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Schaeffler Process Simulations: Torque Converters

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Schaeffler Group / LuK USA

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Overview

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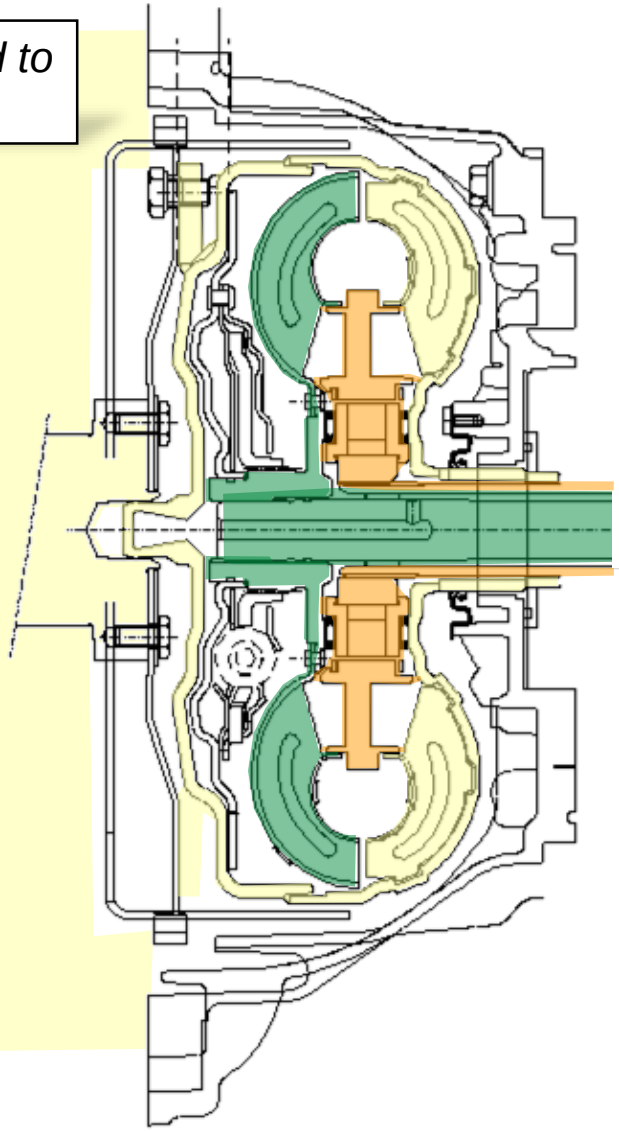
Torque Converter Functionality

Impeller is connected to engine

Turbine is connected to the transmission input shaft



Locked – stator fixed to the transmission housing

Freewheel – stator rotates freely

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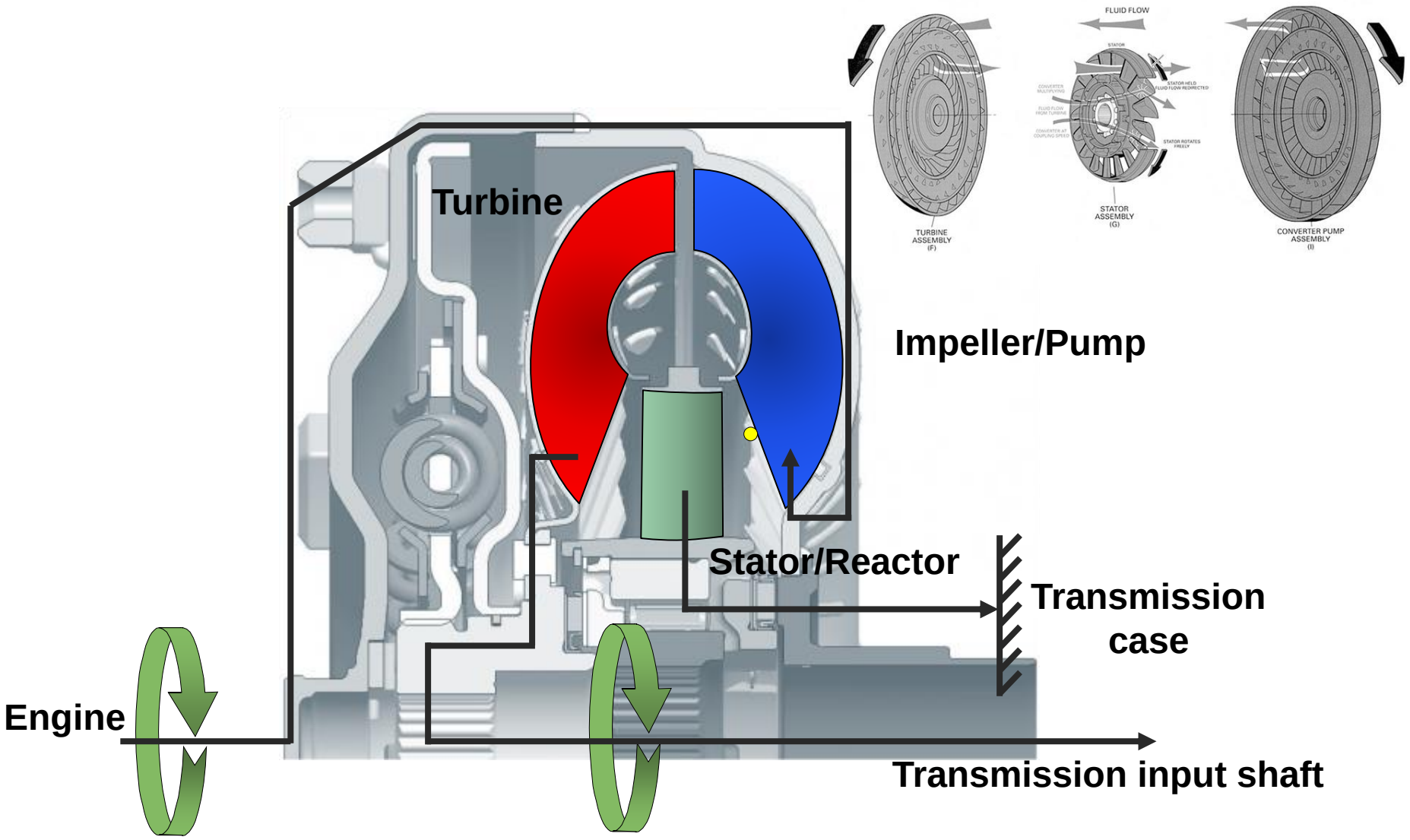
Torque Converter Functionality



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Overview

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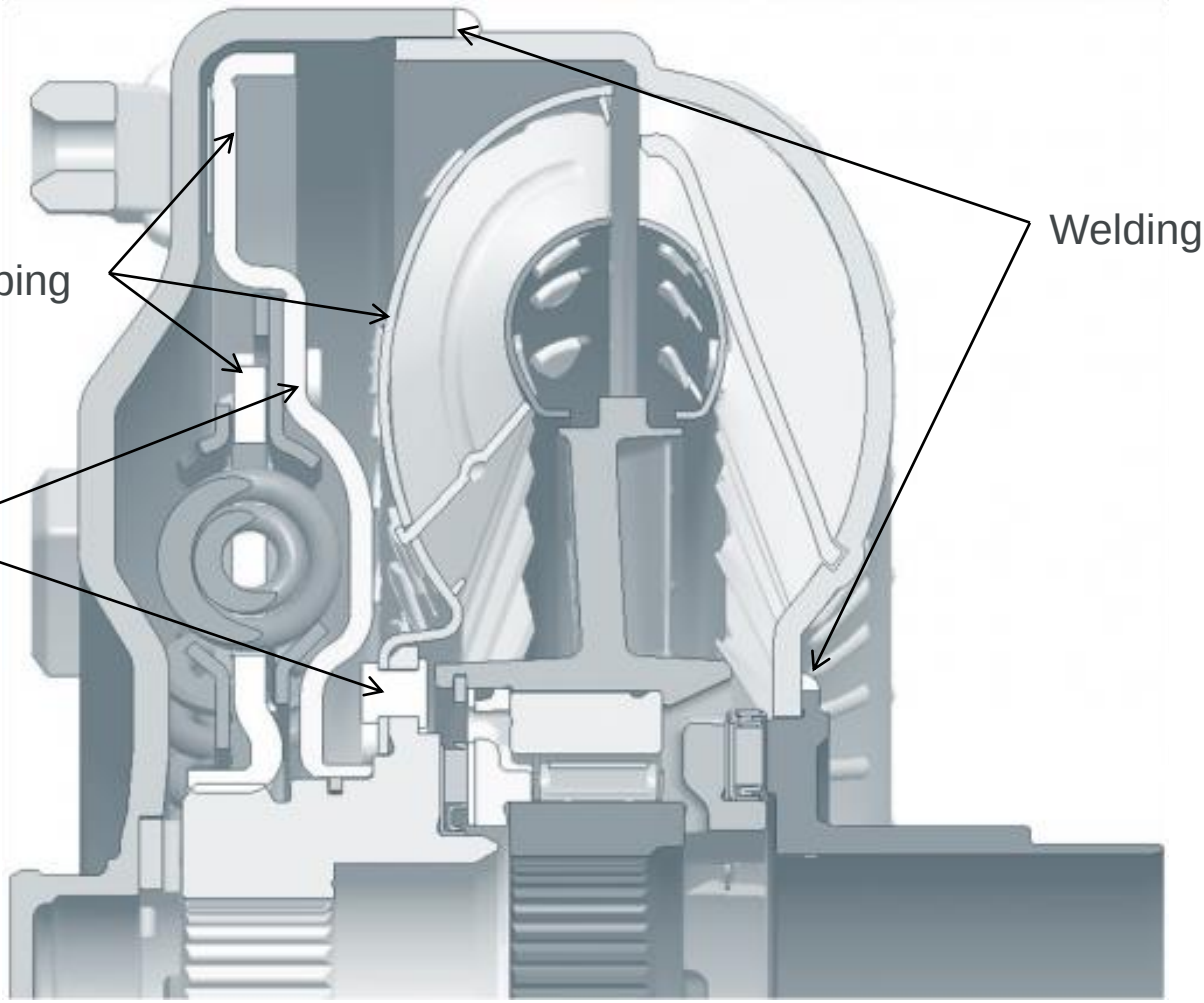
Torque Converter Development

Where are Process Simulations Needed?



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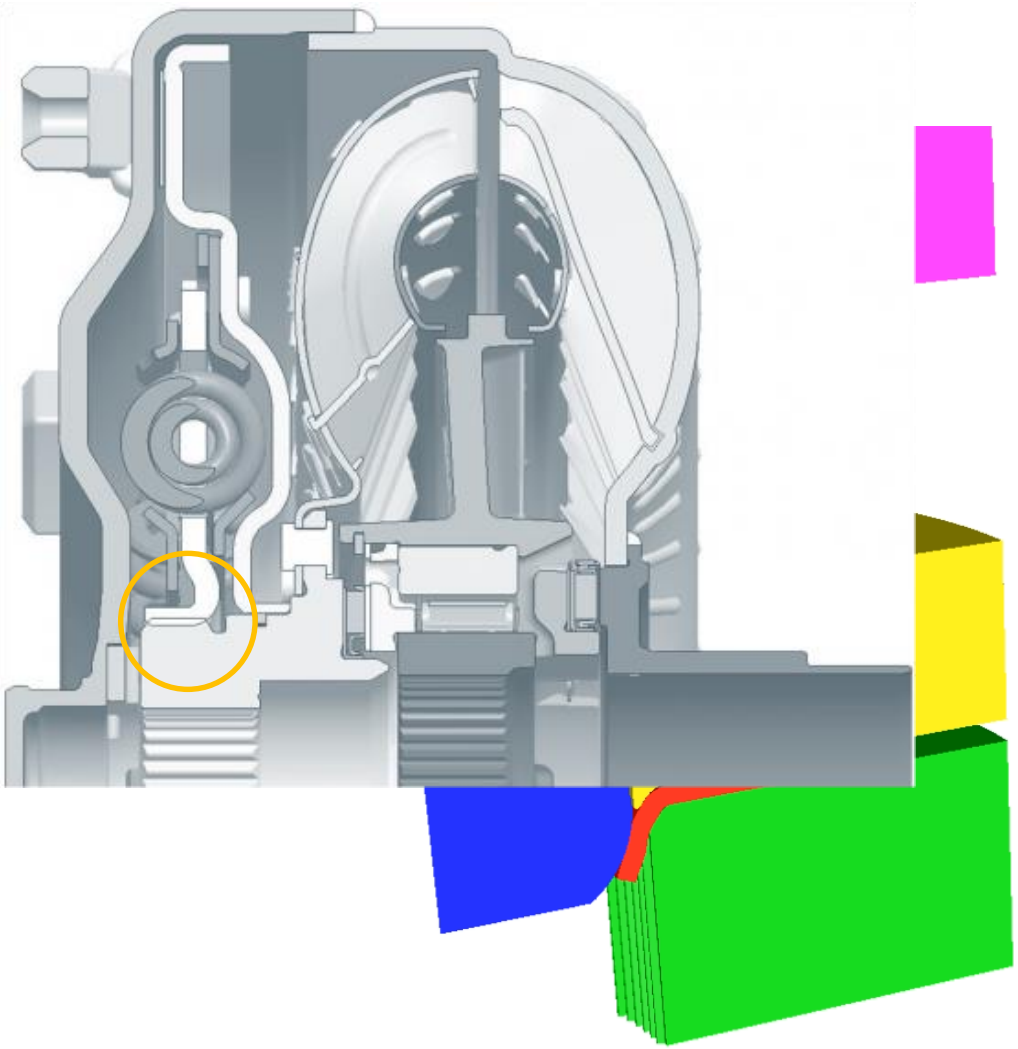
Spline Forming



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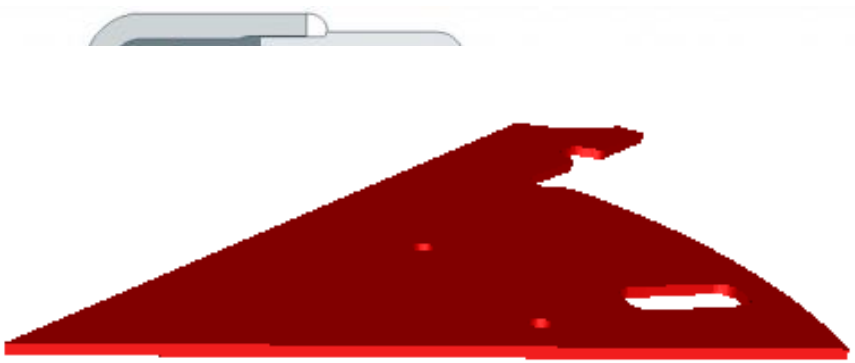
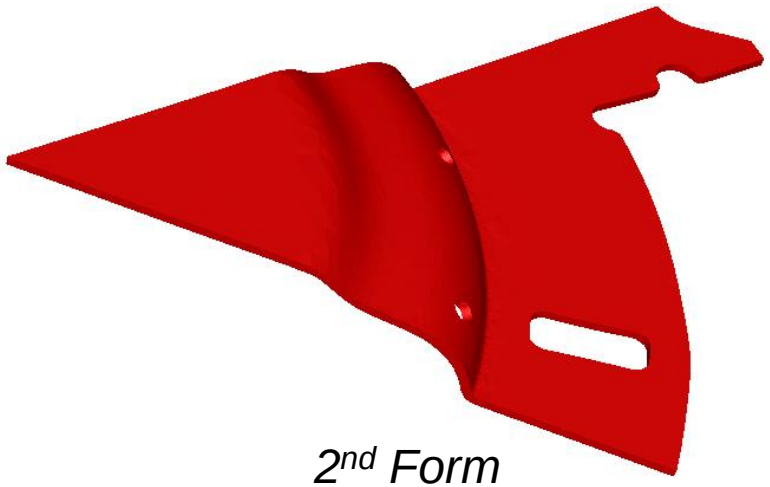
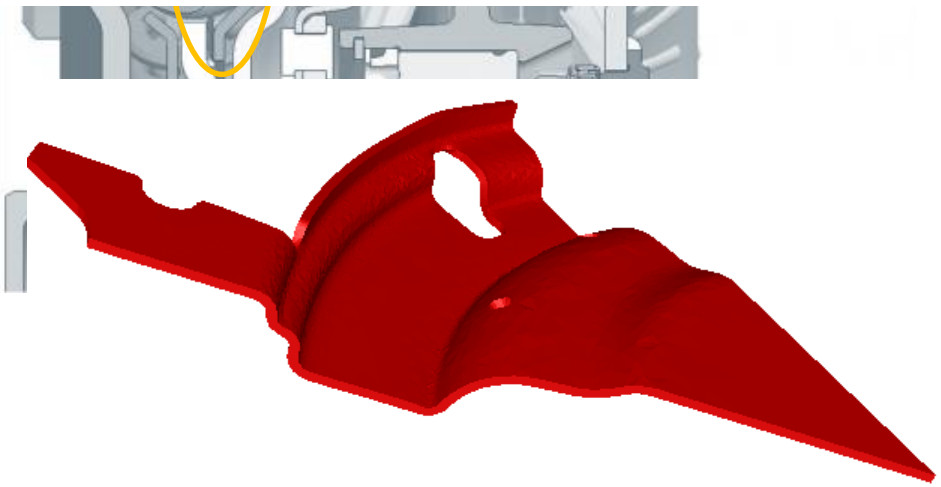
Cover Plate Stamping



1st Form



2nd Form



3rd Form

Final Form

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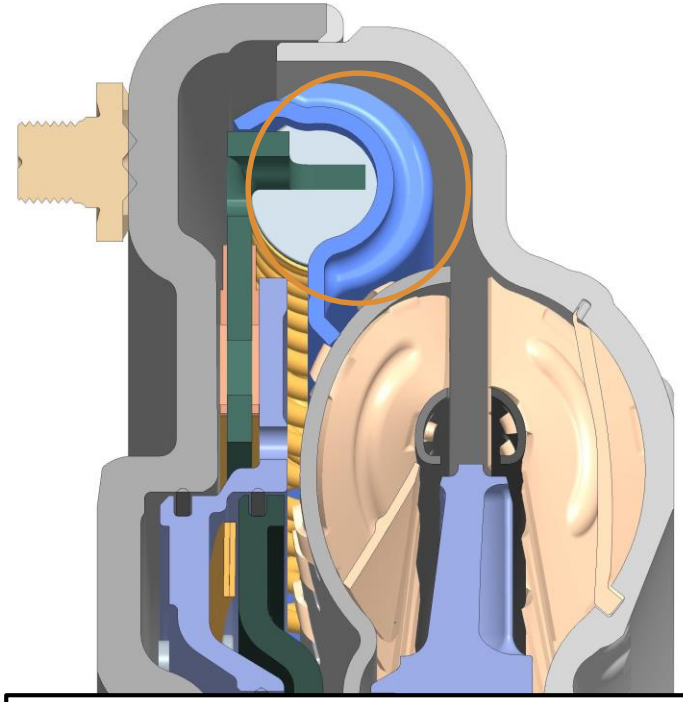
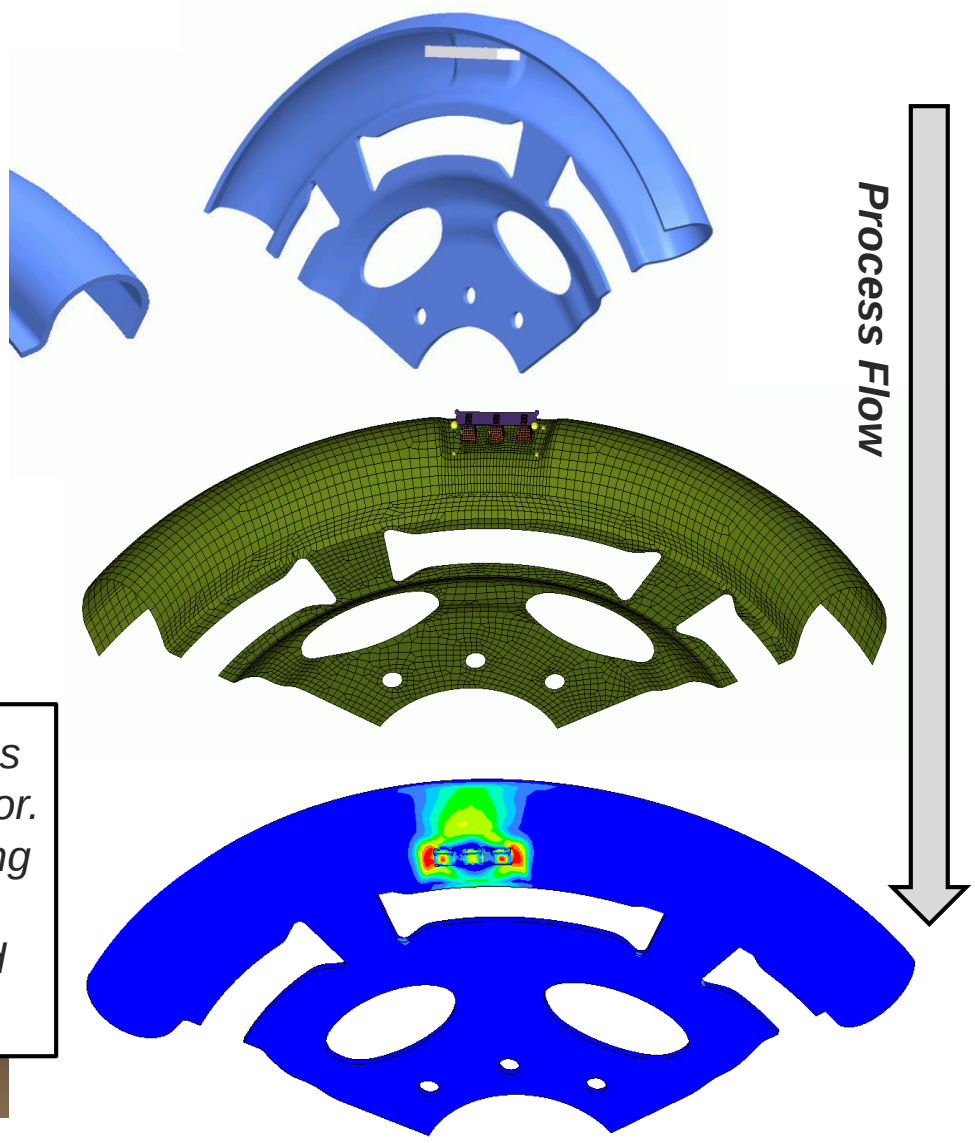
Spring Retainer Development





Forming of the sheet metal rivet and process related residual stresses can be accounted for. In vehicle conditions such as torsional loading from springs or centrifugal loading due to rotational speed can then be simulated and added to durability calculations.

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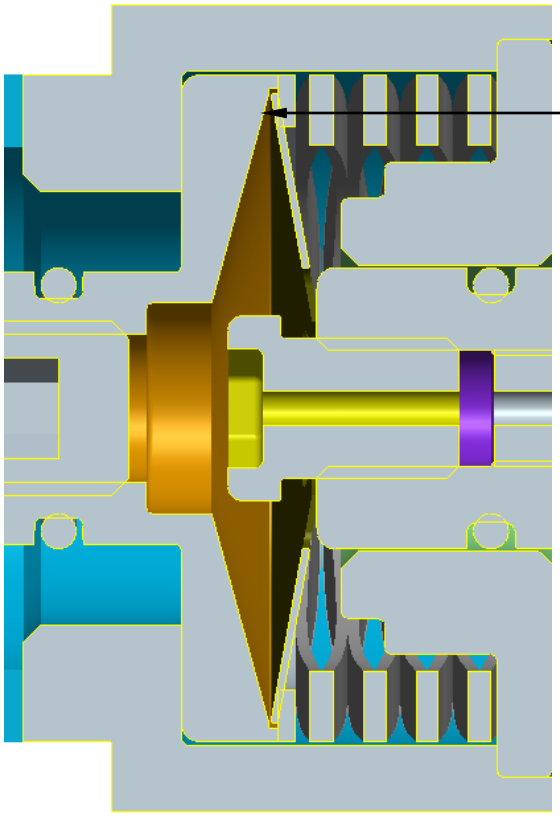
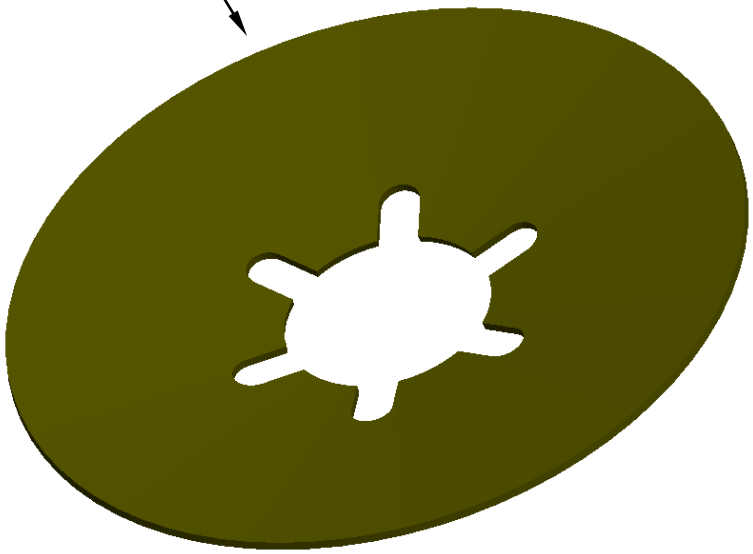
Forming Technology: Snap spring





Snap spring

Thermal forming, stress relief, and application conditions were considered when simulating the snap spring. The spring application is to control oil flow through the valve.

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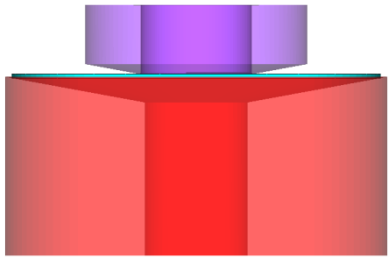
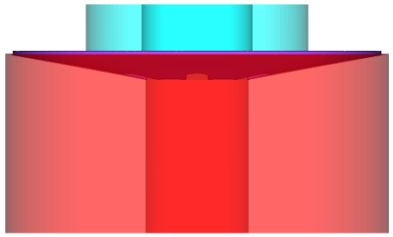
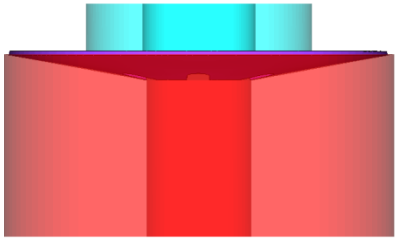
Forming Technology: Snap spring



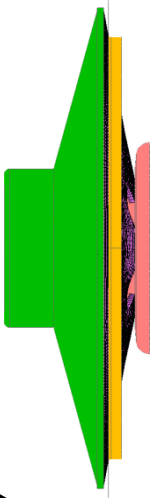
Flat blank clamped into die



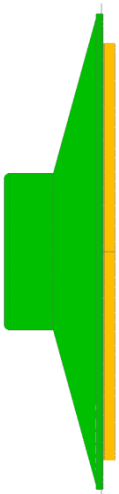
Heated to setting temperature



Cooled to room temperature



Cycled to closed position



Cycled to open position

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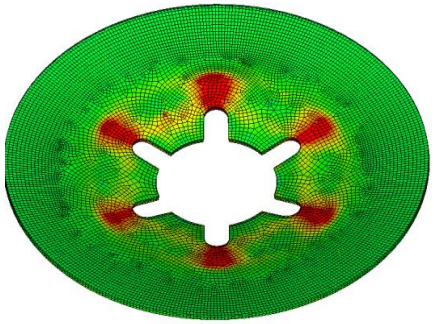
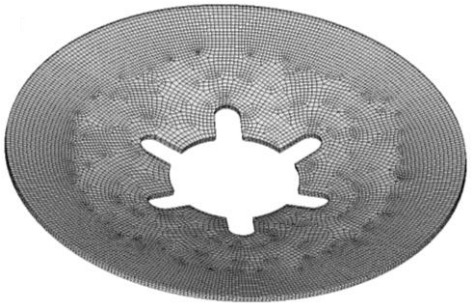
Forming Technology: Snap spring

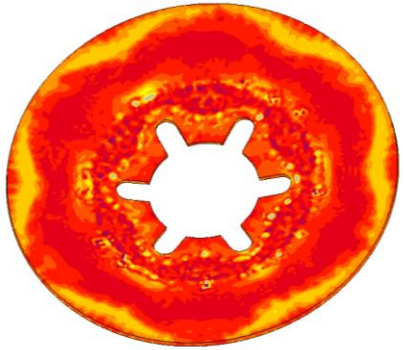


Stress prior to heat forming in fixture



Max temperature during heat forming

Min temperature during cooling



Stress post heat forming

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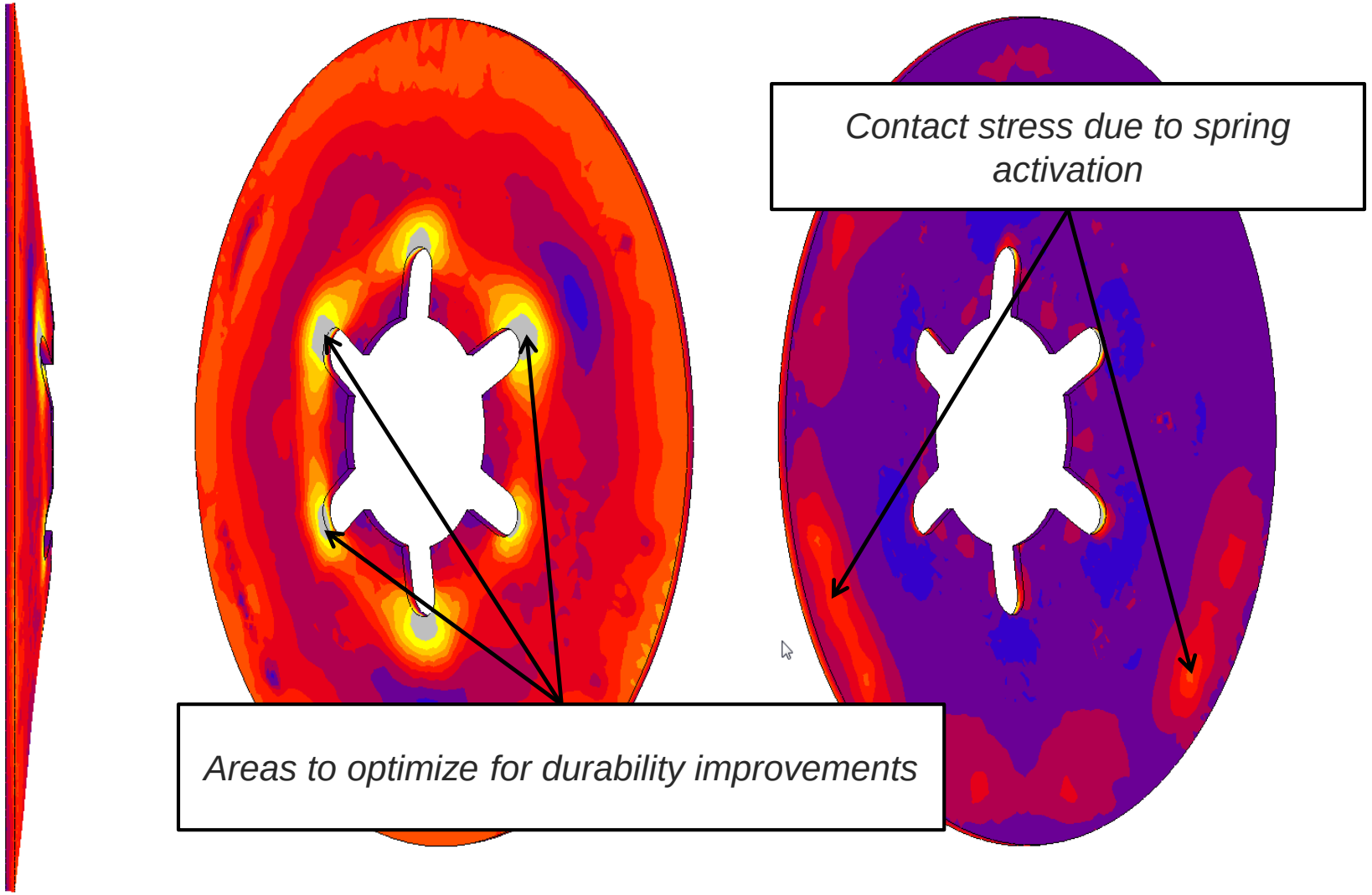
Forming Technology: Snap spring



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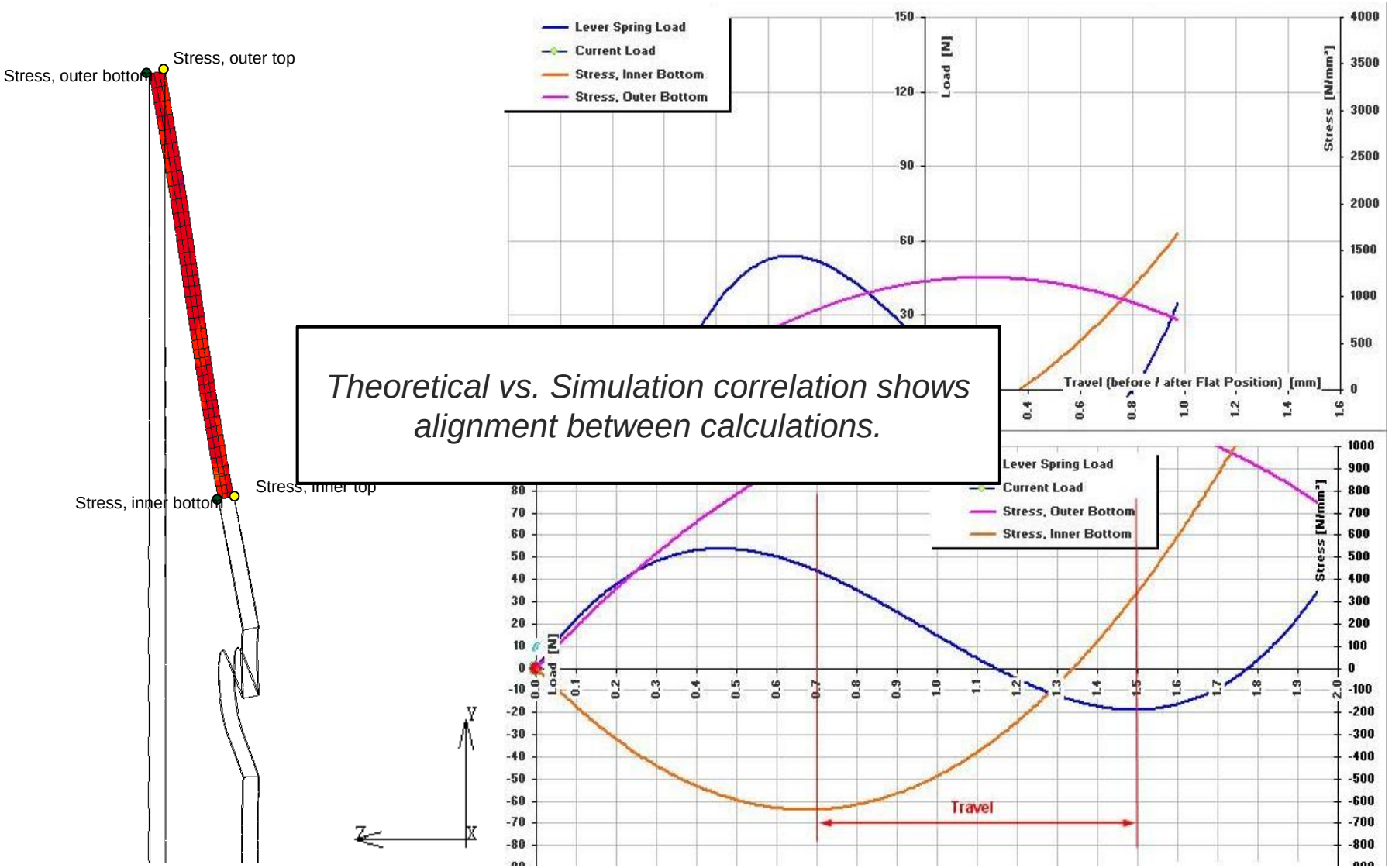
Forming Technology: Snap spring



Theoretical vs. Simulation correlation shows alignment between calculations.

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Forming Technology: Snap spring

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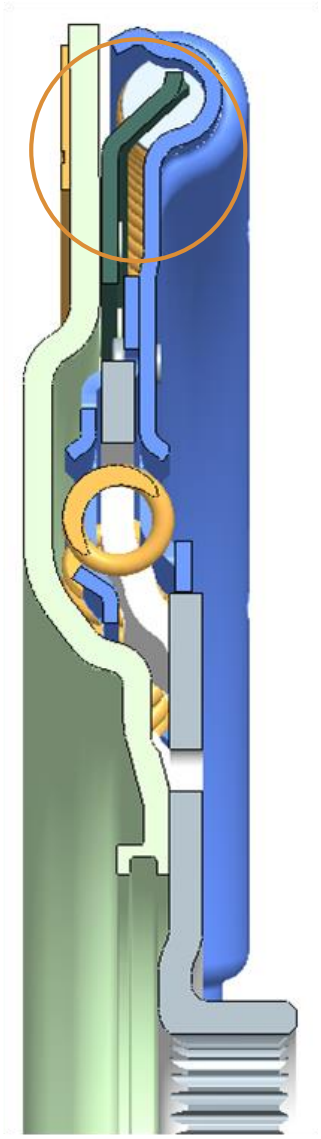
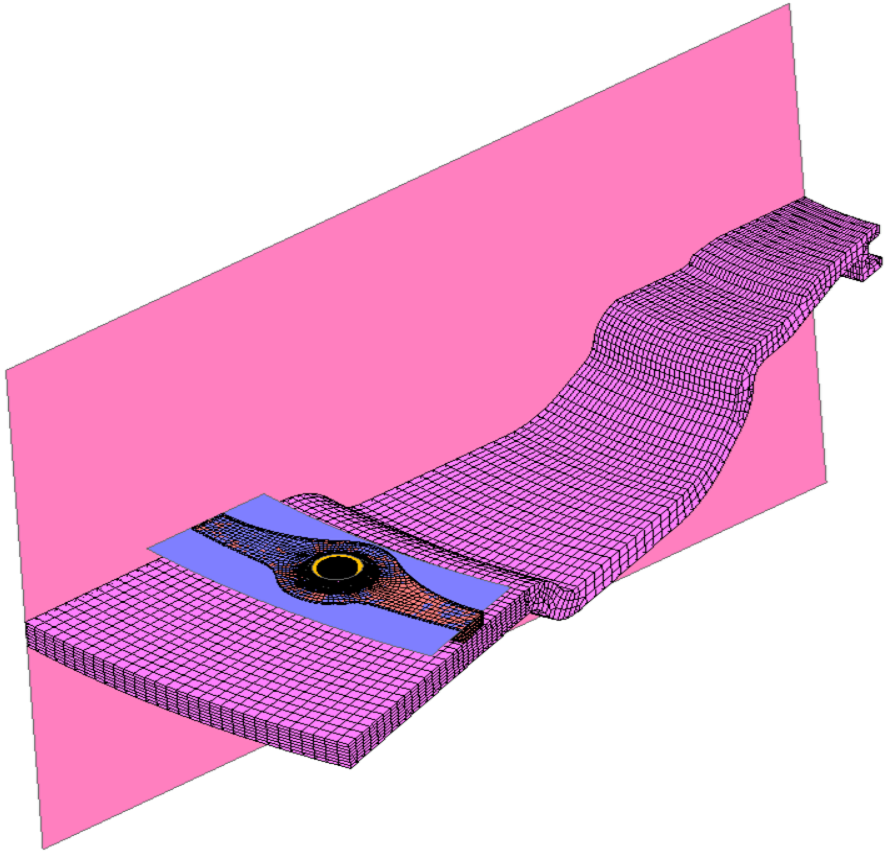
Joining Technology





Simulation goal was to investigate effects of riveting and in vehicle conditions to determine the impact on durability.

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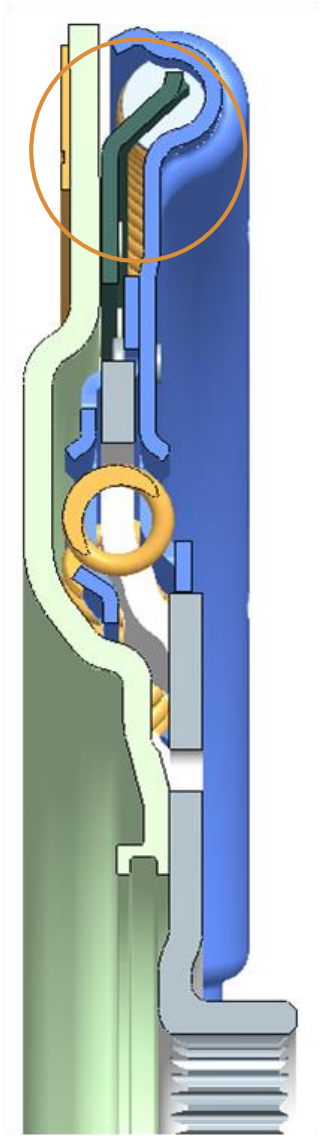
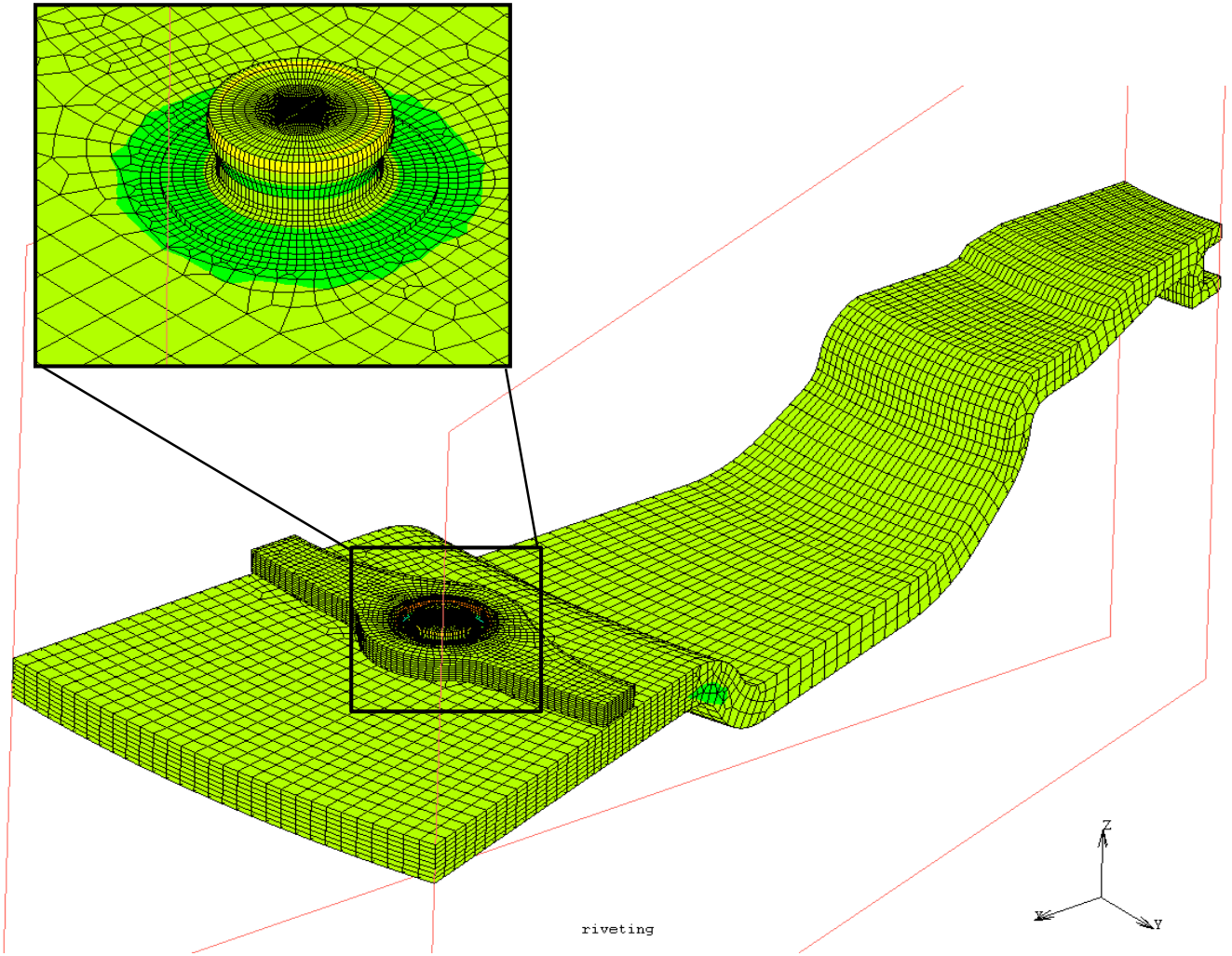
Joining Technology





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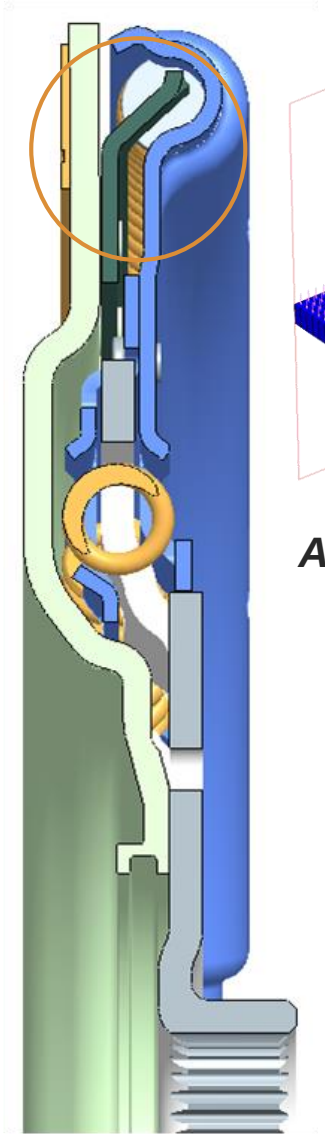
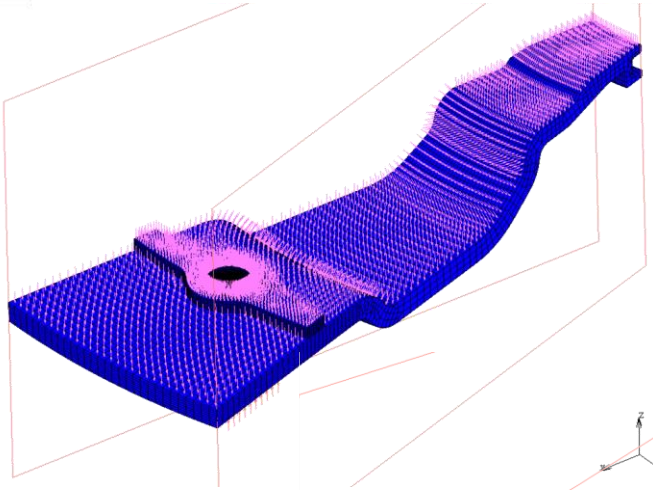
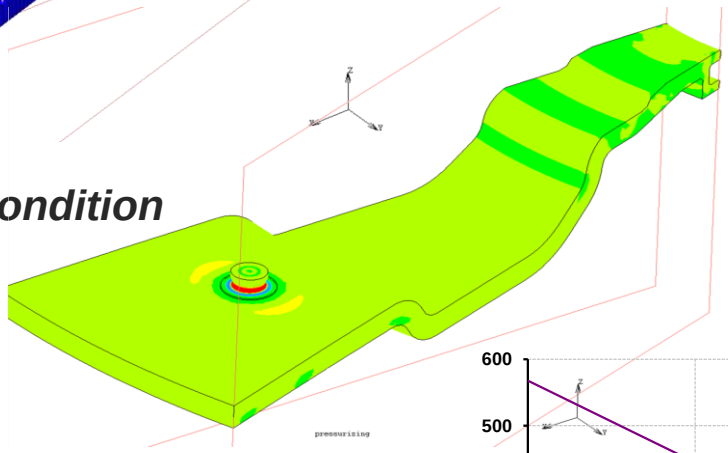
Joining Technology



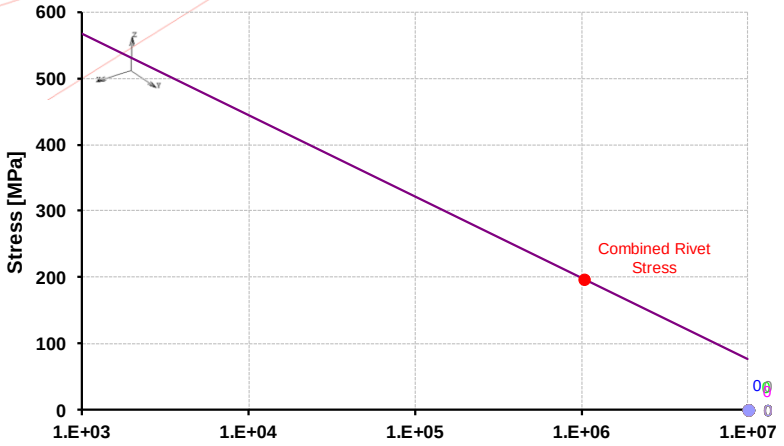


Process Flow

Application Condition



Process + Application Stress



Fatigue Assessment

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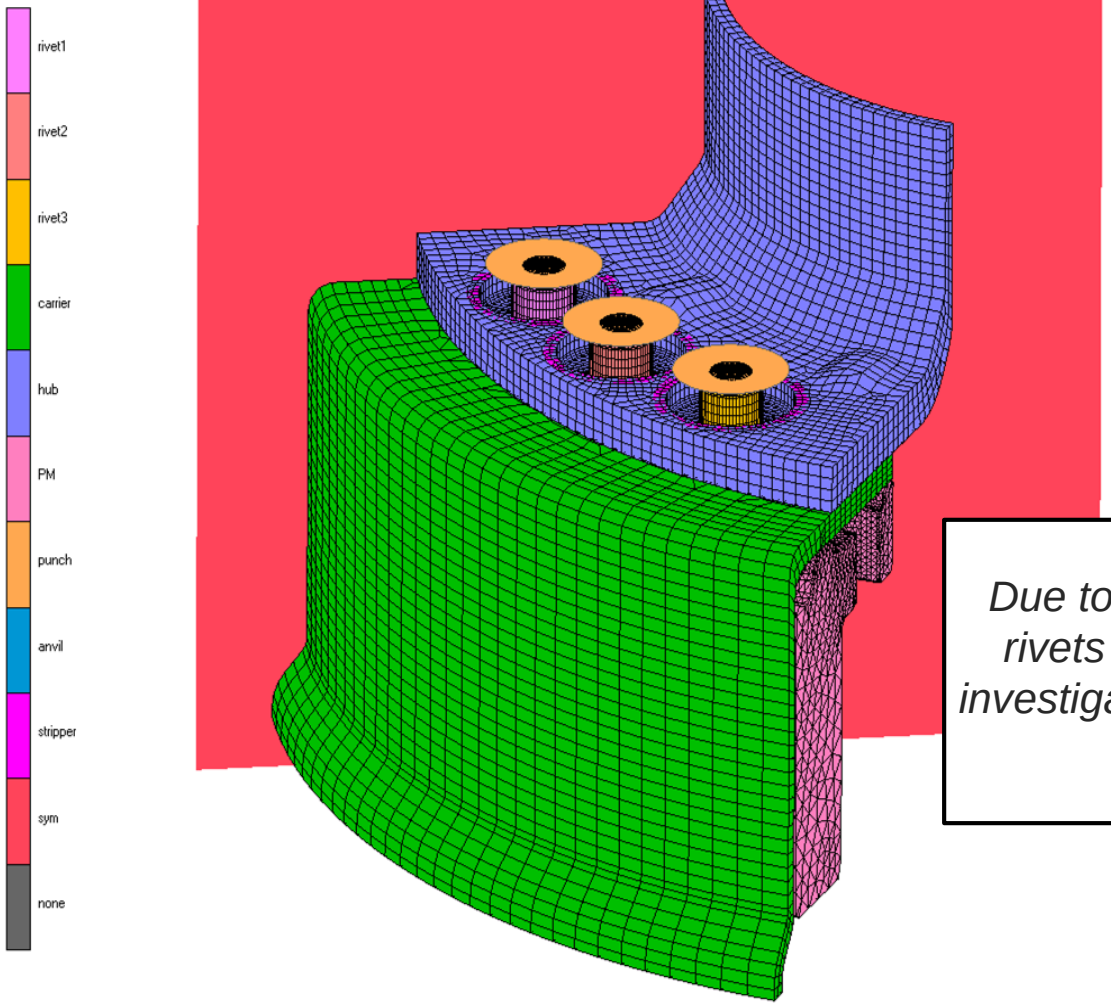
Joining Technology: Multi-Rivet Coining



Due to assembly symmetry, multiple rivets were needed to be coined to investigate down stream manufacturing effects.

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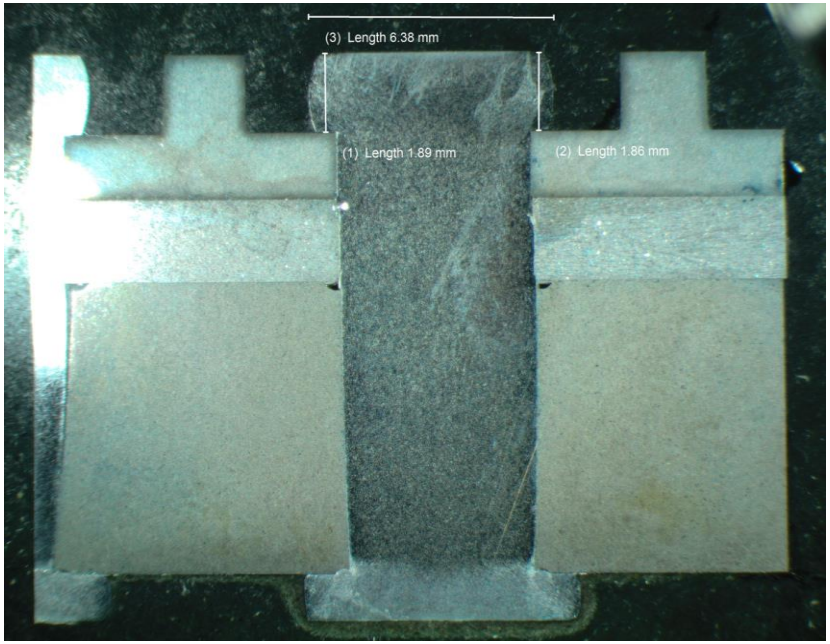
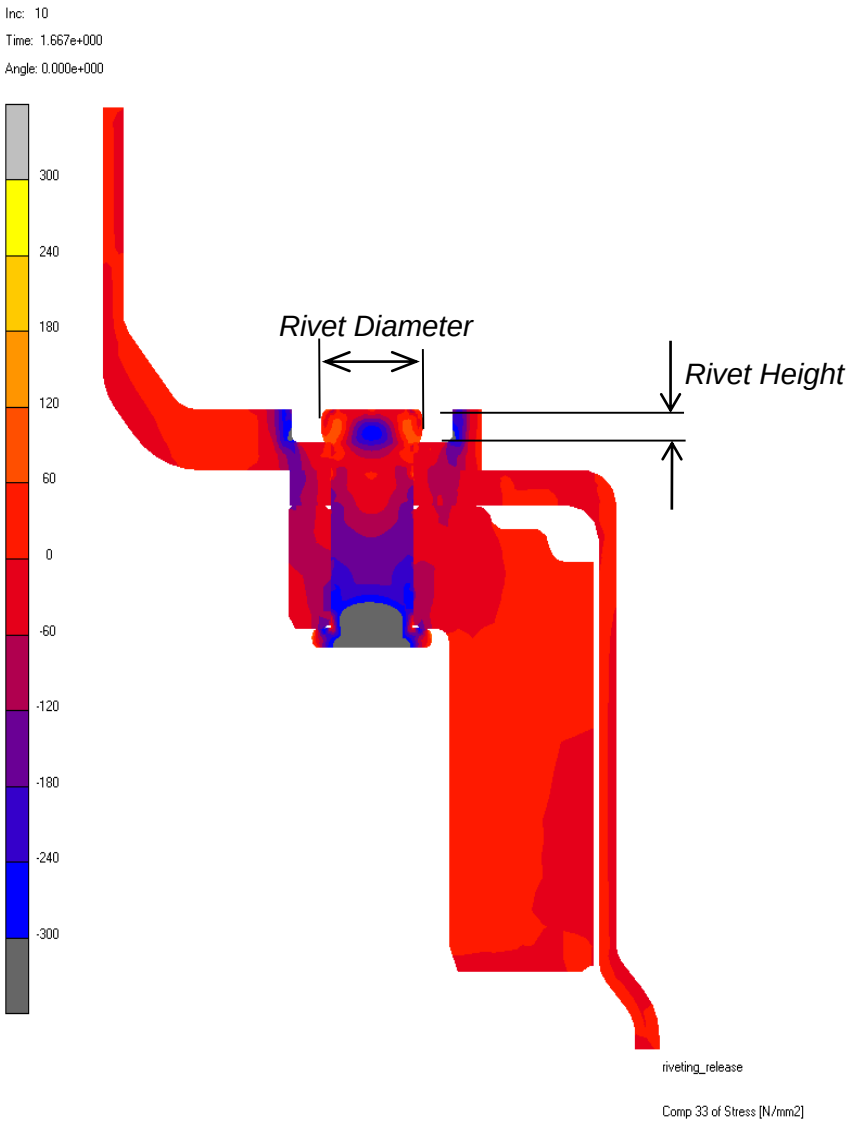
Joining Technology: Multi-Rivet Coining



Analysis correlation to actual sectioned assembly shows excellent comparison of rivet dimensional values.



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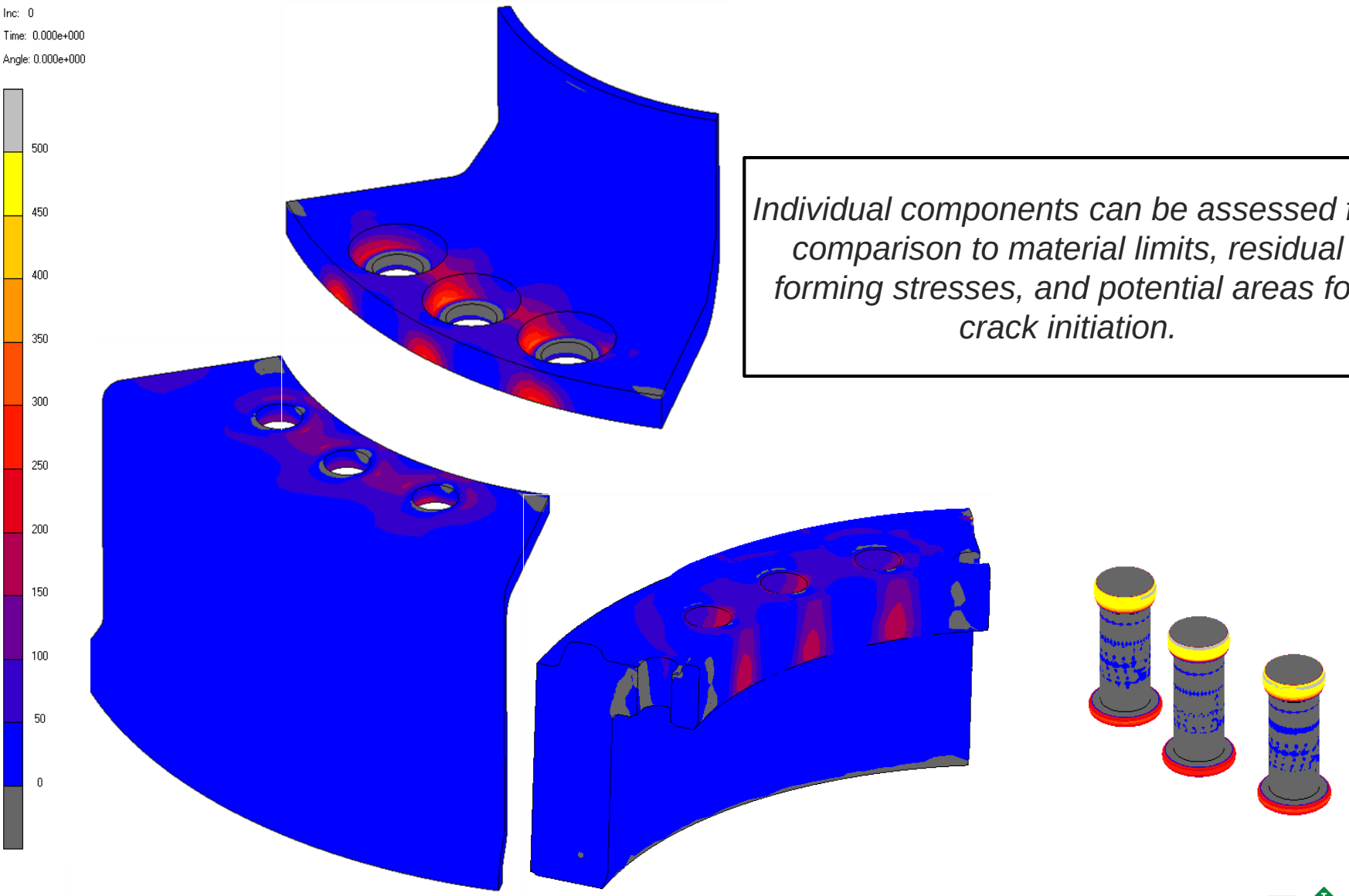
Joining Technology: Multi-Rivet Coining



Individual components can be assessed for comparison to material limits, residual forming stresses, and potential areas for crack initiation.

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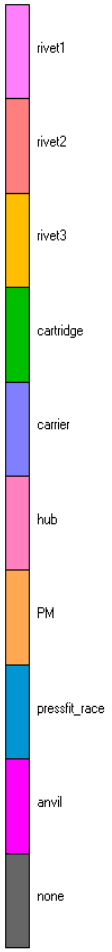
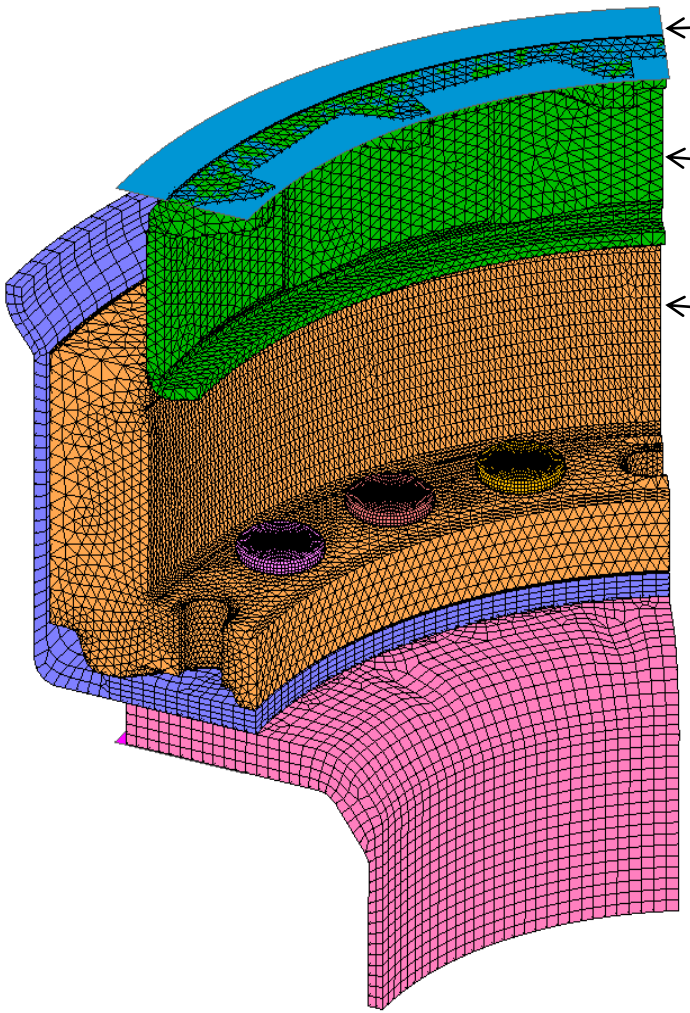
Joining Technology: Multi-Rivet Coining



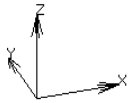


Machine press to insert the inner ring

Inner Ring

Outer Ring

Inner Ring is pressed into outer ring. Residual rivet forming stresses are accounted for to maintain the preload included in the assembly.



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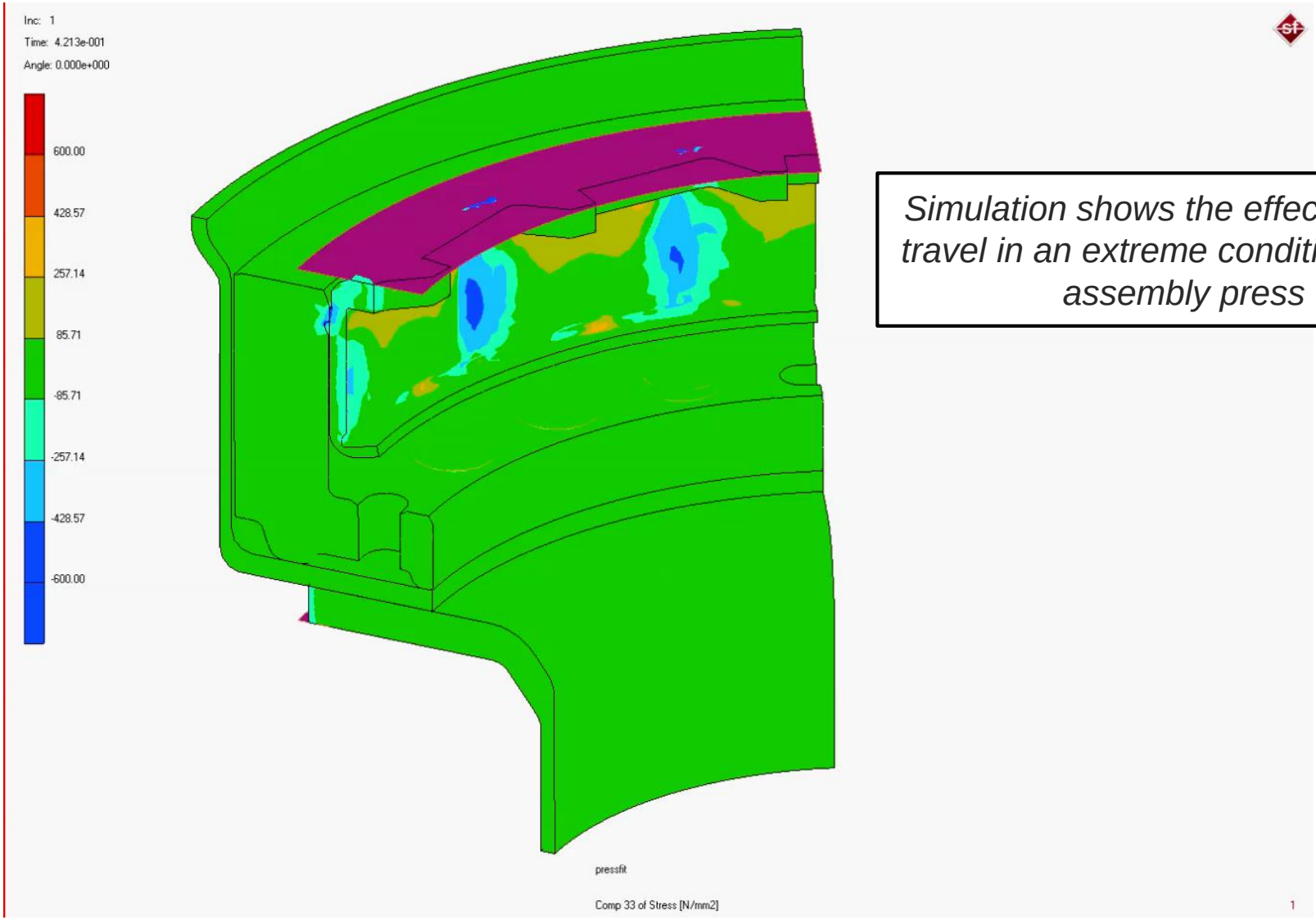
Joining Technology: Multi-Rivet Coining



Simulation shows the effects of over travel in an extreme condition for the assembly press

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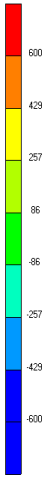
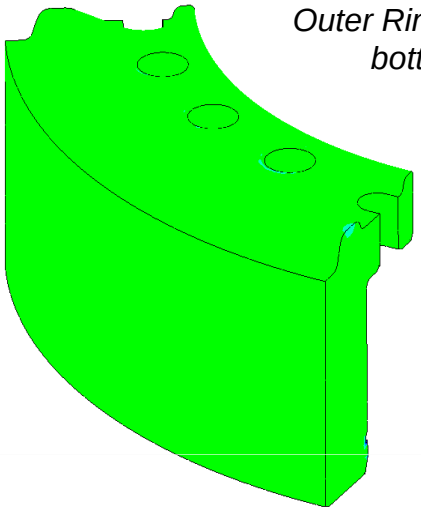
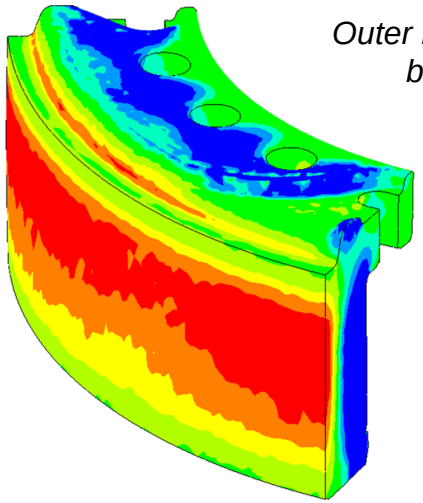
Joining Technology: Multi-Rivet Coining

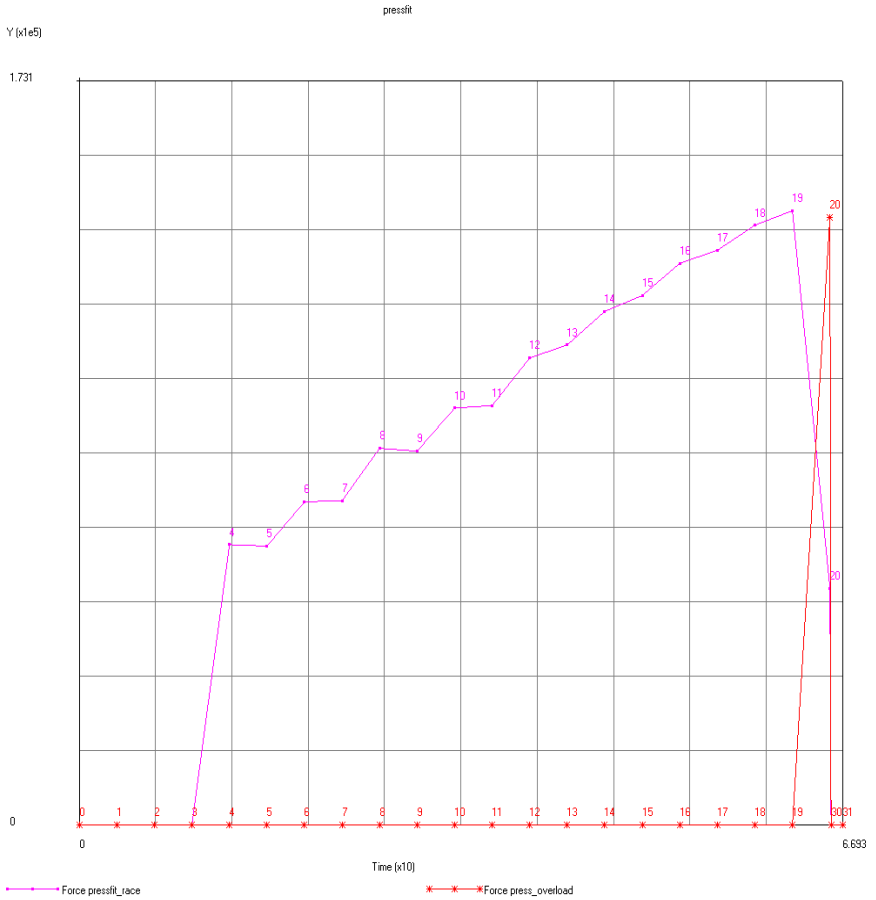




Outer Ring prior to press bottoming out



Outer Ring after press bottoms out



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Overview

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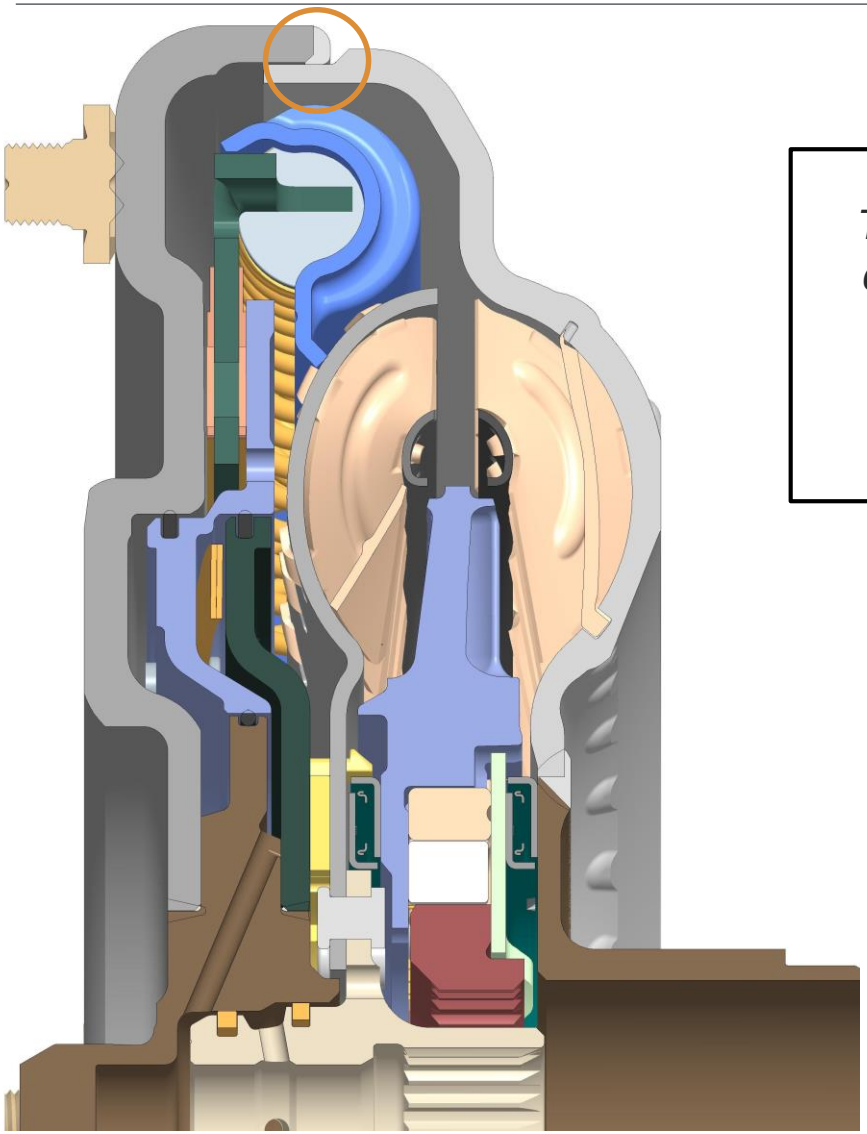
Welding Technology



The outer rim weld on a torque converter, commonly known as a closure weld, was investigated to see how various weld processes affects torque converter deformation.

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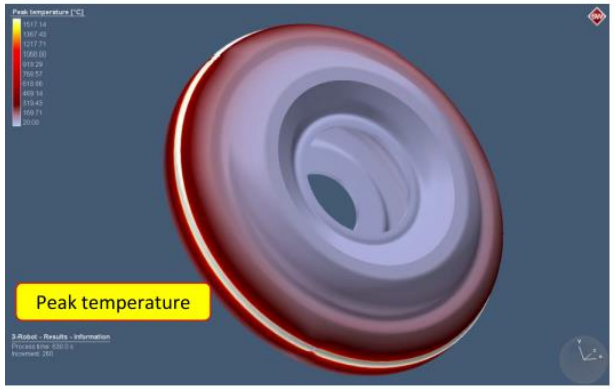
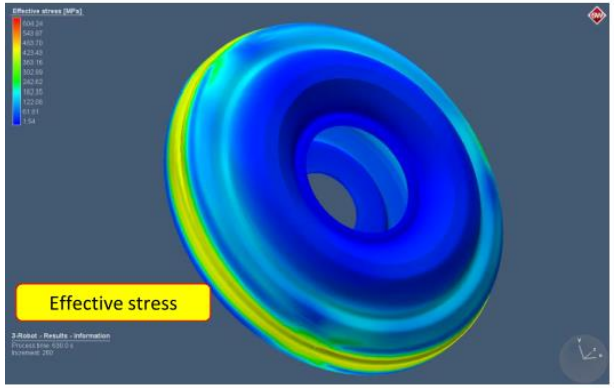
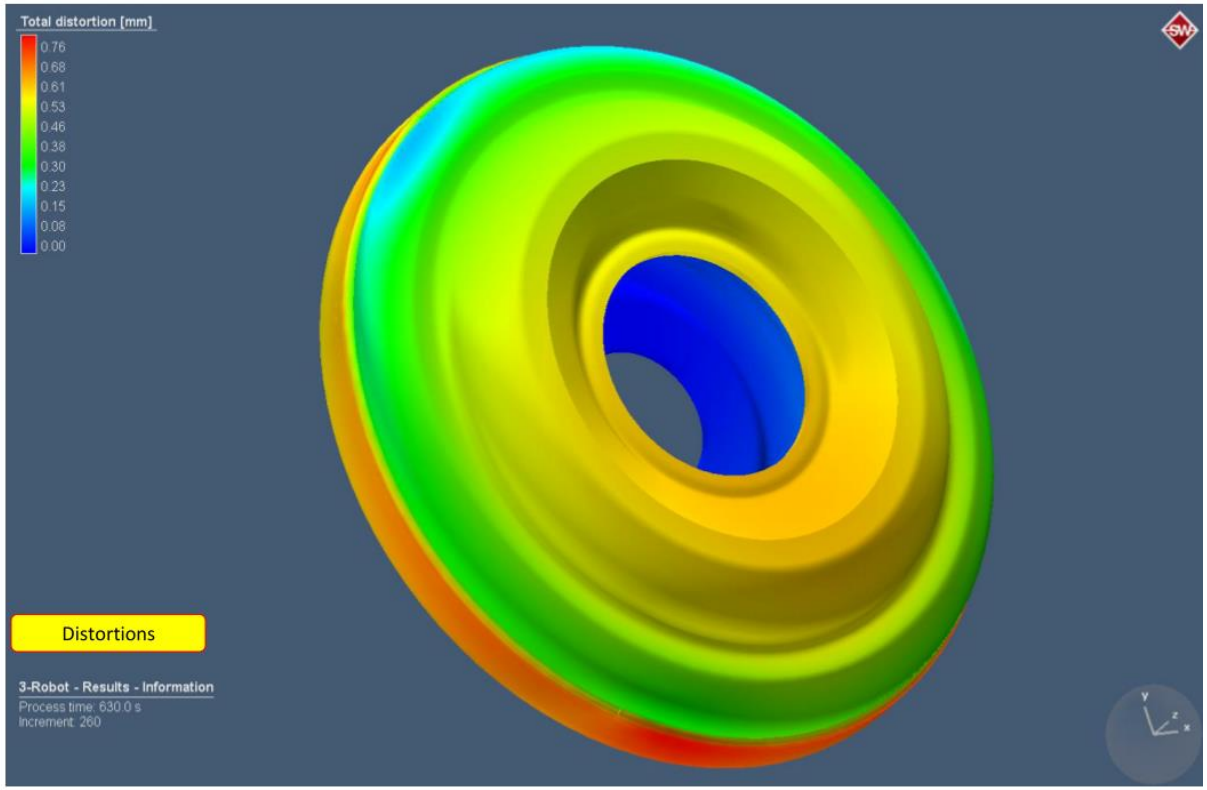
Welding Technology

A process considering 3 weld torches was considered in this simulation. Distortions, residual stress, and peak temperatures were evaluated.







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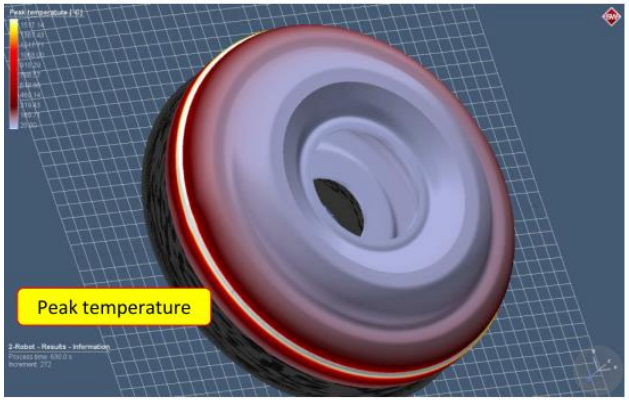
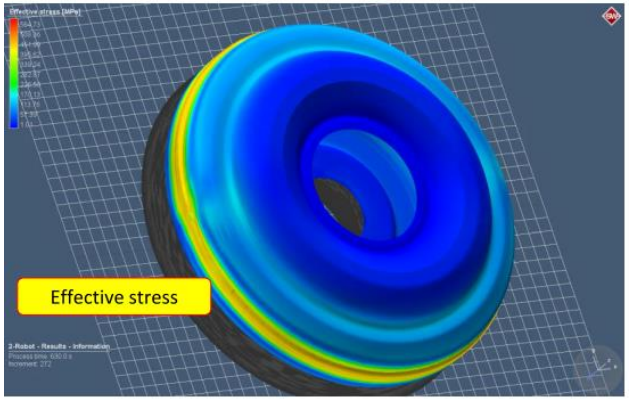
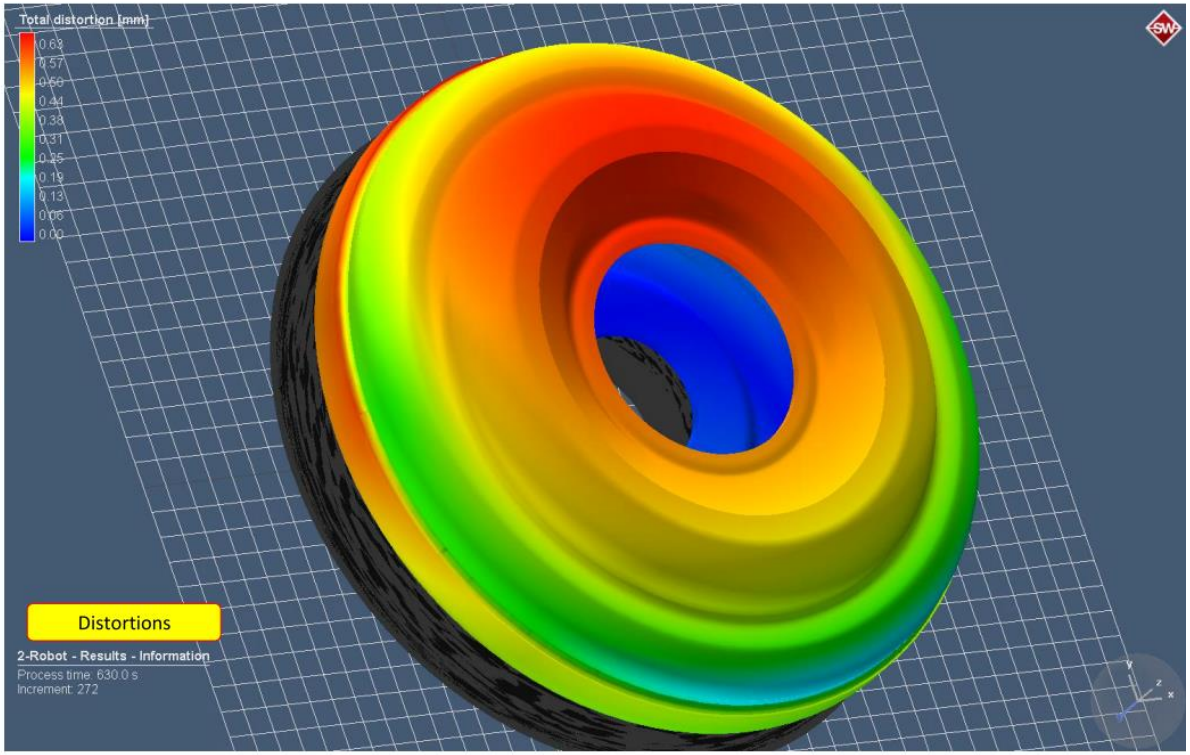
Welding Technology

A process considering 2 weld torches was considered in this simulation. Distortions, residual stress, and peak temperatures were evaluated.







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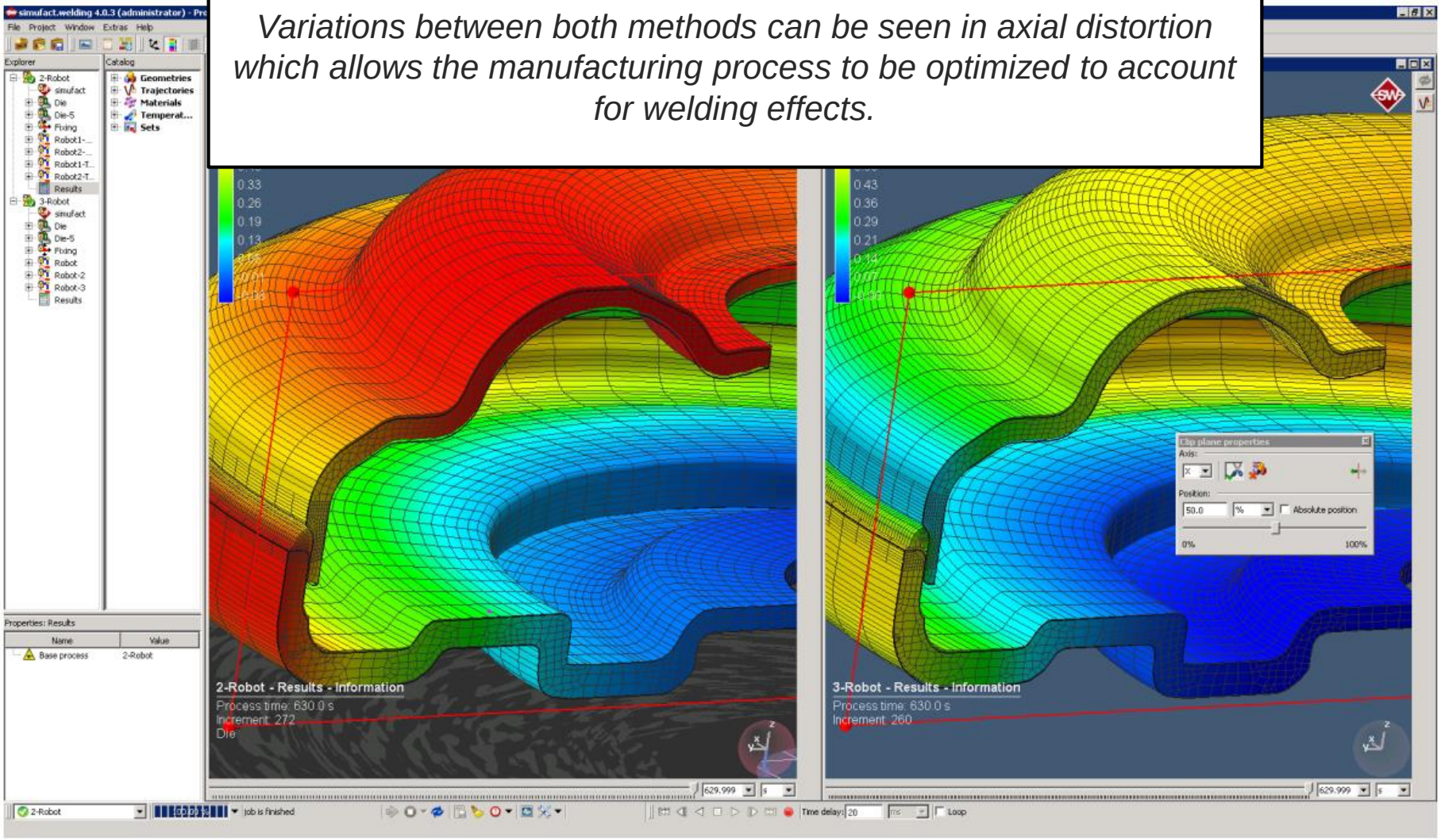
Welding Technology

Variations between both methods can be seen in axial distortion which allows the manufacturing process to be optimized to account for welding effects.



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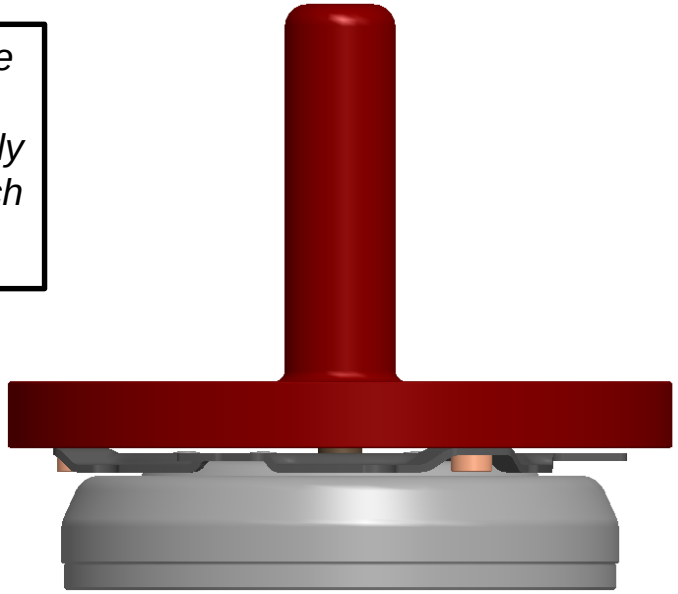
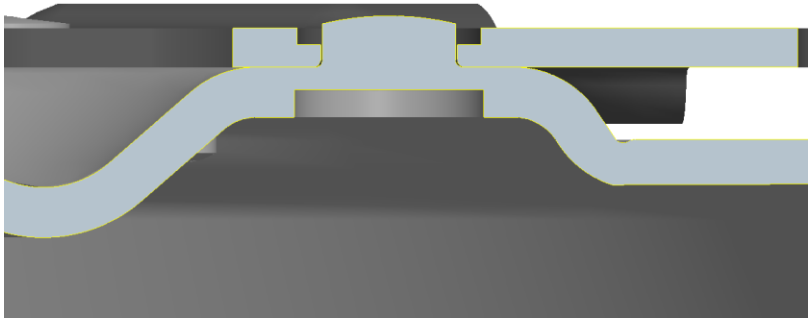
Full Manufacturing – Application Simulation

Purpose of this simulation was to investigate residual stresses in the radius of the extruded rivets. This location is typically the critical stress location for this design. Linear static analysis of this assembly does not account for residual compressive stresses in the rivet which is key to fatigue life of this design.



Bending test



Section through driveplate and cover

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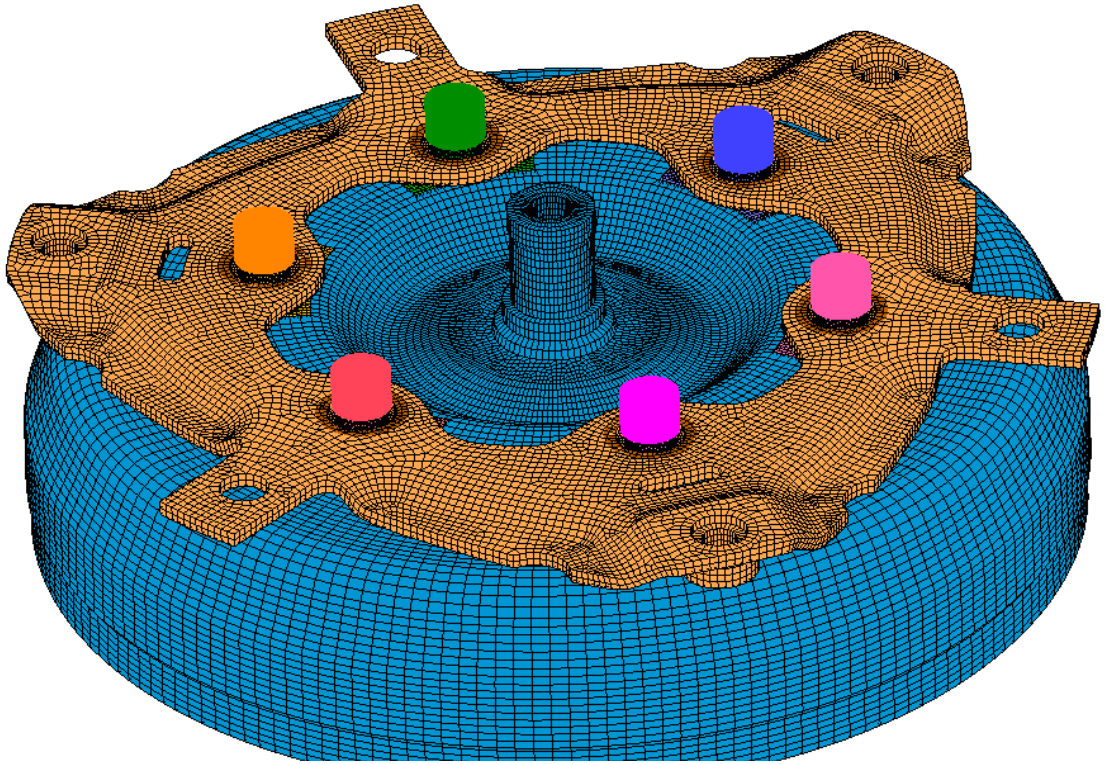
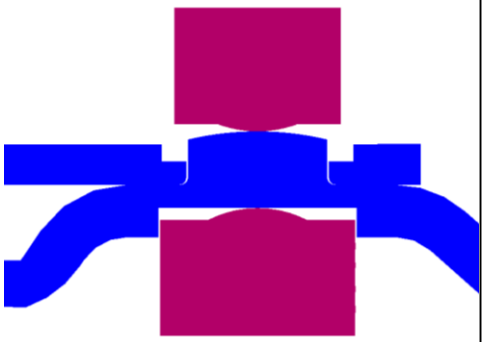
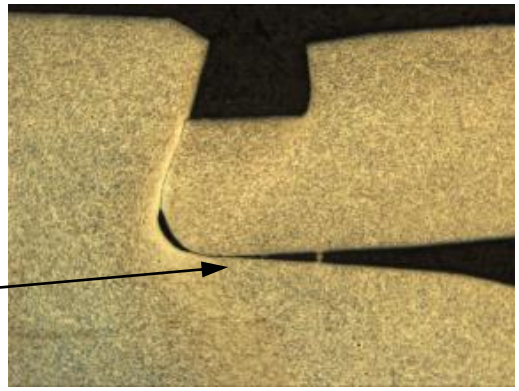
Full Manufacturing – Application Simulation



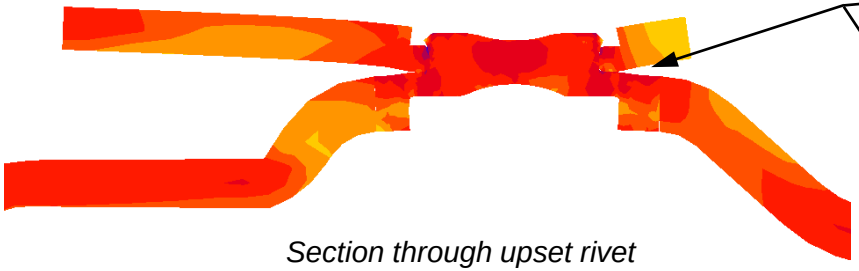


Section cut through unhit extruded rivet

Sectioned Assembly



Gapping



Section through upset rivet

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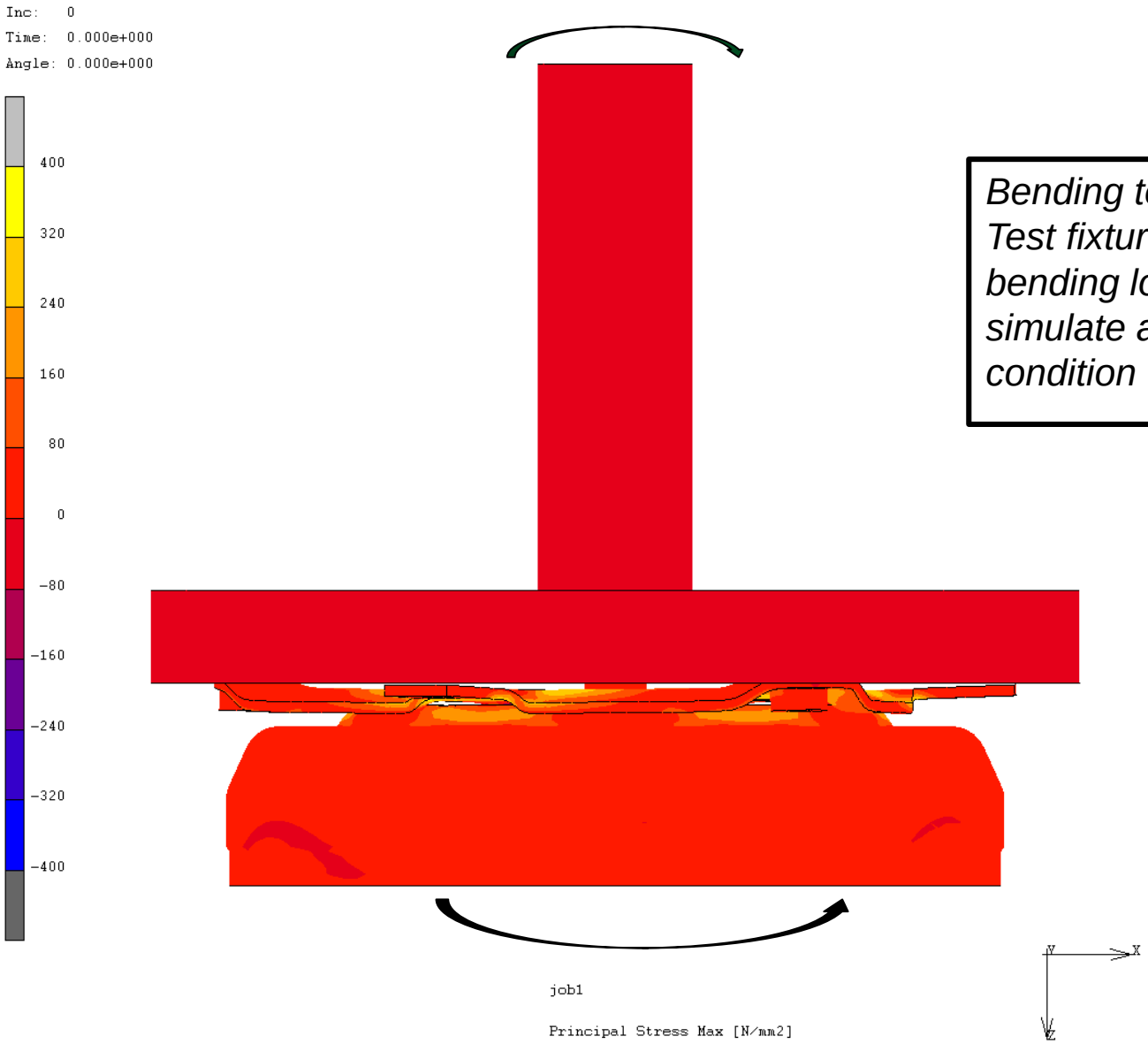
Full Manufacturing – Application Simulation



Bending test:
Test fixture is rotated while bending load is applied to simulate a misaligned shaft condition

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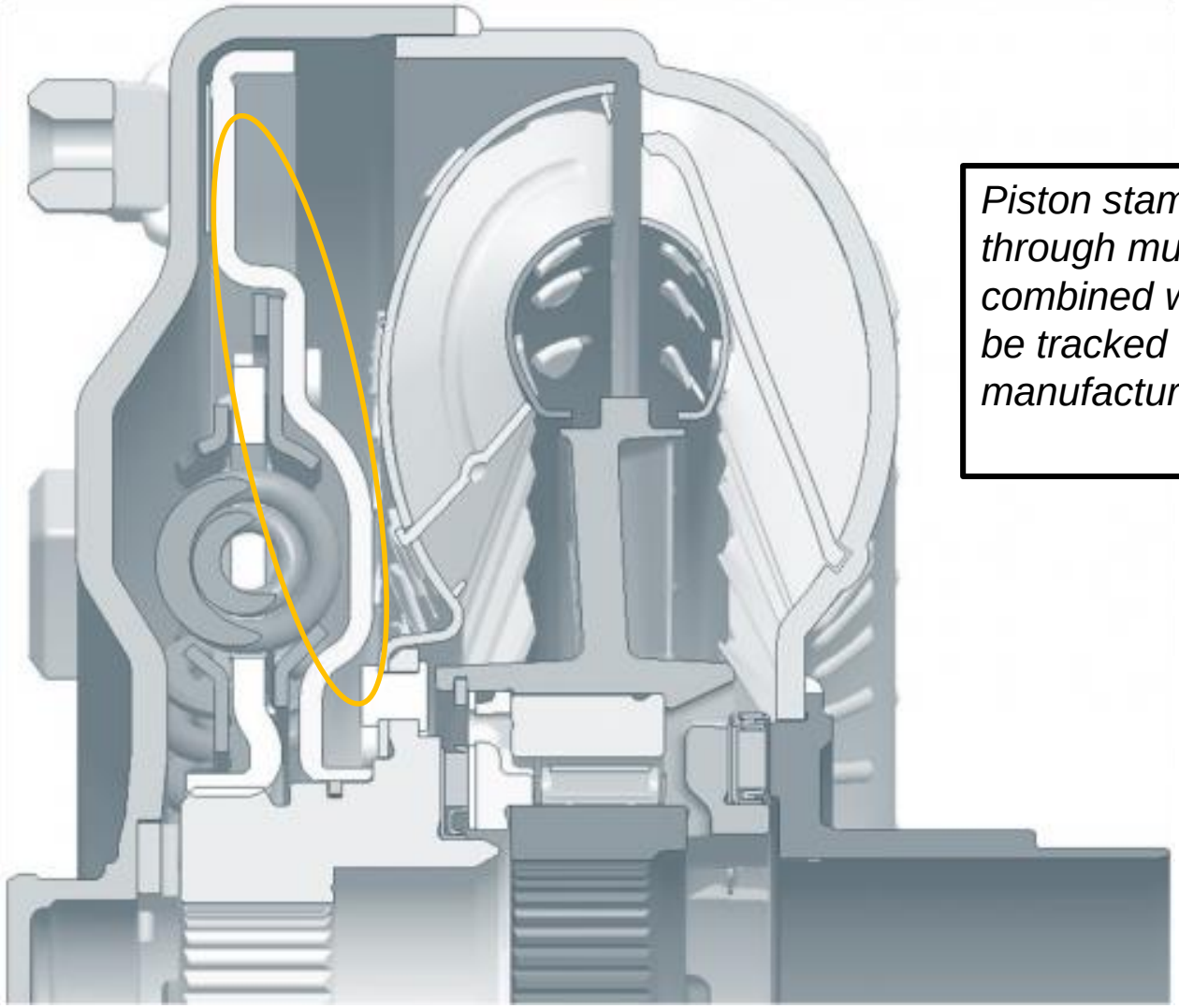
Full Manufacturing – Application Simulation



Piston stamping residual stress through multiple press stations combined with riveting stresses can be tracked through the complete manufacturing process.

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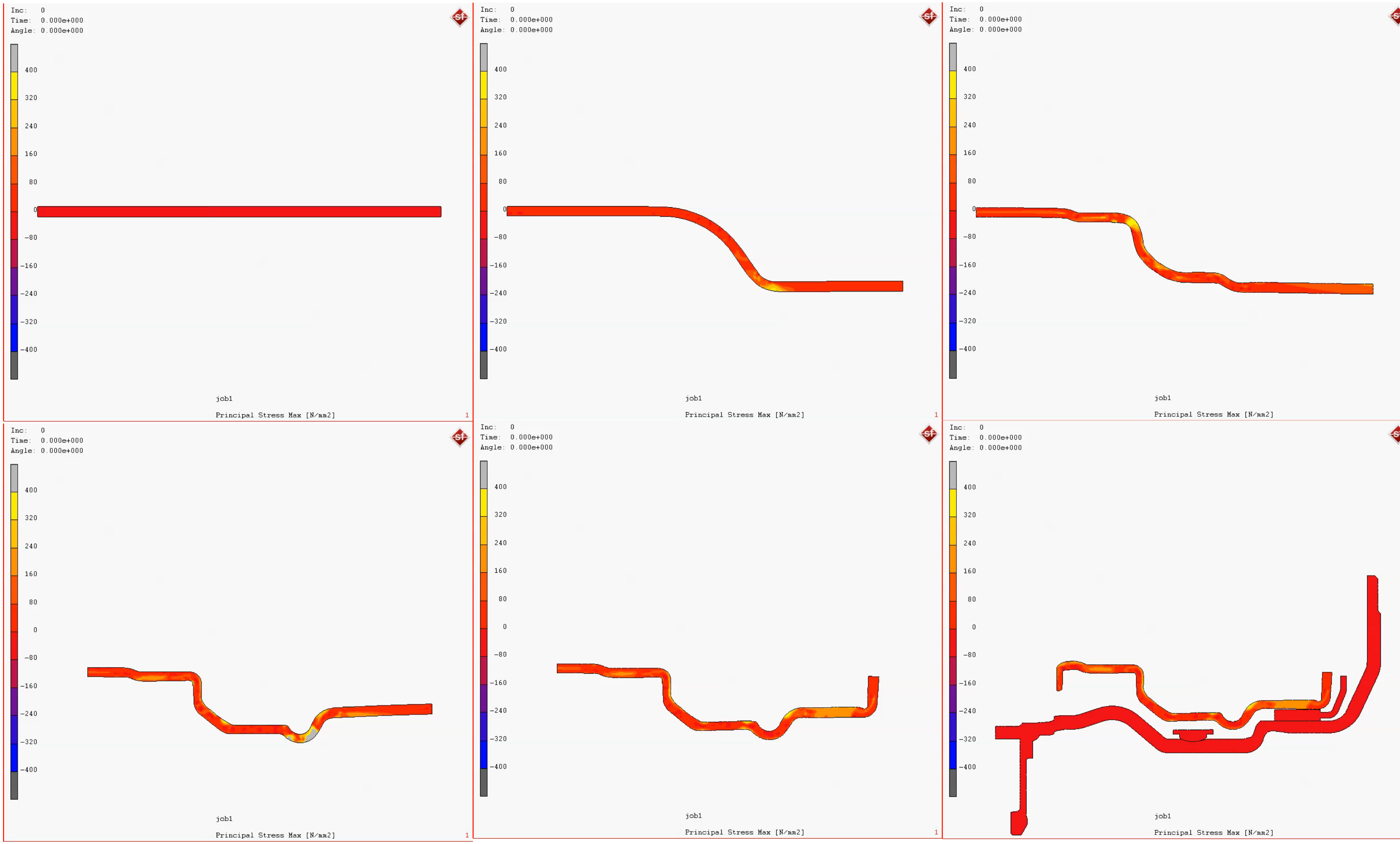
Full Manufacturing – Application Simulation



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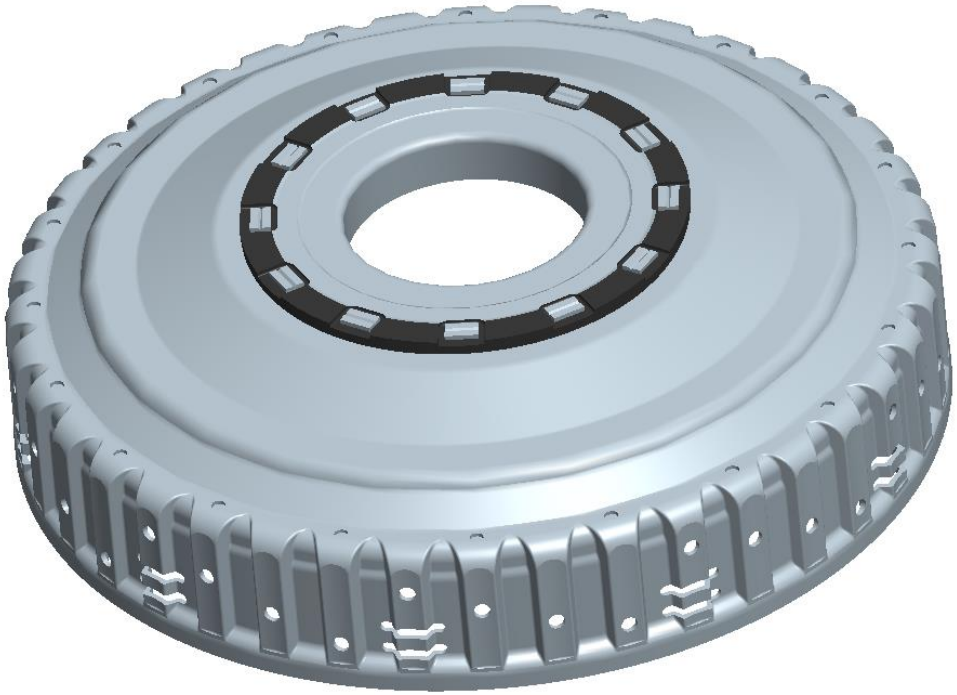
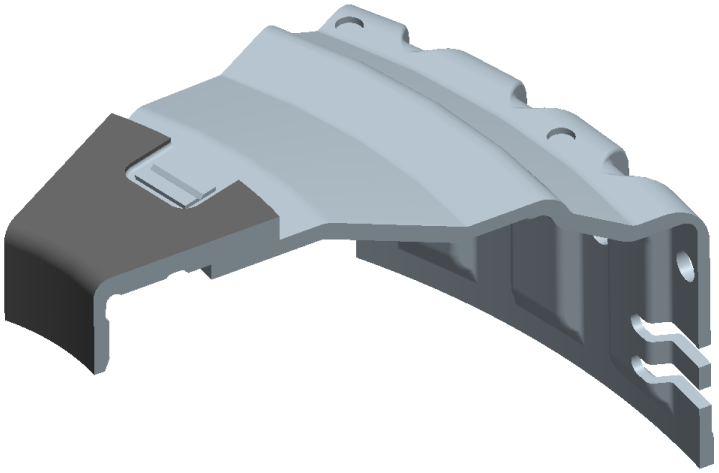
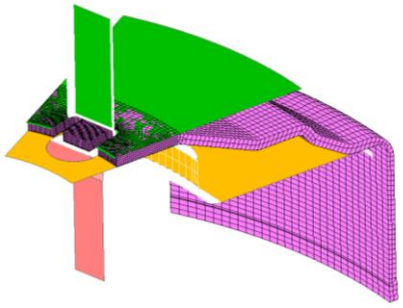
Full Manufacturing – Application Simulation

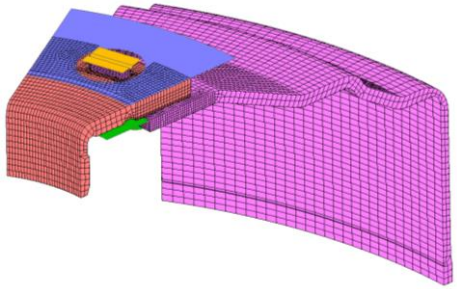




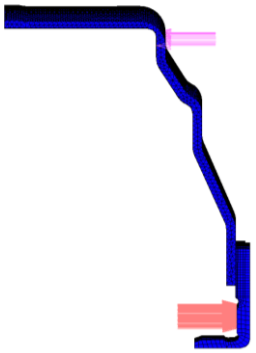
Analysis model using symmetry



Tab Bending



Riveting



Application condition

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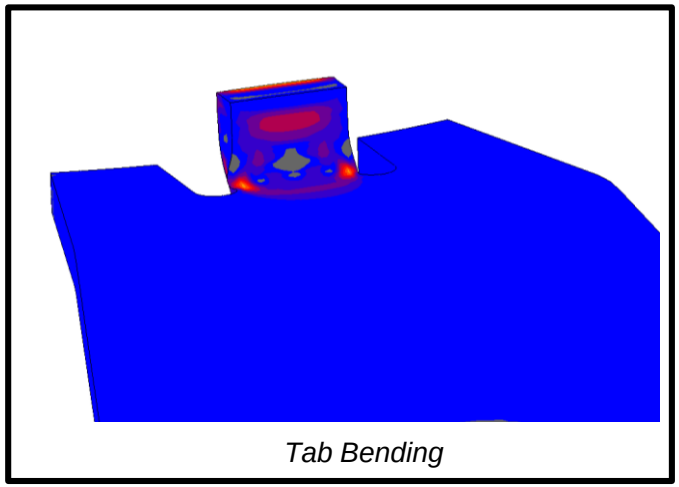
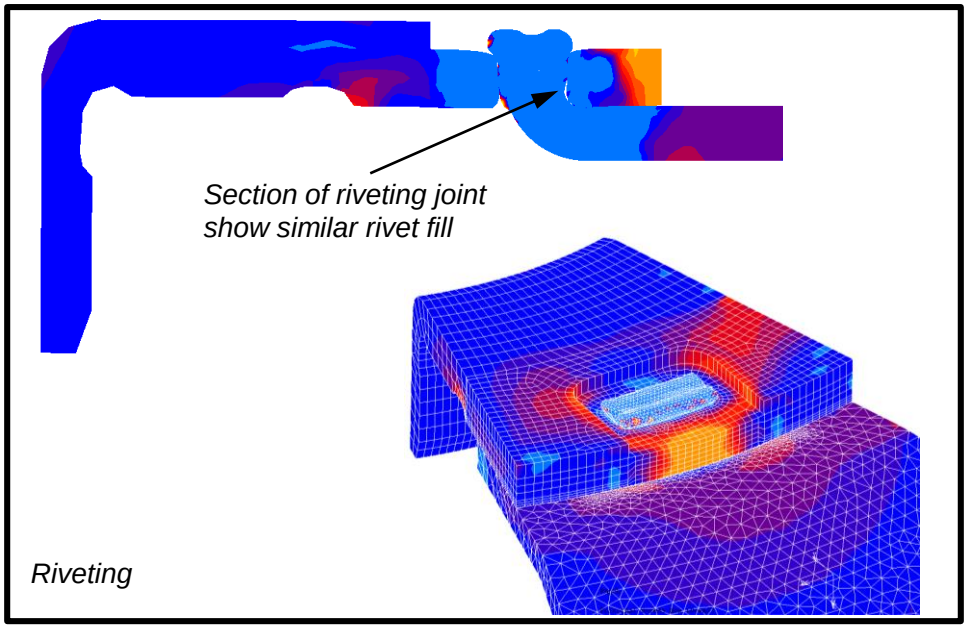
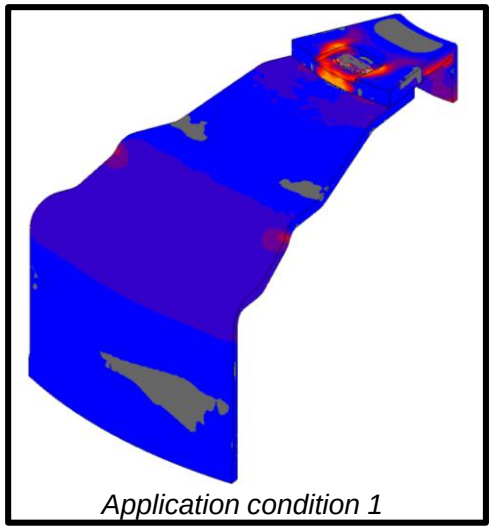
Full Manufacturing – Application Simulation



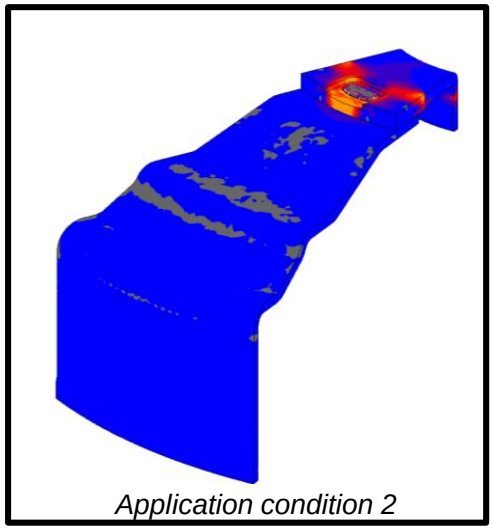
Tab Bending



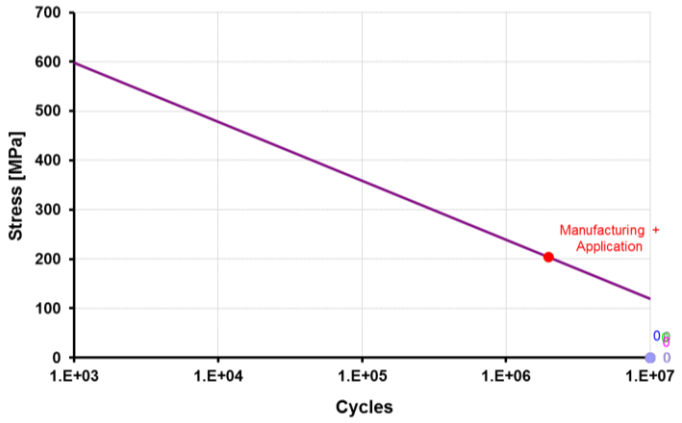
Riveting



Application condition 1



Application condition 2



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Overview

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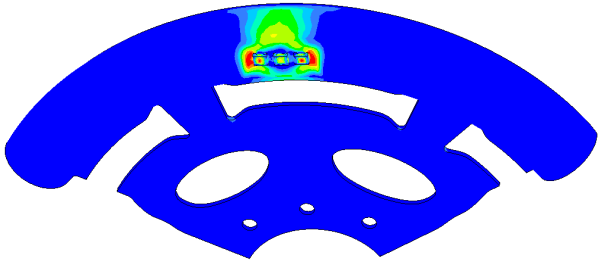
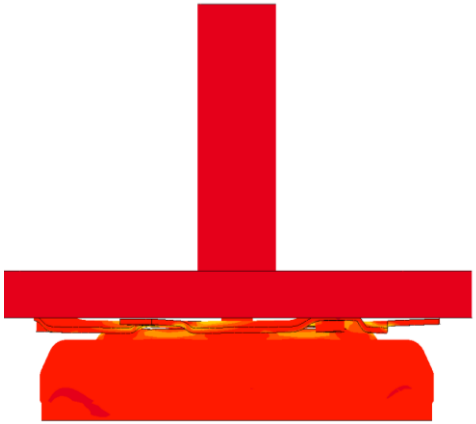
Summary

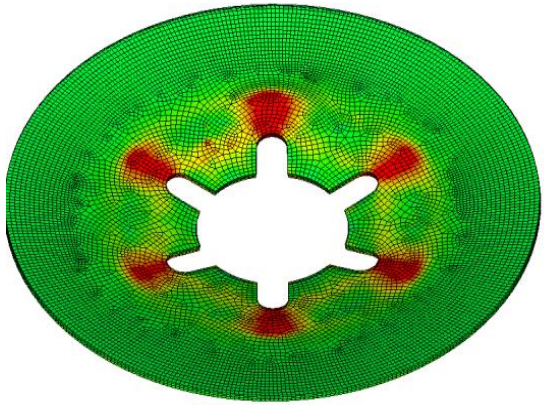


Development

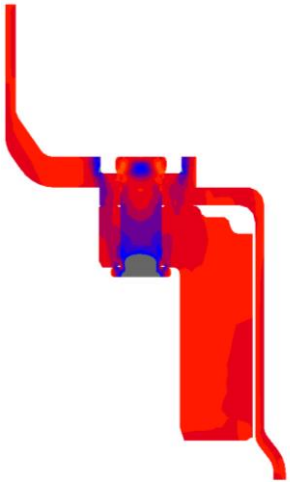
Schaeffler simulation capabilities for Quality torque converter design.



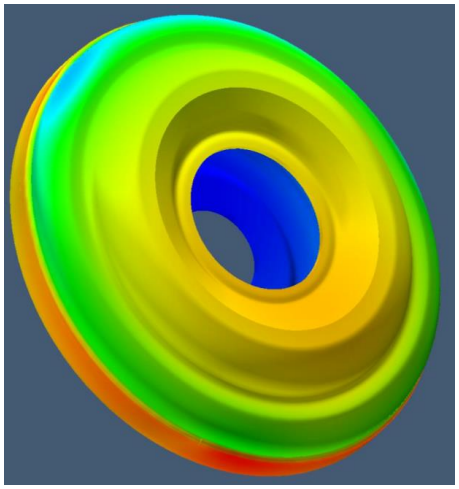
Full Manufacturing - Application



Forming Technology



Joining Technology



Welding Technology

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Thank you for your time!