# SIMULIA TOSCA STRUCTURE 8.1 STRUCTURAL OPTIMIZATION

TOSCA STRUCTURE DELIVERS POWERFUL OPTIMIZATION SOLUTIONS FOR DESIGN OF LIGHTWEIGHT, STIFF, AND DURABLE PARTS AND ASSEMBLIES WITHIN SHORTER DEVELOPMENT CYCLES

SIMULIA TOSCA STRUCTURE 8.1

Tosca Structure is a modular system for non-parametric structural optimization that enables topology, sizing, shape and bead optimization in combination with standard finite element solvers. This allows for a seamless integration in existing CAE environments and guarantees easily interpretable and reliable results. The set-up is very simple as no model parameterization is necessary and existing solver input files can directly be used for optimization setup.
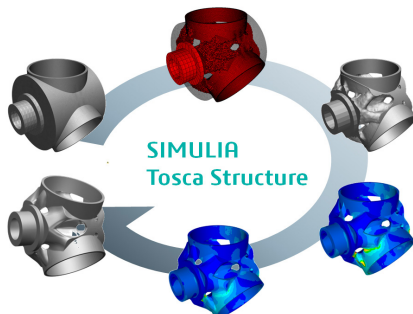
Optimization with Tosca Structure

Tosca Structure supports the complete optimization workflow including result transfer to CAD systems and automatic model verification. A closed development process can be achieved from the first concept to the optimized geometry in the CAD system.

SIMULATION-BASED OPTIMIZATION

Tosca Structure offers simulation-based optimization. Within an optimization a simulation describing the design's performance is executed to iteratively improve the design. This optimization loop is done fully automatically and supports interaction with industry standard FEA solvers.

Optimization with SIMULIA Tosca Structure

Abaqus
ANSYS
MSC Nastran

Fully automatic integration of non-parametric optimization

GENERAL CAPABILITIES

- Solver interfaces: Abaqus, ANSYS, MSC Nastran
- Stable and fast optimization algorithms
- Direct use of existing models
- Efficient handling of very large models
- Support of unlimited number of load cases
- Consideration of multiple FE analyses for response combination
- Optimization in combination with nonlinear analysis (nonlinear material, contact, large deformation)
- Several graphical user interfaces available for pre- and postprocessing of optimization jobs available
- Result visualization with Tosca Structure.view
- Combination of postprocessing data to vtfx reports and office or html documents
- Result preparation for CAD transfer using Tosca Structure.smooth

Tosca Structure.topology

Topology optimization determines an optimum design proposal starting with a given maximum design domain space.

All load scenarios and boundary conditions from the finite element model are taken into consideration during the automatic modification procedure.

- Free choice of objective function terms and constraints of the following design responses: volume, mass, compliance, displacements, rotations, reaction forces, reaction moments, internal forces, natural frequencies, center of gravity, moments of inertia, stress
- Demolding constraints for casting and forging components. Consideration of stamping conditions and tightness
- Various symmetry constraints (plane, rotational, cyclic) and link conditions
- Minimum and maximum membersize filters for wall thickness constraints
- Fully automated generation and analysis of verification models

Topology optimization of a lever (Images courtesy of JCB)

Tosca Structure.sizing

The Tosca Structure.sizing module is a tool for optimizing sheet metal components by modifying the individual sheet thicknesses of single layered shells.

- Free choice of objective function terms and constraints of the following design responses: volume, mass, compliance, displacements, rotations, reaction forces, reaction moments, internal forces, natural frequencies, center of gravity, moments of inertia
- Various symmetry constraints (plane, rotational, cyclic) and link conditions
- Clustering of shell element thicknesses for element areas with constant thickness
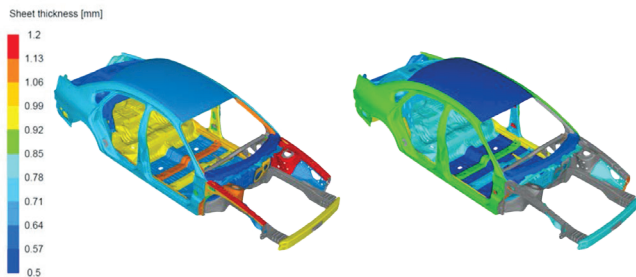

Optimizing a body-in-white using Tosca Structure.sizing

Tosca Structure.shape

In shape optimization, the component's surface is modified to reduce local stress or damage peaks. For the setup of a shape optimization problem in Tosca Structure no model parameterization is necessary. The design area is simply defined via group definitions in the finite element model or directly in one of the available graphical user interfaces.

- Minimization of combinations of equivalent stress values (various stress hypotheses available)
- Maximization of selected natural frequencies
- Specification of a volume constraint
- Mesh-independent manufacturing constraints for casting, forging, stamping, extrusion and drilling
- Minimum and maximum member size
- Various symmetry constraints: plane, rotational, cyclic symmetry and their combination
- Penetration checks to neighboring parts
- Mesh smoothing in each design cycle to keep high quality meshes during optimization
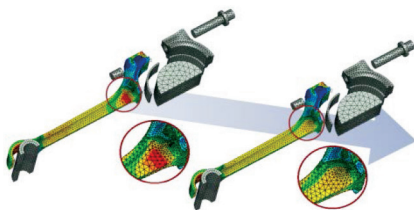
Shape optimization of a connection rod
(Images courtesy of Ford Werke AG)

Tosca Structure.bead

Bead optimization is used to determine the optimum location and orientation of bead stiffeners for sheet metal components. With Tosca Structure.bead, the static stiffness and the vibration behavior can be improved.

- Definition of objective function terms and constraints using the following response types: compliance, natural frequencies, displacements, reaction forces, reaction moments, internal forces
- Symmetry constraints
- Penetration checks to neighbouring parts
- Definition of maximum bead height
- Mesh-independent approach
- Easy interpretation of the results
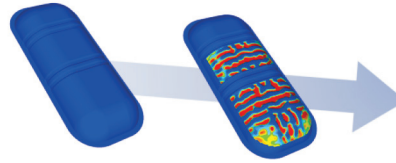
Bead optimization of a muffler (Images courtesy of Tenneco)

PREPROCESSING

Several different graphical user interfaces are available to author Tosca Structure optimization tasks

- Optimization Module within Abaqus/CAE
- Tosca ANSA environment
- Tosca Extension for ANSYS Workbench
- Tosca Structure.gui

The variety of authoring tools offer the possibility to perfectly fit optimization into existing CAE environments.

POSTPROCESSING

The available graphical user interfaces offer integrated optimization postprocessing capabilities. Besides these functionalities the following standalone solutions are provided:
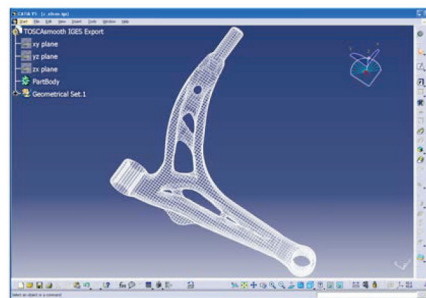
Cutting splines in CATIA V5 (Image courtesy of Otto Fuchs KG)

Tosca Structure.smooth

Tosca Structure.smooth supports the preparation of validation models and the export to CAD-systems:

- Calculation of smoothed isosurfaces of the material distribution after topology optimization depending on isovalue or target volume
- Generation of patched surface geometries for shape and bead optimization
- Visualization in Tosca Structure.view
- Data reduction for CAD transfer
- Calculation of cutting splines and export as IGES files
- Export of patched surfaces in CAD compatible formats (STL, IGES)
- Export as FE surface mesh for manual remeshing and analysis or automatic reconstruct and verification run

Tosca Structure.report

- Collection of 3D animation sequences of the optimization history and x-y-plots of constraint and objective function values
- Export to platform independent, binary and compact vtfx archives
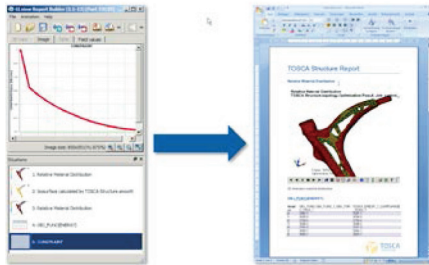
Tosca Structure.view

- Free, high-performance 3D viewer for Tosca Structure data in vtfx format
- Available for Windows and Linux
- Plug-in for Office applications or Internet Explorer on Windows
- Export of images and avi files
- Tosca Structure Report Builder
- Automatic generation of reports for office and html documents
- User defined templates for customized layout
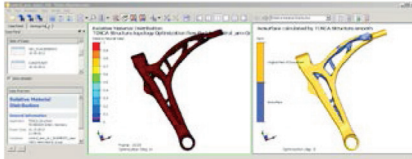
Tosca Structure.view

Tosca Structure Report Builder

- Automatic generation of reports for office and html documents
- User defined templates for customized layout

Tosca Structure Report Builder

ADVANCED MODULES

For challenging optimization applications Tosca Structure offers additional modules that allow to use advanced functionalities:

Durability

- Shape optimization based on results of fatigue simulation
- Use of fe-safe, FEMFAT, Falancs, nCode, DesignLife, Femsite or user specific fatigue code possible

Nonlinear

- Topology and shape optimization of contact models
- Topology and shape optimization using nonlinear material behavior
- Topology and shape optimization based upon geometric nonlinear analysis
- Bead and sizing optimization support all nonlinearities outside the design area

Morph

- Highly flexible mesh manipulation tool for quick and easy geometry changes
- Automatic generation of model variants and submission of analysis runs for these models
- Derivation of optimum start design for a subsequent local shape optimization possible
- Definitions for design variables (design variable constraints and mesh smooth definitions) also apply to morphing areas

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