Designing Light-Weight Parts using ParetoWorks

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ParetoWorks is an Add-in to SOLIDWORKS for fast and easy topology optimization.

Using ParetoWorks, one can create lighter and better-performing products.

ParetoWorks has a built-in super-fast FEA solver.
Why Topology Optimization?

Weight Reduction: A Trial-and-Error Process Today

For engineering companies to be competitive, they have to create lighter and better-performing products. For example, given a structural problem in Figure 1a, engineers need to figure out where and how to remove material. Often, one of the tools engineers use is finite element analysis (FEA); see Figure 1b.

Unfortunately, FEA can only provide hints on where one should remove material. The actual process of carefully removing material can be arduous and error-prone. Figure 2 illustrates a few designs that an engineer might generate. There is no guarantee that the final design generated through this trial-and-error process is even close to optimal.

Topology Optimization: A Powerful Design Tool

Topology optimization is a powerful automated process for performance-constrained weight reduction. It relies heavily on FEA, but it automates the process of material removal, resulting in a highly optimized design. For example Figure 3 illustrates an optimal design generated through topology optimization, using ParetoWorks.

As a second example, consider the bridge problem in Figure 4a. The objective is to reduce the weight of the bridge while satisfying various design constraints. Through topology optimization one can create, within minutes, the optimal bridge illustrated in Figure 5b.
Topology Optimization Saves Time

Topology optimization provides rapid solutions to design problems, shaving weeks off product development cycles. For example, Figure 7 illustrates two distinct design solutions, that are optimal for their respective loading scenario. To be able to arrive such designs in a matter of minutes open new frontiers in product development.

Topology Optimization Today

How does Topology Optimization Work?

There are several topology optimization methods and software implementations. Underneath, all of them rely on FEA and optimization techniques; see Figure 8. They however differ on the specific FEA method, the optimization technique, the number of iterations required, ease-of-use, constraint handling, multi-load and multi-physics capabilities, etc.

Topology Optimization and 3D Printing

There is a lot of excitement today in 3D printing (additive manufacturing). Through 3D-printing one can fabricate parts of virtually any shape. It offers several advantages over traditional manufacturing, and has the potential to revolutionize the way things are made. Topology optimization directly
caters to 3D printing in that the output from topology optimization is typically an STL file, that can be directly 3D printed. Further, for most 3D printing processes (especially, metal 3D printing), material reduction is critical, and through topology optimization, one can dramatically reduce the amount of material used in a design. Figure 9 illustrates the seamless integration of topology optimization and 3D printing.

![Figure 9: From design problem to 3D printing via topology optimization.](image)

### Topology Optimization: ParetoWorks

**ParetoWorks is Easy-To-Use**

ParetoWorks is an Add-in to SOLIDWORKS for topology optimization. Designers can work within the comforts of SolidWorks, and explore topology optimization designs rapidly. ParetoWorks is a full featured topology optimization tool-box, that is capable of handling multi-body, multi-load topology optimization problems at blistering speeds.

![Figure 10: ParetoWorks is a SolidWorks Add-In for topology optimization.](image)

**ParetoWorks is Self-Contained**

ParetoWorks has a built-in fast FEA solver, and does not require SolidWorks Simulation, i.e., ParetoWorks only requires SolidWorks standard. Further, the FEA technology used in ParetoWorks has been designed from scratch to be robust and extremely fast, to meet the demands of topology optimization. ParetoWorks is capable of handling extremely complex SolidWorks models with ease. Figure 11 illustrates FEA of a plastic stool using ParetoWorks.

![Figure 11: FEA of a plastic stool using ParetoWorks.](image)
ParetoWorks has a built-in FEA solver, and only requires SolidWorks Standard, for FEA and topology optimization.

Figure 11: ParetoWorks has a built-in FEA solver.

ParetoWorks is Constraint-Driven
ParetoWorks builds upon on the cutting-edge FEA engine to solve complex constraint-driven topology optimization problems. Designers can impose stress, displacement, manufacturing and design constraints, and ParetoWorks will seek light-weight topologies that satisfy these constraints. For example, Figure 12 illustrates a design problem, constraints imposed and the final topology. Observe that the desired (target) volume fraction is 0.01, but the stress allowed is 150 MPa. ParetoWorks stops at a volume fraction 0.45, when the stress limit is reached.

Figure 12: ParetoWorks is constraint driven.

ParetoWorks can not only solve traditional stiffness-driven problem (as above), but also more challenging, and arguably more important, strength-driven problems. For example, for the problem posed in Figure 12, Figure 13 illustrates the optimized topology when the objective is set to “Max Strength”; the topology is significantly different from the one in Figure 12.
ParetoWorks is Powerful
ParetoWorks can also handle both multi-load and multi-body problems. For example, Figure 14 illustrates the GE-GrabCAD design optimization problem that attracted several hundred design engineers from all around the world. While engineers spent several weeks generating light-weight designs, ParetoWorks can generate a topology optimized solution in less than an hour.

ParetoWorks is Robust and Fast
ParetoWorks relies on a proprietary optimization engine that is both robust and unbelievably fast. You will not find ‘hanging’ surfaces, so your topology is ready to be 3D-printed. You also don’t need to wait for hours for the topology optimization result. On a typical desktop, ParetoWorks can generate insightful designs in minutes.

ParetoWorks is Inexpensive
Compared to competing software solutions, ParetoWorks is inexpensive, and you will recover the cost of your investment through a single client project. Contact us directly at support@sciartsoft.com or contact your SOLIDWORKS reseller, to get a full-featured ParetoWorks trial license.

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"I should note that a single run, from when you hit go till it converges at a solution, took anywhere from 20 to 30min. for this part. Considering that this is conducting FEA with 60,000 to 80,000 nodes at each iteration and running an opto. algorithm, this seemed blindingly fast to me. I was super impressed with this having played with other optimization software."

- Mark G., Charlton & Hill Welding Ltd.