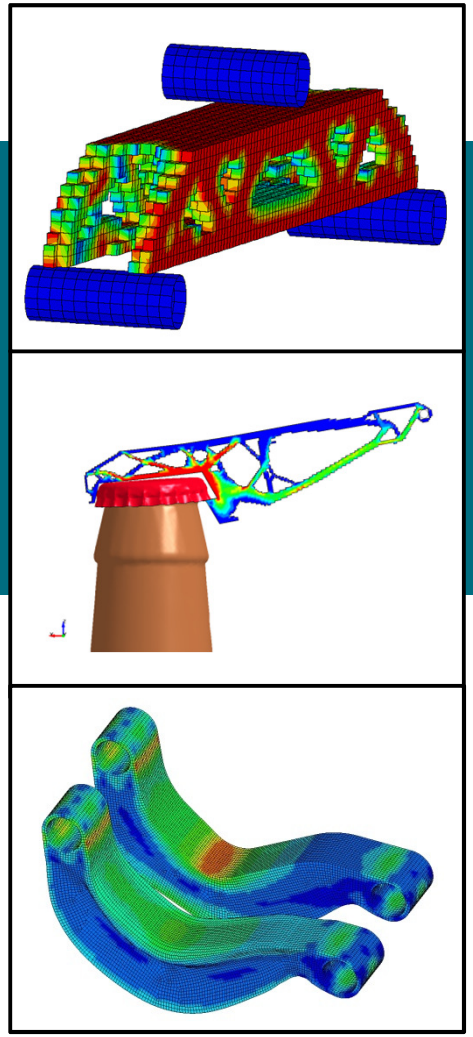

Introduction to LS-TaSC™ - Topology and Shape Computations for LS-DYNA®

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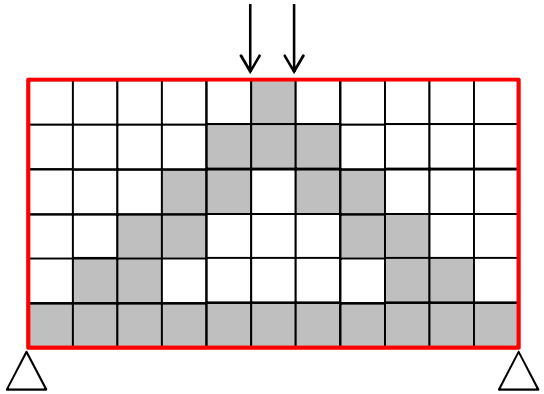
Stuttgart, 10-Dec-14

Topology optimization

- Topology Optimization
  - Redistribution of material within a given domain



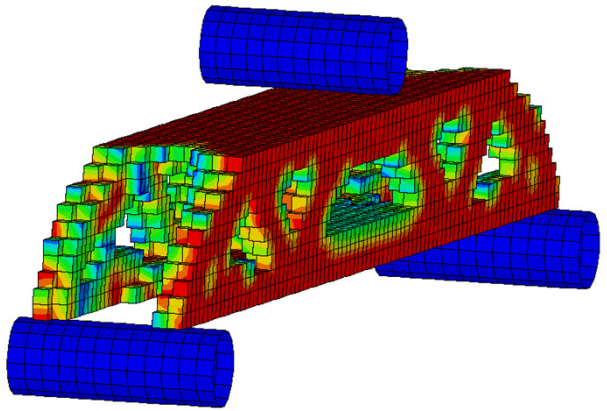
- Design variables
  - Relative density of each element
- Result
  - New material distribution
  - New shape of structure

LS-TaSC - General

- Topology optimization of non-linear problems
  - dynamic loads
  - contact conditions

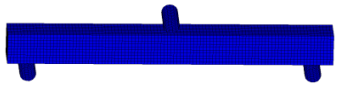
  → find a concept design for structures analyzed using LS-DYNA (implicit and explicit)
- Methodology: Hybrid Cellular Automata (HCA)
  - Objective: Homogenization of internal energy density ( )

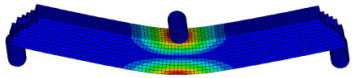
  → uniform loading of material for given mass
- Current production version is LS-TaSC 3.0
- Windows/Linux Versions available
- Download: www.lsoptsupport.com



Hybrid Cellular Automata

Starting design $\rho^0, E^0, \sigma^{y,0}, E^{h,0}$





FE-analysis: IED^j

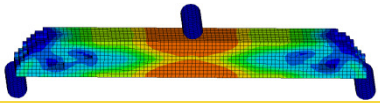
$j++$

Update of density distribution

- Average IED^j within neighbor cells: $\widetilde{IED}^j$
- Inner loop:

  Determine target value $\boldsymbol{IED^{target,j}}$ considering mass constraint and additional constraints

- **New density distribution** ρ^{j+1}



Material update

$E^{j+1} = (\rho_{rel}{}^{j+1})^p \; E_0$

$\sigma^{y,j+1} = (\rho_{rel}{}^{j+1})^q \; \sigma^{y,0}$

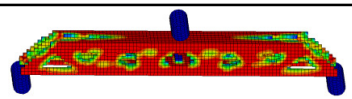
$E^{h,j+1} = (\rho_{rel}{}^{j+1})^q \; E^{h,0}$

Converged?

no

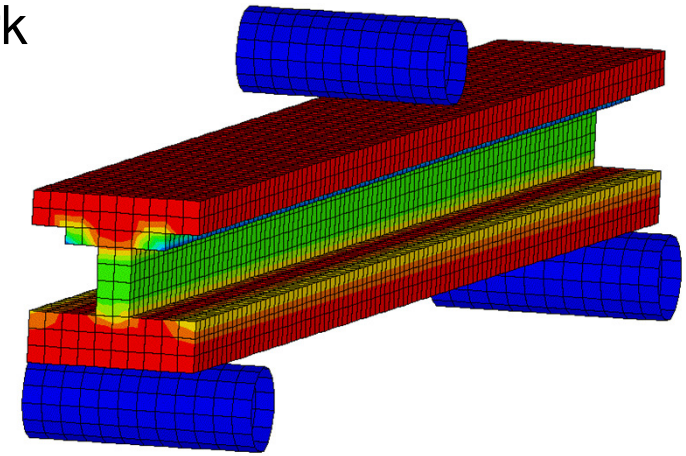
yes

Optimal design



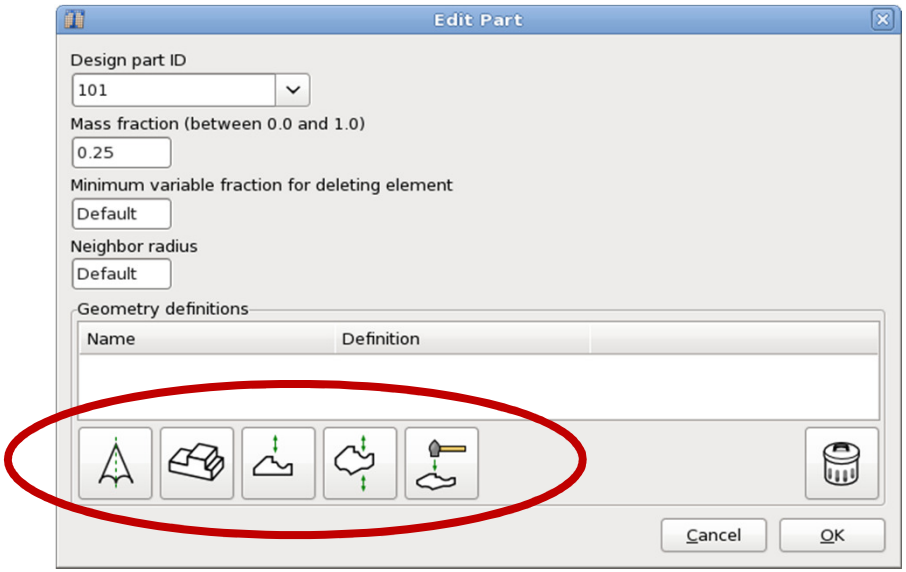
General capabilities

- Solid design using hexahedrons and tetrahedral elements
- Shell design using quadrilateral and triangular elements
- Free Surface Design
- Global constraints
- Multiple load cases
- Tight integration with LS-DYNA
- Large models with millions of elements
- Integration into the LS-PrePost framework

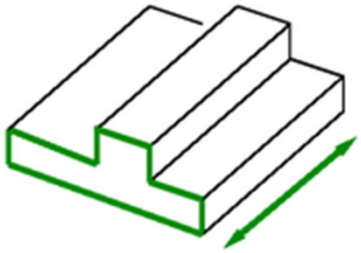


Geometry definitions

- Multiple parts
- Symmetry
- Extrusions
- Casting, one sided
- Casting, two sided
- Forging

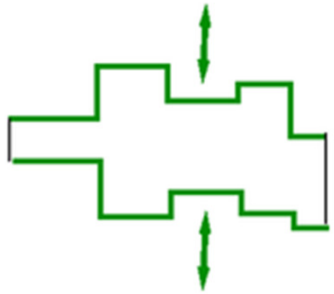


Symmetry



Extrusion

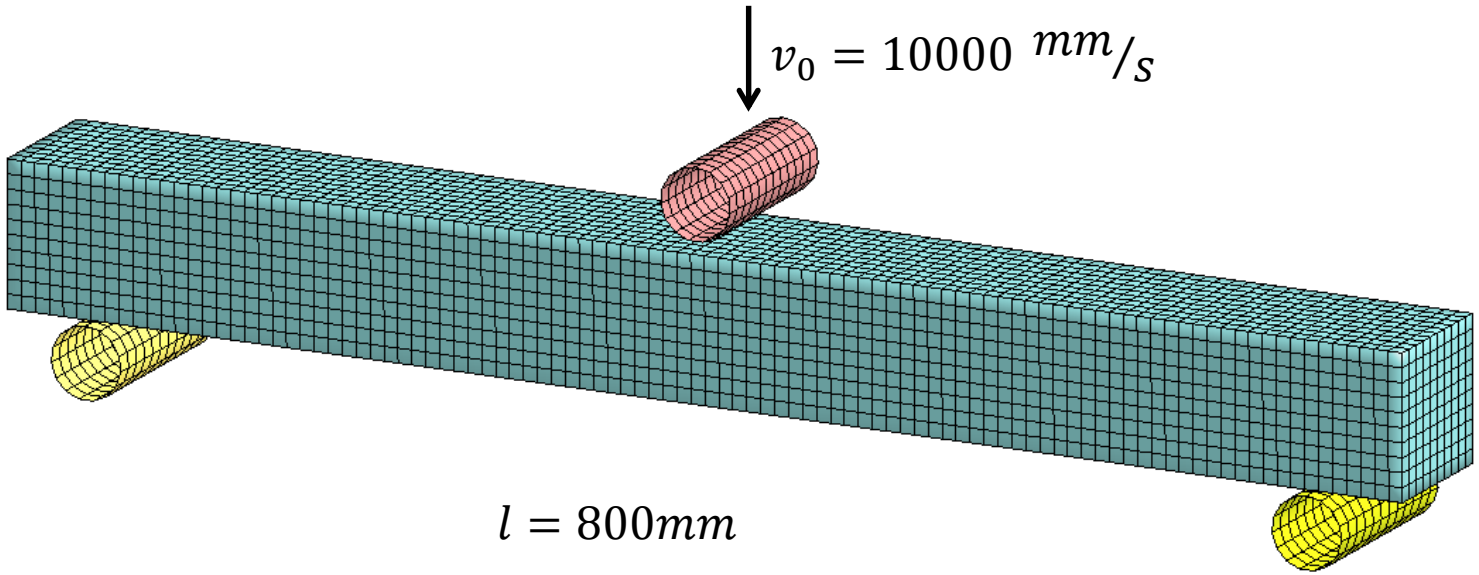
One–sided Casting



Two–sided Casting

Live Demo: 3-Point-Bending

- Starting design and load case
- Material aluminium
- Mass Fraction 20%
- Displacement Constraint

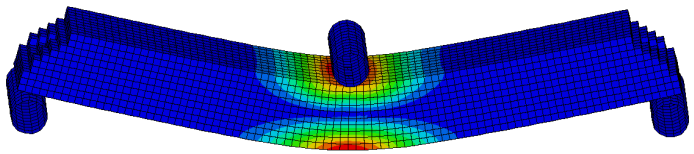


Example

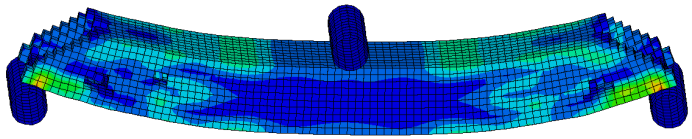
0th iteration: $\rho_{rel} = 0.25$ in whole design domain

FE-analysis:$IED\ [0, 22.0\ N/mm^2]$

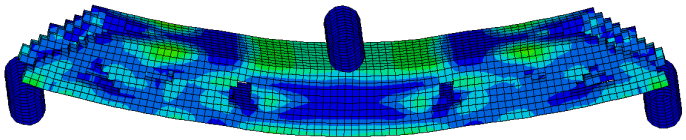
4th iteration:



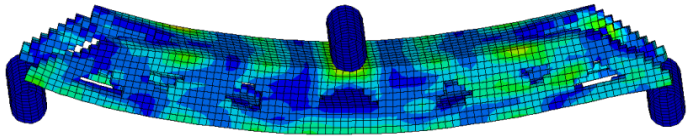
9th iteration:



15th iteration:

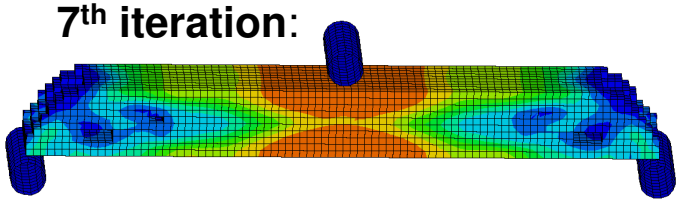


25th iteration:

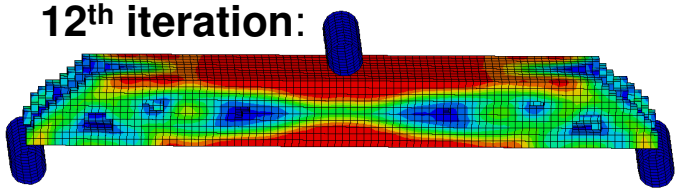


Evolution of density distribution:$\rho_{rel}\ [0,1]$

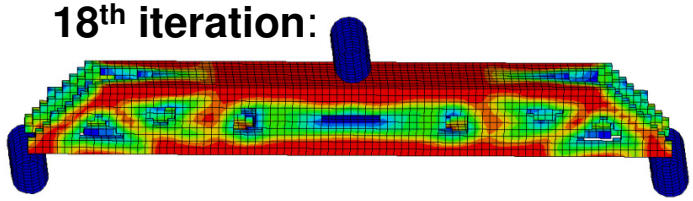
7th iteration:



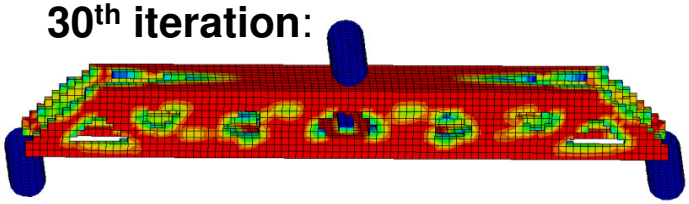
12th iteration:



18th iteration:

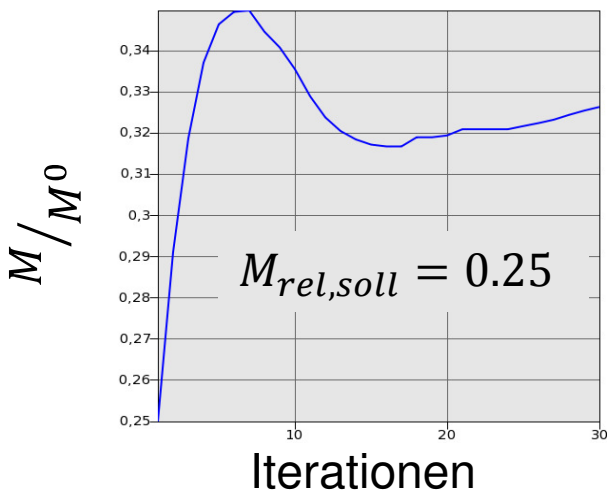


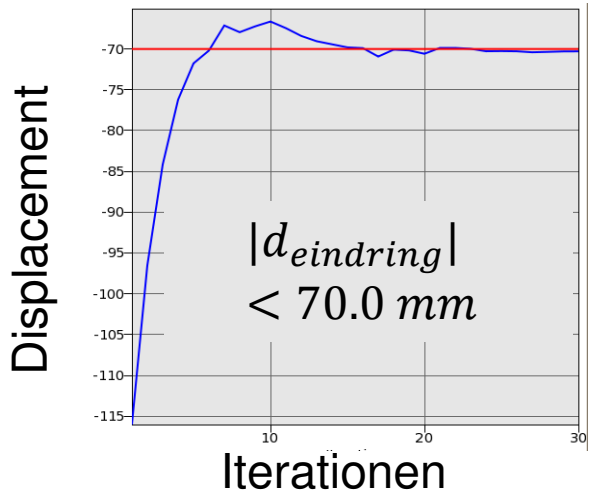
30th iteration:

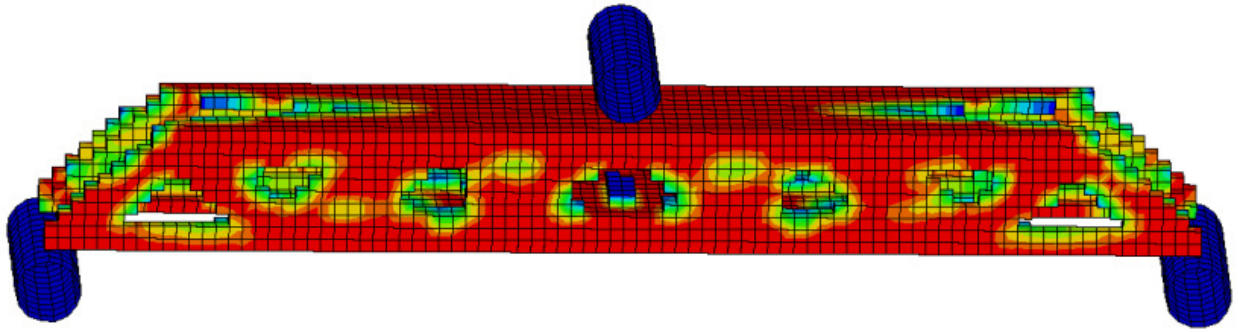


Example

- Result: structure with minimal mass and feasible displacement

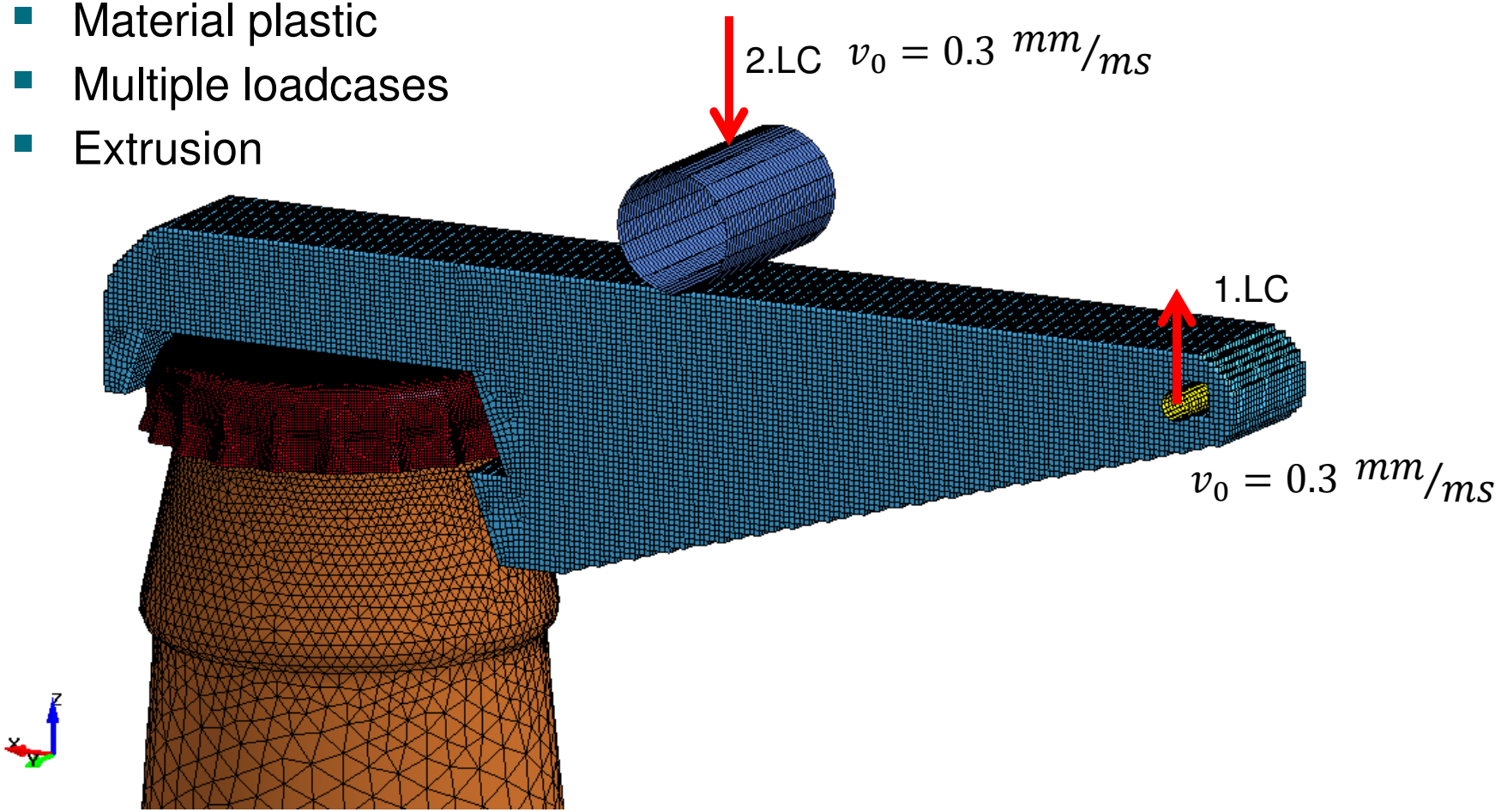






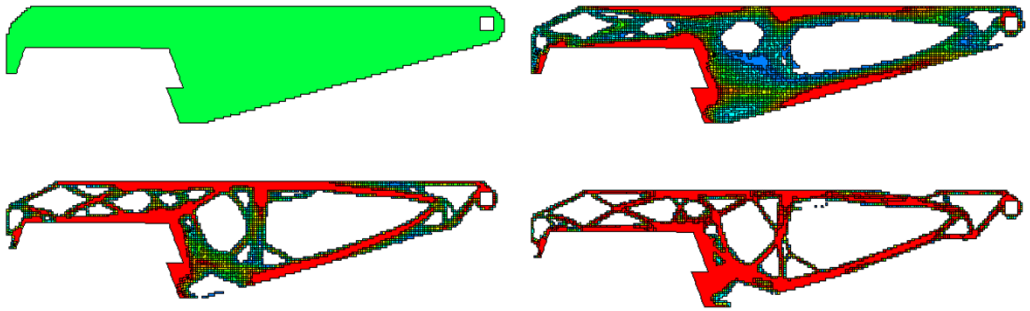
Live Demo: Bottle Opener

- Starting design and load cases
- Material plastic
- Multiple loadcases
- Extrusion

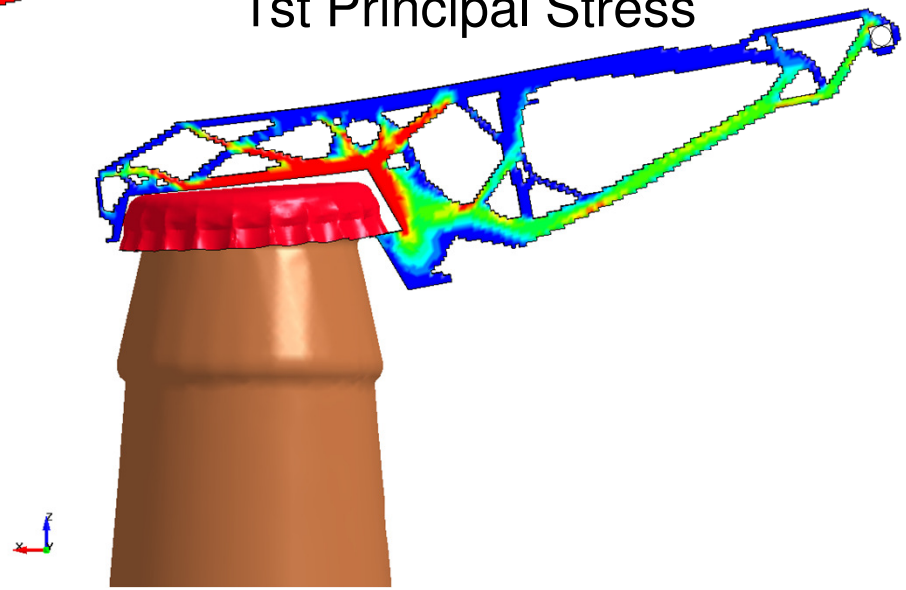


Live Demo: Bottle Opener

- Results
- From Initial Design to Optimized Structure (density distribution)



1st Principal Stress

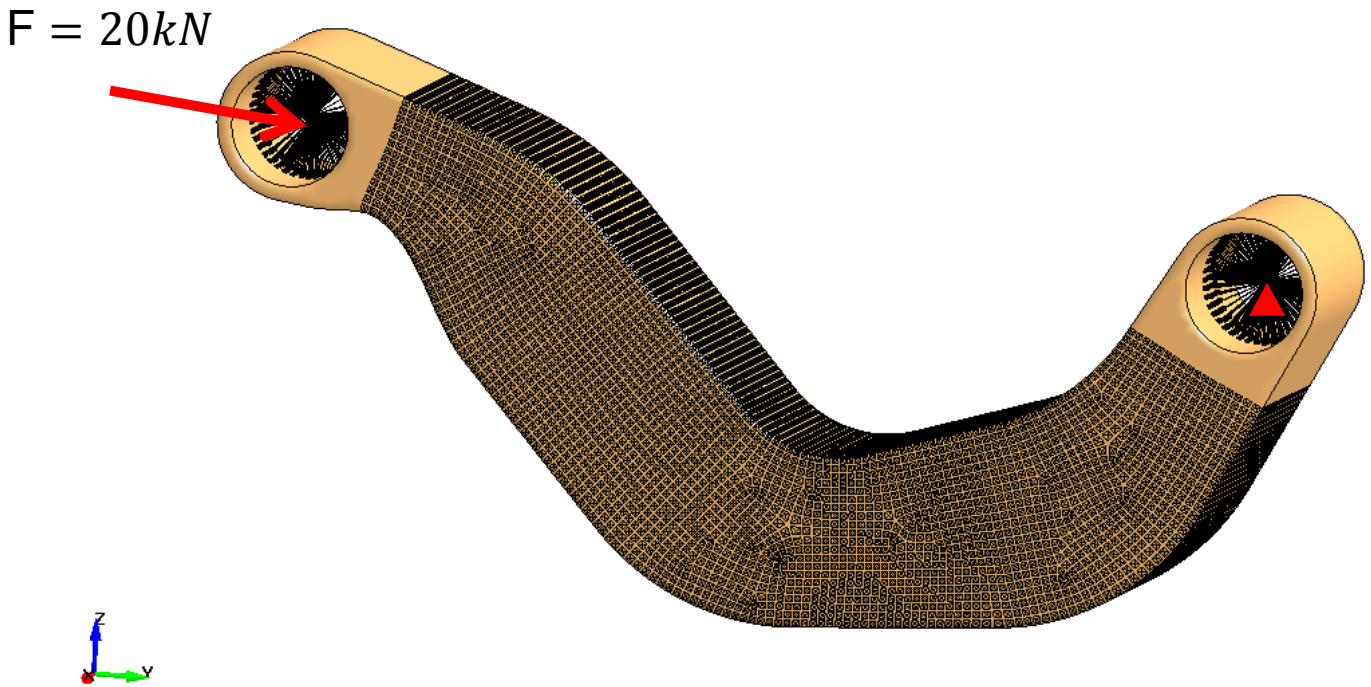


Free surface design

- Redesign of the surface of solids to have an uniform stress (removing the stress concentrations).
- Geometry definitions are allowed.
- Very quick to set up the design problem.

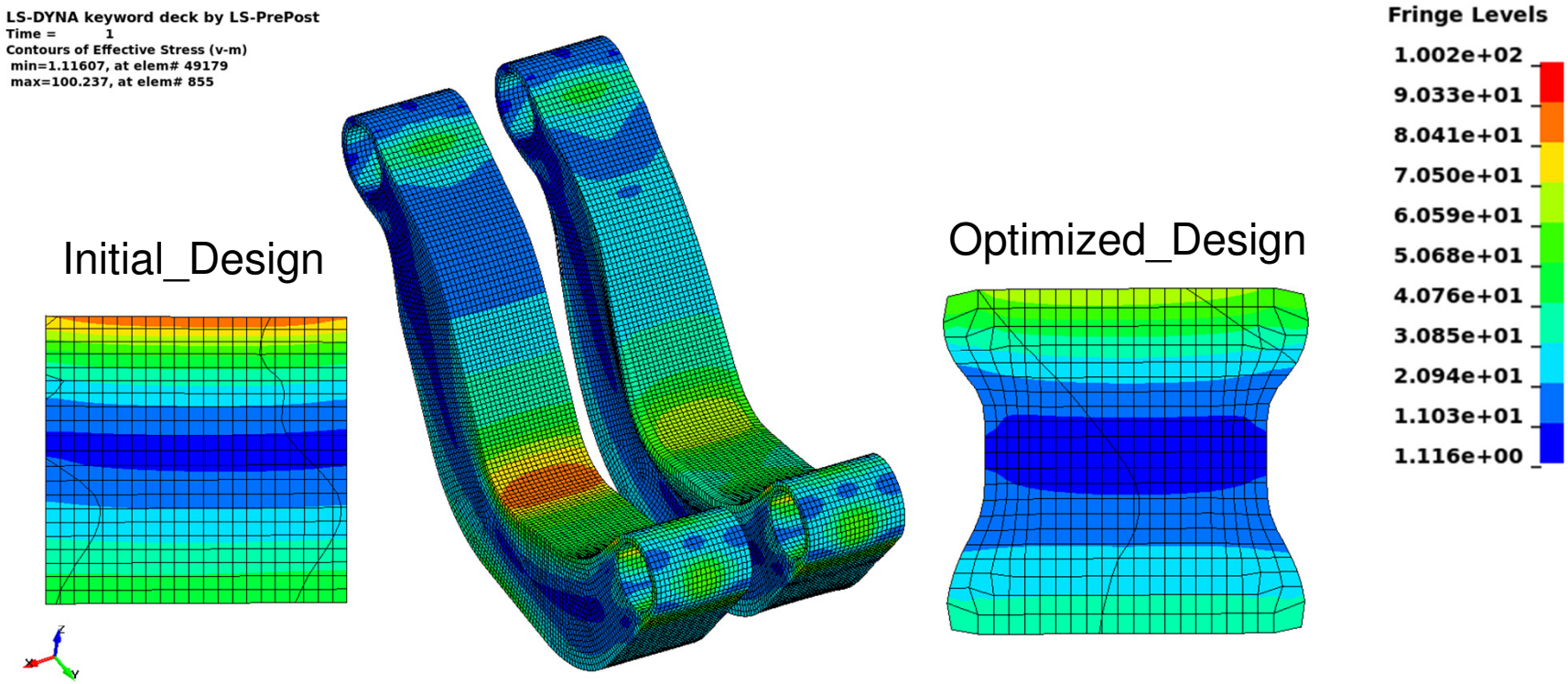
Live Demo: Free Surface Design

- Starting design and load cases
- Material steel



Live Demo: Free Surface Design

- Results



Reducing the stress concentration about 20%

LS-TaSC - Summary

- Topology optimization of non-linear problems
  - dynamic loads
  - contact conditions
- Methodology: Hybrid Cellular Automata (HCA)
- Free Surface Design
- Current production version is LS-TaSC 3.0
- Windows/Linux Versions available
- Download: www.lsoptsupport.com