

I-DEAS® Variational Analysis is a finite element analysis program for mechanical structural analysis. By allowing the introduction of variables into the simulation process, I-DEAS Variational Analysis calculates the relationship between design variables and performance criteria. With a single iteration (one mesh, one solve), I-DEAS Variational Analysis generates all the results for every set of parameter values. These results can be used to provide design guidance, insight into prototype failures, and performance-based tolerances, to name a few.

I-DEAS Variational Analysis has extended the power of variational technology to analysis. With I-DEAS variational design technology (VGX™), you can create a single piece of geometry that describes your entire design space. With I-DEAS Variational Analysis, your design space is directly translated into an evaluation space, so that when you are done with your first evaluation, you know how the design will perform in numerous configuration.

## Improving Design Studies

Today, many companies employ spreadsheets to conduct design studies. These spreadsheet models assess overall characteristics of a design as a function of key parameters. Spreadsheets allow engineers to quickly review global sensitivity behavior. However, these spreadsheet models, which are based on mathematical expressions, cannot match the finite element method for capturing the impact of geometry details, complex environmental conditions, or location-dependent material behavior. I-DEAS Variational Analysis has the benefits of both the finite element method and spreadsheets.

After you perform a single finite element analysis, I-DEAS Variational Analysis lets you generate design curves and surfaces, which relate performance variables to key design parameters. Such curve and surface generation is done without executing any additional finite element solutions. The resulting design curves or surfaces account for interacting effects across all the selected design variables.

## One Model, One Mesh

I-DEAS Variational Analysis uses the same mesh for all configurations. This allows you to make direct comparisons between one configuration and another. Using only one mesh:

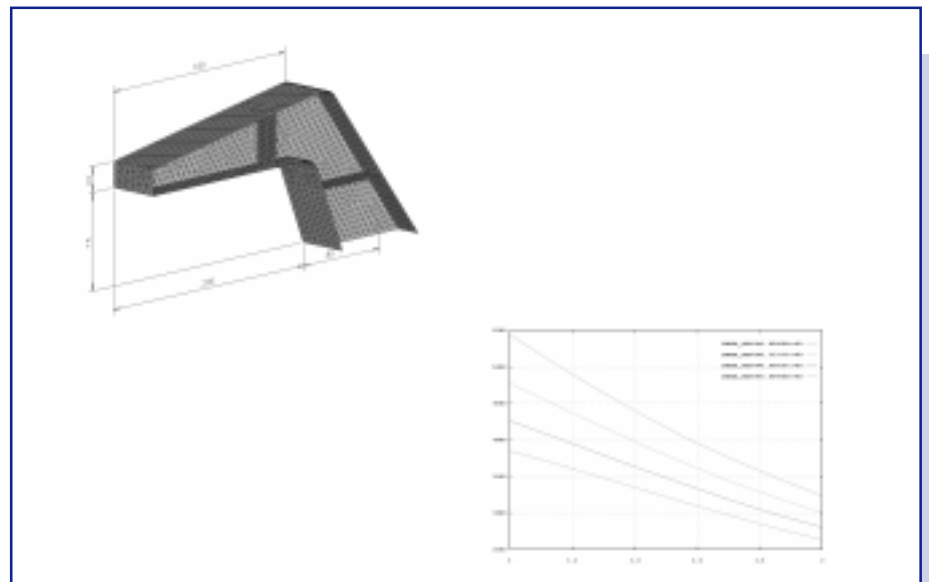
- Saves re-meshing time.
- Reduces the uncertainties associated with mesh effects.
- Gives you more confidence in the accuracy of the results.

I-DEAS Variational Analysis is integrated into the I-DEAS Model Solution™ solver, and supports linear structural static analysis for components and assemblies (Assembly FEM). This integration enables the use of the Sparse solver technology, which enables very fast solutions times. Additionally the very robust and reliable element library within I-DEAS Model Solution is being used. Once you have meshed the part and selected the design variables, you hit one button and get the results for the entire design space in one solve.

These element types are supported:

- Solid linear and parabolic tetrahedrons
- Solid linear and parabolic wedges
- Solid linear and parabolic bricks
- Axisymmetric solid linear and parabolic triangles
- Axisymmetric solid linear and parabolic quadrilaterals
- Plane strain linear and parabolic triangles
- Plane strain linear and parabolic quadrilaterals
- Plane stress linear and parabolic triangles
- Plane stress linear and parabolic quadrilaterals
- Beam - 2 node (linear)
- Beam - 2 node (tapered and curved)\*
- Beam - 3 node
- Constraint
- Rigid
- Lumped mass
- Spring node-to-ground translational
- Spring node-to-node translational
- Spring node-to-ground rotational
- Spring node-to-node rotational

\* Variational changes not permitted.



Once you have meshed the part and selected the variables, you hit one button and you get the results for the entire design space in one solve.

## One Solution

I-DEAS Variational Analysis can greatly improve both the quality and speed of redesign. By evaluating interactively the effects of changes for various parameters (e.g., geometry, physical and material properties), it allows you to find the combination of design changes that satisfy the performance criteria and the objectives for the structure without having to perform multiple simulations.

Although requiring only one solve, I-DEAS Variational Analysis provides you with the flexibility to perform three different types of analysis:

- **Baseline Analysis** - A baseline analysis is recommended before performing a sensitivity or parametric analysis. The baseline analysis provides the same results as a non-variational solution. The baseline analysis can verify the consistency of the results. Additionally mesh convergence may be checked by using a series of baseline solutions. If the design variable behavior is fairly well understood and the number of design variables is reasonable, you can go directly to a parametric analysis to study the relationship between the design variables. But if the design parameters of the structure are not well understood, it is best to perform the sensitivity analysis to gain some understanding about each of the design variables.
- **Sensitivity Analysis** - Sensitivity Analysis enables designers to understand the behavior of the parameters. Due to the relatively inexpensive cost of a Sensitivity Analysis, a large number of parameters can be studied. I-DEAS Variational Analysis performs a Taylor series expansion about the baseline configuration to obtain the results for the various parameter values.

- **Parametric Analysis** - Parametric Analysis deals with a reasonable number of parameters to enable you to understand the behavior of the interaction of the parameters with each other. With this understanding, a better mechanical design can be obtained. I-DEAS Variational Analysis uses a multi-parameter Taylor series expansion about the baseline configuration to obtain the results. All the parameters can be modified simultaneously for a fully coupled analysis. Using the parametric results, you can then perform several interactive optimizations to determine various sets of parameter values that satisfy different objectives.

## Easy to Use

To perform a variational analysis, you first define a mesh and apply boundary conditions, just as you would for a traditional analysis. Next, you solve the model and create a variational output database. Using the variational output database, you can then interactively modify parameters and have the results immediately available, allowing you to create digital design handbooks. These design handbooks allow the non-specialist to make design decisions, fully aware of how those decisions will impact performance.

## Post-Processing

Display and management of results data is also provided. Once you generate the variational output database, you can plot the results as an XY(Z) function or histograms, or use the Visualizer to see the results as a contour, arrow or element plot.

- **XY(Z) Graphing** -You can display, review, and manipulate all results using extensive XY(Z) graphing capabilities.

Results include:

- Displacements
- Stress and strain
- Strain energy
- Element forces
- Reaction forces
- Mass
- **Histograms** -You can weigh parameters with respect to one or several scalar criteria. You can then use Histograms to sort out the parameters by displaying the weight in decreasing or increasing order.
- **Visualizer** - You can use the Visualizer to review and make decisions about your results. The Visualizer enables you to view multiple results simultaneously, and to easily plot the display. Using the Visualizer, you can:
  - Display contour plots.
  - Create element displays.
  - Display arrow plots.
  - Review deformed geometry.
  - Animate results.

## Prerequisites

Core Simulation

## For More Information

For more information, contact your local SDRC representative or call 1-800-848-7372.