

Solve Your Complex Thermal – Mechanical Simulations with Marc

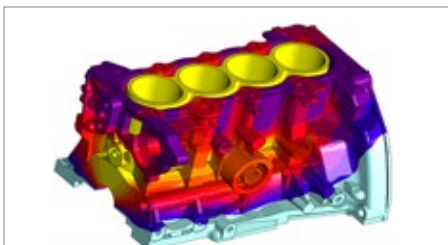
Thermal - Mechanical Simulations in Marc

Marc provides solutions for thermally driven problems of complex engineering systems. Marc has been successfully applied to multi-physics applications in the aerospace, automotive, energy and manufacturing industries.

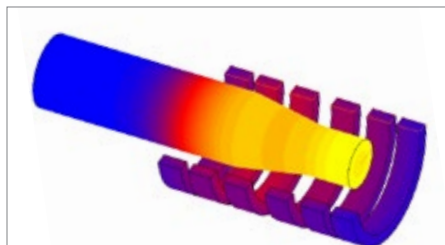
Engineers can simulate complex heat transfer and thermal stress problems using the complete and integrated solutions inside Marc to improve the quality of their design.

Marc Advantages

- Coupled simulation incorporating multiple physics.
- Accurate prediction of nonlinear structural behavior including large strains and buckling.
- Accurate calculation of thermal strains and stresses for all nonlinear problems.
- Material models for any application.
- Model temperature dependent material properties, including phase transformations and latent heat.
- Complex boundary conditions can be applied to the geometry or the finite element model.
- Contact capability to easily represent energy flow and contact loads including friction.
- Ability to use local adaptive meshing to improve the accuracy of the solution.
- Ability to use global adaptive meshing to overcome large mesh distortions.
- Predict damage, crack initiation, crack propagation and fatigue.
- Model welding and other manufacturing processes.
- Ablation and pyrolysis for thermal protection system and rocket engines.
- Fully integrated with modern GUI.



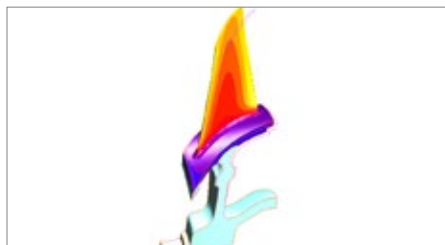
Heat transfer and thermal stress analysis of piston, engine, radiator, batteries and exhaust system can be used in automotive industry.



Induction heat and other E-M driven problems including chips, solder joints, actuators, MEMS. Other processes include plastic curing and metal manufacturing.



Pressure vessel and piping systems used in the energy and chemical industries.



High temperature applications including jet engines, vanes, blades and combustion liners.

Analysis Types

- Steady State and Transient Heat Transfer
- Uncoupled Thermal Stress Analysis – Calculation of Thermal Strains and Resultant Stress
- Coupled Thermal Stress Analysis –The Inelastic Behavior Generates Heat, and the Deformations Influence the Thermal Behavior.
- Quasi-Static or Dynamic Structural Analysis
- Electrical Resistive (Joule or Ohmic) Heating
- Electrostatic and Magnetostatic Thermal Solutions
- Magnetodynamic / Thermal
- Thermal Piezoelectric
- Thermal Diffusion

General Material Capabilities

- Isotropic, Orthotropic and Anisotropic
- Composites
- Temperature Dependent Properties
- Material Database
- Material Encryption
- User Subroutines

Thermal Behavior

- Phase Transformations
- Latent Heat
- Curing Kinematics
- Pyrolysis

Structural Properties

- Elastic-Plastic
- Rate Dependent Material Properties (Creep)
- Shape Memory Material
- Rubber
- Viscoelasticity Including Thermally Rheologically Simple Behavior
- Gaskets
- Material Damage

Electromagnetic Properties

- Nonlinear B-H

Contact and Boundary Conditions

- Structural, Thermal, E-M behavior
- Deformable and Rigid Bodies
- General Contact Assembly Modeling Glue
- Interference Fit, Friction, Wear Modeling
- Thermally Activated Contact
- Treatment of Small Gaps, Spatially Dependent Behavior
- Conventional Thermal, Structural and Electromagnetic Boundary Conditions
- Radiation View Factor Calculation (dependent on deformation)
- Heating Generation (Inelastic Behavior/Friction)

Process for Solving Thermal Simulations with Marc

1 Import CAD Models in Marc

One can import complex parts or assemblies for CAD or import an existing finite element model. Geometric models can be constructed as well. Boundary conditions may be intuitively applied directly to the geometry.



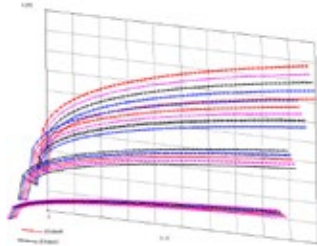
2 Generate the Mesh for the Model

A straightforward process, using a combination of beams, shells and solid elements. Robust automatic meshing tools are available. Either lower order or higher order elements are available along with special elements to model gaskets, composites, and cohesive regions. Tools for geometry and mesh manipulation are available.



3 Create Material Models

Temperature dependent materials may be used. Marc provides a rich set of material models. Material data fitting of the Johnson-Cook plasticity model is shown here which captures temperature and rate effects.



4 Define Contact & Boundary Conditions

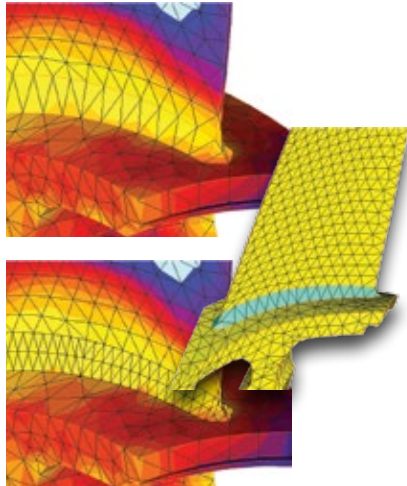
Contact between different parts can be quickly identified. Congruent meshes are not required. Thermal and mechanical interfaces including friction (which can be temperature dependent) can easily be defined. Large deformations which may change both the structural modeling and the conduction, convection and radiation boundary conditions can be incorporated.



Contact Bodies

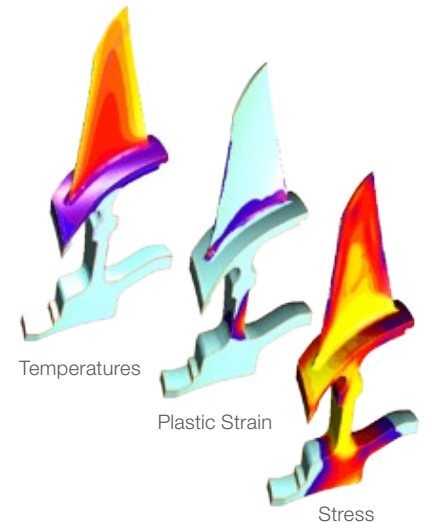
5 Adaptive Meshing to Improve the Accuracy

Define regions where either local or global adaptive meshing is used to capture large gradients. This can improve accuracy and reduce the computational costs by placing elements in the critical location, such as the blade root as shown here.



6 Choose the Analysis Physics and Review the Results

One can visualize the temperature, thermal distortions, stress, damage or magnetic field while the simulation is running to observe the critical regions. Contour, vector, tensor plots may be shown of any quantity to provide deeper insight. Time history displays show the progression of behavior which path or cutting planes can be used to visualize the results in the interior.



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