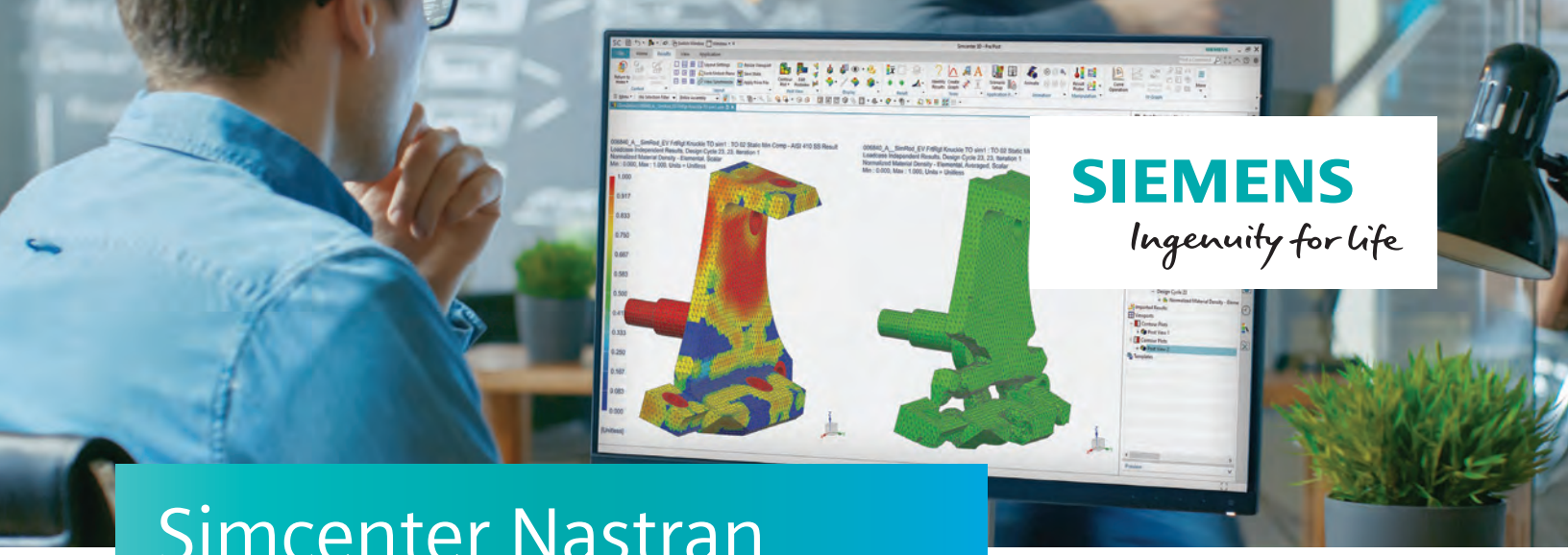

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Simcenter Nastran Topology Optimization

Optimize topology for performance and manufacturing targets

Benefits

- Reduce time-to-market by starting from optimal topology for a large set of targets related to stiffness, modal and buckling analysis
- Use multiple design areas with different materials and multiple solution types in the same optimization
- Execute complete workflow from concept to final design, all hosted in Simcenter 3D
- Take into account different types of manufacturing constraints to control the shape of the results for manufacturing or functional requirements
- Predict solid and lattice zones

Summary

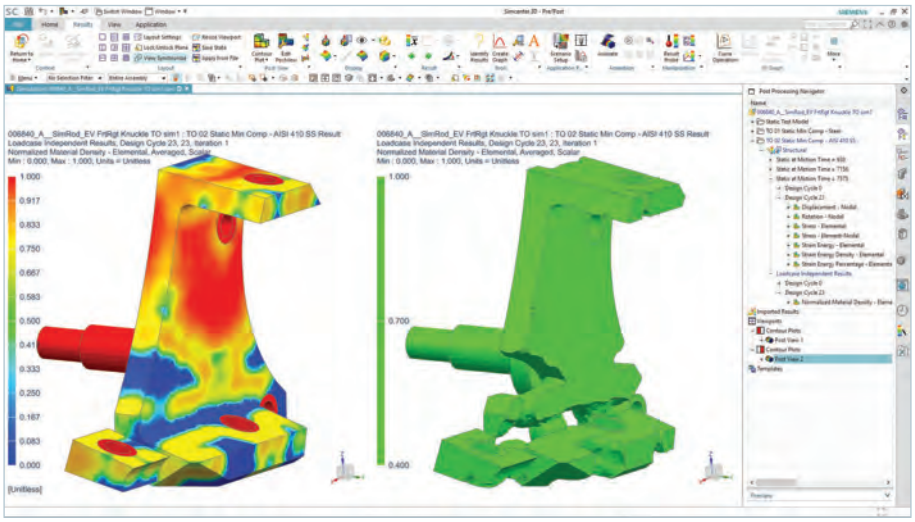
Topology optimization generates innovative designs for new families of products. But while optimizing topology is becoming mainstream, the creation of new manufacturing processes like additive manufacturing are opening new horizons to innovation.

Based on the Simcenter™ Nastran® SOL 200 solution, Simcenter Nastran Topology Optimization software offers the capability to optimize many different criteria based on linear statics, modal and buckling analysis, to genuinely support generative engineering. The solution can optimize the topology of regions defined as solid or shells, and also offers the capability to predict solid and lattice zones.

Major capabilities

Many methods are available to build the finite element (FE) model and define the design areas and the surrounding supporting scenery. This can include any mix of the following:

- Orphan mesh (without CAD model)
- Single CAD part model and single finite element model (FEM)
- CAD assembly and single FEM or an assembly FEM (AFEM)



Simcenter Nastran Topology Optimization

The design areas can be 2D shell or 3D solid elements, and the scenery can be any Simcenter Nastran element types supported by the selected analysis types.

With the same topology optimization, the user can have a mix of analysis subcases selected from the following types:

- Linear statics
- Normal modes
- Direct frequency
- Modal frequency
- Buckling

Each subcase can have its own parameters to control the analysis.

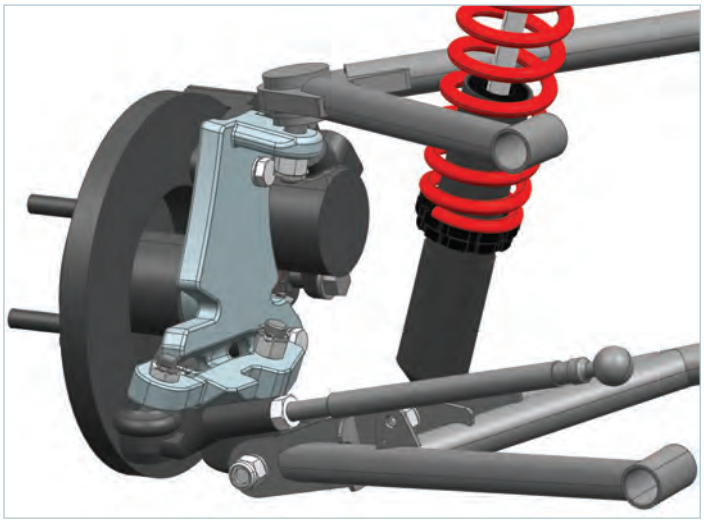
Any of the loads and constraints supported by the supported solutions (101, 103, 105, 108, 111) are available for inclusion in a topology optimization model.

A single optimization objective is used and can be placed either at the global or subcase level depending on the response being measured and the user's requirements.

Any number of optimization constraints can be used. These can also be placed either at the global or subcase level depending on the response being measured and the user's requirements.

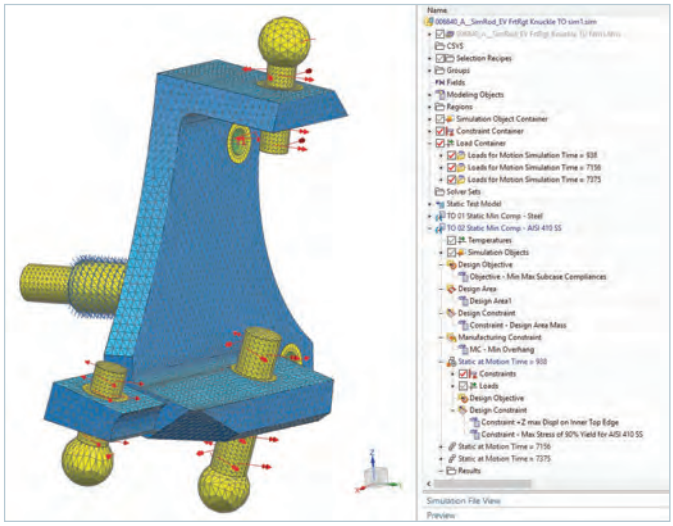
Both the objective and constraints reference a response, and there are a very large number of responses available (see table). Below these choices there are many more options depending on the element type, for example for stress:

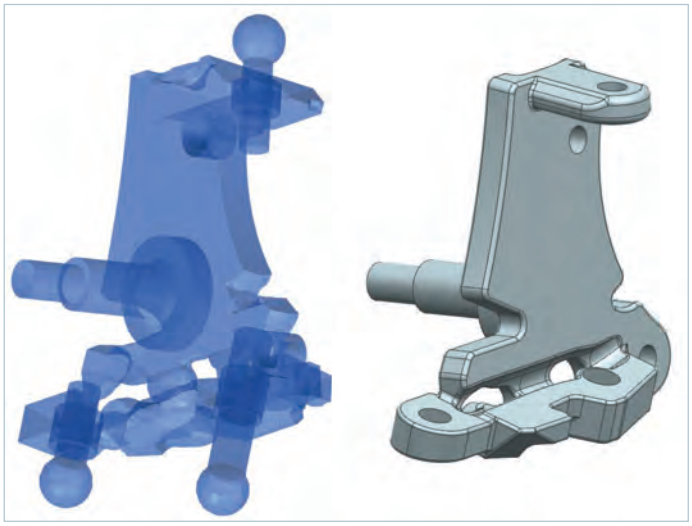
- Normal
- Shear
- Axial
- Von Mises
- Maximum and minimum
- Translation



Table

Responses for optimization objective and constraints
Total model weight
Design area weight
Total model volume
Compliance
Normal modes
Buckling modes
Displacement
Strain
Strain energy
Stress
Force
Single point constraint (SPC) force
Acoustic pressure
Eigenvalue modes
Complex eigenvalue modes
Frequency response force
Frequency response SPC force
Frequency response stress
Frequency response displacement
Frequency response velocity
Frequency response acceleration
Random response displacement
Random response velocity
Random response acceleration
Transient response displacement
Transient response velocity
Transient response acceleration





Manufacturing constraints
Manufacturing constraints are important tools that control the shape of the optimization results. Multiple constraints can be applied, and the following types are available:

- Planar symmetry
- Cyclic symmetry
- Maximum member size
- Minimum member size
- Casting die direction
- Extrusion
- Maximum overhang angle (for additive manufacturing)

Controlling the optimization process
Parameters are available to control the optimization process, including maximum number of cycles, convergence criteria, and others.

There are three penalty laws that control the topology optimization algorithm: linear, solid isotropic material with penalization (SIMP) and rational approximation of material properties (RAMP). The lattice penalty law can also be used to predict optimized zones where a lattice could be used instead of homogeneous solid material.

Simcenter 3D exposes a lot of the Simcenter Nastran SOL 200 Topology Optimization functionality in the graphical user interface (GUI). Users can also take advantage of re-useable, user-defined text objects for all the advanced options not available through the GUI.

Results
The user can choose how many optimization cycle result sets are saved in the Simcenter Nastran .op2 file. This enables the user to reduce the size of the result file, or study how the optimizer got from the initial to the best state.

- Initial and best cycles
- Initial and every nth cycle
- Initial and all cycles

The user can select which datasets (stress, strain, displacement, kinetic energy, model contribution, velocity, etc.) that they want Simcenter Nastran to return for each subcase. This enables the user to control the size of the result files and focus on the datasets they want to study.

All of the Simcenter 3D postprocessing tools are available to study the results and an automated command is available to identify the elements that will define the optimized results. This also enables the further study of the submodel and exporting of the facet geometry to NX CAD for further design work.

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