CP235118

How Generative Design Can Make Your Product More Sustainable (and help make you more money!)

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Learning Objectives

- Learn to use Generative Design in Autodesk Fusion 360 for lightweighting
- Explore additive manufacturing options for lightweight parts
- Learn how Autodesk Netfabb can simulate and optimize the manufacturing process
- Learn how generatively designed lightweight parts can significantly reduce the environmental impact of your product through cradle-to-grave life cycle assessment

Description

Are you trying to design and make better products and parts that have less environmental impact on the planet? Are you seeing customer demand for more environmentally friendly products? Do you have sustainability goals you're trying to meet?

In this session, you'll learn how to re-design existing products and parts to be more sustainable and also learn about more efficient manufacturing processes that can reduce energy and material use. Starting with a baseline design, you'll apply generative design and sustainable design principles to improve your design. You'll also hear about various Autodesk tools that can reduce the amount of material and energy used through the manufacturing process and the product's full lifecycle. You will realize that sustainable design can drive cost reductions while adding a significant competitive advantage to your company.

Speaker:

Zoe Bezpalko is building her career at the intersection of sustainability, technology and design. With a master's degree in Environmental Engineering and an MBA in Design Strategy, she has international experience in helping organizations become sustainable, through innovative design solutions and business models. At Autodesk, she now leads sustainability strategy for the Design & Manufacturing industries, identifying technology to maximize value for Autodesk, its customers, and the planet.

Generative Design for Lightweighting – Fusion 360

Using the generative design capabilities in Autodesk Fusion 360, you can quickly generate high-performing design alternatives—many that you'd never think of on your own—from a single idea or preexisting product. In this course, we explore how a generatively designed part can outperform a traditional design in terms of functionality, manufacturing supply chain, and environmental impact.

What is Generative Design?

Generative design mimics nature's evolutionary approach to design. Designers or engineers input design goals into generative design software, along with parameters such as materials, manufacturing methods, and cost constraints. The software explores all the possible permutations of a solution, quickly generating multiple design alternatives. It tests and learns from each iteration what works and what doesn't.

Lightweighting with Generative Design

Generative design is particularly helpful when seeking to improve the material efficiency of a design while maintaining performance parameters and functionality requirements. By nature, the software removes material where it isn't needed, and organically restructures material based on stress and strain patterns. As a result, a generatively designed part can achieve the same functionality with as high as an 80% reduction in material!

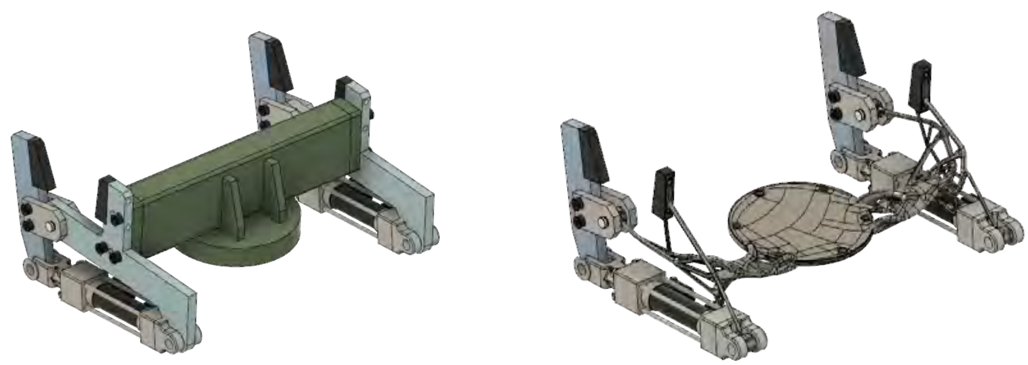


Fig.1: The original end-effector part (left) and the generatively designed part (right) in context.

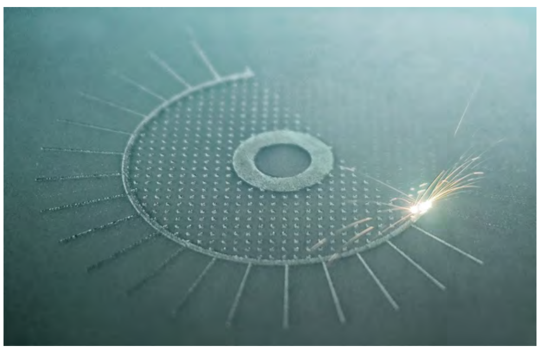
In this course, we explore the design of a robot welder assembly sub-component referred to as the "end-effector". You can already see that the original part is bulky, heavy, and requires assembly (3 sub-components and 6 fasteners). By inputting the functional and physical requirements of the original end-effector part into the Generative Design space in Fusion 360, we obtain a new, optimized part which requires no assembly and uses 77% less material!

Manufacturing of Lightweight AGD Parts

Now that we have our improved, lightweight model, we had to determine how to make it. Due to the complex, organic nature of generatively designed parts, traditional subtractive manufacturing is often not feasible. However, additive manufacturing (methods allow us to build these parts with minimal process steps - simplifying supply chain, inventory and assembly logistics.

3D Printing for Generative Design

Additive manufacturing (AM), aka 3D Printing, allows for the efficient fabrication of highly complex and innovative designs that are often not easily manufactured with traditional methods. We explore two 3D Printing methods to manufacture our improved end-effector part based on two potential material choices: steel and polycarbonate. To print in steel, we use *powder bed fusion (PBF)*, an AM method where a laser fuses metallic powder layer by layer. To print in polycarbonate, we use *fused deposition modeling (FDM)*, where a continuous filament of material resin is fed through a mobile nozzle onto the developing workpiece.



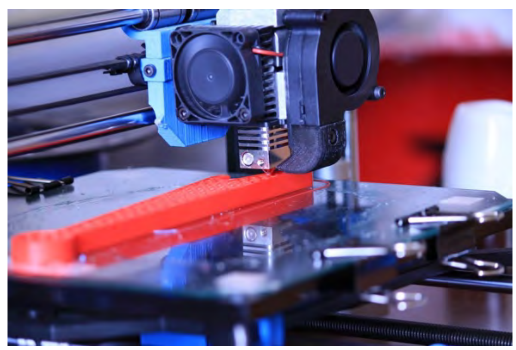
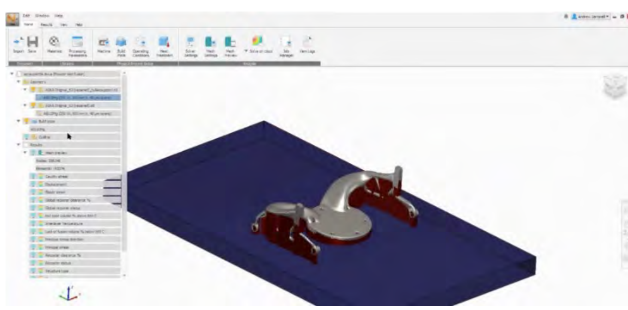


Fig 2: Powder Bed Fusion (PBF) and Fused Deposition Modeling (FDM) technologies

Autodesk Netfabb – 3D Printing Optimization

Autodesk Netfabb additive manufacturing software has tools that help streamline your workflow and quickly get from a 3D model to successfully printed parts. In particular, Netfabb allows you to optimize the required use of support structure, as well as feeds, speeds, orientations, bed arrangements and more to minimize the material use, energy use and environmental impact of the process itself.



Lightweighting and Generative Design for Sustainability

To adequately understand the environmental impact factors of the part and process update, we perform a cradle-to-grave life cycle assessment (LCA) on the part. This analysis will confirm whether or not our updated part carries a lower embodied energy and carbon footprint as a result of the material reduction and material efficiency of additive manufacturing processes.

Life Cycle Assessment

A cradle-grave LCA takes into consideration the environmental impact of all steps of the manufacturing and use process including raw material processing, manufacturing, use and end-of-life. Performing such an analysis on our lightweight end-effector part provides us with a holistic understanding of the environmental impact embodied by the part, and how it compares to the original part and process. In this study we compare the original part produced by subtractive machining and hand assembly, with a generatively designed version in both steel using PBF and polycarbonate using FDM. We analyze these parts and processes through the impact categories of Global Warming Potential (GWP) and Cycle Energy Demand (CED), using LCI data from Worldsteel as well as the sources below.

Results

Our study confirms that the generatively designed part fabricated with PBF carries a significantly lower embodied GWP and CED than the original part fabricated with subtractive methods. This is primarily due to the significant reduction in mass of the part, as well as the high material efficiency of the AM process.

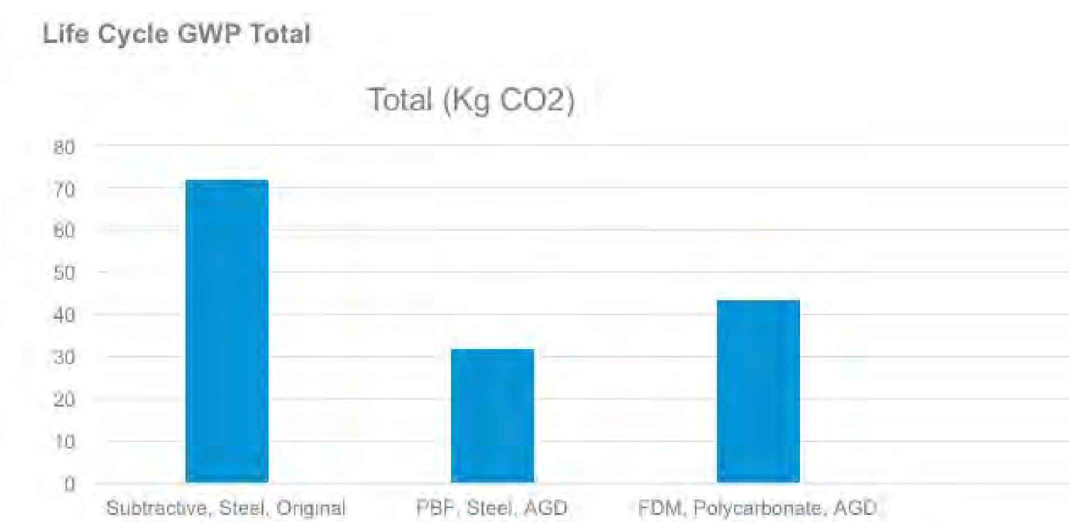
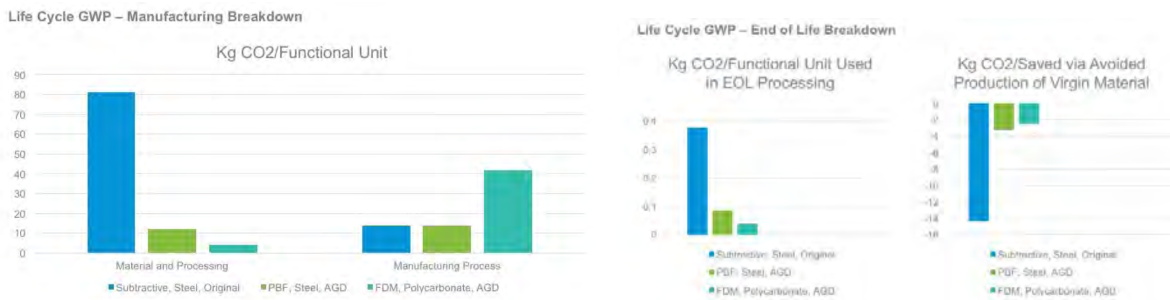


Fig. 4: The total life-cycle Global Warming Potential in KgCO2 for each part and process.

A breakdown of the total GWP results is shown below. Although the energy required in the manufacturing process itself is similar or more for AM (Fig. 6), it is significantly outweighed by the embodied energy of the input material required for the traditional process and part (Fig. 5). Additionally, the recycling of more material does increase the saved carbon emissions from avoided virgin material production (Fig 8.), but is not enough to compensate for the overall excessive material usage in the traditional process. The magnitude of energy required in the end of life process itself is relatively insignificant in comparison to the embodied energy in input material (Fig. 7)



Figs. 5 - 8: A breakdown of individual analyses within the LCA.
Results are added to obtain the total GWP.

Cost Analysis

Manufacturing

Assuming low-volume production, we analyze the cost of producing one end-effector by taking into consideration input material cost, operator compensation, and electricity usage of machinery. Results indicate that, despite material reduction, an increase in cost is associated with manufacturing the updated part via additive processes (Fig. 7). This is primarily due to the relatively high cost of processed input material for additive manufacturing, as well as the additional post-processing requirements of additive manufacturing.

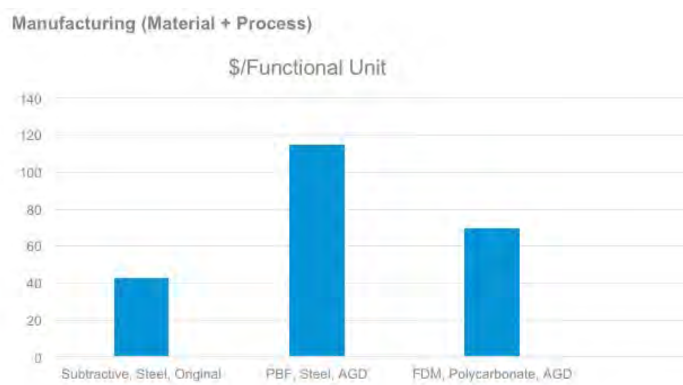


Fig. 7: Primary manufacturing costs including processed input material and machine electricity costs.

Operator Labor Cost (Time Value)

However, due to the simplified manufacturing process, less hands-on operator time is required for AM. For the traditional process, the operator has to perform a setup, calibration, and post processing for 3 individual components, as well final assembly of the components. They must then repeat each step for each individual part. In the updated process, the operator only sets up once and monitors occasionally until post-processing. In the case of PBF, parts are typically produced in small batches, therefore only one set-up and post-process is required for the entire batch. The saved time value in manufacturing logistics can compensate for the increased cost of materials.

Fig. 8: Operator time value per process. Simplified AM processes lead to decreased hands on operator costs.

Conclusion

Generative design capabilities can help make products more sustainable by offering innovative design solutions that use less material, consolidate parts, and increase performance. Coupling these solutions with additive manufacturing technologies simplifies fabrication processes and ultimately reduces the impact your product has on the environment. Certain elements of this process can be more expensive. However, it can be integrated in such a way that optimizes supply chain and labor logistics, which ultimately can compensate for other increased costs.

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