ANSYS® RELEASE 13.0

ANSYS Multiphysics Solutions

Comprehensive Multiphysics Built on Proven Solver Technology

In real world product environments, multiple coupled physics act simultaneously on designs — the flow of electric current generates heat, fluid pressures create mechanical stresses, and temperature gradients induce thermal stresses. By incorporating multiphysics simulation into the design process, engineers reduce error margins, increase product reliability, and ultimately create more innovative product designs. Multiphysics simulation from ANSYS provides a portfolio of high-fidelity engineering analysis tools that enable engineers to accurately predict real-world behavior. ANSYS multiphysics solutions combine the most comprehensive set of solver technology for all physics disciplines — structural mechanics, heat transfer, fluid flow and electromagnetics — with an open and adaptive ANSYS® Workbench™ environment, flexible simulation methods, and parallel scalability. Together these cutting-edge technologies form the foundation for comprehensive multiphysics simulation capable of solving the most complex engineering challenges.

Unified Simulation Environment

The ANSYS Workbench platform is a powerful multi-domain simulation environment that harnesses the core physics from ANSYS, enables their interoperability, and provides common tools for interfacing with CAD, repairing geometry, creating meshes and post-processing results. An innovative project schematic ties together the entire simulation process, guiding the user through complex multiphysics analyses with drag-and-drop simplicity.

Flexible Simulation Methods

ANSYS multiphysics solutions deliver proven methods to solve multiphysics problems, including solutions for both direct and sequentially coupled problems. These solution techniques provide the technology required to solve a broad range of multiphysics problems, such as induction heating, electrostatic actuation, resistive heating and fluid structure interaction (FSI).

Product Features

Structural Analysis
- Static, modal, harmonic and transient analysis
- Spectrum analysis
- Buckling analysis
- Random vibration
- Geometric, material and contact nonlinearities
- Displacements transferred to thermal, electric, magnetic or fluid analysis

Thermal Analysis
- Steady-state and transient analysis
- Spectrum analysis
- Conduction, convection and radiation
- Phase change
- Mass transport
- Fluid elements
- Temperature-dependent material properties
- Temperatures transferred to structural, electric, magnetic or fluid analysis

Electrostatic Analysis
- Charge-based electric elements
- Trefftz method for open domain
- Electrostatic forces transferred to structural analysis

Steady-State Current Conduction
- Current-based electric elements
- Infinite elements for open domain
- Currents transferred to magnetostatic analysis
- Resistive losses transferred to thermal analysis

Low-Frequency Electric Field Analysis
- Charge and current based elements
- Infinite elements for open domain
- Time-harmonic and time-transient quasistatic
- Resistive and dielectric losses transferred to thermal analysis
- Currents transferred to magnetic analysis

Product Features

Magnetostatic Analysis
- Magnetic vector potential and scalar potential elements
- 3-D edge flux element formulation
- Resistive losses transferred to thermal analysis
- Magnetic forces transferred to structural analysis

Low-Frequency Magnetic Analysis
- Magnetic vector potential elements
- 3-D edge flux formulation
- Quasistatic magnetic
- Time-harmonic analysis for linear materials
- Time-transient analysis for linear and nonlinear materials
- Permeable and saturable materials
- Permanent magnets
- Resistive and eddy current losses transferred to thermal analysis
- Magnetic forces transferred to structural analysis

High-Frequency Electromagnetic Analysis
- First- and second-order tangential vector elements
- 3-D brick, pyramid, prism and tetrahedral element shapes
- Cavity modal analysis
- Harmonic analysis: wave propagation, radiation and scattering
- Isotropic and anisotropic materials
- SPICE-equivalent circuit output
- Resistive and dielectric losses transferred to thermal analysis

Circuit Analysis and Coupling
- Coupled electromagnetic field analysis and discrete electric circuits
- Resistors, capacitors, inductors, diodes, transformers, voltage and current sources
- Electromechanical transducer
- Interactive circuit builder
- Coupling to both stranded and massive conductors

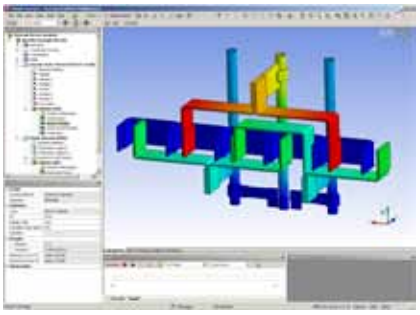
Ion Optics
- Charged-particle tracing in electric or magnetic static fields, or both
- Plot trajectories in 2-D or 3-D

Direct Coupled-Field Elements

Direct coupled-field elements allow users to solve multiphysics problems by employing a single finite element model with the appropriate coupled-physics options set within the element itself. A direct coupled-field solution simplifies the modeling of multiphysics problems by allowing the engineer to create, solve and post-process a single analysis model for a wide variety of multiphysics applications.

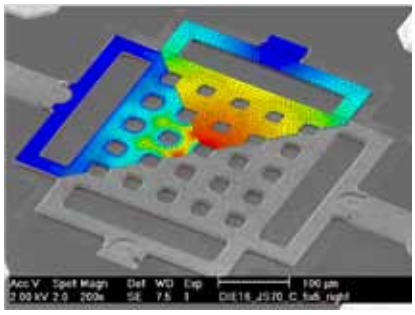
Key Features of Direct Coupled-Field Elements

- Single model simplifies multiphysics simulation
- Support for a broad array of coupled physics
- Robust for highly nonlinear multiphysics solutions
- Support for parallel processing
- Includes nonlinear material and geometric effects



Buss-bar of a short-circuit test transformer with current up to 150 kA – thermoelectric-structural coupling solved in the ANSYS Workbench environment

Model courtesy of WEG Electrical Equipment



Coupled electrostatic-fluid-structural model shows pressure (left quadrant) and displacement (right quadrant) overlaid on scanning electron microscope image of an RF MEMS switch

Image courtesy of EPCOS NL and Phillips Applied Technology

Sequential Coupling

Sequential coupling allows engineers to solve multiphysics problems with the automated multiphysics coupling available in ANSYS Workbench, which couples multiple single-physics models into one unified simulation. The platform supports both one-way and two-way sequential solutions for multiphysics problems such as thermal-stress analysis, microwave heating and fluid structure interaction.

Key Features of Sequential Coupling

- Automated load mapping between analysis systems
- Both one-way and two-way coupling options
- Support for a dissimilar mesh interface between physics models
- Allows collaboration between physics experts
- Advanced fluid structure interaction

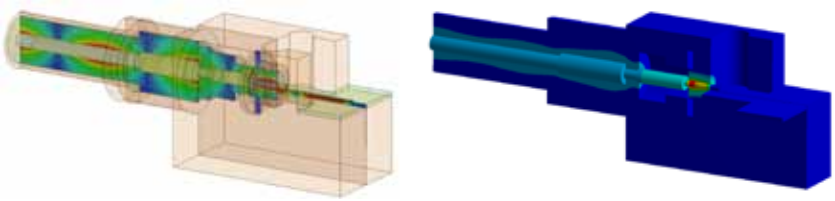
Benefits of Multiphysics Solutions from ANSYS

ANSYS continues to lead the CAE industry in developing multiphysics solutions that provide the high-fidelity simulations required to meet the challenges of today's demanding product R&D processes. ANSYS multiphysics solutions offer a portfolio of software that provides powerful simulation tools for solving industry's toughest multiphysics challenges. Features include:

- Advanced solver technology for all physics
  - Structural mechanics, heat transfer, fluid flow and electromagnetics

ANSYS®

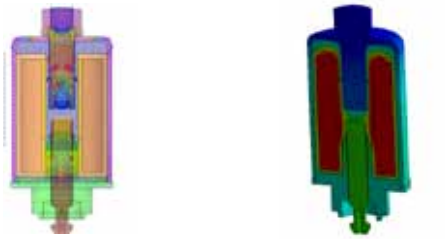
- A unified simulation environment for multiphysics simulation
- Fully parametric multiphysics analysis
- Parallel scalability for multiphysics simulation
- World class support and services from ANSYS



High-power connector, electric field results calculated in HFSS (left) and steady-state temperature results (right) solved with ANSYS Mechanical

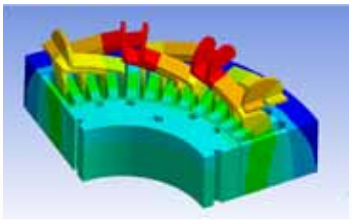
Multiphysics Product Spectrum

Multiphysics solutions from ANSYS are offered through a range of products to meet current simulation requirements along with a seamless upgrade path for future simulation needs.



Solenoid actuator, magnetic flux results calculated in Maxwell (left) and steady-state temperature results (right) solved with ANSYS Mechanical

ANSYS® Multiphysics™ software offers a comprehensive solution for multiphysics and single-physics analysis, including structural, thermal, fluid and electromagnetic analysis. The product includes solutions for both direct and sequentially coupled physics problems for supported physics.



Steady-state temperature of a generator, eddy current, core and resistive losses from Maxwell imported into ANSYS Mechanical

ANSYS® Mechanical™/Emag™ software is a comprehensive solution for structural, thermal and low-frequency electromagnetic analysis. The product includes solutions for direct and sequentially coupled physics problems for supported physics.

ANSYS Mechanical/CFD-Flo is a comprehensive solution for structural, thermal and fluid analysis. The product includes solutions for both direct and sequentially coupled physics problems for supported physics.

ANSYS Mechanical technology is a comprehensive product solution for structural and thermal analysis. The product includes solutions for direct and sequentially coupled physics problems for supported physics.

Product Features

Fluid Flow Analysis
- Tetrahedral, hexahedral, prism and/or pyramid elements
- Steady-state and transient flow
- Laminar and turbulent flows
- Incompressible, compressible – subsonic, transonic, supersonic
- Rotating or stationary frame of reference
- Conjugate heat transfer
- Radiation
- Newtonian and non-Newtonian fluids
- User-defined equations and species transport
- Free surface modeling
- Fluid structure interaction
- Fluid pressures and temperatures transferred to structural analysis
- Heat flux and temperatures transferred to thermal analysis

Acoustics
- Modal, harmonic and transient analysis
- Fluid medium
- Fully coupled fluid–structural

Direct Coupled-Field Elements
- Piezoelectricity
- Piezoresistivity
- Piezocaloric effect
  - Thermoelastic damping
- Coriolis effect
- Electroelasticity
- Thermoelectricity
  - Joule heating, Peltier, Seebeck and Thomson effects
- Thermal–structural
- Thermal–electric–structural

Sequential Coupling Options
- Electrostatic–structural
- Electrostatic–structural–fluid
- Thermal–structural
- Thermal–electric
- Thermal–electric-structural
- Thermal–electric–fluid
- Thermal–fluid
- Electromagnetic–thermal
- Electromagnetic–structural
- Electromagnetic–fluid
- Electromagnetic–thermal–structural
- Fluid structure interaction

Product Features

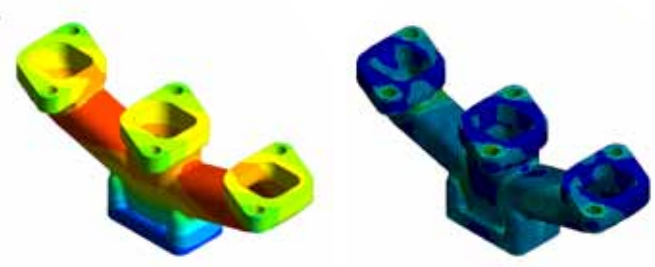
Optimization
- Design optimization
- Topological optimization
- Probabilistic design
- Variational technology
- Parametric simulation

ANSYS Parametric Design Language
- Macros
- Parametric modeling
- If-then-else constructs
- Do-loop features
- Array parameters
- Array parameter operations
- Trigonometric functions

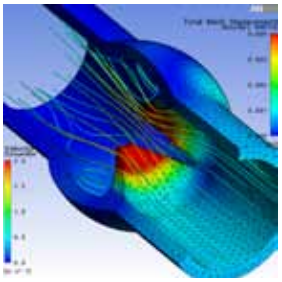
Solvers
- Sparse direct
- Jacobi conjugate gradient (JCG)
- Incomplete Cholesky conjugate gradient (ICCG)
- Pre-conditioned conjugate gradient (PCG)
- Quasi-minimal residual (QMR)
- Algebraic multigrid (AMG)
- Eigensolvers
  - Block Lanczos
  - PCG Lanczos
  - Supermode modal solver
  - Householder (reduced)
  - Unsymmetric
  - QR-damped

ANSYS Supported Platforms
Refer to www.ansys.com for a current list of supported hardware platforms and operating systems.

Additional Modules
- ANSYS® HPC
- ANSYS® DesignModeler™
- ANSYS® DesignXplorer™
- ANSYS® Fatigue™
- ANSYS® Rigid Dynamics
- ANSYS® Explicit STR™



Exhaust manifold, temperatures (left) from a conjugate heat transfer model solved with ANSYS® FLUENT® mapped to an ANSYS Mechanical thermal-stress (right) solution using the ANSYS Workbench platform.



Two-way fluid-structure interaction of a three lobe valve, solved using ANSYS CFX and ANSYS Mechanical

ANSYS CFD is a comprehensive solution for computational fluid dynamics, which includes both the ANSYS® CFX® and ANSYS FLUENT solvers. The product incorporates one-way and two-way FSI when combined with an ANSYS Mechanical license.

HFSS™ is a comprehensive solution for 3-D full-wave electromagnetic field simulation. Surface and volumetric losses can be imported into ANSYS Mechanical, enabling thermal simulation.

Maxwell® software is a comprehensive solution for low-frequency electromagnetic field simulation. The product includes links to ANSYS Mechanical and ANSYS FLUENT, enabling fluid, thermal and stress analysis for electromechanical designs.

The ANSYS Advantage
With the unequalled depth and unparalleled breadth of ANSYS engineering simulation solutions, companies are transforming their leading-edge design concepts into innovative products and processes that work. Today, almost all of the top 100 industrial companies on the "FORTUNE Global 500" invest in engineering simulation as a key strategy to win in a globally competitive environment. They choose ANSYS as their simulation partner, deploying the world's most comprehensive multiphysics solutions with engineered scalability that delivers the flexibility to solve their most complex engineering challenges.

ANSYS®

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