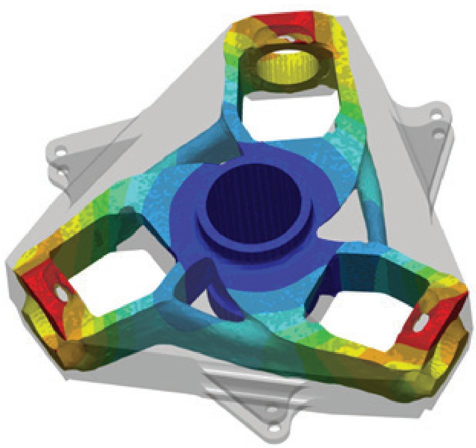
Application Brief

ANSYS Topology Optimization Upgrades Designs to Take Full Advantage of 3-D Printing

Most design projects begin with a basic idea of the what the design should look like. The design is typically optimized by making incremental changes, such as adjusting the size or thickness of features to optimize characteristics like strength, weight, size and manufacturing cost. Product designers usually don't even consider starting with a blank sheet of paper because of the impracticability of manufacturing random shapes and the time and cost that would be required to totally rethink the design. The innovation of 3-D printing has changed the design landscape by making it possible to build virtually any shape without regard for design for manufacturability rules. Now ANSYS provides designers with the tool they need to take full advantage of these capabilities — automated topology optimization integrated with its full suite of multiphysics software. The new ANSYS topology optimizer dramatically reduces the engineering cost and lead time required to design a new generation of parts or products that are optimized to reduce weight and manufacturing cost while delivering the same performance as the current generation.



Challenge

Traditional manufacturing methods impose stringent design for manufacturability and assembly constraints. For example, manufacturability rules for molding typically include the need for draft angles to enable ejection of the part, uniform wall thickness to minimize warpage, radiused corners to improve plastic flow during molding, etc. Three-dimensional printing eliminates these and other restrictions for plastic and metal parts, making it economically feasible to build complex structures that provide higher performance-to-weight and performance-to-cost ratios than can be achieved with conventional manufacturing methods. The design freedom offered by additive manufacturing opens an infinite array of product designs for potential exploration. Taking advantage of this freedom requires overturning conventional wisdom and force of habit by daring to design products based on entirely new paradigms. Traditional simulation methods, in which designs are explored one at a time by manually defining their geometry, or dozens at a time by parametrically varying their dimensions, are not up to the task of exploring a potentially unlimited design space.

Solution

Topology optimization is well-suited to fully exploit the design freedom provided by additive manufacturing by starting from blank space and iterating to an optimized design while changing both the basic shape and dimensions of the part. Topology optimization violates common rules of thumb, such as maintaining uniform thickness, round holes, uniformly spaced features, etc., in order to minimize the weight and cost of the part while meeting the objectives specified by the design engineer or analyst. Topology optimization is not a new technology, but companies interested in taking advantage of it have up to now faced several obstacles. Topology optimizers have largely been stand-alone solutions that use relatively basic solvers, limiting the accuracy of the optimized design. Today's topology optimizers require learning a new simulation environment and converting the optimized design back into another simulation environment for validation and simulation with respect to other physics such as flow, vibration, nonlinear effects, heat and electromagnetic radiation. Topology optimization often requires many solver runs, and the stand-alone solvers used by these tools are often not very efficient at utilizing computing resources, resulting in long solution times. Finally, the intricate geometries that usually result from the topological optimization process can often be very difficult to manipulate using conventional parametric modeling tools.

The new ANSYS topology optimizer overcomes these limitations through its integration with ANSYS Mechanical and the ANSYS Workbench multiphysics simulation environment. Topological optimization is performed with the industry-leading ANSYS Mechanical solver, which provides a complete set of element behavior, material models and equation solvers for nearly any mechanical design problem. Design engineers and analysts can perform topology optimization in an environment they already know and perform multiphysics simulations such as thermal, nonlinear, fluids, vibration, and electromagnetic without having to translate their geometry. Like other topology optimizers, the ANSYS solution only optimizes the shape of the part with respect to structural loading. However, since ANSYS technology was designed from the ground up for multiphysics, the potential exists in the future for complete multiphysics optimization. ANSYS technology enables highly scalable HPC deployment, providing virtually unlimited capacity for high-fidelity topological optimization. Lastly, the ANSYS SpaceClaim Direct Modeler makes it easy to work with the complex models that often result from topology optimization, enabling users to create and modify any portion of the design simply by pushing, pulling and rotating faces while nearby geometry adjusts in real time.

The first step in performing topology optimization is to understand the load environment and the design objectives. The user then defines the starting geometry to the full extent of the envelope that limits the outer boundaries of the part. Any features that must be present on the part, such as mounting surfaces, are then defined. The last step is defining the objectives of the optimization. This could be, for example, to minimize the weight of the part while holding stress and deflection within specified values. After the solver returns the optimized geometry, the design engineer or analyst typically opens the geometry in ANSYS SpaceClaim and performs any needed modification and simplification without having to be concerned with parametric constraints.

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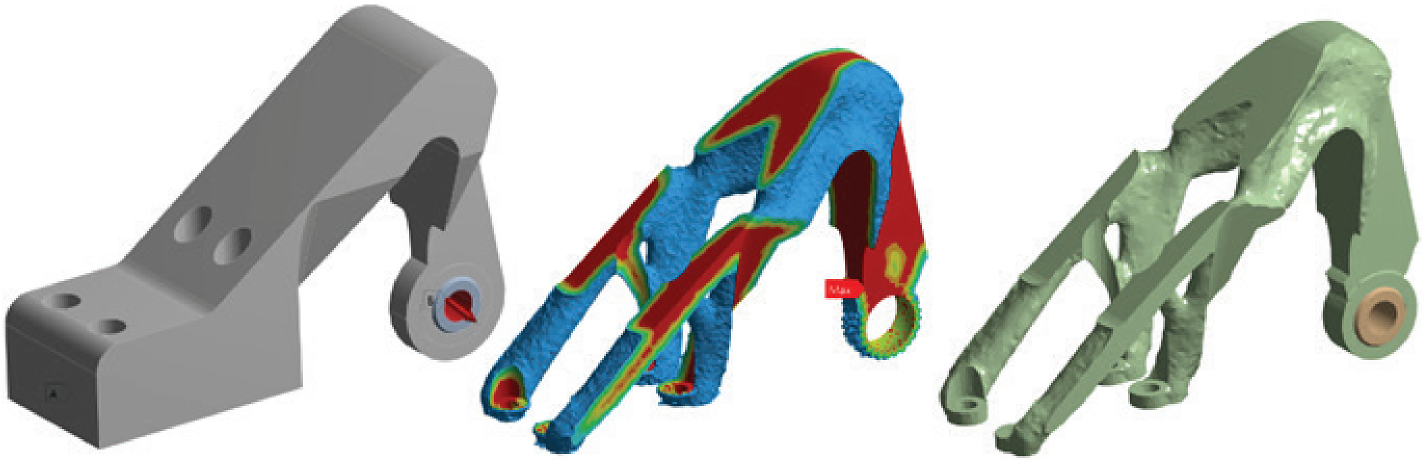

Original design going through topology optimization

Summary

ANSYS topology optimization empowers designers and analysts to take full advantage of the capabilities offered by 3-D printing by optimizing the design of parts and products without regard for the constraints imposed by conventional manufacturing processes or previous practice. The new simulation technology makes it possible to reduce weight and manufacturing costs while ensuring that parts and products deliver the same level of structural performance as the previous generation. Topology optimization reduces the time and expense of the product design process by automating the process of exhaustively exploring the complete geometrical design space and iterating to the design that best meets the specified objectives. Design engineers may also be able to improve the performance of parts by using topology optimization to eliminate a resonant frequency that could not be removed using conventional design methods. Simply reducing the weight of a part may improve the performance of the product. For example, lightweighting a rocker arm can often increase engine performance.

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