PERMAS
Topology Optimization

**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**
Topological Optimization of a bearing support (courtesy of ZF Friedrichshafen AG).

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

Sound radiation power density at a selected frequency

Frequency response of cumulated sound radiation power

Optimized bearing support after surface smoothing

Design space with invariant regions (blue)

~50%

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

**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.

**Clear Shape**
for a design close to final product

**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).

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.

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