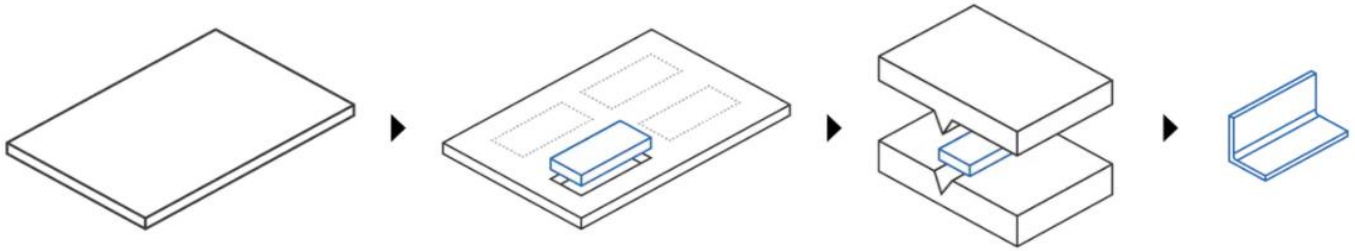
Ansys Forming in Metal Forming Simulation

An end-to-end tool for Sheet Metal Manufacturing Process Simulation – *Ansys Forming*

- **Accurate, Fast, Easy**
  No compromise
- **Streamlined UX**
  One software for all metal stamping needs
- **Trusted Solver**
  LS-DYNA solver is already used for Metal Stamping solutions



How does Ansys Forming simulate Metal Forming?

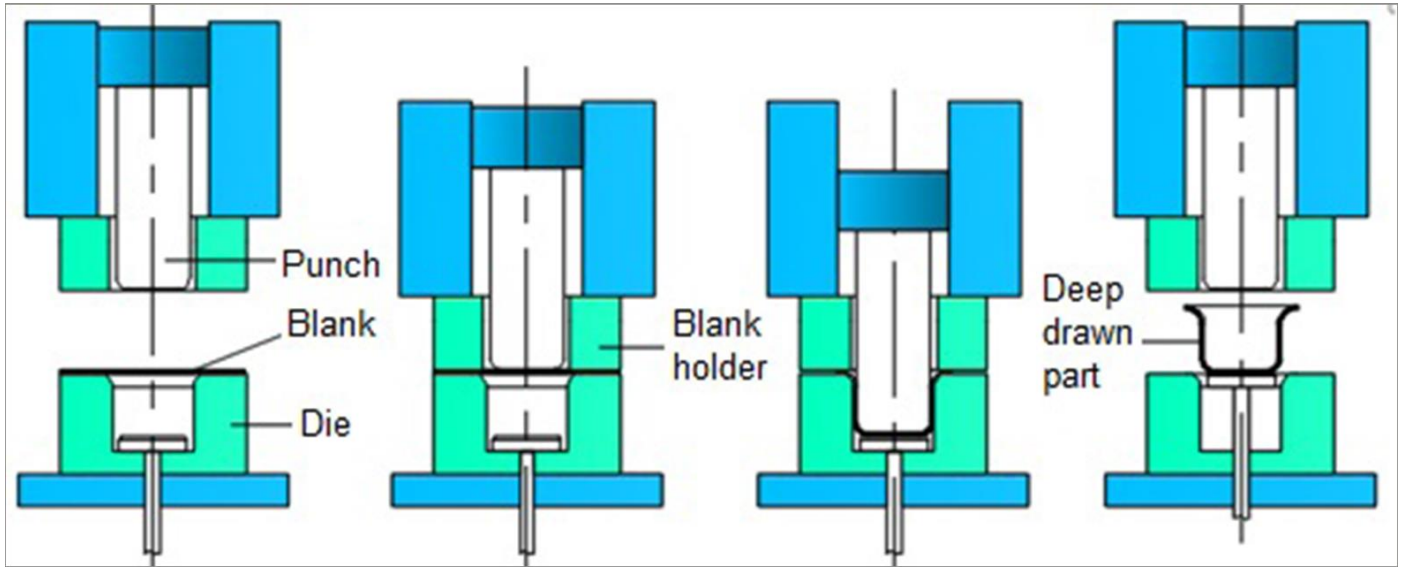


Stock sheet metal

Cut out sheet metal blank

Forming

Formed metal part



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Major Applications for Ansys Forming

Automotive Industry

Consumer Appliances

Aerospace Industry

Food and Packaged Goods

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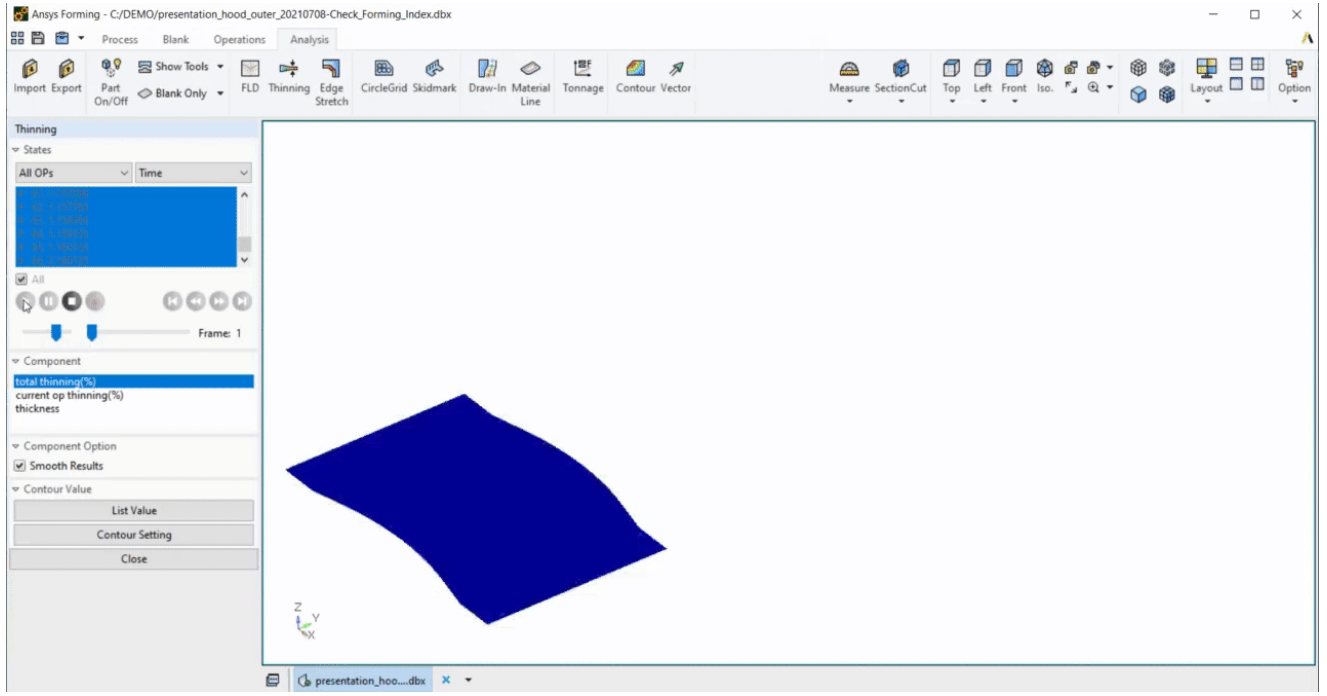
Ansys Forming Simulation

Multi-Stage Forming Process Validation:

- Material Data library and management
- Process definition
- Tool setup & preview
- Drawbead definition
- Multiple Lancing operation
- Stamping specific post processing (FLD, Formability Index, Wrinkling, Skidmark etc.)



DRD

Summary

- LS-DYNA is the technological leader in stamping simulation
  - It is the most accurate code, especially for springback prediction
  - Many of the new functions come from internal innovations

- As a multi-physics FEA software, LS-DYNA has been applied for all the stamping related processes

- Ansys Forming is an end to end tool for sheetmetal manufacturing process simulation and it has truly redefined how sheetmetal forming is done using our trusted LS-DYNA solver.

Questions ?