HEXAGON | MSC Software

MSC Nastran™ Composites

Evaluate and optimize the performance of composite materials

Overview

Usage of composites in structural designs continues to grow robustly. While aerospace industry leads in the adoption of composites, manufacturers from automotive, sports and consumer products, energy, electronics and medical industries are also heavily investing in these highly customizable materials due to the weight and performance advantage they provide. Some examples of advanced composite usage include:

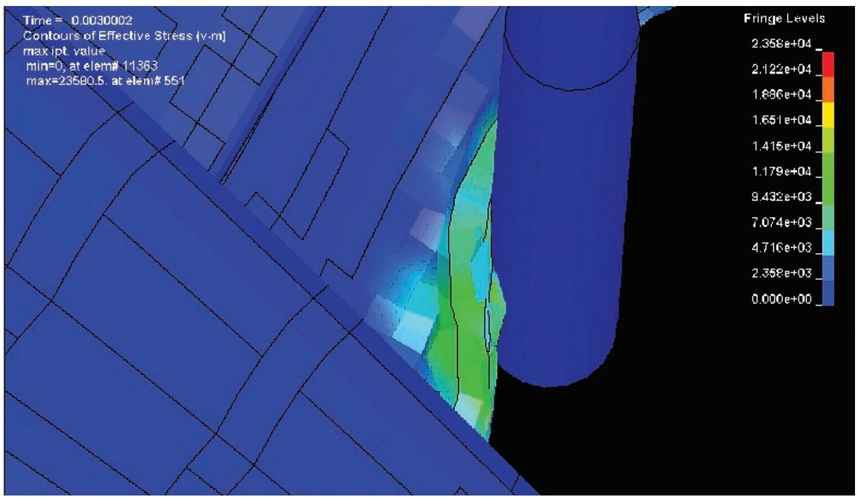
- Aircraft landing gear doors made of Kevlar-graphite/epoxy
- Graphite/epoxy-honeycomb payload bay doors in the Space Shuttle
- Graphite/epoxy in golf club shafts to decrease weight
- X-ray tables made of Graphite/epoxy
- Glass/epoxy leaf springs for smoother rides in automotive applications
- Wind turbine blades

While composite structures can provide significant advantages when compared to traditional materials, effective use of these materials comes at a cost in design and development. Due to composite's customizable nature, it is critical to ensure their performance for a multitude of in-service loads. However, since physical testing can be very expensive, leading manufacturers turn to the robust, trusted simulation solutions from MSC Software.

Trusted, proven stress analysis

Since composite material properties are often designed to be orthotropic or anisotropic, it is important to understand their behavior, without which the designs may not perform as ex-pected. MSC Nastran provides you with capabilities to model composites in the 1D, 2D or 3D domains with appropriate elements to model the material behavior. Multiple analysis types offered by MSC Nastran help you study the behavior of your structures with confidence. Analysis types include, but are not limited to:

- Linear and Nonlinear Static
- Linear and Nonlinear Transient
- Normal Modes
- Buckling
- Direct or Modal Frequency Response
- Direct or Modal Complex Eigenvalue

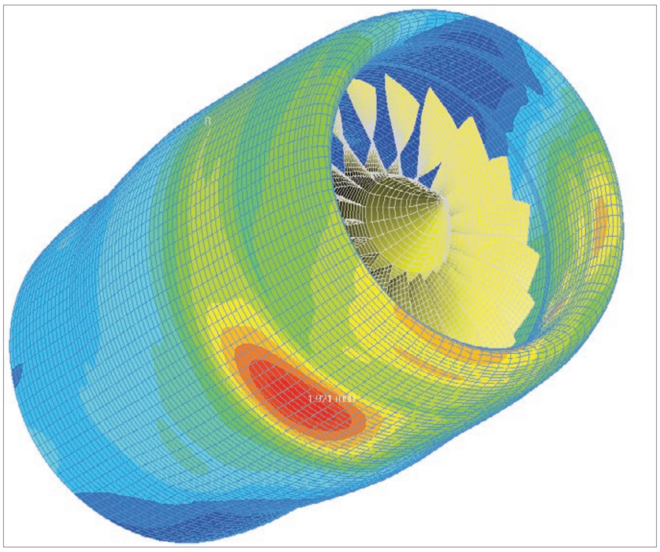


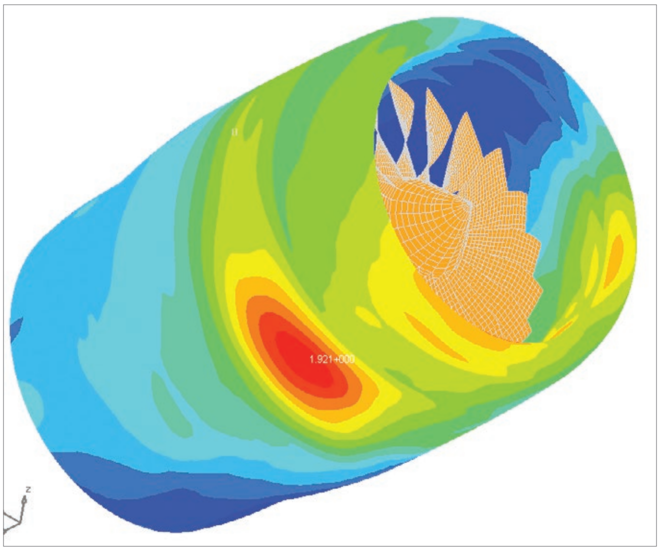
- Direct or Modal Transient Response
- Heat transfer
- Thermal-structural analysis

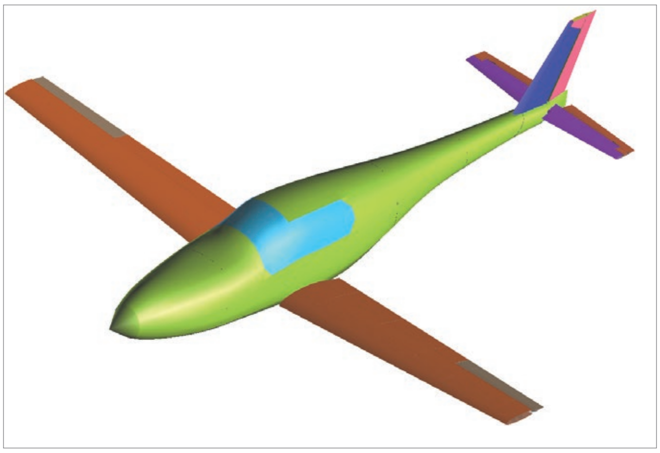
In addition, capabilities available to homogenous structures are also implemented to simplify composite structure analysis. Capabilities include:

- Automatic, nonlinear iteration algorithms
- Support for large strains and deformations
- Temperature dependent material properties

Contact model set up and analysis can be time consuming for any analysis, especially when you have multiple components in your model, and you do not have prior knowledge of contact zones. MSC Nastran makes the contact set up easier and intuitive and is applicable to any of the analysis capabilities available to users. The easy, robust algorithms not only reduce your modeling effort, but also provide you with improved accuracy of simulations.







Progressive failure analysis

Because of multiple materials and the generally layered nature of composites, multiple failure mechanisms can come into play during service. The damage buildup in composites is often gradual leading to ultimate failure. It is thus important to understand the damage and failure mechanisms to improve the composite designs. Through the Progressive Failure Analysis capability of MSC Nastran, engineers can monitor the structural weakening and degradation of load bearing ability. Users can select from a number of failure criteria including Maximum Stress, Maximum Strain, Hill, Hoffman, Tsai-Wu, Hashin, Puck, Hashin-Tape, Hashin-Fabric, and user defined subroutines.

Delamination

Delamination is a common failure mechanism in layered structures. If the bond between the plies is not strong enough, the bond can fail and grow, leading to a weaker structure and even catastrophic failure. It is thus critical to understand the structural response under multiple loads that it may be subjected to during its life. Cohesive Zone Modeling (CZM) implemented in MSC Nastran introduces special interface elements used to model the bond between the laminae. These elements, which could be of zero thickness, can undergo either reversible or irreversible damage and help provide a more accurate simulation of delamination.

Capabilities

- Analyze sandwich composites, UD Tape, adhesively bonded joints, and similar built up composite materials
- Analyze advanced composites for a wide range of analysis types including linear, nonlinear stress analysis, dynamics, heat transfer, and more
- Optimize your composites for objectives including, but not limited to, weight, stiffness, and ply lay up
- Predict the onset and growth of cracks with the Virtual Crack Closure Technique
- Evaluate the damage progression and ultimate capacity of advanced composites with MSC Nastran's Progressive Failure Analysis capability
- Simulate delamination between plies by using the Cohesive Zone Modeling Technique
- Analyze Shear Lap Joints
- Take advantage of MSC Nastran's robust and advanced contact capabilities
- Utilize your computing hardware efficiently with parallel solvers

Benefits

- Develop advanced composite structures with confidence
- Create laminates of optimal weight and stiffness
- Achieve higher productivity with easy modeling and faster solutions
- Improve product life and reduce warranty costs

Crack propagation

Virtual Crack Closure Technique (VCCT) has become popular in calculation of energy release rate for cracks due to its simplicity and applicability to all modes of crack growth. This capability can be used to analyze line cracks in 2-D solid elements and for shell elements, and surface cracks in 3-D and for stacked shells. It can also be used to analyze crack propagation at the interface of two glued contact bodies. With the automatic release of glued interface, users can evaluate the strength of the bond and performance of a damaged structure.

Optimization

Since composite materials can be engineered to suit specific applications, it is important to be able to optimize composite properties without trial and error physical prototyping, which can be very expensive as there can be multiple design variables you need to work with. MSC Nastran offers design optimization capabilities that enable users to find local and global optimal values of an objective function, subjected to design constraints. For example, you can use MSC Nastran to compute individual ply thickness and orientations while minimizing weight and satisfying strength and stiffness requirements. Using MSC Nastran's support for design variables and constraints that could span across multiple disciplines, you can get a better optimized solution easier and faster.

Performance

MSC Nastran is continuously developed to take advantage of the latest numerical methods and computing hardware. Because of the laminate nature of composites, analysis requires extensive computing resources. With the use of MSC Nastran's advanced solvers, you can obtain accurate solutions faster by efficient use of available resources. In addition, you can take advantage of share memory and distributed memory multi-processor systems to run your simulations in parallel to improve your productivity.

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.

Learn more about Hexagon (Nasdaq Stockholm: HEXA B) at hexagon.com and follow us @HexagonAB.