MSC.Marc™

Nature is Nonlinear; the best designs use nature as an ally.

OVERVIEW

MSC.Marc 2003 allows the user to perform a wide variety of structural, thermal, and coupled analyzes using the finite element method. These procedures provide solutions for simple to complex linear and nonlinear engineering problems. Analysts can graphically access all features via the MSC.Marc Mentat™ or MSC.Patran™ interfaces. This helps cut time, cost and risk in aircraft development and improve the quality of new designs.

CAPABILITIES

Linear

Superposition of load cases
Fourier (asymmetric) analysis of axisymmetric bodies

Nonlinear

Adaptive load/time control
(static, post-buckling, dynamic, creep, heat transfer)

√ New AUTO STEP enhancements

- Convergence automation
- Automatic time step reduction
- Arc length methods
- User-controlled load/time stepping

Large Deformation and Finite Strain

Total and updated Lagrange procedure
Buckling - linear and nonlinear
Creep buckling
Post-buckling - with adaptive load step
Perturbation buckling
Finite strain plasticity

Automated Contact Analysis

√ 2-D and 3-D contact
Discrete or analytical rigid contact surfaces
Continuous normals using spline and Coons surfaces

√ Ability to use higher-order elements

√ Beam-to-beam contact
Load/velocity/position controlled rigid bodies
Friction models (Coulomb, shear, user defined)
Total stick, stick-slip or continuous friction model
Interference fit calculations
Dynamic impact
Stress-free initial contact

√ Thermal contact

√ *Enhancement in 2003*

PRODUCT LINE

MSC.Marc™

CAPABILITIES

BUSINESS SOLUTIONS:

- Consulting
- Implementation
- Training
- Global Support
- Simulation of multi-physics
- Simulation of product performance
- Accurate results
- Solutions to complex contact problem
- Support of all engineering materials
- Open Architecture

BENEFITS

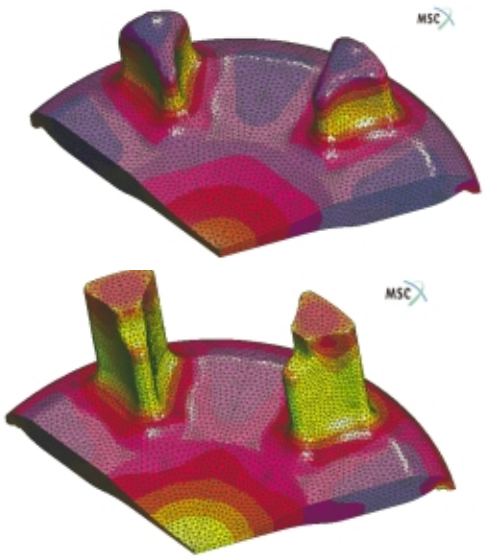
- Improved design
- Improved quality of manufactured product
- Reduced time-to-market
- Reduced need for physical prototyping
- Reduced failures
- Reduced warranty costs

MSC.Software Corporation
MSC.Marc Products
UL
REGISTERED FIRM
ISO 9001 A6713

MSC SOFTWARE
SIMULATING REALITY

Global Remeshing/Rezoning Capability

2-D (lower order quad, and tri) automatic remeshing
√ 3-D (lower order tetrahedral)
Remeshing criteria based on increments, penetration, element distortion, or instructed request
Adaptive refinement based on curvature.
Advanced meshing technology including - overlay, advancing front and Delauney triangulation
Remeshing of multiple deformable bodies



Shown here is a closed die forming simulation using tetrahedral elements and remeshing capabilities in MSC.Marc

Local Adaptive Meshing

Linear and nonlinear analyzes
Choice of multiple adaptive criteria
Special capability for contact analysis
Structural and heat transfer analyzes
Mesh refinement and mesh consolidation

Dynamics

Eigenvalue extraction: inverse power sweep and Lanczos
Transient response
Modal superposition
Direct integration
• Generalized Newmark operator
• Houbolt operator
• Single step Houbolt operator
• Explicit dynamics - central difference operator
Harmonic response
Spectrum response
Time-stepping - fixed or adaptive

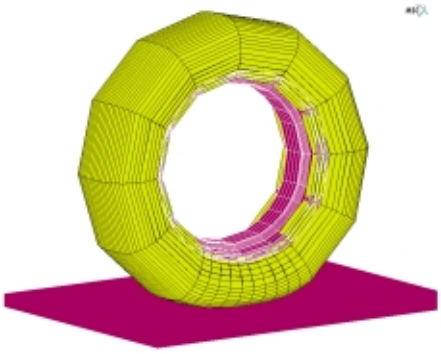
Heat Transfer

Steady-state and transient
Conduction - linear and nonlinear
Convection - radiation boundary conditions
Latent heat and phase changes
Adaptive time steps
Radiation view factors for 2-D, axisymmetric, 3-D cavities
Thermo-Mechanical
Quasi-coupled thermally driven stress analysis
Fully coupled thermo-mechanical analysis
Heat generated by plastic deformation and friction effects
Large displacement effects on thermal boundary conditions

Fracture Mechanics

Linear and nonlinear
Brittle and ductile models
J-integral - static and dynamic calculations

√ Steady State Tire Analysis



Tire under steady state rolling condition

Fluid Analysis

Navier-Stokes equations in 3-D
Mixed method or penalty approach to satisfy incompressibility
Newtonian or Non-Newtonian fluid
Fluid-thermal coupled analysis
Fluid-solid coupled analysis
Fluid-thermal-solid coupled analysis

Hydrodynamic Bearing

Lubrication problems
Pressure distribution and mass flow

Acoustics

Rigid reflecting boundaries
Eigenvalue and transient analyzes
Coupled structural acoustic analysis

√ *Enhancement in 2003*

Joule Heating
Coupled electric flow with heat transfer
√ Coupled electrical-thermal-mechanical
Electrostatics
2-D, 3-D scalar potential
Magnetostatics
2-D, 3-D vector potential
Nonlinear B-H relations
√ Permanent magnets

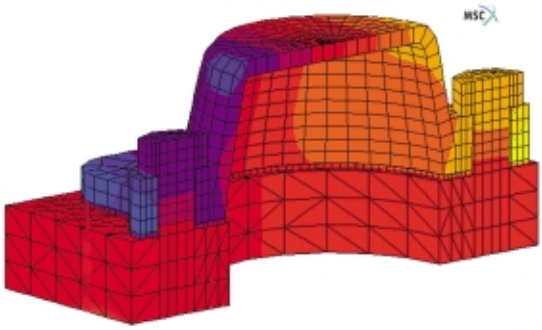
Ultrasonic Motor Transient Simulation

√ Piezoelectric Analysis
√ 2-D, 3-D modal, harmonic or transient response
Electromagnetics
Fully-coupled Maxwell equations
Harmonic and transient analyzes

MATERIAL MODELS

MSC.Marc has an extensive library of metallic and non-metallic material models, which allows representation of virtually all materials.

Linear Elastic
Isotropic, orthotropic, and anisotropic (temperature dependent)



Pre-tension bolt gasket engine joint assembly

Elastic-Plastic
Isotropic, kinematic, or combined hardening
von Mises yield criterion
Drucker-Prager yield criterion
Oak Ridge National Laboratory model
Analytical hardening behavior models
• Additive power law
• Cowper-Symonds
• Multiplicative power law
• Kumar
• Johnson-Cook
Strain rate effects
Hill's anisotropic plasticity
√ Barlat anisotropic plasticity
Temperature-dependent properties
Gurson damage model for metal plasticity
√ Chaboche viscoplastic model
Finite Strain (additive decomposition or multiplicative decomposition $[F_eF_p]$)
Elastomers
Nonlinear elastic in Total/Updated Lagrange framework
Generalized Mooney-Rivlin model
Ogden model
Boyce-Arruda model
Gent model
Foam model - large strain compressible
Large-strain viscoelastic model
Elastomer damage and fatigue
Hypoelastic
Nonlinear elastic (reversible)
Rigid-Plastic Flow
Fast sheet metal forming analysis
Plane stress option
Superplastic forming simulation
Creep
Deviatoric or volumetric strains
Piecewise linear or exponential rate of equivalent creep strain
Temperature dependence
ORNL model: combines creep, plasticity, cyclic loadings
√ Implicit creep with plasticity

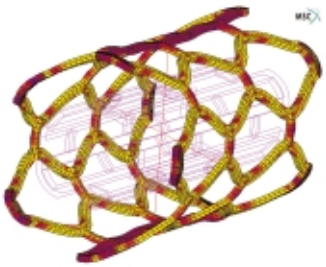
√ *Enhancement in 2003*

Viscoelasticity
- Maxwell and Kelvin models
- Hereditary integrals formulation for small and large strains
- Thermo-Rheologically Simple behavior
- Narayanaswamy viscoelastic thermal expansion
- Isotropic and anisotropic materials

Viscoplasticity
- Combined plasticity and Maxwell creep model

Powder Metallurgy
- Viscoplastic model of powder materials
- Hot isostatic pressing process
- Temperature and density changes

√ Shape Memory
- Saeedvafa and Asaro model
- Auricchio model



Volume Fraction of Martensite at the Maximum Displacement for Thermo-Mechanical Shape Memory Model

Composites
- Laminated plates and shells
- Elastic-plastic behavior
- Arbitrary material orientations
- Relative ply angle for each layer
- Multiple failure criteria - max. stress, max. strain, Tsai-Wu, Hill, Hoffman, or user-defined
- Progressive failure

√ Heat transfer analysis

√ Gasket material for thermo-mechanical analysis

Soils and Poro-Plasticity
- Yield surfaces as a function of hydrostatic stress
- Linear or parabolic Mohr-Coulomb law
- Fully-coupled fluid-solid soil problem
- Modified Cam-Clay model

Concrete
- Low-tension cracking crushing surfaces
- Rebars

ELEMENT LIBRARY

Over 175 elements are available for structural, thermal, and fluid analyzes. These elements are modern, robust, accurate, and can handle large displacements, large rotations, and finite strains.

- Truss
- Beam
- Plane stress
- Plane strain
- Generalized plane strain
- Plate
- Incompressible
- Large rotation, reduced integration shell
- Axisymmetric
- 3-D solid
- User-defined elements
- Semi-infinite
- √ Rebars (continuum and membrane
- Special elements (gaps, rigid, pipe-bend, etc.)

ANALYSIS FLEXIBILITY

Design Sensitivity and Optimization
- Static design sensitivity
- Modal dynamic design sensitivity
- Resizing of design variables, material properties and composites
- Multiple load cases
- Efficient for large number of design variables

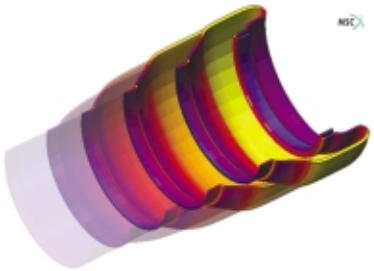
Parallel Processing
- Scalable performance on various parallel architectures: shared, distributed and network computers
- Domain Decomposition Method

User Subroutines
- Over 120 user-defined subroutines are available to customize MSC.Marc's user applications. These may be used, for instance, to define the geometry parametrically, describe the material behavior, or prescribe complex nonlinear boundary conditions. This capability provides for tremendous flexibility to solve real-world problems.

Solvers
- Direct profile solver
- Direct sparse solver
- Direct multifrontal sparse solver
- Iterative solver - preconditioned conjugate gradient method with performance improvements
  - Diagonal
  - Incomplete Cholesky
- Nonsymmetric solver

√ *Enhancement in 2003*

√ Loads and Constraints
- Mechanical loads - concentrated, distributed, centrifugal, Coriolis, volumetric, and gravity
- thermal loads
- Wave loading for beam and pipe elements
- Initial stresses and initial plastic strains
- √ Cavity - pressure - volume constraint
- Kinematic constraints
- Transformation of DOFs
- Elastic foundation
- Tying (multipoint constraints)
- √ MSC.Nastran compatible RBE2 and RBE3
- Cyclic symmetry
- √ Nonlinear springs
- √ Insert of elements within elements, automatic constraints



Initially the air spring is pressurized; as the moles of gas are increased, the pressure and volume increase. During operation the pressurized air spring is compressed. Because the moles of gas are fixed, the volume decreases while the pressure increases.

Ease of Use
- AXITO3D: Axisymmetric transfer to full 3-D (parallelized)
- Analysis progress reporting
- Customized exit messages
- Dynamic memory allocation
- Fully integrated with MSC.Marc Mentat and MSC.Patran
- Energy calculations and output
- √ Forming limit evaluation

MSC.Marc, providing solutions for your engineering needs.

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