Roadrunner 3D

DESIGN FOR ADDITIVE MANUFACTURING (DfAM)

Learn the principles of 3D printing design and how to overcome the challenges of producing quality prototypes rapidly

INTRODUCTION

When you are prototyping parts in manufacturing, you need to create a quality design that meets your specifications, but you also need to do it quickly. The longer you take in the design and prototyping process, the longer it will take to get to market.

Making a mistake in the design process is not uncommon. It may take several iterations to get things right before your design is ready for mass production. Even the best engineers may need to go through a bit of trial and error to be confident their design meets specs and passes the quality assurance phase.

With the right equipment and expertise, applying Design for Additive Manufacturing (DfAM) principles can allow for “design on the fly” — a faster and easier way to design in a 3D environment, print, and test parts in rapid succession to design iterations faster, reduce costs, and get your products to market more quickly.

CHALLENGES WITH DESIGN FOR ADDITIVE MANUFACTURING

One of the big advantages of commercial and industrial 3D printing is the ability to rapidly produce prototypes.

However, many companies lack the digital infrastructure and expertise necessary to manage additive manufacturing processing efficiently with complete traceability. For example, many companies are still creating solid models within their CAD system and then converting them into a triangulated model to optimize structures and run simulation analyses. This can require multiple software programs. When there is a build failure or flaw discovered, design engineers must start over and go step-by-step through the entire design/build process again.

This is aggravated in companies doing additive manufacturing that do not have additive manufacturing expertise. In some cases, this leads to engineers trying to design components for 3D printing that aren’t quite the right fit. The learning curve can be steep.

This back-and-forth time, especially for complex geometric designs, can lengthen production times and drive-up production costs. This significantly reduces the efficiency of 3D prototyping.

It’s why so many companies today outsource their design and 3D prototyping to overcome these challenges.

OVERVIEW

Design for Additive Manufacturing (DfAM) is the process of creating efficient designs to reduce costs, increase production speed, and streamline throughput. In this white paper, we will discuss ways to solve DfAM challenges, including:

The benefits of DfAM

We will discuss the benefits of robust design for additive manufacturing strategies that are unique to 3D printing, including:

- Producing complex parts
- Minimizing material waste
- Eliminating design flaws
- Getting faster feedback
- Simplifying assembly
- Using a variety of materials
- Cost-effective customization and prototyping

The principles of DfAM

Learn how employing the principles of design for additive manufacturing (AM) can reduce costs and improve prototyping, including:

- Design for minimal material usage
- Design for improved functionality
- Design for consolidation
- Design for orientation
- Design for segmentation and bonding

Accelerating design and iteration

The areas that impact speed and quality and how you can overcome them, including:

- Equipment
- Materials
- Software
- Expertise

We'll also look at the ways you can manage settings with your equipment to accelerate the printing process.

THE BENEFITS OF DESIGN FOR ADDITIVE MANUFACTURING

Optimizing your designs for 3D printing is essential to building quality parts. Managing every aspect of the build can provide several benefits, such as:

Producing complex parts: Additive manufacturing allows you to create highly complex parts with improved functionality.

Minimizing material waste: By optimizing the distribution of materials and maximizing design, engineers can create lightweight parts that use fewer materials. Tools for generative design, lattice structures, and topology optimization, can help to identify unnecessary material for removal without compromising structural integrity.

Eliminating design flaws: Before AM, products designed digitally could only be analyzed virtually. Small flaws in the design phase might go unnoticed until production molds were created and production was begun — an expensive and time-consuming process. 3D printing allows engineers to design and iterate rapidly, test prototypes in a cost-efficient manner, and eliminate any design flaws much more quickly. Physical prototypes can be tested in real-world scenarios.

Getting faster feedback: By creating affordable prototypes before going into full-scale production, you can more easily get feedback from stakeholders. Changes in texture, finish, functionality, size, strength, and other elements can be adjusted quickly within the design software and you can see the changes in short order.

Simplifying assembly: In traditional manufacturing, individual parts are created and assembled. In additive manufacturing, multiple parts can be created and consolidated into a single build. Large components can be created using 3D printers and bonded, reducing the number of parts that require assembly. This also reduces inventory since you can print on demand.

Using a variety of materials: The variety of print materials can reduce costs versus traditional materials. For example, some high-performance thermoplastics can be used for engineering applications that produce a more lightweight part that can substitute for some metal parts. Engineers may also be able to design parts using multi-material properties.

Cost-effective customization and prototyping: Additive manufacturing facilitates rapid and multiple design iterations. This allows you to customize and test various design strategies quickly and affordably until you get the perfect design. During the production phase, it also enables customization at scale.

THE PRINCIPLES OF DESIGN FOR ADDITIVE MANUFACTURING

For engineers, additive manufacturing removes many of the limitations of traditional manufacturing.

Parts can be significantly more complex, consolidated into one piece, and customized rapidly. Following the principles of design for 3D printing, engineers can design on the fly to iterate rapidly without sacrificing quality.

Design for Additive Manufacturing

DfAM requires a change in mindset for engineers. In traditional manufacturing, the thought process is often about subtraction. Material may start as a block and then get chipped away until it reaches the final form. Materials might also be molded, using either metal or plastic, to create the final form in one process.

In additive manufacturing, the process is reversed. AM production occurs layer-by-layer with each step adding a layer over the top of the previous one. While this creates more flexibility in design and allows for more complex geometries, it can also cover up design flaws as new layers are added.

So, the first principle of DfAM is to design for additive manufacturing rather than traditional manufacturing.

Following are other DfAM principles that engineers should keep in mind.

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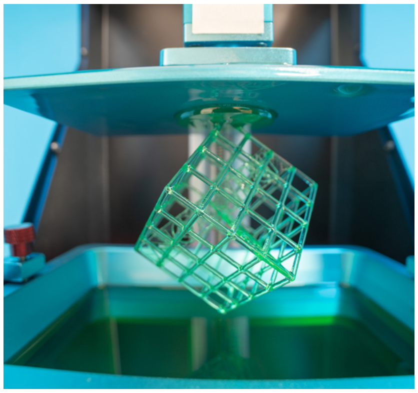


Design for Minimal Material Usage

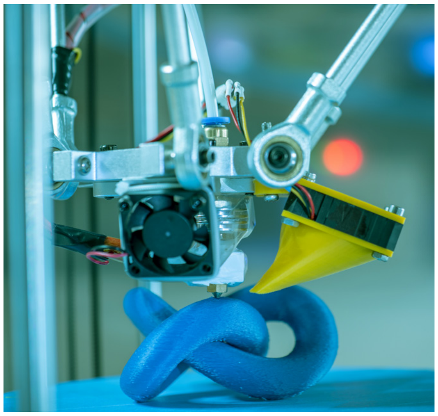
Material usage plays a significant role in the cost and time it takes to print a part. While you need to take into account the functional material and any additional support material necessary for a build, engineers need to master design methodologies to minimize material utilization.

Some examples of designing for minimal material waste include:

- Lattice structure
- Topology optimization
- Self-supporting geometry
- 45-degree chamfers

Design for Improved Functionality

To maximize designs with AM, engineers need to understand the nuances of 3D printing and what it can achieve that the traditional manufacturing process cannot. For example, added surface texturing to parts, internal structures, or complex customization.



By consolidating multiple parts into a single build process you can reduce assembly time, reliance on part production or delivery, and inventory.

Design for Consolidation

One of the big benefits of 3D printing is the ability to consolidate the number of parts required to complete a component. By consolidating multiple parts into a single build process, you can reduce assembly time, reliance on part production or delivery, and inventory.

The more you can consolidate your parts into a complete design, the more efficiently you can provide the results you need. However, there are some challenges. While consolidation can make production easier and faster, it can also cause problems for users if maintenance or repair is required. Engineers must take maintenance and repair into account when consolidating.

Design for Orientation

How a part is positioned on the printing bed can make a difference. For example, a component built standing up will likely have the best appearance but may have a weaker structure. A part laid on its side will provide the most accuracy and strength, but a part laid flat will print the quickest. When you are doing rapid prototyping, it may be best to print the fastest and then alter your orientation once you have the design dialed in.

Design for Segmenting and Bonding

Some parts will be too big to 3D print, but that doesn't mean you can't use additive manufacturing as a solution. Engineers can design components in multiple parts that can then be bonded together after post-processing.

Segmenting can help, especially in the prototype phase, to avoid having to tie up traditional manufacturing equipment for inefficient small print runs.

ACCELERATING DESIGN AND ITERATION

Accelerating the design, build, test, and iterate process is one of the biggest challenges that many additive manufacturers face. This is typically related to one of several issues or a combination thereof:

- Equipment
- Materials
- Software
- Expertise
- Scale

Equipment

Without the right 3D printing environment, even the best design principles will fail. This requires you to have the right equipment on-site to accommodate the type of parts you plan to print. If you don't have the right equipment, outsourcing to a 3D manufacturing partner will significantly increase your iteration and production process.

As companies have embraced 3D printing, the equipment has evolved rapidly. If you're using equipment that is several years old, there are more powerful ways to do additive manufacturing. For example, HP multi jet fusion (MJF) printing technology has dramatically leapfrogged its competitors, allowing you to mix materials and produce parts up to 10X faster than traditional manufacturers.

Materials

Poor-quality additive manufacturing materials will create poor-quality products. In 3D printing objects, lower-quality materials will impact strength and hardness. Low-grade materials, such as a filament that is contaminated, can also jam extruders and damage expensive equipment.

It can also impact overall quality. For example, if a filament's diameter is inconsistent, you may see inconsistencies on a printed wall, bulges, or cavities as the 3D printer extrudes more material in one place and less in another as different diameters are run through the printhead.

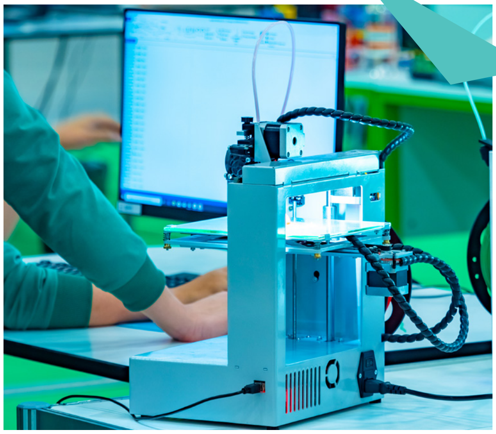
Not only do you need high-quality materials, but you need the expertise to know the difference.

Software

In any manufacturing design process, the software is key. Just like equipment, without the right software to guide your design and production process from start to finish, you will struggle. If you find you are having to switch between software programs or use workarounds for software limitations, you need to invest in the right software to drive your design/build process.

Expertise

The biggest challenge of all may be expertise – traditional design differs from additive manufacturing design. And, because additive manufacturing is still a relatively new manufacturing process, there can be significant skills gaps. As you begin any DfAM project, you need to make sure you have engineers with the proper skill set to optimize cost, quality, and speed.



The biggest challenge of all may be expertise - traditional design differs from additive manufacturing design.

Accelerating the AM Printing Process

Perfecting the 3D printing process takes experience. There are multiple ways to accelerate your prototyping and printing by managing print speed, for example, that can be done without affecting quality. For example, you might consider:

- Increasing print speed in slicer settings
- Adjusting acceleration and jerk settings
- Choosing different infill patterns
- Managing infill density, wall thickness, and shells
- Using dynamic/adaptive layer settings
- Printing multiple objects in a single print
- Reducing supports

Additive manufacturing engineers can make the appropriate adjustments to speed up the design-build process even more. However, it takes experience to know which areas can be adjusted without compromising the quality. A misstep in settings can cause significant problems.

Roadrunner 3D

Roadrunner 3D, a subsidiary of Westwind, provides a digital manufacturing center featuring state-of-the-art machines and materials. With deep engineering and AM talent, Roadrunner 3D's print specialists work can fabricate products and parts for one-off or ongoing needs – from quick-turn prototypes to repeatable, production-grade manufacturing for end-use parts.

With deep experience and talent in the 3D technology space, the Roadrunner 3D team is excited to help you push beyond the boundaries of legacy technology. Contact us today!

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