MSC Nastran Advanced Nonlinear

Simulate reality with robust nonlinear analysis

Competitive markets are forcing manufacturers to innovate and introduce new and better products faster than ever. Hence, simulation is pushed earlier into the development cycle in order to reduce costs and decrease uncertainty. Since CAE solutions have traditionally been focused on specific disciplines, users have had to use multiple products to achieve their design goals, leading to longer simulation times and increased potential for errors.

MSC Nastran, the leading solver used by manufacturers around the world, addresses this key problem through a multidisciplinary solution approach. MSC Nastran provides a single, integrated solution to solve simulation problems across a broad spectrum, including linear and nonlinear statics, nonlinear dynamics, thermal, coupled and rotor dynamics to name a few. Its modular package allows users to adapt the available capabilities to their needs providing a cost-effective analysis solution.

The MSC Nastran Advanced Nonlinear module provides implicit nonlinear capabilities required to address your challenging problems, with the added benefits of a single solver which include reduced training and higher productivity. By accounting for all the possible sources of nonlinearities, namely, geometric, material and boundary condition nonlinearities including contact, you can accurately simulate reality.

Nonlinear materials

Being able to model materials that exhibit a nonlinear stress-strain (constitutive) behavior is important to obtain the accurate response of a structure. MSC Nastran offers multiple nonlinear material models that you can use to model the complex behavior of your engineering structures. These include, but not limited to:

- Metal plasticity
- Nonlinear elasticity
- Hyperelasticity (rubber elasticity)
- Viscoelasticity
- Creep
- Temperature dependent properties
- Composites
- Shape memory alloys
- Gasket materials

Analysis customization

The User Defined Services (UDS) capability gives users a mechanism to utilize custom subroutines or applications within MSC Nastran. UDS can be used to create customized element formulations, materials, contact definitions, co-simulation with CFD, and more.

Contact

When considering either highly flexible components, or structural assemblies comprising of multiple components, progressive deformation may give rise to the possibility of either self or component-to-component contact. Simulating accurate interaction between these various components requires robust contact algorithms as these analyses can be computationally intensive and highly nonlinear depending on the materials and the magnitude of deformation and distortion.

- MSC Nastran provides superior contact solution through its unique functionality:

- Intuitive, easy to set up without the need for prior knowledge of contact regions

- Faster pre-processing, with automatic detection of contact boundary

- Improved accuracy through the use of NURBS for analytical contact for rigid body definition

- Reduced effort with no need to mesh rigid bodies

- State of the art segment-to-segment contact detection for improved accuracy

- Support for 1D, 2D and 3D elements for improved flexibility

- Moment transfer between continuum elements and shells and beams for improved accuracy and easier modeling

- For assembly modeling, define numerous contact interactions with ease through the use of contact pairs
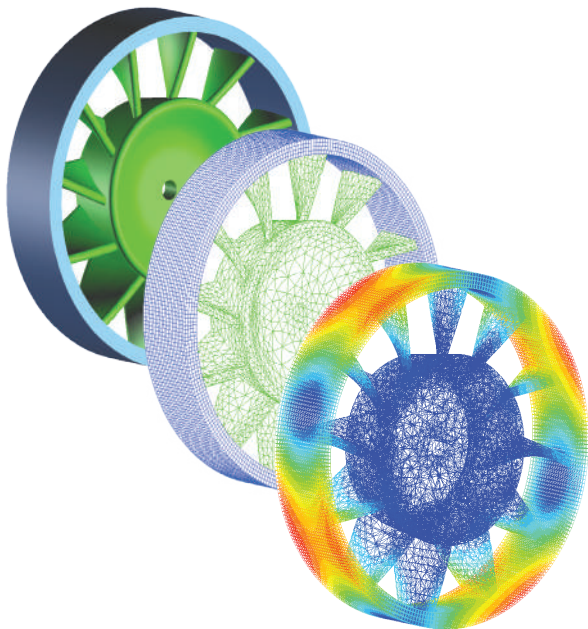
Chained Analysis

Structures are often subjected to loads that span multiple disciplines and for improved accuracy, it is critical to account for all these disciplines. In solvers focused on single discipline efficiency, the chaining between multiple disciplines can be inefficient and cumbersome.

With MSC Nastran, users can model the effects of the various disciplines. Some examples include:

- Perturbation analysis to perform a linear analysis based on the nonlinear equilibrium state of a structure

- Multiple options for perturbation analysis, including linear statics, normal modes, buckling, direct and modal frequency response, direct and modal complex Eigenvalues, modal transient response, static aeroelastic response, and aerodynamic flutter

- Chained thermal-structural analysis (thermal analysis followed by a separate stress analysis)

Composites - Stress and failure analysis

Designing and testing of composite structures is expensive and time consuming. MSC Nastran makes it easy to model and analyze composite materials helping you analyze the stress/strain response of each ply in a laminate and also understand the failure behavior of the structure.

The tools offered are ideal for any of the common types of composites, including polymer ma-trix, metal matrix, ceramic matrix, carbon matrix and more. In addition, the ability to quantify damage and predict failure helps improve safety of your composite products.

With MSC Nastran, users can model the effects of the various disciplines. Some examples include:

- Stress analysis of any possible lay-up configuration for either linear or nonlinear response

- Material properties that can be temperature dependent

- Choice of elements, including shell, solid shell and solid (continuum) elements best suited for your applications

- Multiple composite failure criteria to choose from, including maximum stress, maximum strain, Hill, Hoffman, Tsai-Wu, Hashin, Puck, Hashin-Tape, or Hashin-Fabric

- Progressive Failure Analysis of composite material to analyze structural behavior after complete material degradation

- Virtual Crack Closure Technique for crack growth resistance and crack propagation studies

- Interface elements using a cohesive zone model for delamination analysis, applicable to both homogeneous and composite structures

## Thermal Analysis and Thermal-Structural coupling

Thermal analysis is only second to structural analysis in terms of its usage because of the need to account for temperature variations on structural performance. MSC Nastran provides a complete set of capabilities to solve your thermal problems including a number of nonlinear and temperature dependent properties.

The thermal variations often affect structural response and vice versa requiring a coupled analysis for better understanding of the physics. For example, friction in brake systems generates heat and the temperature gradients may lead to warping which in turn could be the source of unwanted noise. MSC Nastran helps you simulate multiple physics in a single model giving engineers ability to simultaneously simulate the interaction of structural and thermal loads.

- Thermal analysis accounting for all modes of heat transfer (conduction, convection and radiation)

- Efficient calculation of radiation view factors for higher productivity

- Steady state and transient heat transfer analysis

- Temperature dependent material properties for improved accuracy

- Linear and nonlinear material properties for better representation of behavior

- Thermal contact to allow heat transfer across components

- Perform thermal stress analysis with temperatures as initial conditions

- Coupling of thermal and structural behaviors

- Inclusion of friction and internal plastic heat generation

Capabilities

- Select from a large set of nonlinear material models including elastic-plastic, hyperleastic, shape memory alloys, composites, temperature dependent, and many more

- Chain multiple analyses together for a one model multidiscipline analysis

- Perform transient and steady state heat transfer analysis

- Carry out coupled and uncoupled thermal-structural analysis

- Take advantage of state-of-the-art solvers optimized for performance and accuracy

- Implement parallel processing on shared and distributed memory machines

- Observe the damage and failure of nonlinear materials

- Monitor the delamination and progressive failure of advanced composites

- Use 1D, 2D and 3D elements optimized for Nonlinear Analysis

- Apply glued contact for easy constraint applications

- Use glued contact to join dissimilar meshing

- Perform thermal contact for accurate heat transfer between various components
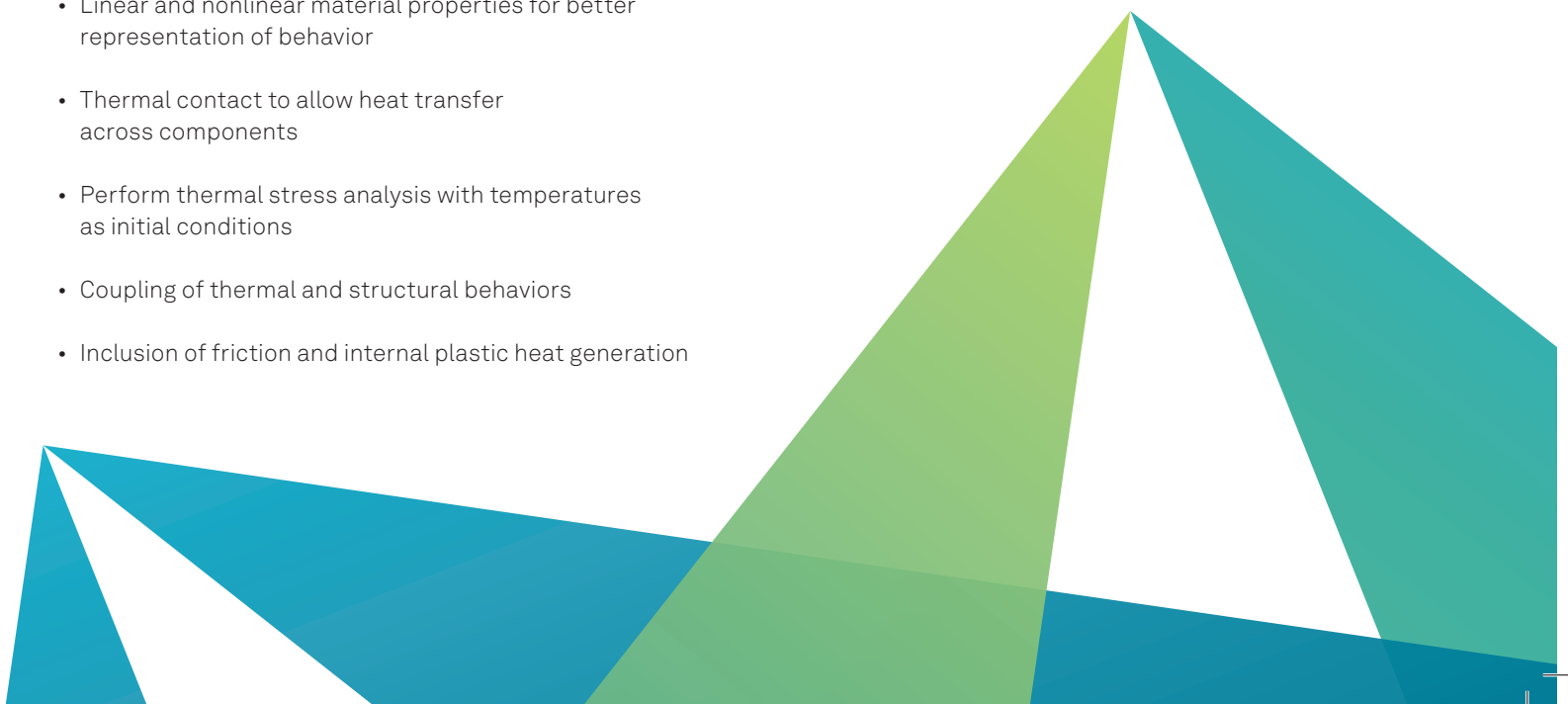
Performance

With increased use of simulation, both the model size and the number of simulations are on the rise. However, tighter time constraints would mean that these analyses need to be run faster. To address this challenge, MSC Nastran continues to prove its leadership in High Performance Computing (HPC) by addressing the issue on multiple fronts.

- Faster, efficient direct and iterative sparse solvers

- Efficient use of system resources, including GPU devices for additional floating point compu-ting power

- Parallel solvers that can provide you with faster solution times on both distributed and shared-memory systems

Benefits

- Conveniently transition from linear to nonlinear analysis for improved productivity

- Use one solver for multiple disciplines while reducing training costs

- Utilize robust solvers to enhance the value of nonlinear analysis

- Improve accuracy of your simulations through multidisciplinary integration

- Save time remeshing and aligning dissimilar meshes in large models with MSC Nastran's glued contact capability

Hexagon is a global leader in sensor, software and autonomous solutions. We are putting data to work to boost efficiency, productivity, and quality across industrial, manufacturing, infrastructure, safety, and mobility applications.

Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous – ensuring a scalable, sustainable future.

MSC Software, part of Hexagon's Manufacturing Intelligence division, is one of the ten original software companies and a global leader in helping product manufacturers to advance their engineering methods with simulation software and services. Learn more at mscsoftware.com. Hexagon's Manufacturing Intelligence division provides solutions that utilise data from design and engineering, production and metrology to make manufacturing smarter.

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