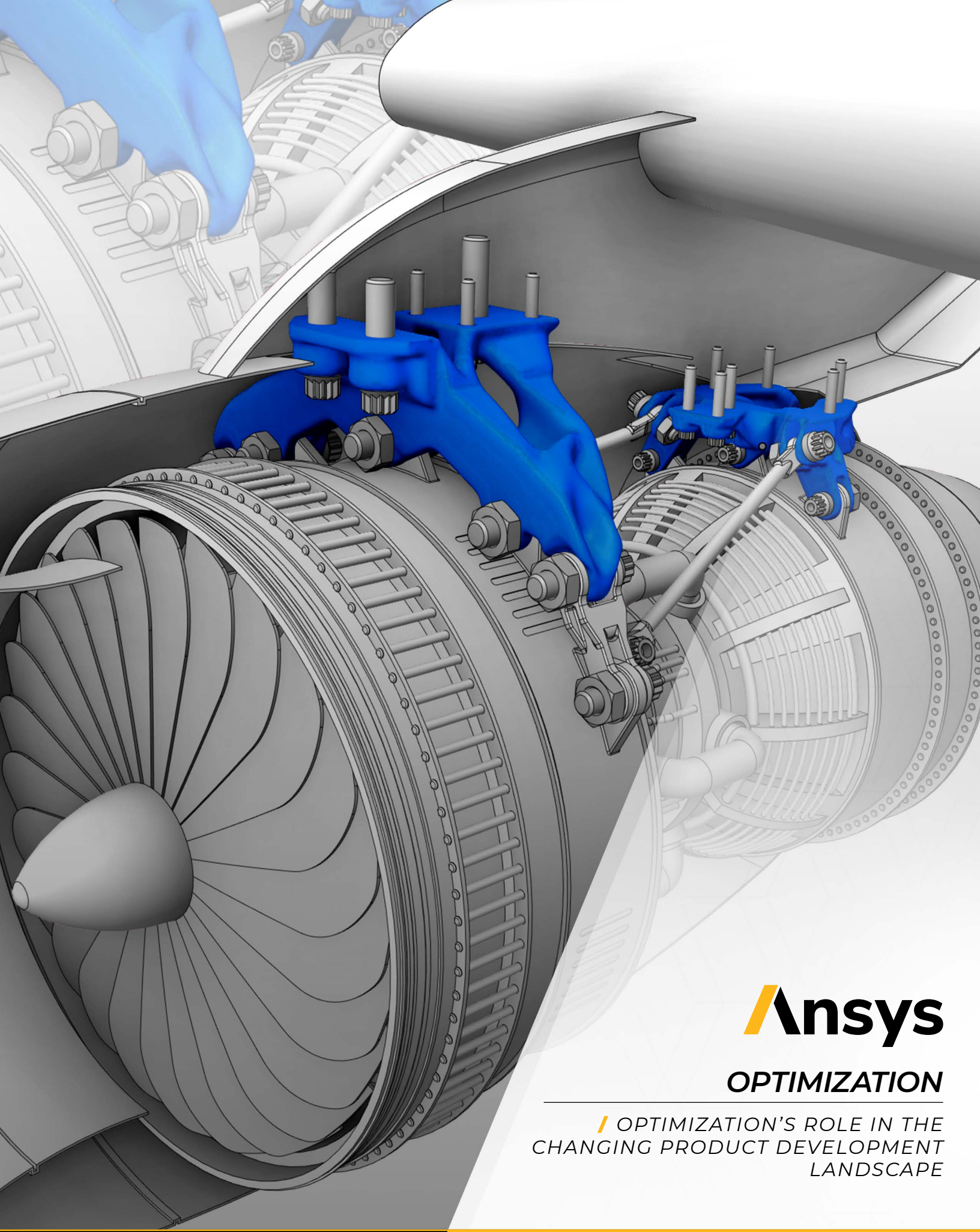

Ansys

OPTIMIZATION

OPTIMIZATION'S ROLE IN THE CHANGING PRODUCT DEVELOPMENT LANDSCAPE

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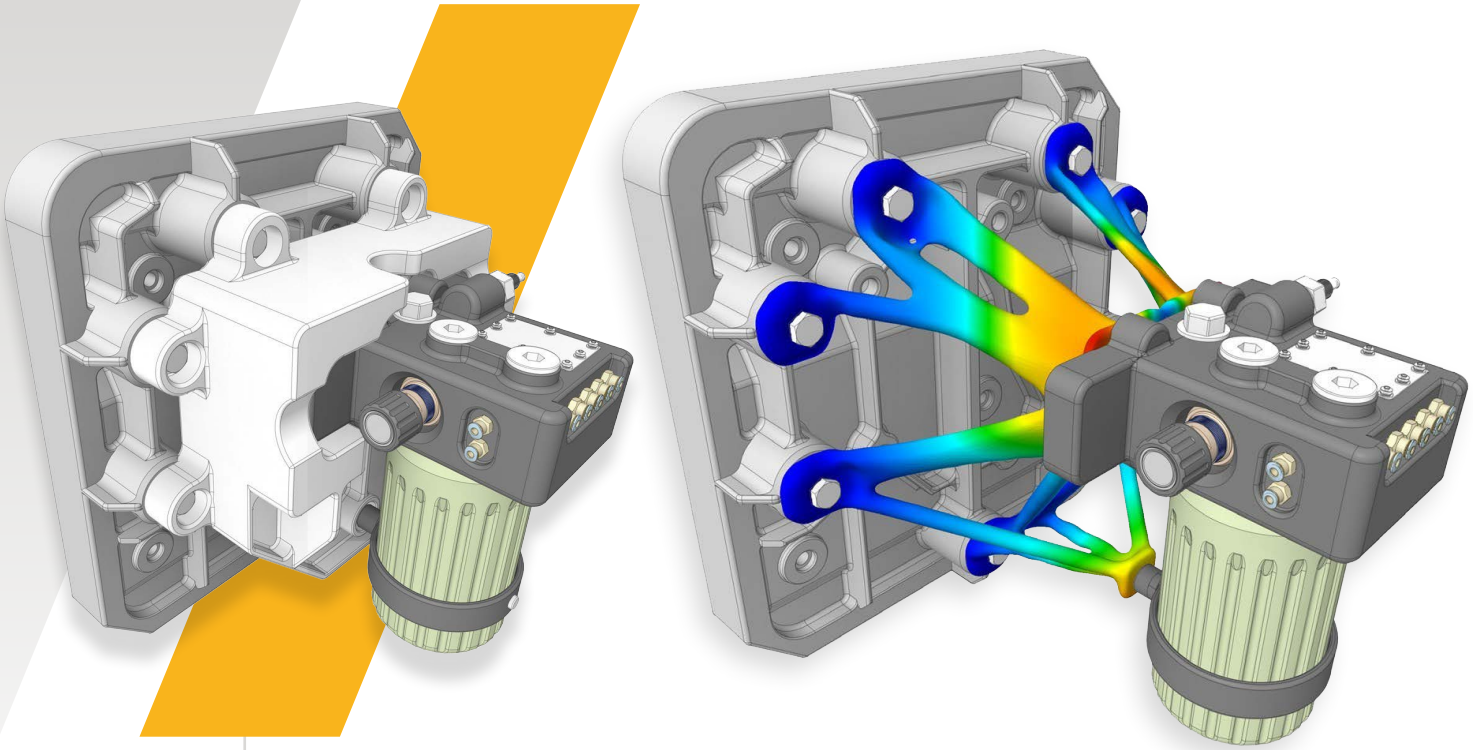
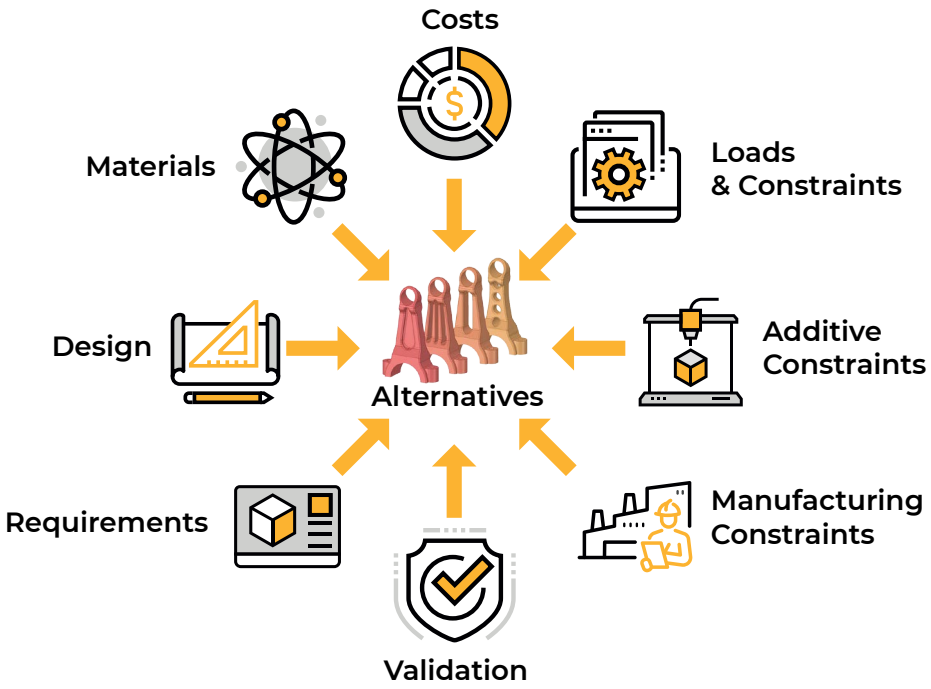


Changing Landscape in Product Engineering

When it comes to product engineering, the landscape is changing. Companies must contend with a host of new challenges when designing and developing products. First, competition is stiff and growing. Product companies must compete not only with local rivals, but overseas competitors as well. To succeed in this hyper-competitive environment, companies need to design products that meet all requirements and bring them out to market quickly, all while keeping costs down.

Companies also continue to grapple with rising product complexity. Today, products must meet requirements spanning multiple engineering disciplines. They have to operate under challenging load conditions. They must also satisfy form, fit, and function while being aesthetically pleasing, safe, and made from environmentally sustainable materials. If that sounds like a lot, it's because it is. These requirements are extensive and all- encompassing—and they are growing by the day.

This competitive landscape requires engineers to develop products that are lightweight, use the cheapest material, and satisfy functional requirements. They must also design, test, and produce these products faster than ever before. The best way to meet these challenges is two- fold. First, companies must optimize product designs for cost, weight, and other important goals. Second, they must stay abreast of developments in additive manufacturing and leverage them. Using these technologies to their fullest extent is critical for success.

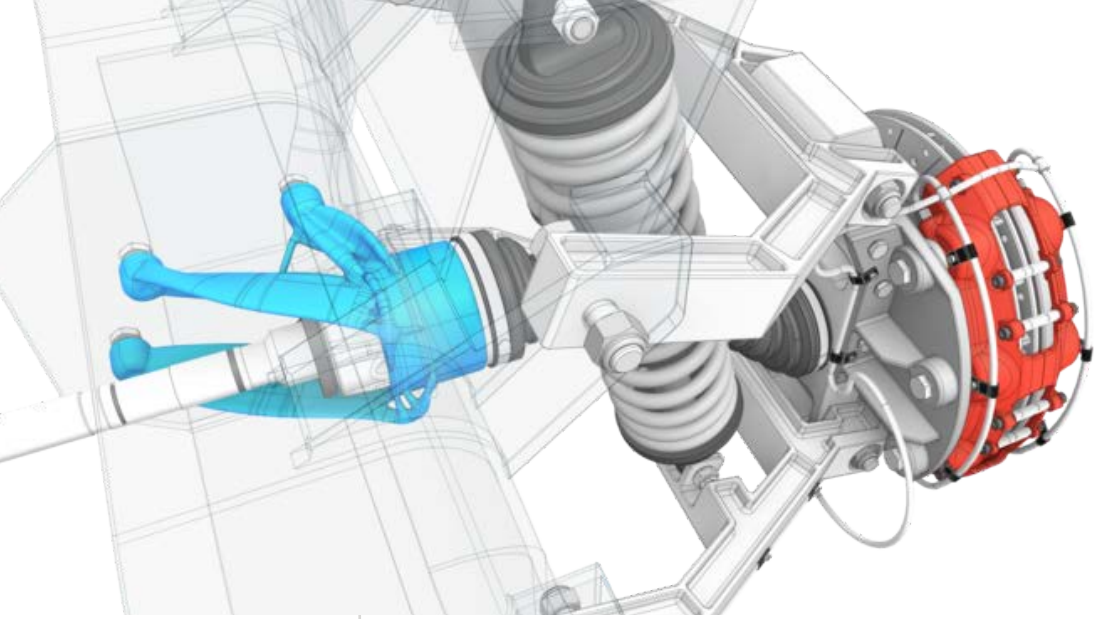


Product Design Process

Companies that wish to overcome these obstacles and succeed must have a robust product design process. The objective of a design process is to create a product that meets all the engineering and business requirements. But in this hypercompetitive environment, most organizations want to do better than just good. A good product becomes a great product when product design is optimized to ensure lower costs, better sustainable materials, and easy manufacturability.

The product design process often starts off in a CAD solution. Engineers will try to incorporate product requirements into the product design concept. They will harness the solution's simulation tools to verify that the design meets product requirements. A series of simulations will guide the process, during which engineers will also use optimization techniques to improve the design. Once the product is ready, users must explore prototyping and manufacturability. New software tools can take companies all the way through the design process, allowing companies to optimize manufacturability for both traditional and additive manufacturing.

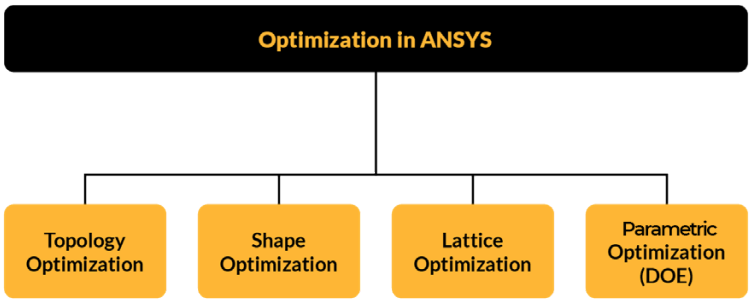
Ansys offers a range of software products that can help engineers take their products from good to great. Ansys Discovery can handle both design and simulation. Engineers that need advanced simulation capabilities can turn to Ansys Mechanical. They can use either Ansys Discovery or Ansys Mechanical to optimize their designs. And Ansys Additive can simulate the 3D printing process for components that will be produced in that manner.



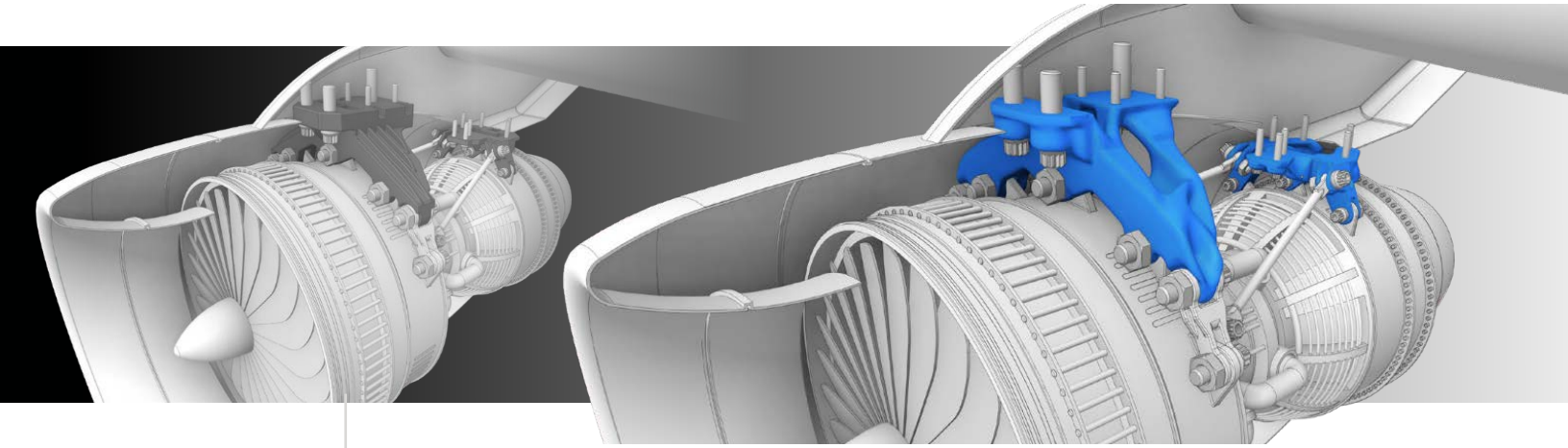
Classification of Optimization Techniques

Engineers need options when it comes to product design optimization, such as topology optimization, lattice optimization, shape optimization, and geometry optimization using the design of experiments technique. A varied optimization toolset empowers companies to adopt the technique best suited for their manufacturing and product design methods.

Incorporating optimization into the product design process yields multiple benefits. Optimization automatically reduces the amount of material in the product without compromising performance. Lighter products cost less to produce and require less energy in the end-use application, which improves environmental sustainability. Optimization also saves time. This automated process enables companies to come up with better designs faster, shrinking the production timeline. Because optimization also considers manufacturing methods, it reduces the time necessary for the manufacturing planning stage as well.



Ansys products offer optimization choices to engineers. Ansys Discovery has real-time topology optimization using GPU acceleration. Ansys Mechanical has topology, shape, lattice, and DOE-based geometry optimization. It also offers high-fidelity simulation, extensive engineering material models, non-linear loading, fatigue analysis, and more. Product companies can use Ansys to better optimize product designs.



Topology Optimization

Topology optimization is an automated procedure that allows a design engineer to develop an optimal product structure. The resulting design will meet all specified material requirements, space constraints, manufacturing constraints, and operating load conditions.

Topology optimization allows companies to resolve conflicting, yet essential goals in the spheres of engineering, manufacturing, and business. On the engineering side, topology optimization considers physics-based targets such as structural strength, stress peak, eigenfrequency, thermal conduction, etc.

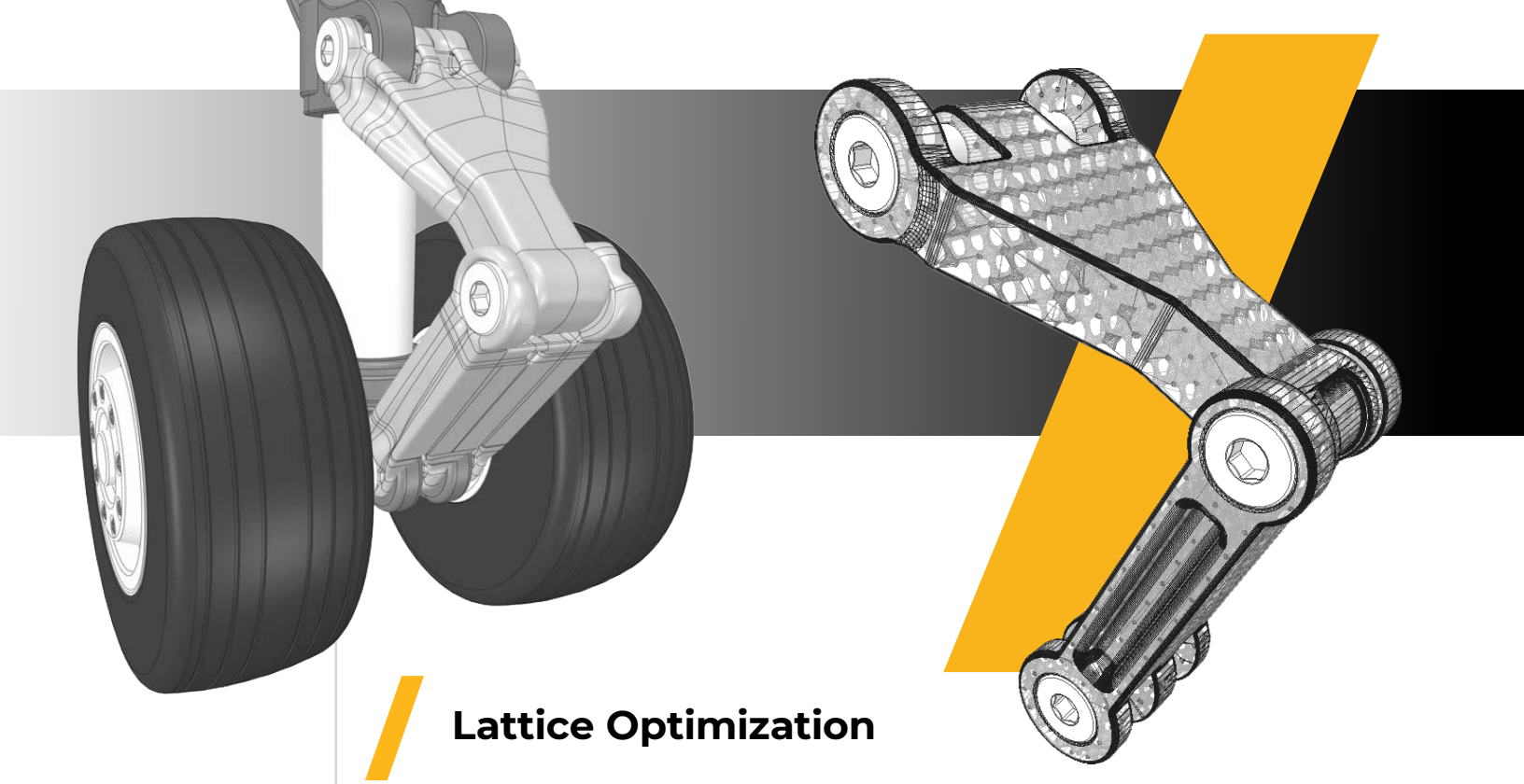
Topology optimization must also meet and respect all manufacturing constraints. To achieve business goals, topology optimization should focus on weight reduction, cost reduction, and improved sustainability. A design engineer can watch these goals being balanced in real time using Ansys Discovery's GPU-enabled real- time topology optimization.

Performing topology optimization in Ansys involves a number of steps.

- First, engineers create an initial working domain in Ansys Discovery or Ansys Mechanical, or import one.
- Engineers need to define design optimization objectives, such as reducing product weight by at least 30%. Users can also set performance optimization criteria, such as a safety factor greater than 3 in every product region.
- Users then assign materials, loads, boundary conditions, operating conditions, manufacturing processes, manufacturing tolerances, minimum thickness in regions, exclusion areas, and regions permitted for material removal.
- Next, Ansys optimizes the product design. Engineers can watch the geometry optimization in real time in Ansys Discovery, which helps them understand the rationale behind the changes.
- Meanwhile, full optimization occurs in Ansys Mechanical. Designers are similarly able to study each change that occurs during optimization.
- Finally, engineers can compare the final design to the initial concept to see the weight reduction and the differences in structural performance.

40%

reduction in weight



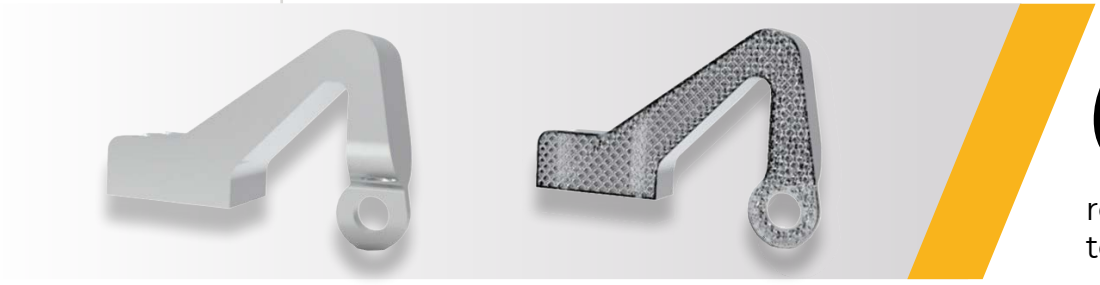
Lattice Optimization

Topology optimization allows engineers to create an optimal product design, but lattice optimization allows engineers to take things a step further. Engineers can reduce weight even more by adding lattices to their components. Incorporating these lattices can be difficult, but lattice optimization assists engineers with this task. Like topology optimization, lattice optimization considers all loading conditions, constraints, and manufacturing processes, helping to produce an optimal design.

Lattice optimization aims to reduce product weight while maintaining manufacturability. Engineers must consider the type and size of lattice that is necessary while ensuring the product meets all structural requirements. Metal lattice structures can either be 3D printed or cast. Lattice optimization guarantees that the design can be manufactured.

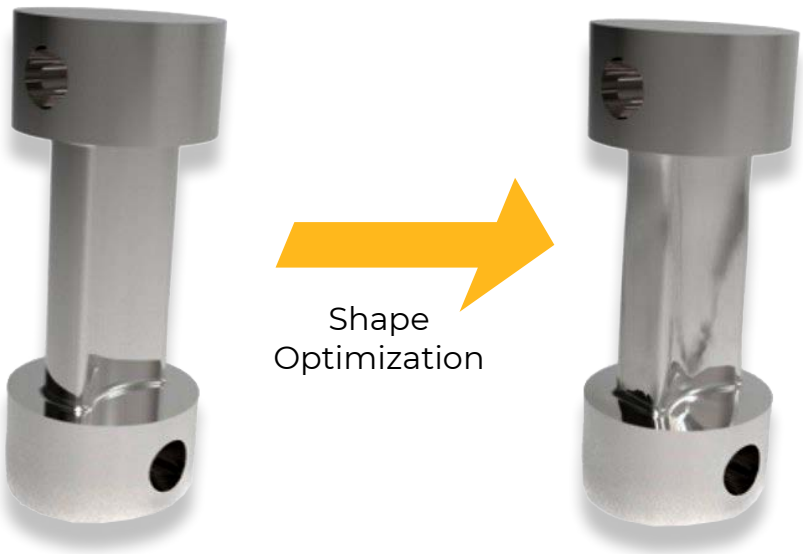
When performing lattice optimization in Ansys Mechanical, engineers must:

- Create an initial design concept or import one. In some cases, users may have already optimized the topology of their product design.
- Next, engineers assign materials, loads, boundary conditions, operating conditions, manufacturing constraints, type of lattice, size of lattice, and lattice regions.
- Ansys Mechanical then creates the design with the lattice structure. This process is automatic and the new design is validated by simulation.
- The optimization process continues until the algorithm arrives at the final validated design.
- Finally, engineers can compare the final design to the initial design to see the amount of weight reduction.



64%

reduction in weight due to lattice optimization



90%
reduction in
plastic strain

85%
reduction in
deformation

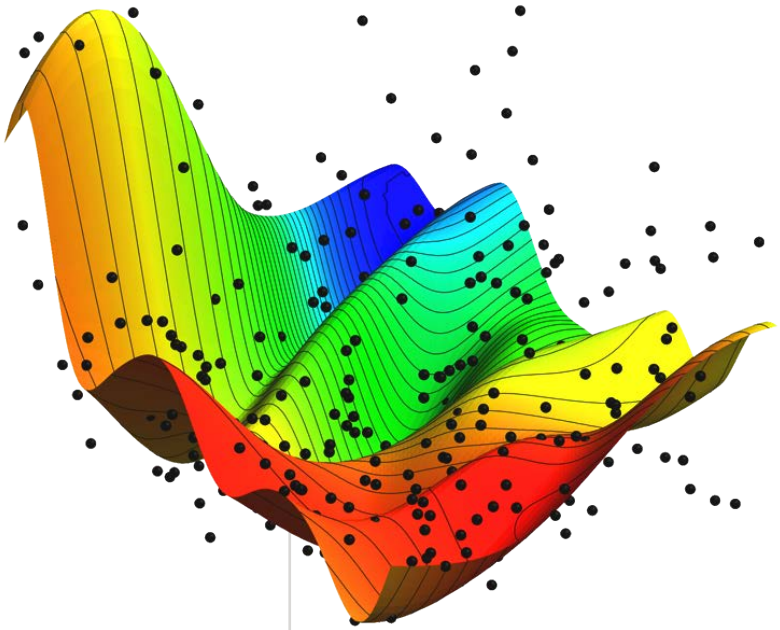
Shape Optimization

Sometimes, engineers need to improve the performance of existing designs. For example, a product may have too high a deformation or plastic strain in certain regions, making it unsuitable for certain applications. Shape optimization allows engineers to create a new design from the existing design, so they don't have to restart from scratch. This process subtly modifies the geometry of the high stress, strain, and deformation areas to achieve the desired level of performance.

Unlike topology or lattice optimization, shape optimization does not remove material. Instead, it morphs the geometry in critical areas. Shape optimization allows design engineers to consider materials and loading conditions to create new designs that meet all structural performance criteria. Users can also use topology or lattice optimization on a shape-optimized design for further weight reduction.

When performing shape optimization in Ansys Mechanical, engineers must:

- Import an existing design.
- Engineers must then assign materials, loads, boundary conditions, operating conditions, and target criteria for quantities such as stress, strain, deformation, and more.
- Next, Ansys Mechanical automatically creates a new shape that satisfies all the product criteria.
- Finally, engineers compare the final design to the initial design, noting improvements in structural quantities like stress, strain, and deformation..



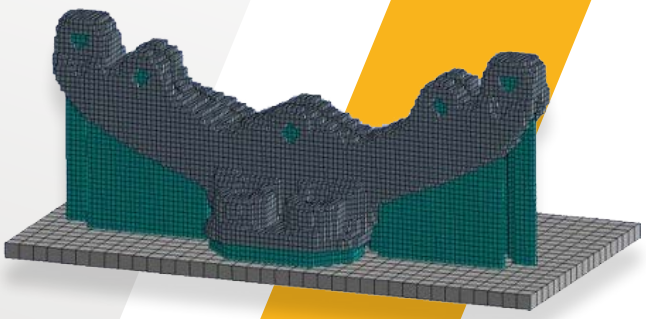
Geometry Optimization using Design of Experiments

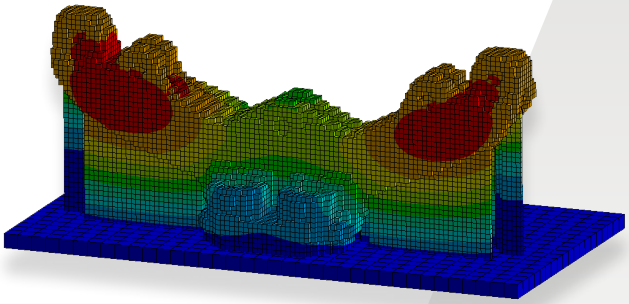
Geometry optimization also helps engineers turn good designs into great ones. In parametric design, critical geometry dimensions such as thickness, the fillet's radius, and the hole's diameter must fall into a range of acceptable values. Using the design of experiments, geometry optimization automatically creates various acceptable designs that meet specified criteria. Designers can filter the different designs to select the best option.

Geometry optimization only varies the geometry parameters that the designer chooses to change. Like other optimization techniques, geometry optimization allows design engineers to consider materials, loading conditions, and manufacturability constraints to create design alternatives that meet all requirements. Engineers can use geometry optimization as the first in a series of steps to arrive at an optimal design. For example, the design engineer can use both geometry and lattice optimization to determine the optimum volume filled with lattices.

When performing geometry optimization in Ansys Mechanical, engineers:

- First create an initial concept design, or import one.
- Engineers need to define a design objective, such as reducing weight by at least 30%. They can also set performance objectives, for example, stipulating that deformation does not exceed a particular value.
- Then engineers assign materials, loads, boundary conditions, operating conditions, and upper and lower bounds for the various dimensions in the design.
- Next, Ansys Mechanical automatically creates multiple designs that meet all the criteria.
- To accomplish this, the software first creates a response surface with the various dimensions as parameters.
- The design engineer then filters through the options to choose one that meets the stated objectives.
- Finally, engineers can compare the selected design to the initial design to see the weight reduction and perform a high-fidelity simulation before prototyping.



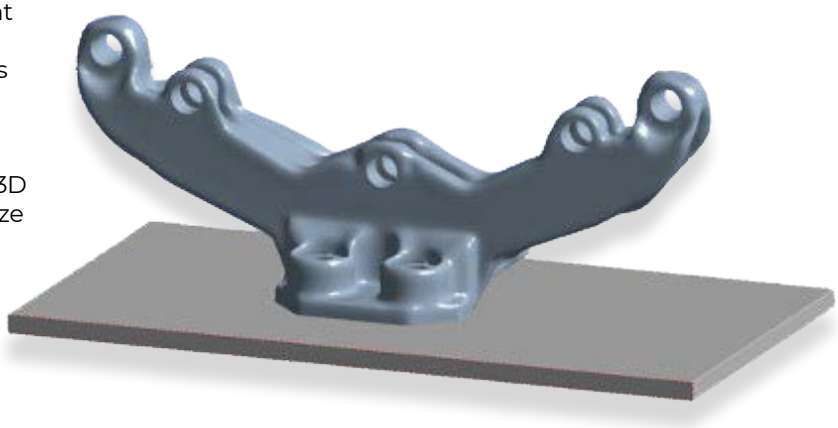


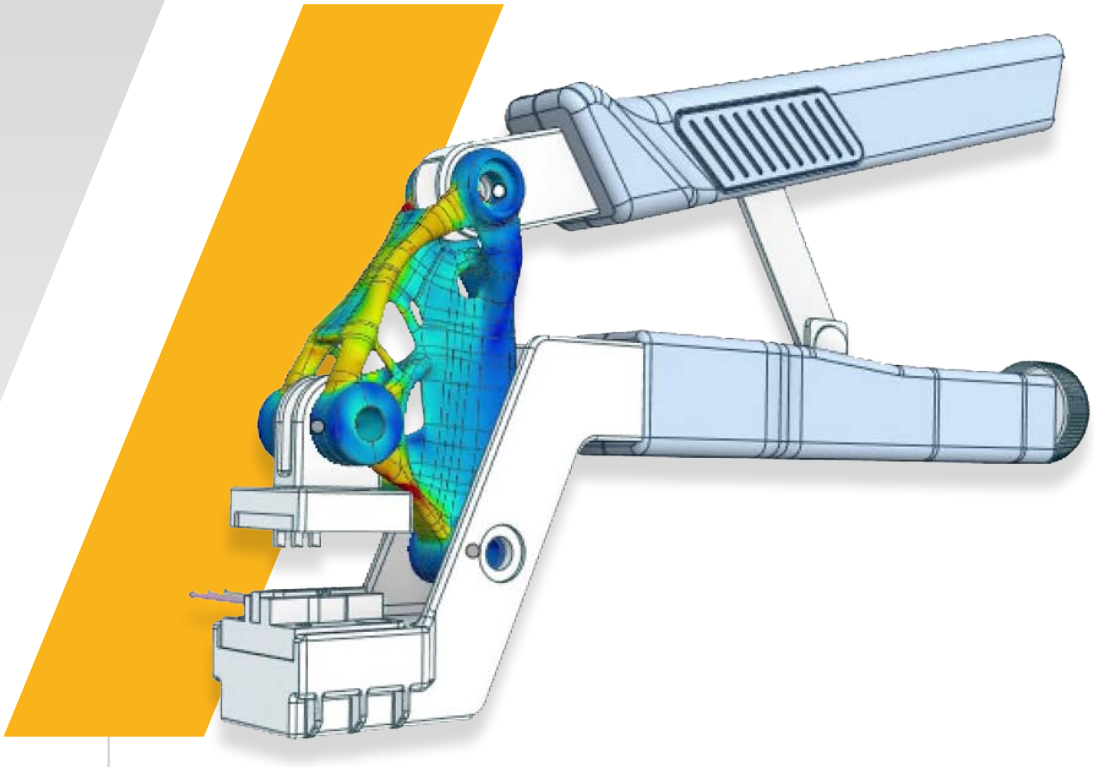
Role of Additive Manufacturing

Additive manufacturing or 3D printing is a digital transformation technology that produces lighter, more robust products. This novel technology allows manufacturers to create innovative products that aren't possible using traditional manufacturing techniques. The additive process creates a three- dimensional product by raising one fine layer at a time.

Many of the optimization techniques mentioned in this eBook produce designs that are difficult to manufacture using conventional methods. However, these innovative designs are ideally suited for 3D printing. By adopting additive manufacturing, companies can make and sell highly optimized parts. Additive manufacturing supports many engineering materials. This includes plastics, resins, polyamide powder, metal powder, metals, resins, and carbon fibers. Metal 3D printing, in particular, is becoming a very competitive technology. Companies are increasingly adopting this technique to produce next-generation engineering products.

Before engineers can 3D print their products, designs must be suitable for printing. Ansys Additive can help engineers validate their designs for the printing process. It can also simulate popular metal 3D printing processes and analyze various materials for their products. This platform enables engineers to 3D print parts successfully the very first time.





Key Capabilities in Ansys Supporting Optimization

Ansys contains a number of features that help product companies perform product optimization:

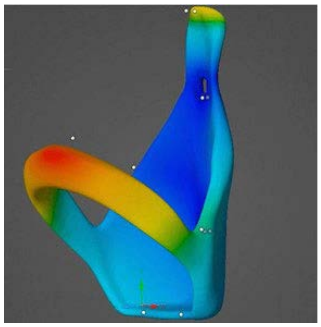
- Real-time shape optimization ensures speed by shortening the time to optimize a design. With this feature, engineers get an optimal design shape in less than a minute.
- Part consolidation enables designers to reduce the number of components needed for a product. The new design shrinks the time involved in manufacturing planning and product assembly. This feature also brings down the overall cost of the product.
- Lightweighting reduces product weight without compromising performance. This feature allows engineers to identify designs that minimize material use. The chosen designs will meet performance criteria, maintain design goals, and respect engineering constraints.
- Structural and model compliance enables engineers to integrate high-fidelity simulation tools into the topology optimization process. Topology can then support multiple case loads and physics, including modal and structural simulations. As a result, engineers can be confident about the product's performance.
- Validation and support for additive manufacturing help design engineers leverage Ansys Additive Suite. The Additive Suite is a comprehensive 3D printing solution. This solution facilitates design for additive manufacturing (DfAM) through validation, print design, process simulation, and exploration of materials. Engineers can avoid build failure and create parts that accurately conform to design specifications with Ansys Additive Suite. In this way, they can print parts right the first time. This minimizes the risk of printing incorrect parts.
- Leveraging the cloud gives engineers the option to deploy high-performance computing (HPC) solutions when solving challenging design problems. In this way, they can arrive at optimized solutions quickly and on demand.

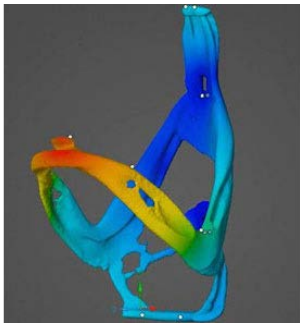
Case study: Predator Cycling

Predator Cycling innovates and manufactures high-quality racing bikes. Aram Goganian, the company's founder, has been pushing the boundaries of racing bike design for years. One issue that bike racers face is that bottles are ejected from bottle cages on the bike during a race, which can cause racers to slow down and ultimately result in injuries.

Designing a water bottle cage that solved this issue was prohibitive. About three years ago, Goganian came up with an idea for a water bottle cage that had a shark-mouth opening, where a racer could come in from the top—almost straight down—to access the water bottle. Unfortunately, Goganian could not create the product using traditional manufacturing processes.

Ansys Discovery's topology optimization features made Goganian's ideal design a reality. Starting from an initial concept, Goganian and his team used the topology optimization in Ansys to automatically come up with a range of designs and validate them quickly on the computer. The novel design was also optimized for 3D printing. The product design team was able to create the new water bottle cage as a result, and Predator Cycling continues to use Ansys tools to develop innovative bike component designs.





Case study: Taesung Software & Engineering DfAM Lab

Taesung Software & Engineering DfAM Lab, established in 2018, is a premier institute in Korea for designing and manufacturing engineering products in aerospace. Using Ansys, the lab redesigned the liquid oxygen (LOX) valve for Korea Aerospace Research Institute. The new design won the lab the 2nd prize in Korea's 4th Annual DfAM competition.

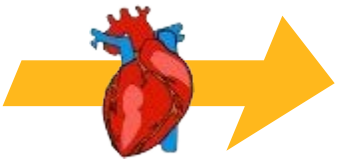
The LOX valve redesign had considerable challenges for the Taesung team. The old valve design had three parts assembled using electron beam welding. But this posed serious quality problems as the welding outcome determined the chances of a leak from the welded joints. A leak during launch will be a critical failure resulting in possible loss of life. The Taesung DfAM lab was tasked with creating a new valve using a single part. The design must be lightweight and must be 3D printed.

Using a suite of Ansys solutions - Ansys Discovery, Ansys Mechanical, and Ansys Additive, the Taesung DfAM lab was able to redesign the old valve entirely and, at the same time, meet all its earlier design requirements. They used the topology optimization in Ansys Discovery to consolidate the three parts and develop a novel heart shape design. Then they validated the new design using Ansys Mechanical for thermal deformation, stress due to internal pressure, random vibration using power spectral density of launch sequence, and first frequency mode constraint. The new valve weighed 15% less than the original one and was cheaper to produce because it had no welding. Finally, using Ansys Additive, the team at Taesung was able to design adequate support and simulate the additive manufacturing process before attempting to print the LOX valve. Using Ansys Additive, the team detected critical fault areas near flanges and blade crash problems. They quickly rectified this issue by adding support reinforcements. Because they validated the printing using Ansys Additive, the team was able to successfully 3D print the LOX valve the first time with no issues.

Original Valve

Mass 100%

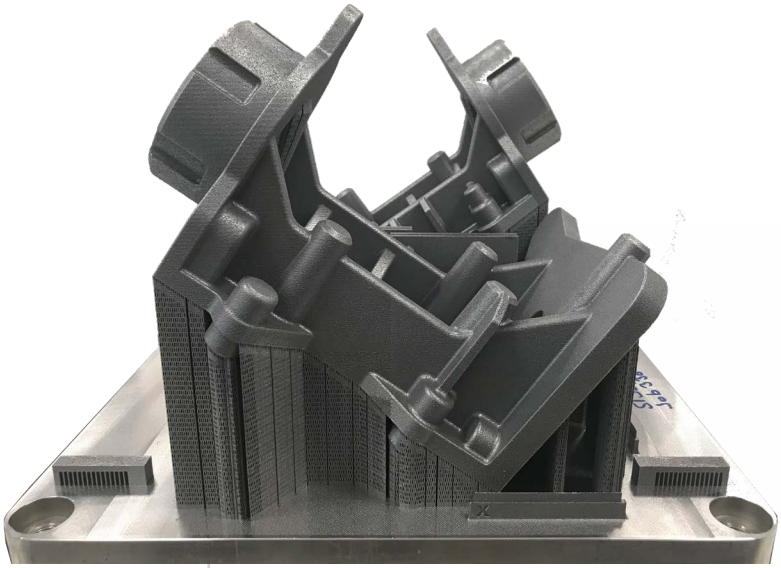
Organic Shape Concept



as "Heart"

Optimized Valve

Mass 85%

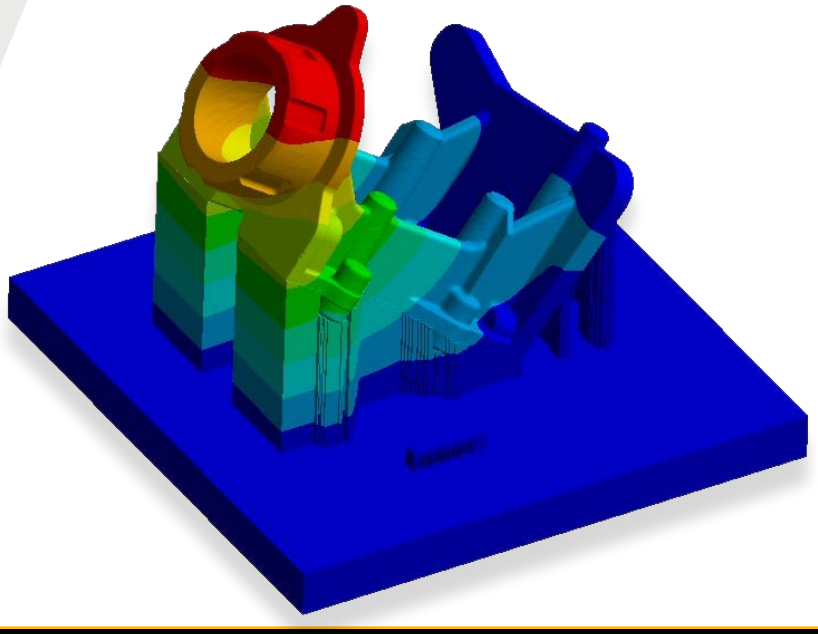


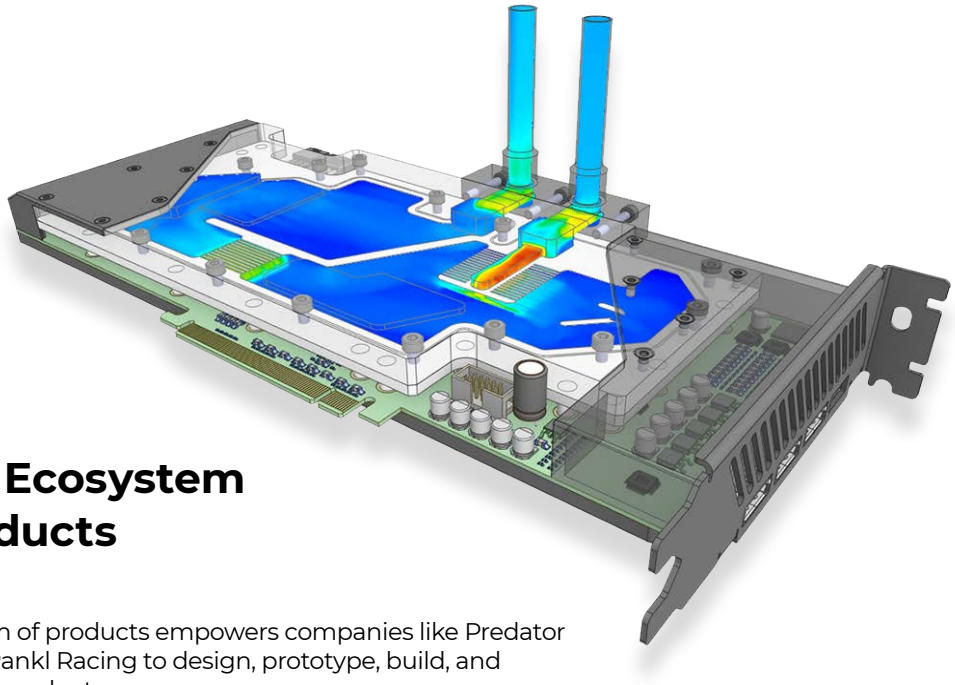
Case study: Pankl Racing

Pankl Racing is working to apply additive manufacturing to produce large, complex product systems for motorsports teams and other high-performance automotive applications. Selective laser melting is key to unlocking the potential of 3D printing for Pankl Racing. This technology opens the door to leveraging 3D printing in demanding environments like race engines.

Selective laser melting occurs during the printing process and adds extra heat to the part being printed. This thermal stress can warp parts. As a result, engineers had to figure out how to best incorporate selective laser melting into their additive manufacturing process.

Ansys Mechanical empowered Pankl to overcome these design challenges by creating part designs that are more conducive to 3D printing. Pankl engineers are able to design support structures that anchor the parts to the substrate plate to conduct heat away from the area that is being printed. Simply put, Ansys allows Pankl to design effective support structures and define strategies that reduce reliance on support structures.





Ansys Ecosystem of Products

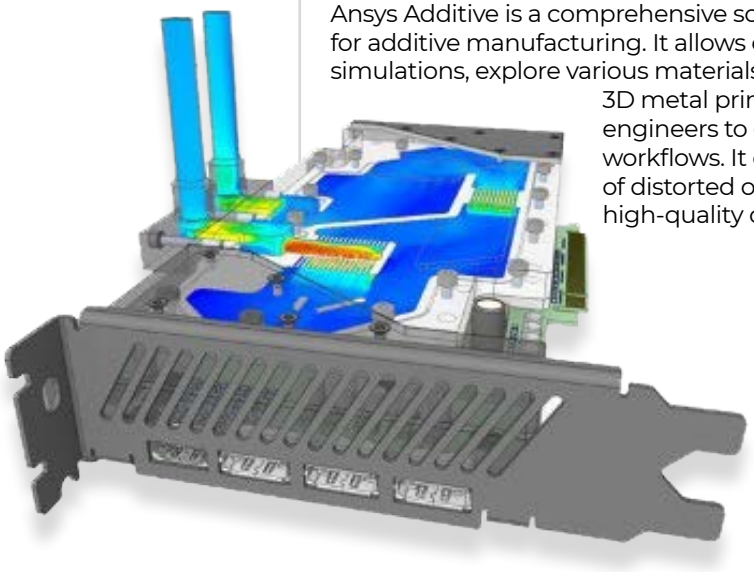
The Ansys ecosystem of products empowers companies like Predator Cycling, Voith and Pankl Racing to design, prototype, build, and manufacture better products.

Ansys Discovery helps product design teams uncover critical insights early in the design process. This product combines interactive geometry modeling and GPU accelerated multi- physics simulation in a single solution. Discovery's upfront and easy-to-use approach to simulation saves time and effort on prototyping. Through early simulation, engineers can explore multiple design concepts in real-time and employ topology optimization to greatly improve the initial design.

Ansys Mechanical helps engineers solve complex structural problems using FEA solvers. This solution contains structural, thermal, acoustic, transient, and nonlinear capabilities that improve product modeling and design. This dynamic solution empowers engineers to solve problems involving composite materials, plastics, fatigue, crack propagation, noise, vibration, harshness, and more. Mechanical has high-performance computing capabilities to quickly solve complex problems.

Product design teams can employ structural and topology optimization to vastly improve the initial design. Engineers can make better, faster design decisions with Ansys Mechanical.

Ansys Additive is a comprehensive solution for designing products for additive manufacturing. It allows engineers to perform 3D process simulations, explore various materials, and validate and print designs. This 3D metal printing simulation software also allows engineers to gain insights through automated workflows. It contains tools that eliminate the risk of distorted or out-of- tolerance parts, ensuring high-quality components.



Recap and Conclusions

Product companies are facing more competition than ever before. This has pushed design teams to develop more complex, innovative products. But creating a good product is not enough. Companies must develop great products. Embracing CAD solutions, such as Ansys' family of products, empowers product design teams to use various optimization techniques to develop great products.

Changing Landscape in Product Engineering

Product design engineers are required to develop complex products faster than their competition while maintaining product requirements and incorporating new technologies, such as additive manufacturing.

Product Design Process

Using simulation and optimization techniques allows engineers to take product designs from good to great.

Classification of Optimization Techniques

Engineers can use various optimizations techniques, such as lattice, topology, and shape optimization to create better product designs.

Topology Optimization

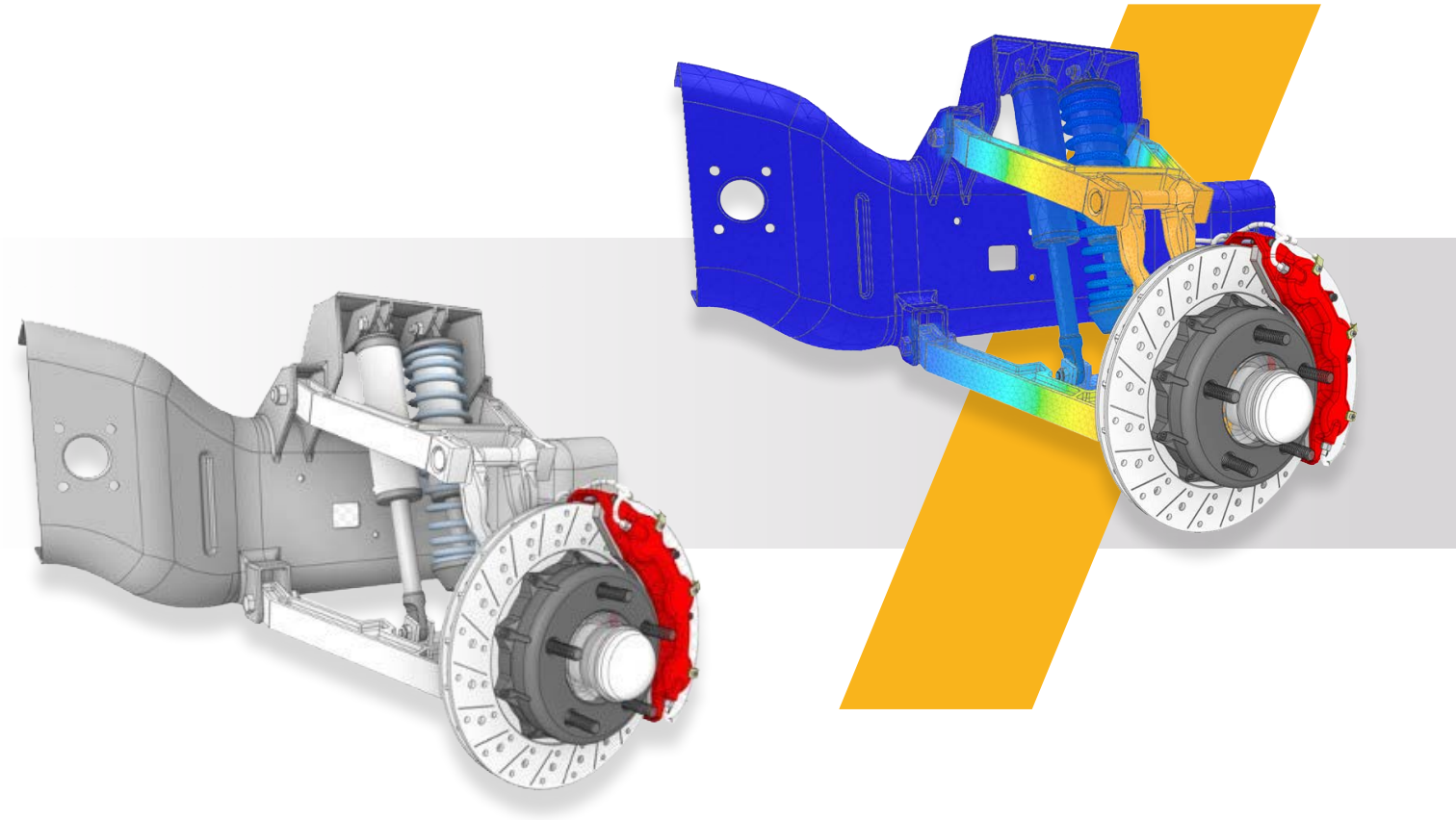
Topology optimization helps engineers balance engineering, manufacturing, and business goals all at the same time.

Lattice Optimization

Automated lattice optimization reduces product weight while ensuring the product meets all structural requirements and can be manufactured.

Shape Optimization

Shape optimization allows engineers to create new product designs from an existing design.



Geometry Optimization using Design of Experiments

Engineers can use geometry optimization techniques to develop multiple product designs that meet product specifications.

Role of Additive Manufacturing

Additive manufacturing allows product engineers to create optimized parts, but designs have to be optimized for 3D printing processes.

Key Capabilities in Ansys Supporting Optimization

Ansys contains a number of features, including real-time shape optimization and structural and model compliance, to take products from good to great.

Predator Cycling

Predator Cycling uses Ansys products to develop innovative racing bike designs that were not possible without Ansys optimization techniques.

Voith

The Voith engineering team uses Ansys simulation to improve sustainable energy.

Pankl Racing

Pankl's and Ansys's partnership has pushed the limits of both additive manufacturing and racing car component design.

Ansys Ecosystem of Products

Engineers can use Ansys Discover, Mechanical, and Additive to create exceptional product designs.

When visionary companies need to know how their world-changing ideas will perform, they close the gap between design and reality with Ansys simulation. For more than 50 years, Ansys software has enabled innovators across industries to push boundaries by using the predictive power of simulation. From sustainable transportation to advanced semiconductors, from satellite systems to life-saving medical devices, the next great leaps in human advancement will be powered by Ansys.

Take a leap of certainty ... with Ansys.

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