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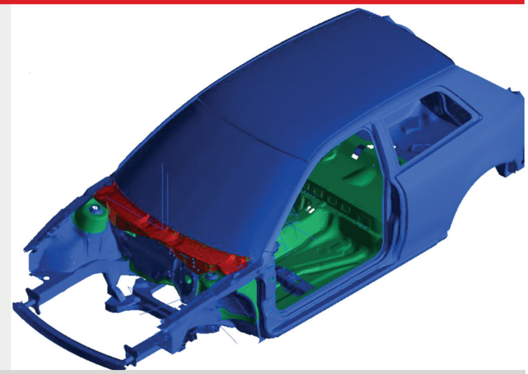


MSC Nastran™ Optimization

Optimize your Designs for Performance and Efficiency

Overview

Product development is rife with trade-offs between contradicting attributes of cost, weight, manufacturability, quality and performance. As design and development teams strive to improve products by incorporating new customer requirements, they also are under pressure to save on development and material costs. Engineers often rely on team's empirical expertise to achieve incremental design improvements, which is not only time consuming and resource intensive, but also unreliable as it is often hard to account for all the design constraints and responses.

MSC Nastran offers a complete and robust set of capabilities to help engineers achieve improved designs in shorter time. Since these capabilities are integrated with widely popular MSC Nastran, users are in a familiar environment keeping training costs lower. With the optimization module of MSC Nastran, engineers can produce more efficient designs, perform trade-off, feasibility and design sensitivity studies, and correlate test data and analysis results.

The optimization module of MSC Nastran supports all the popular methods of Sizing, Shape and Topology optimizations, as summarized below.

Sizing Optimization

Using sizing optimization, engineers can compute optimal properties and parameters of a model to achieve a given a design objective such as a target weight reduction. Numerous properties such as cross sectional areas, moments of inertia, layer angles and thicknesses, elastic moduli, Poisson's ratios, densities, and others can be considered to help engineers arrive at an optimum solution.

An extended sizing optimization procedure, namely, topometry optimization, which is an element-by-element procedure, is also available in MSC Nastran, giving users tremendous control over their designs. Unlike conventional sizing optimization, where all elements with same property are grouped as one design variable, topometry method assigns an independent variable to each designable element. Since it enables review of a broader design, this method may find a better design than the conventional approach.

Shape Optimization

Shape optimization can help users go further than optimizing model parameters by providing improved designs for parts with complex geometric features. With this method, you can optimize the boundary profile of your design (shape) to, for example, minimize the weight while satisfying constraints on the stress resulting from a range of loading conditions. A special case of shape optimization, named Topography optimization, is particularly powerful for designing sheet metal parts. In this procedure, finite element grids are moved along normal to shell surface or user specified direction. Efficient algorithms are used to generate shape design variables based on bead dimensions, and to arrive at optimum shape.

Topology Optimization

Use of topology optimization early in the development cycle helps determine optimal distribution of material in the designs given package space, loads and boundary conditions. A challenge with topology optimization is that it can produce a large number of voids, introduce large number of smaller members, and lead to design proposals that are difficult or impossible to manufacture. These difficulties are overcome by providing user control over the complexity of the design including minimum member constraint. Multiple manufacturing and symmetry constraints also help you obtain solutions that ensure manufacturability.

Topology optimization can be used to generate a conceptual design proposal with emphasis on global design responses, then a sizing and/or shape optimization can be performed on the topology design proposal with emphasis on local design responses.

Optimization Problem Statement

The basic optimization problem statement requires the following four items to be defined:

Capabilities

- Optimize designs for linear statics, normal modes, buckling, direct or modal frequency response, complex eigenvalue, static aeroelasticity, fatigue life and aeroelastic flutter analysis
- Use topology optimization for defined 2-D or 3-D geometric design space combined with load and boundary condition requirements
- Determine the optimal shape of parts with topology optimization
- Use the efficient density approach for topology optimization
- Take advantage of superior solvers to handle large 3-D problems more efficiently
- Apply manufacturing constraints to ensure manufacturability
- Impose design constraints that are frequency dependent
- Consider multiple design variables in an optimization task
- Enhance boundary profiles with shape optimization
- Take advantage of optimization package through the pre and post processor Patran
- Find optimal designs of composite laminates
- Consider linear isotropic, orthotropic, and anisotropic materials in your optimization task
- Include the permanent glued contact capability in optimization tasks
- Combine two or more related optimization tasks into a single combined optimization task by using the MultiOpt capability
- Use OpenMDO to access personal or other available optimization codes
- Use the adjoint method for NVH optimizatio
- Use multi-start global optimization method to explore better designs
- Use multi-model optimization to find optimal solution with the use of separate design models and multiple analysis types

MSC Software®

- Design Responses – What calculated output am I interested in?
- Design Objective - What do I want to achieve?
- Design Variables – What can be changed?
- Design Constraints – What are the limits on the Design Responses?

Design Variables and Design Properties

Design variables are quantities that can be directly changed to satisfy the optimization statement. MSC Nastran distinguishes between dependent and independent design variables and supports discrete design variables, giving users flexibility in problem statement. Users can define design properties such as element thicknesses, material properties, beam cross-sectional area, moment of inertia etc. as functions of design variables. A unique feature of MSC Nastran's optimization capability is its beam library that allows the user to define the dimensions of standard cross section types.

Design Objective

The design objective is a scalar quantity that is either minimized or maximized during the optimization which is often defined in terms of design responses. Examples of design objectives include minimization of the weight or the minimization of the maximum stress for a fixed weight budget.

Design Responses

MSC Nastran enables users to define design objectives from a broad set of design responses. Some design responses supported include weight, volume, natural frequency, displacement, strain, stress, force etc. MSC Nastran also supports synthetic responses formed from a combination of basic design responses, design properties and design variables. User can also invoke client-server technology to calculate responses that require a combination of design variables/responses computed by MSC Nastran and special purpose user supplied code.

Design Constraints

Design space is always subjected to certain constraints, and variations could be limited by factors like allowed displacement or maximum permissible stress or minimum permissible frequency. The restrictions on the responses help limit the solution space to be search for an optimum. These constraints can be as simple as restriction on displacement at a given location or as complex manufacturing constraints like:

- Symmetry and cyclic symmetry
- Extrusion constraints for uniform thicknesses along draw direction
- Single and two die casting constraints for preventing cavities along die movement
- Minimum member size constraints

Multidisciplinary Optimization

A structural design often requires synthesis of requirements from multiple disciplines. If the focus of optimization is on a single discipline, optimizer could come up with a sub-optimal solution, or require users to run additional design cycles to ensure all the disciplines are addressed adequately. MSC Nastran implementation of design sensitivity and optimization addresses this by integrating multiple analyses into a single job. The responses from these combined analyses can then be included in the optimization step, so that all the applicable requirements are considered simultaneously. Common analysis types like linear statics, normal modes, buckling, direct or modal complex eigenvalue, direct or modal frequency, modal transient, fatigue life, static aeroelasticity, and flutter are supported.

Multi-model Optimization

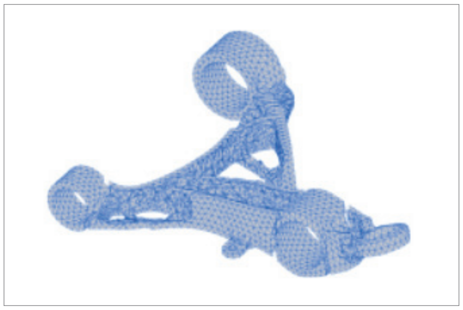
In order to enable companies to truly integrate optimization into their design process, MSC Software offers MultiOpt, a feature that helps integrate models from different disciplines and simultaneously optimize the complete design to meet high-level objectives such as performance, cost, life and weight. The optimization process automatically integrates results from each model and performs an overall optimization. This approach is highly beneficial to optimize a baseline design and a number of variants simultaneously so that the final result would be applicable to each of them, and where different teams have created distinct finite element models for their specific disciplines. An example includes when the stress engineers and NVH engineers have their own representation of the same vehicle and with this approach the design of these two representations can be combined in a single optimization task.

Global Optimization

Many industry optimization applications have multiple local minima and the solution obtained depends on initial starting points, which is particularly evident in composite and dynamic response optimizations. While finding a global optimum is very hard for general nonlinear problems, MSC Nastran uses a multi-start method to find an approximate global solution with relatively modest computing cost. The Global Optimization process can also be utilized to search for a feasible design when a local optimization method is unable to find one.

Benefits

- Generate efficient design proposals in the conceptual design phase
- Improve existing product designs
- Reduce significant amounts of material in insignificant areas for given design space, boundary conditions, loads, and required design performance
- Save significant modeling time by including models that implement glue contact, capability of joining dissimilar meshes
- Design with higher certainty by ensuring the manufacturability of products
- Assess the effect of design changes and ensure that product designs meet all requirements



Corporate
MSC Software Corporation
4675 MacArthur Court
Suite 900
Newport Beach, CA 92660
Telephone 714.540.8900
www.mscsoftware.com

Europe, Middle East, Africa
MSC Software GmbH
Am Moosfeld 13
81829 Munich, Germany
Telephone 49.89.21093224
Ext.4950

Asia-Pacific
MSC Software Japan LTD.
Shinjuku First West 8F
23-7 Nishi Shinjuku
1-Chome, Shinjuku-Ku
Tokyo, Japan 160-0023
Telephone 81.3.6911.1200

Asia-Pacific
MSC Software (S) Pte. Ltd.
100 Beach Road
#16-05 Shaw Towers
Singapore 189702
Telephone 65.6272.0082

MSCNO*2016MAR*DS