



Product Behavior

Characterizing the behavior of a product (a part or an assembly of parts) under operational conditions can be done in three ways:

Empirical characterization refers to creating a prototype(s) of the product that, optimally, replicates the manufacturing steps to be used in its production run. The product then is tested to determine its behavior and to make final judgment on whether the product will perform successfully in the field. Typically, this judgment is of a yes–no nature. In other words, the product will fail or not; hence its design is acceptable or not.

Deterministic characterization typically refers to an analysis of the product without testing it. This analysis could range from simple engineering handbook calculations to elaborate finite element analyses (FEA). Once again, the typical judgment is of a yes–no nature.

Probabilistic characterization quantifies the reliability or quality of the product by means of a statistical analysis. Probabilistic characterization combines the deterministic characterization, either handbook or FEA analysis, with statistical analysis tools to address the effect of statistical variability and uncertainty influencing the product's behavior. Probabilistic analysis typically involves four areas of statistical variability: geometric shape, material properties, loading and boundary conditions. For example, the statistical variability of the geometry of a product would try to capture product-to-product differences due to manufacturing imperfections quantified by manufacturing tolerances. Because the statistical analysis typically requires many data points, a combination of computer-based FEA analysis with statistical analysis is the most time- and cost-efficient method in practice. Unlike the first two methods, probabilistic characterization provides a probability of success or failure and not just a simple yes–no evaluation. For instance, a probabilistic analysis could determine that one part in 1 million would fail or the probability is of a product surviving its expected useful life.

Quantify the Quality of Products with ANSYS® DesignXplorer™

Design for Six Sigma (DFSS) builds quality into a product. By assessing the variations that a product experiences during manufacture and use, it is possible to make a product that performs its intended function regardless of these variations; such a product is “robust,” and, therefore, Design for Six Sigma is sometimes called Robust Design.

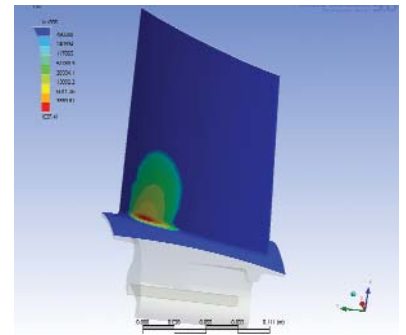
Design for Six Sigma is an analysis technique to determine the extent to which uncertainties in the model affect the results of an analysis. Based on a probabilistic characterization, Design for Six Sigma enables users to quantify the quality of a product by addressing issues such as minimizing warranty costs and by assessing the reliability of the product. DFSS goes one step further than a probabilistic characterization by allowing users to optimize design variables to achieve a particular probabilistic result such as Six Sigma, which, including long-term effects, is 3.4 failures in one million parts!

Six Sigma initiatives try to optimize the manufacturing process so that it automatically produces parts conforming to Six Sigma quality. In contrast, DFSS optimizes the design itself so that the part conforms to Six Sigma quality even with variations in manufacturing. For both Design for Six Sigma and Robust Design, quality is an explicit goal of the optimization.

ANSYS DesignXplorer software enables Robust Design by allowing the user to define both design variables and uncertainty variables, and then to optimize a set of reliability goals for quantities such as fatigue life, stress or deflection.

Variational Technology

Users can look beyond traditional aspects of simulation and analyze entire systems with ANSYS DesignXplorer software using the Variational Technology method. This gives users a broader view of design concepts, providing complete FEA results for every design point. Depending on the analysis problem, the Variational Technology (VT) method can provide acceleration factors up to 100. With VT, users can approach product design decisions much more efficiently.

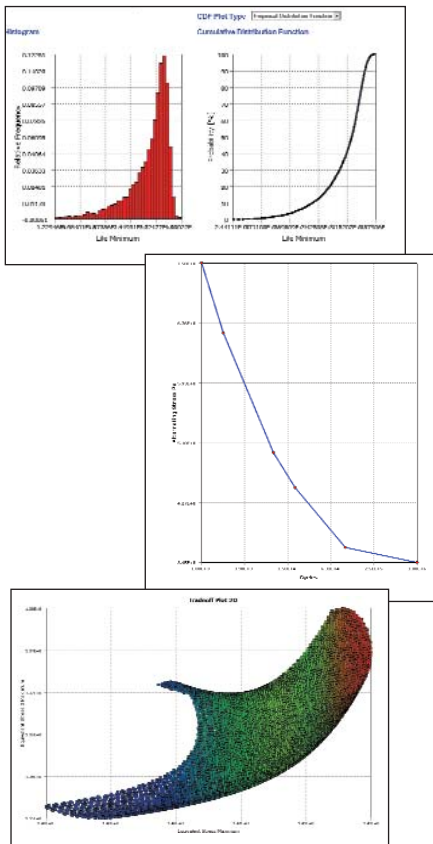


Product Features

ANSYS DesignXplorer software using DOE works with the ANSYS Workbench environment, APDL-based files and any application or sequence of applications, including in-house codes, by using the third-party plug-in.

ANSYS DesignXplorer using the VT method works within the ANSYS Workbench interface to select geometric CAD parameters or geometric parameters from ANSYS DesignModeler, active or inactive spot welds, parts and bodies, element parameters, material properties, and loads.

ANSYS DesignXplorer using the VT method works within ANSYS to select material properties, real constant values (such as thickness), active or inactive element parameters, and loads.



Using the VT method to automatically calculate the entire design envelope within a single finite element solution, ANSYS DesignXplorer software allows users to perform quick and accurate what-if scenarios to periodically test design ideas. A traditional design of experiments (DOE) approach requires many solutions to capture the behavioral changes due to parameter variations. For boolean parameters, the practical limit using traditional methods is about 10 boolean parameters, but the VT method handles up to 20 boolean parameters.

The VT method allows designers and analysts to make intelligent design decisions given multiple competing objectives. These variations can include geometric computer-aided design (CAD) parameters, element properties, material properties and load variations. ANSYS DesignXplorer software allows engineers and designers to study, quantify and graph the structural analysis response to alternative design parameters.

The Variational Technology method addresses many kinds of parameters:

- ▶ Geometric variations (CAD or ANSYS® DesignModeler™)
- ▶ Boolean variations (active or inactive status of spot welds, stiffening ribs, bolts, etc.)
- ▶ Element property variations (shell thickness, spring stiffness, point mass)
- ▶ Material variations (engineered plastics, composites, metals)
- ▶ Load variations (inertia as well as surface structural and thermal loads)

Design of Experiments

ANSYS DesignXplorer provides solutions for analyses that go beyond linear statics and normal modes by using Design of Experiments on any ANSYS® Workbench™ simulation, including those with CAD parameters. Although it requires more analyses to be performed, Design of Experiments is not limited in terms of analyses types. In fact, ANSYS DesignXplorer software can be used with ANSYS® Parametric Design Language™ (APDL)-based files to perform DOE on existing or new ANSYS analyses. ANSYS DesignXplorer allows the user to perform optimization and Design for Six Sigma with any application or sequence of applications, including in-house codes, by using the third-party plug-in.

ANSYS DesignXplorer software has a powerful suite of DOE tools. Automatic Design Points can be generated two ways: Central Composite Design (CCD) or Optimal Space-Filling. CCD provides a traditional DOE sampling set, while Optimal Space-Filling's objective is to gain the maximum insight with the fewest number of points. After sampling, ANSYS DesignXplorer software provides four different meta-models to represent the simulation's responses: Full Second-Order Polynomial, Kriging, Non-Parametric Regression and Neural Network. Kriging has two variants, pure Kriging and Radial Basis Function. These meta-models can accurately represent highly nonlinear responses. Once the simulation's responses are characterized, ANSYS DesignXplorer supplies three different types of optimization algorithms: Screening (shifted Hammersley), Multi-Objective Genetic Algorithm (MOGA) and Nonlinear Sequential Quadratic Programming (NLPQL). Thus, ANSYS DesignXplorer software offers a full suite of sampling, modeling and optimization routines to address a wide variety of applications.