FEMtools™ Optimization

An Integrated Solution for Structural Design Optimization

FEMtools Optimization is a toolbox for general purpose and structural design optimization. In combination with FEMtools Model Updating, it provides the unique possibility to perform design optimization on validated and/or updated finite element models.

Based on the acting loads, the design constraints, and the required structural behavior, FEMtools Optimization computes the optimal design parameters for the considered component or structure. The state-of-the-art optimization techniques of FEMtools Optimization enable to increase the performance of the considered component considerably faster than conventional development methods.

FEMtools Optimization has an open architecture providing virtually unlimited flexibility in the problem definition and offering the possibility to solve the optimization problem using your preferred FE-solver.

Overview

FEMtools Optimization provides tools for

- **Sensitivity analysis** – Analyses how changes of parameters influences the responses
- **General non-linear optimization** – solving arbitrary non-linear optimization problems
- **Size optimization** – optimizing component parameters such as cross-section and thickness
- **Shape optimization** – optimizing the shape of existing components
- **Topometry optimization** – optimizing component parameters on an element-by-element basis
- **Topology optimization** – creating new designs with a layout optimized for a given load
- **Design of Experiments and Response Surface Modeling** – Efficient sampling of the design space and create an approximate model

Benefits

- **All-In-One** – A single dedicated program with all capabilities required for efficient structural design optimization.
- **Model Size** – FEMtools has been designed to optimize structural finite element models that are used in industrial applications. There are no fixed limitations in model size.
- **Availability** – Native versions of FEMtools are available on all hardware platforms that are popular for CAE applications.
- **Validation** – In combination with FEMtools Model Updating, it is possible to validate the FE model of the initial design using test data.
- **Open Environment** – Besides an internal static and dynamic solver, FEMtools Optimization provides interfaces and drives for using external FE solvers: NASTRAN, ANSYS, ABAQUS, etc.
- **Scripting** – easy-to-learn internal scripting language FEMtools Script, offering unlimited possibilities in the definition of optimization problems.
- **Competitiveness** – Optimization stimulates innovation and increases competitiveness.

General Non-Linear Optimization

FEMtools Optimization is build around a powerful general non-linear optimization solver supporting

- Non-linear constraints
- Multi-objective optimization
- Constraint screening
- Least-square distance minimization
- Pareto optimization (MiniMax problems)

Any arbitrary objective or constraint function can be used for optimization by programming it using the FEMtools Script language.

There are no fixed limits on the number of optimization parameters, objective functions or constraints.

Sensitivity Analysis

Efficient structural optimization requires the analytical computation of gradient information of the objective and constraint functions.

FEMtools Optimization has an internal sensitivity module that provides gradient information for the following parameters and responses

- **Parameters** – element stiffness properties, element mass properties, geometrical properties, boundary conditions, lumped masses, and damping factors.
- **Responses** – mass, static displacements, dynamic displacements, resonant frequencies, model displacements, MAC, FRFs, and FRF correlation functions.

Computation of gradients for any other response and parameter combination can be programmed using FEMtools Script language.

Size Optimization

- Easy selection of a wide range of sizing parameters
- Fast gradient computation with the FEMtools sensitivity module
- Full flexibility in the problem definition
- Possibility to solve the optimization problem using

an external FE solver

Shape Optimization

The FEMtools shape optimization module offers the following features

- Modifying FE-models without requiring the underlying CAD data
- Possibility to handle large mesh deformations by using integrated mesh morphing technology
- Full flexibility in the problem definition by using the FEMtools Script language
- Possibility to solve the optimization problem using an external FE solver

Topometry Optimization

Topometry optimization enables element-by-element size optimization of FE-models. The topometry optimization module offers a solution for the following design problems:

- Minimum static compliance design
- Maximum fundamental eigenvalue design
- Minimum maximal FRF-level design

A series of constraints are provided to ensure the manufacturability of design:

- Symmetry manufacturing constraint
- Extrusion manufacturing constraint
- User-defined manufacturing constraint: any arbitrary constraint can be added using the FEMtools Script language

Topology Optimization

Topology optimization module can handle both 2D and 3D design spaces. The following design optimization problems are available:

- Minimum static compliance design
- Maximum fundamental eigenvalue design
- Minimum dynamic compliance design

A series of constraints are provided to ensure the manufacturability of design:

- Symmetry manufacturing constraint
- Minimum member size constraint
- Extrusion manufacturing constraint
- Die-casting manufacturing constraint
- User-defined manufacturing constraint: any arbitrary constraint can be added

DOE/RSM

- Sample parameters using factorial, central composite, Latin hypercube or D-optimal designs.
- Create RSM using regression analysis and use this approximate model for design optimization.

User Interface

- Dedicated graphics viewers for model inspection and results evaluation
- Complete digital documentation
- Point-and-click interactive selection
- Unlimited customization using FEMtools Script

Prerequisites

- FEMtools Framework with FEA Solvers (included)
- FEMtools Dynamics (included)

Options

- FEMtools Model Updating and Optimization
- FE interfaces and drivers (Ansys, Abaqus, LS-DYNA, MSC.Nastran, Simcenter Nastran, OptiStruct, SAP2000, Universal File)
- Add-ons (Data Acquisition, Modal Parameter Extractor, Rigid Body Properties Extractor)

Services

- Installation, training and customization
- Support by e-mail, phone and support site
- Custom software development
- Project research

Supported Platforms

- Windows 10, 11 (64-bit)
- Linux 64-bit

For more information, contact us at

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