PERMAS

Topology Optimization

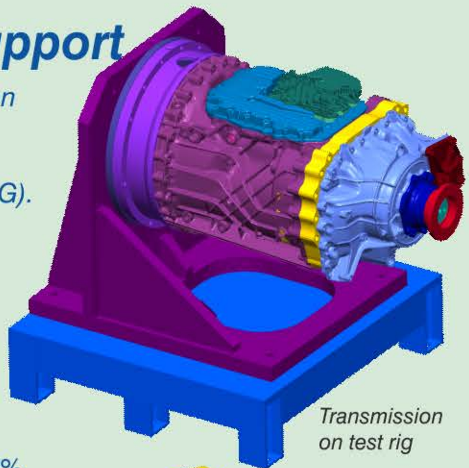
For a design close to final product

Procedure:

- ***Initial model:***
  A complete structure with Finite Element model and results is available (as reference).
- ***Design space:***
  For that part of the structure, which has to be optimized, a design space will be defined and newly meshed, which uses the maximally allocatable volume.
- ***Design objective:***
  The design objective and its constraints are defined.
- ***Optimization:***
  The design is determined by a topology optimization including a smoothing of the surface.
- ***New model:***
  The surface is exported and the design is newly meshed.
- ***Comparison:***
  A new analysis of the complete structure with the new part is performed and the results are compared with the reference.

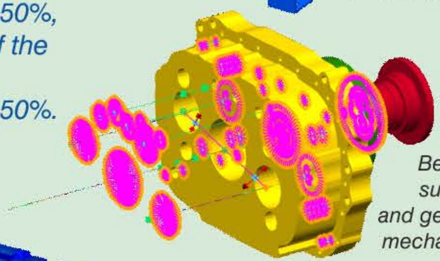
Bearing Support

Topology Optimization of a bearing support (by courtesy of ZF Friedrichshafen AG).

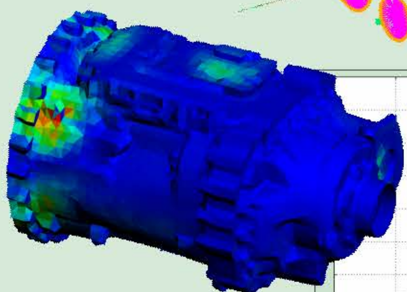


Transmission on test rig

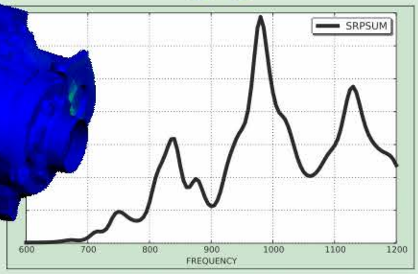
The sound radiation of the housing was reduced by about 50%, while the weight of the housing was also reduced by about 50%.



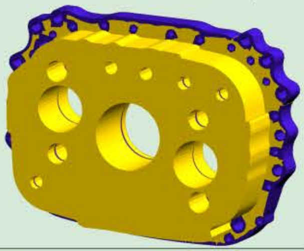
Bearing support and gearing mechanism



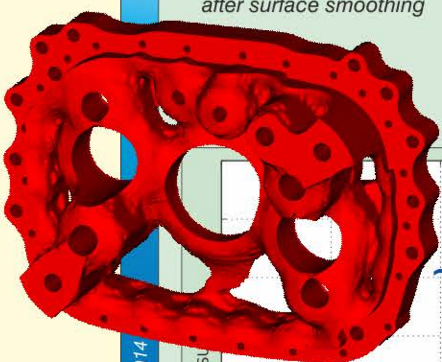
Sound radiation power density at a selected frequency



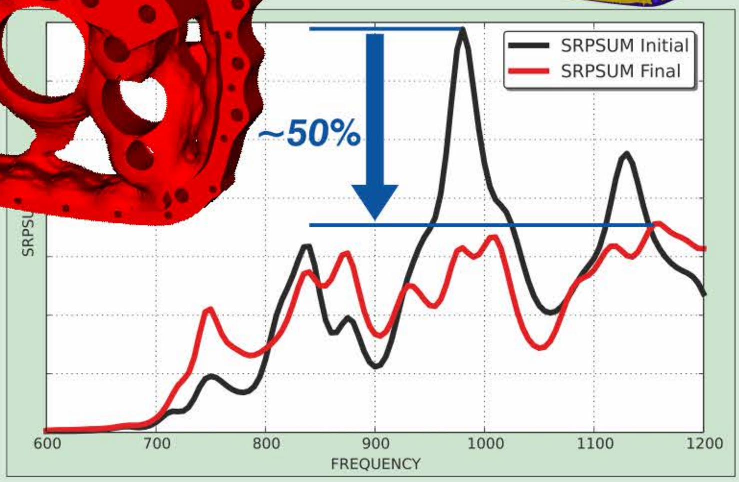
Frequency response of cumulated sound radiation power



Design space with invariant regions (blue)

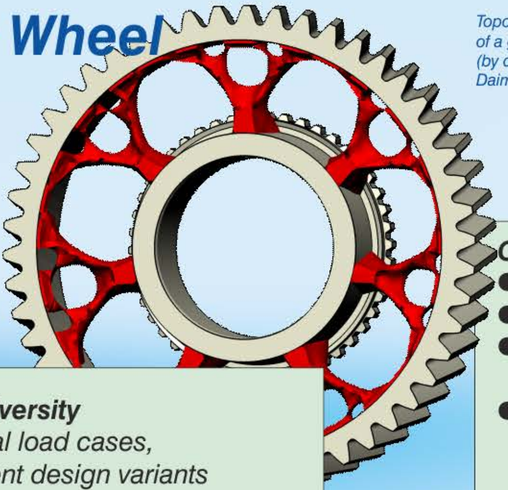


Optimized bearing support after surface smoothing



Frequency response of cumulated sound radiation power (50% reduction of maximum amplitude)

Gear Wheel



Topology optimization of a gear wheel body (by courtesy of Daimler AG)

Model diversity

- Several load cases,
- Different design variants (like boundary constraints),
- Several analysis types (like static analysis with contact, dynamics with vibration modes and frequency response analysis),
- Substructuring.

Objectives and constraints

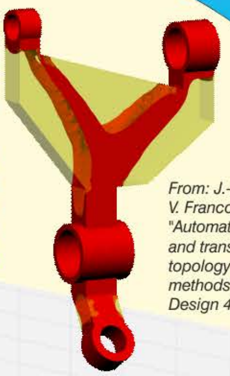
- Compliance
- Weight
- Static (Stiffness, reaction forces, displacements),
- Dynamic (real eigenvalues, frequency response of displacements, velocities, accelerations),
- Outside of design space stresses, element forces, sound radiation,
- Composed constraints with arbitrary functions using the above listed quantities.

VisPER

VisPER features the graphically guided description of optimization models:

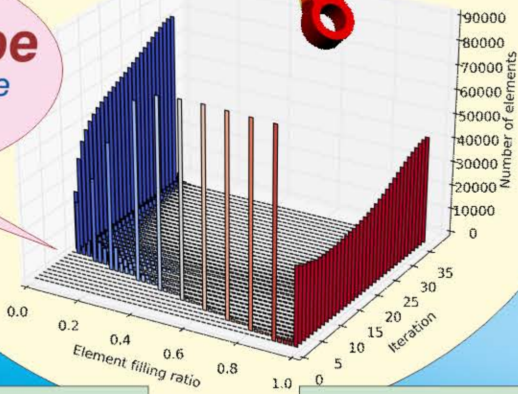
- Defining the design space,
- Defining the design parameters,
- Selecting objective function and design constraints,
- Defining manufacturing constraints,
- Generation of a smoothed hull.

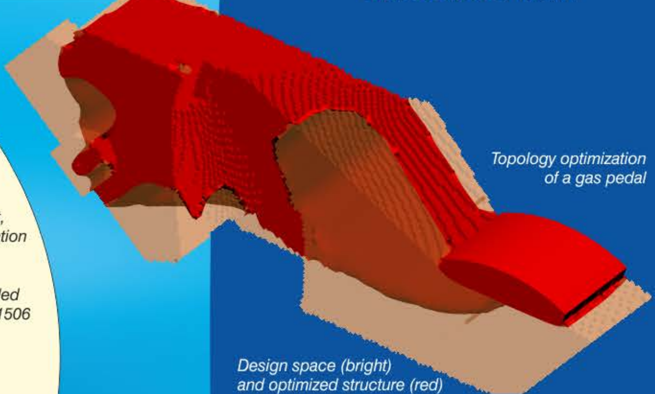
The filling ratio of the elements is the design variable of the topology optimization with values between 0 (zero) and 1 (one). After optimization, filling ratios near 1 (for the remaining structure) and near 0 (for the omitted structure) are obtained. The diagram shows this clear separation during the iteration process.



From: J.-C. Cuilliére, V. Francois, J.-M. Drouet, "Automatic mesh generation and transformation for topology optimization methods", Computer-Aided Design 45 (2013) 1489-1506

Clear Shape
for a design close to final product





Topology optimization of a gas pedal

Design space (bright) and optimized structure (red)

Pedal

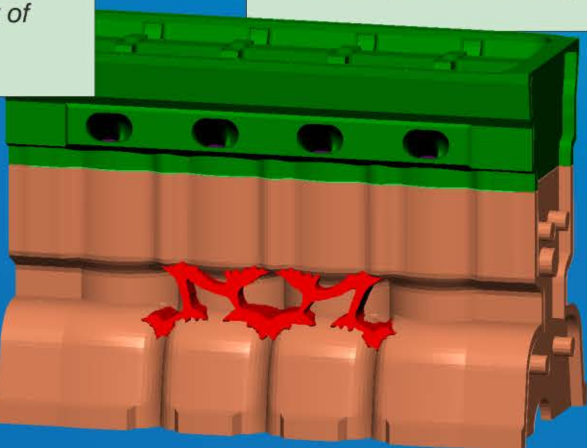
View from below with rib structure due to release directions

Manufacturing constraints

- Several and different release directions,
- Parting line,
- Symmetry (planar, axial, cyclic),
- Repetition of patterns,
- Maximum and minimum wall thickness,
- Frozen regions (not changeable, but part of design space),

Results

- Element filling ratio (with values near 0 and near 1),
- History plots of objective function and constraints,
- Hull generation and smoothing of surface,
- Polygon reduction and export of hull (as mesh or STL).



Topology optimization of a rib structure

Ribs

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