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GENERATIVE DESIGN:

Unlocking Your PRODUCT DEVELOPMENT Potential

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Generative design is promising to revolutionize products and the way they're made. Drawing on the strengths of cloud computing and artificial intelligence, the technology creates designs unlike anything engineers might come up with on their own.

How exactly? Here are the basics:

What is Generative Design?

Generative design is a technology in which 3D models are created and optimized by computer software. The process leans on a stack of technologies, including topology optimization and simulation. All of these technologies work together, but the engineer remains in control. Using an interactive process, the user sets up requirements for the model, such as manufacturing processes, loads, and constraints. The software will then autonomously produce a set of design alternatives that meet those requirements.

For example: Say your company has the capability to produce a part by milling, casting, or additive manufacturing. Which process and materials are optimal for the part you're designing? To find the best solution, you can use generative design to show possible combinations of the various materials and manufacturing methods. In the end, you choose the one that best fits your requirements, and further refine from there.

That doesn't mean the designer is off the hook. Generative design doesn't replace engineers. Instead, it's a complement to the design process. There is still a lot of thought put into weight limits, physical constraints, availability of materials, and so on. The better the engineer defines these different criteria, the better the system can discover possible solutions and help create better, more innovative products.

Fortunately, especially for novices, the software can help them explore constraints too. For example, you could set up a design for 3D printing, and then try it again with 3-axis milling. From there, decide which result best suits your budget, time schedule, etc., and set that as the optimal solution moving forward.

In Creo, you can also get additional assistance with Generative Topology Optimization (GTO) and the Generative Design Extension (GDX). Used together, these AI-driven generative design tools can help you deliver more innovative, differentiated products, reduce the time to market, and reduce overall product costs. More on those later.

NOTE: WHILE GENERATIVE DESIGN IS OFTEN ASSOCIATED WITH ADDITIVE MANUFACTURING, IT ISN'T LIMITED TO THAT. IN CREO, YOU'LL FIND SUPPORT FOR BOTH SUBTRACTIVE AND ADDITIVE METHODS.

What Problems Does Generative Design Solve?

Generative design yields hundreds of innovative design options in a short time—especially if the software is tapping the cloud for computing resources.

It's then up to the user to evaluate tradeoffs. For example, even though two models meet specifications, option 1 might be lighter, while option 2 is slightly stronger. Both work, but it's nice to have choices.

(LEFT) A DESIGN FOR A BRACKET ON AN OFFICE CHAIR BEFORE – AND AFTER (MIDDLE) – USING GENERATIVE DESIGN. (RIGHT) THE PART IN THE CONTEXT OF THE CHAIR ASSEMBLY.

The overall benefit is that generative design brings innovative products to market in record time. Though not as immediately apparent, generative design also makes a significant difference to companies that want:

> **Product differentiation.**

Let's be honest, most designs are based on models that worked before. We make incremental changes and hope it's attractive to customers. Generative design allows you to break out of that rut by creating high-performing new parts and products that exceed requirements. Plus, they're not easily duplicated by the competition.

> **Expert results (even from novice engineers).**

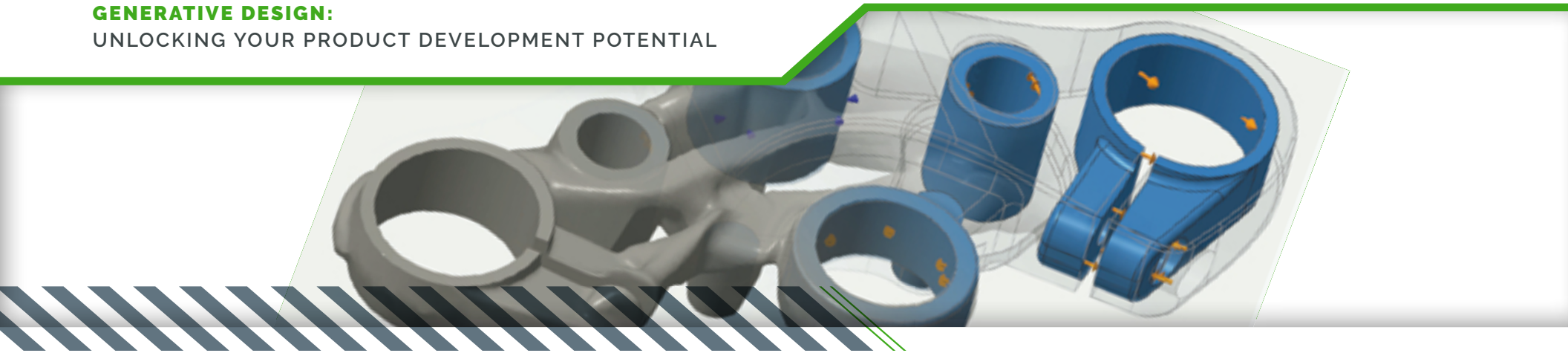
Concerned about the skills gap? An entry-level mechanical engineer can now create a part using generative design without extensive knowledge. (And when the system returns hundreds of suitable solutions? Generative design technology can quickly help you filter myriad design options).

> **Optimized reliability.**

Carry out stress analysis on the generative design results to validate the quality and durability of the designs. This ensures your design works in the real world. (It also saves costs in manufacturing and service support).

> **Improve legacy designs.**

Older products may still be functional, but are they optimized? It's common for engineers to update designs from previous generations. However, generative design may help you find ways to dramatically improve part strength, and reduce overall weight and material use, in legacy designs.



A Faster, More Reliable Approach to Design

Imagine you're a leading manufacturer, and your product designs need months of lead time to produce. New customer demands and competitors are quickly overwhelming you. If innovation doesn't become a cornerstone of your strategy, it's all over.

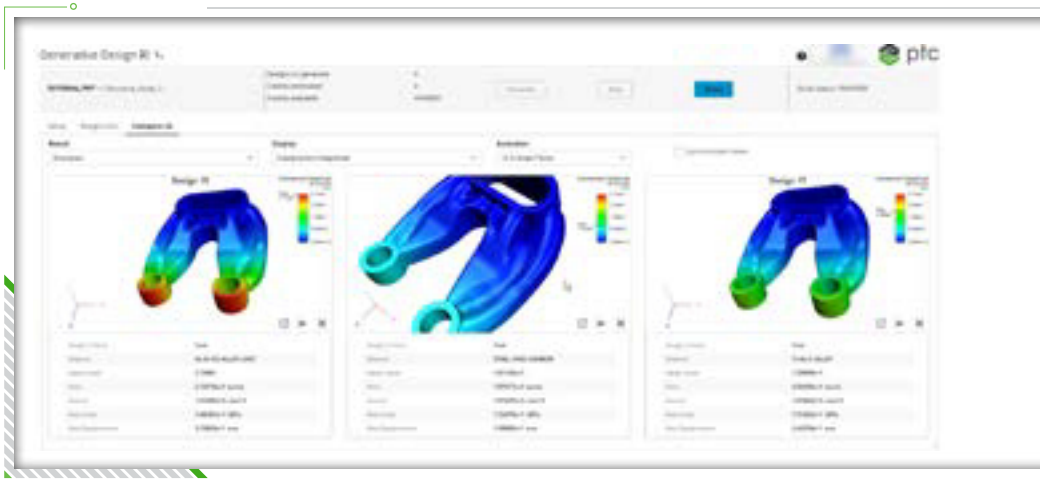
So, what are you going to do?

One idea is to bring artificial intelligence (AI) to bear on your product design process. Generative design is not just a tool, it's also a powerful approach to product development.

To start, your product designers construct a "study." That is, they define the problem they want to solve, choose the design constraints, loads, materials, and manufacturing methods, and feed those requirements to the software. The software then studies that problem, doing countless iterations, and returns an optimum set of solutions to the product team.

The study results are more numerous than the team could have produced on their own. And there are creative design alternatives the team wouldn't have considered. Even more impressive is that all of these designs still meet requirements.

From a strategic point of view, generative design can not only yield higher-quality designs, but also enable you to manufacture lighter weight parts that use less material, and show a positive impact on cost of goods sold (COGS).



GENERATIVE DESIGN SOLUTIONS FOR DIFFERENT MATERIAL OPTIONS.

What Makes Generative Design in PTC Creo More Reliable?

It's no secret that generative design and the closely related topology optimization tools have been available for a long time. However, workflows with generative design can be more reliable than traditional CAD workflows, and here's why:

You're building requirements into the design.

All products start with requirements. These requirements could be driven by system engineering models tied into the product's requirements and managed in PLM. Or you can use requirements you've validated yourself in the course of earlier design work. The point is that with generative design, applying requirements to your model is part of setting up your study. Again, every solution that study returns will meet those requirements.

The manufacturing method informs the design.

Typically, you design a part, validate it using simulation and analysis tools, do some further refining, and then turn the part over to the process engineer for the first of several rounds of feedback before the design is finalized.

Using generative design saves time because you add manufacturing criteria to your study. This ensures you've gotten the design off to the best possible start before you call in the specialized expertise of your colleagues.

THESE CRITERIA MAY INCLUDE:

- A build direction for parts that will be 3D printed.
- A parting line for parts that will be cast or molded.
- A linear extrude for parts that will be extruded or machined.

You generate multiple concepts quickly.

Think back to how you handle the initial design phase. Maybe you come up with a handful of concepts. But if you're like most professionals, you're also going to revert to what your experience proves will work, and iterate from there. With generative design, the software iterates far faster than humans can, and it does so without a bias towards previous product designs.

You can modify the resulting model in the Creo design environment.

The part model that generative design creates produces B-rep (boundary representation) geometry. That means you can work on it in Creo just as you would any of your models.

Products and Companies Already Using Generative Design

Engineers are already starting to leverage generative design software to explore new design options. Here's what they're finding out:

THE GE BRACKET REDESIGN SHOWN IN THE ANIMATION ABOVE WAS 75% LIGHTER THAN THE ORIGINAL DESIGN AND OPTIMIZED TO STAY WITHIN THE MATERIAL YIELD STRESS USING GENERATIVE DESIGN.

Cummins, the world's leader in diesel and natural gas engines, power generation equipment, and related products, used generative to reduce the material in parts by 10–15%. This helped them meet both cost and sustainability targets.

View Case Study >>

Jacobs

As an engineer, I like right angles, flat surfaces, and round dimensions, and generative design says that may not be the best solution. And so, if I want to be the best possible engineer at my job, I look to generative design to find those kinds of solutions.

Jesse Craft, Sr. Design Engineer & Innovation Project Manager, Jacobs

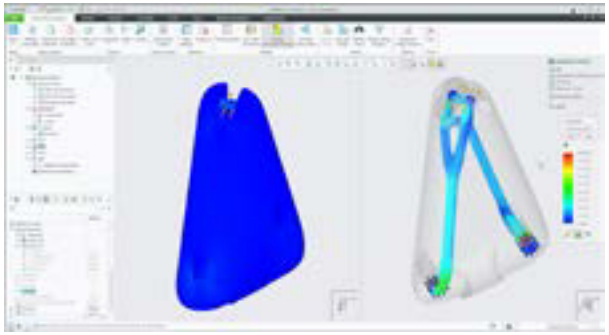
PTC Creo Extensions: GTO and GDX

It's helpful to understand the difference between generative design and topology optimization, because the two terms are often used interchangeably. From PTC's perspective, Topology Optimization converges on a single solution based only on functional objectives, constraints, and loads. Generative design evolves multiple solutions simultaneously to converge on the best possible set of solutions based on requirements.

While topology optimization has been around for decades, advancements in generative design make it an indispensable tool for engineers. And the combination of generative design plus cloud computing promises to be the way of the future. That's where Creo extensions can boost your design efforts.

Creo Generative Topology Optimization (GTO) and the Generative Design Extension (GDX) are two industry-leading tools that are similar, but not synonymous. Here's a quick primer on what they are and when to use their strengths to your advantage.

Generative Topology Optimization



A GENERATIVE DESIGN STUDY IN WORK.

Generative Topology Optimization (GTO) is a great way to build a design that carries no excess material, without sacrificing strength. It ultimately creates a lighter, less expensive part and a more efficient manufacturing process. But GTO in Creo is more than just contouring an existing design.

Once you have the basic optimization set up in Creo, you can select the material and manufacturing process, and GTO will optimize the part design for that combination.

Because this all happens within Creo, there are no import/export hassles, and nothing is lost in translation. The output from GTO is not your final design. You can take that output, modify it, and analyze it in Creo Simulation Live.

The GTO Workflow

1. First, define the study you want to run.
   a. Designate a body as the starting geometry in the study. This indicates the body you want to optimize.
   b. Choose any bodies to be either preserved or excluded from the study.
   c. Use Contact between bodies to connect them in the model.
   d. Set constraints and load conditions. You can use more than one load case for the study, and optimization is calculated separately for each.
   e. Define the design criteria, such as the design goal, materials, and manufacturing method. You can define multiple criteria, but only one will be active at a time.
2. Run Generative Topology Optimization.
3. Display the simulation results. This can also be animated if you choose.
4. Use the Generative Design feature to save it, or send it on to the Generative Design Extension for multiple design options. (More on that below.)

Generative Design Extension

The Generative Design Extension (GDX) takes all the benefits of GTO and extends them with cloud-powered computing.

To use GDX, you first set up the basic optimization in GTO. However, unlike GTO, you can add multiple design criteria, and multiple materials for each design. This collection, or study, is sent to GDX. That's where the magic begins.

Instead of the single design you get from Generative Topology Optimization, GDX harnesses the power of the cloud to generate multiple designs simultaneously. It will even automatically identify the top options for your review. You can quickly investigate the many design scenarios and discover innovative geometry solutions that you and your team may not have found using traditional methods.

Designs produced in GDX can be downloaded from the cloud environment to your local Creo environment for further refinement and analysis.

The Generative Design Extension extends the abilities of GTO to further save on time and material costs, reduce waste, and ultimately produce higher performing designs. Even if you only use GTO, and not GDX, you will still increase engineering efficiency, as well as save on materials costs with lighter, more durable designs.

CLICK TO VIEW A VIDEO OVERVIEW OF GENERATIVE DESIGN CAPABILITIES IN CREO.

The GDX Workflow

Setting a study is easy and takes just minutes.

1. Define load cases. These represent the operating environments that your model must survive.

2. Specify design constraints. Think of this as a way of optimizing, such as aiming towards a target safety factor. You can optimize towards a minimum mass, maximized stiffness, or fundamental frequency.

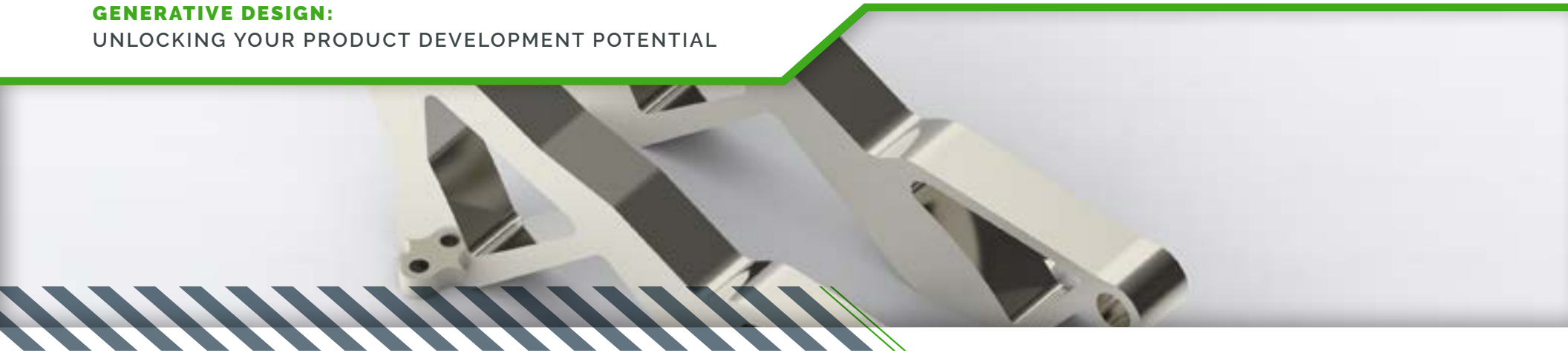
3. Select materials and design criteria. A study can contain many design criteria.

4. Run the optimization on the desktop before pushing an array of studies to the cloud. Apply the study settings to control the time and resources used.

5. Run the optimization.

6. View the results.

THE RESULTS OF THE GDX STUDY SHOWING DIFFERENT OPTIMIZED SOLUTIONS.



Use Them Separate or Together

Clearly, GTO and GDX have their differences, depending on what you need for a project. Think of GTO as the right solution when you want to optimize a model for a specific material and manufacturing design process. Bring in GDX when you want to quickly develop and compare many scenarios in parallel, for more innovative solutions to your critical design challenges.

Staying Competitive with Generative Design

As manufacturing becomes more globalized, competition increases. Mergers and acquisitions are on the rise, and worker flexibility is foremost on the minds of hiring managers. To stay competitive in the world economy, you need differentiated products. And, you may have to do it with fewer engineers.

Within the next few years, there could be a gap of up to two million workers in the manufacturing industry. Senior engineers and analysts with decades of experience are nearing retirement age. There aren't enough younger skilled workers to take their place. Naturally, productivity begins to dip, and new technology needs to be developed to close the gap.

That's where the latest generative design tools can help. Utilizing artificial intelligence (AI) within these tools, younger engineers can step up to larger projects and contribute by specifying requirements and using generative design to produce arrays of product possibilities. In minutes, the generative design engine can iterate through dozens of design options until the optimal geometry is achieved within the design constraints, a process that can take days or weeks using traditional design practices. This productivity boost frees up engineering time for other critical tasks.

Going Forward with Generative Design

We hope this answered some of your questions about generative design and the seemingly alien models it sometimes creates. In short, it's simply a powerful technology to help companies deliver their best designs in less time.

If you want to explore what's possible, visit ptc.com/en/technologies/cad/generative-design today.

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Creo is the 3D CAD solution that helps you accelerate product innovation to build better products faster. Easy-to-learn Creo uses a model-based approach to seamlessly take you from the earliest phases of product design to manufacturing and beyond. Combining powerful, proven functionality with new technologies including generative design, real-time simulation, advanced manufacturing, IIoT and augmented reality, Creo helps you iterate faster, reduce costs and improve product quality. Creo is also available as a SaaS product, providing innovative cloud-based tools for real-time collaboration and streamlined license management and deployment.
The world of product development moves quickly, and only Creo delivers the transformative tools you need to build competitive advantage and gain market share.

Need more information? **CONTACT US** →

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