IM467718

# How To Redesign Parts For Metal 3D Printing

Björn Ullmann
One Click Metal

## Learning Objectives

- Learn how to best identify parts for redesign for metal additive manufacturing (AM)
- Discover basic DFM (design-for-manufacturing) rules for metal AM
- Learn about limits and possibilities of metal AM
- Learn how to save money using AM

## Description

When using metal additive manufacturing, it’s not all about organic topology optimized parts. Often, it’s sufficient to use simple operations in Fusion 360 to redesign a part in order to get an economical use case. That is the goal of this class. You learn about identifying parts that are suitable for redesign – because it does not always make sense with all components. You discover basic DFM-rules (design-for-manufacturing rules) and learn about limits and possibilities of metal additive manufacturing. Finally, you learn about how to save money when using AM-technologies.

## Speaker

**“Everyone can successfully use additive manufacturing technologies”** - Björn Ullmann, CEO, and founder of One Click Metal


With several years of experience in 3D printing, development and start-ups, Björn Ullmann brings his expertise not only to his company One Click Metal, but also to conferences and events. The newly founded start-up One Click Metal, with Björn as CEO, aims to make metal 3D printing more accessible and affordable and has developed a holistic metal 3D printing system that lowers the entry barriers into the technology, allowing any company to possess its own metal 3D printer.

## Part I: What is metal 3D printing?

There are 18 different metal 3D printing technologies within the process landscape – as seen in Figure 1. The laser powderbed fusion-technology, or short LPBF, is the most adapted and most mature one in the market, it's highlighted in green in Figure 1.

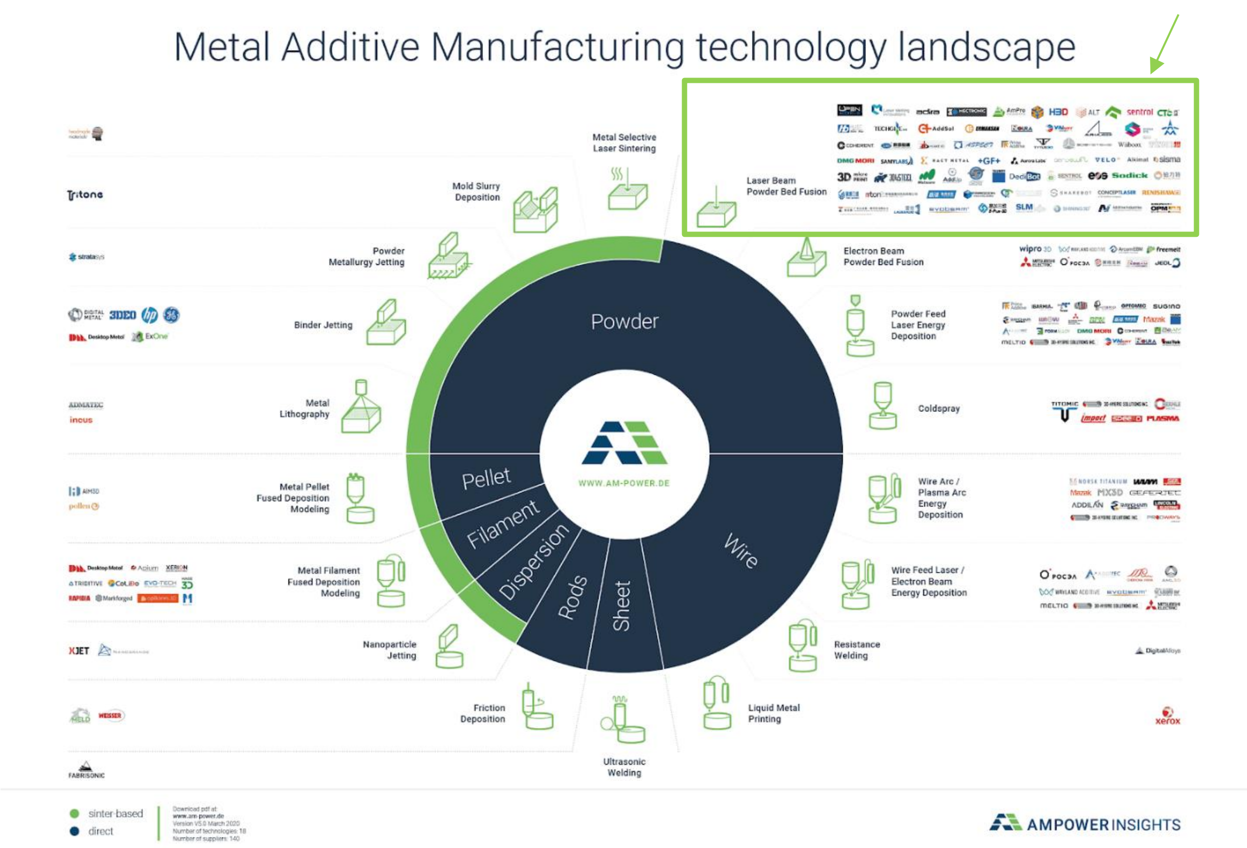



*FIGURE 1: METAL ADDITIVE MANUFACTURING TECHNOLOGY LANDSCAPE (SOURCE: AMPOWER INSIGHTS).*

### What is laser powderbed fusion?

LBPF is an additive manufacturing process that uses a laser to melt thin layers of metal powder. Once the layer is solidified, a new powder layer is spread, and the process repeats itself until all layers are applied and the part is created (see Figure 2).

Because LBPF has a lot of names out in the market, it's important to know the most common synonyms:

- SLM (selective laser melting)
- DMP (direct metal printing)
- LMF (laser metal fusion)
- DMLS (direct metal laser solidification)
- Laser cusing

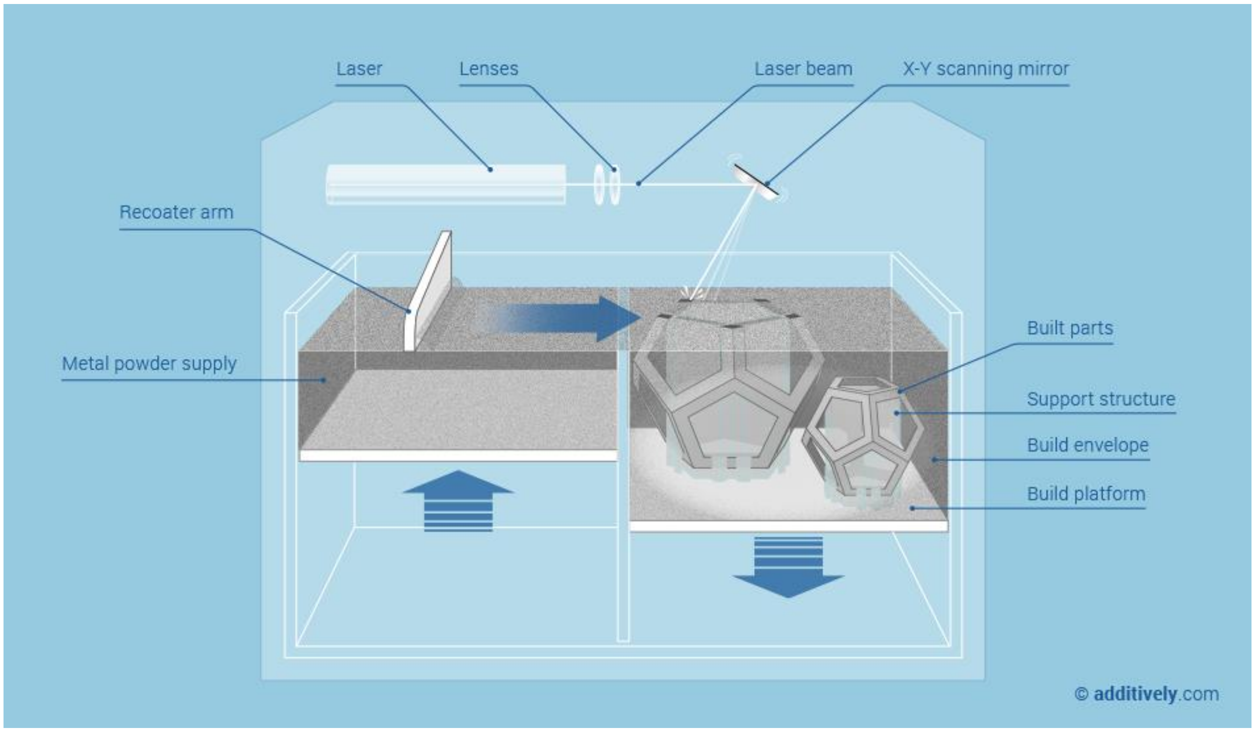



*FIGURE 2: WHAT IS LASER POWDERBED FUSION? (SOURCE: ADDITIVELY).*

### How does LBPF work?

Basically, the whole process consists of four steps.

- **Step 1: CAD-Design**
  - You need to design your parts with AM rules and build direction in mind.
- **Step 2: Data preparation**
  - Placing and orienting your parts in the build envelope.
  - Placing supports
  - Assigning process parameters.
- **Step 3: Printing process**
  - Fusing the part layer by layer onto the build plate.
- **Step 4: unpacking and postprocessing**
  - Removing the powder
  - Heat treatment (optional)
  - Remove parts from build plate
  - Remove supports
  - Blasting
  - CNC machining

In this class, we are concentrating on the first step, the CAD-design as this is the basis and starting point for a successful print job.

## Part II: Identifying parts for redesign

First, you have to decide what kind of parts or assemblies are suitable for redesign. Additive manufacturing does not make the same sense for all components. You have to evaluate different factors to decide whether additive manufacturing offers added value. We have compiled four different types of components for you.

### Parts with high degree of machining

Parts that have a high degree of machining are a good candidate for 3D printing in general. The cost of printing the part can easily be lower than conventional manufacturing processes.

Components made from high strength alloys like Inconel or CoCr alloys can be printed first and are only machined on functional surfaces to reduce tool wear.

Small inaccessible features can usually be printed very easily.

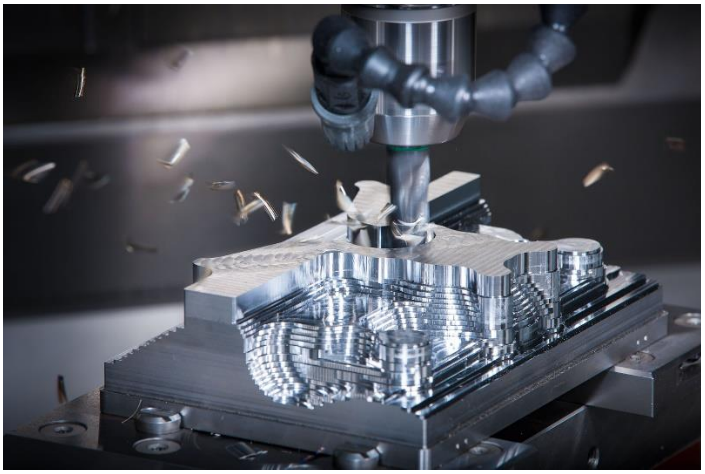


*FIGURE 3: PARTS WITH HIGH DEGREE OF MACHINING (SOURCE: IOT BUSINESS NEWS).*

### Assemblies with many parts

Combining many parts into one gives you two advantages:
1. You have less parts to handle
2. You have less joining operations

All in all, you have reduced handling and quality control efforts, which comes very handy.

See also the example as seen in Figure 4: Siemens burner head 13 parts combined to one.

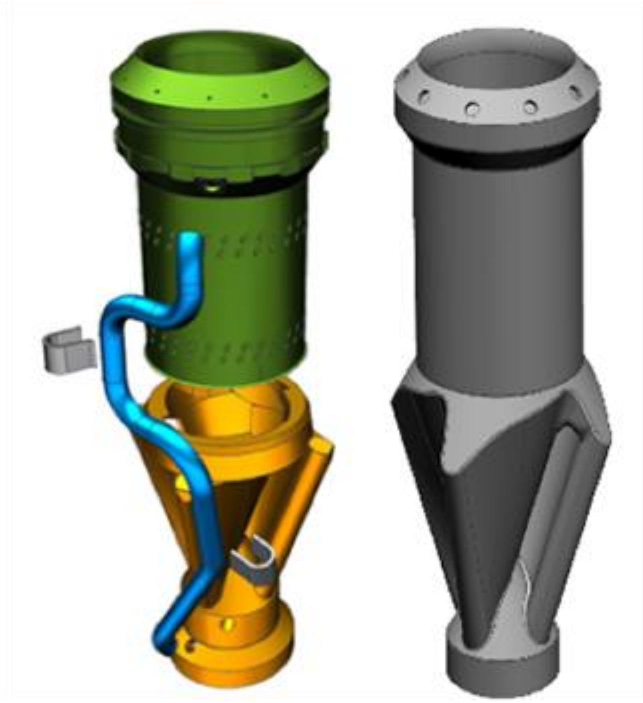


*FIGURE 4: SIEMENS BURNER HEAD 13 PARTS COMBINED TO ONE PART (SOURCE: SIEMENS AG).*

### Parts with internal channels

Components that have internal channels are good candidates for metal 3D printing as seen in Figure 5.

**Tooling**
One example is injection molding toolings. With cooling channels close to the contour of the part the cycle time can be reduced significantly. Therefore a more expensive tooling can be justified

**Manifolds**
In Manifolds the distribution of the fluids can be handled better. The pressure drop can also be optimized.

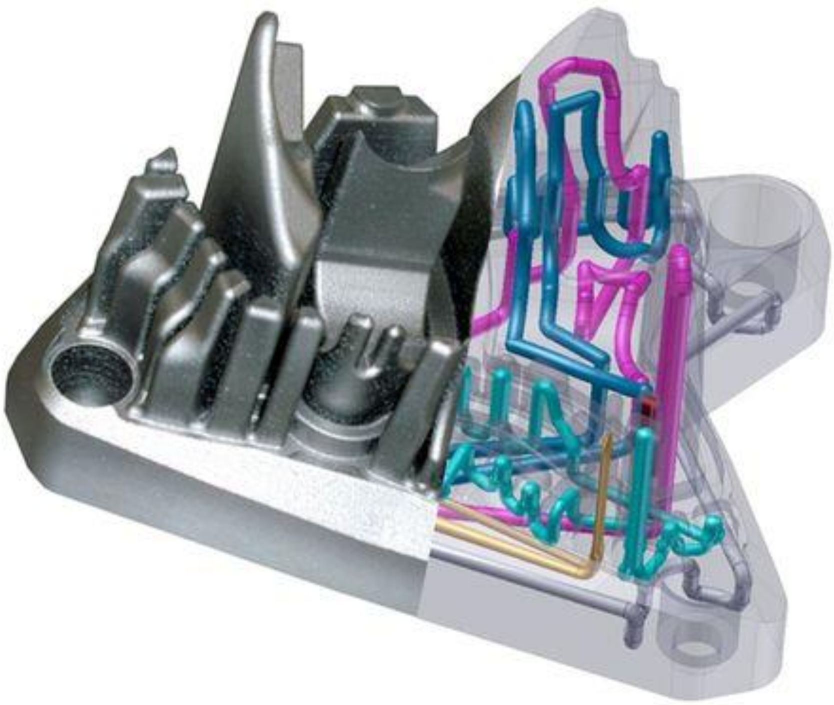


*FIGURE 5: PARTS WITH INTERNAL CHANNELS (SOURCE: RENISHAW).*

### Parts with low part volume

Especially for low volume production 3D printing can be much more economically viable since it is a tool free process.

Often the lead times can also be significantly reduced using metal 3D printing as seen in Figure 6.

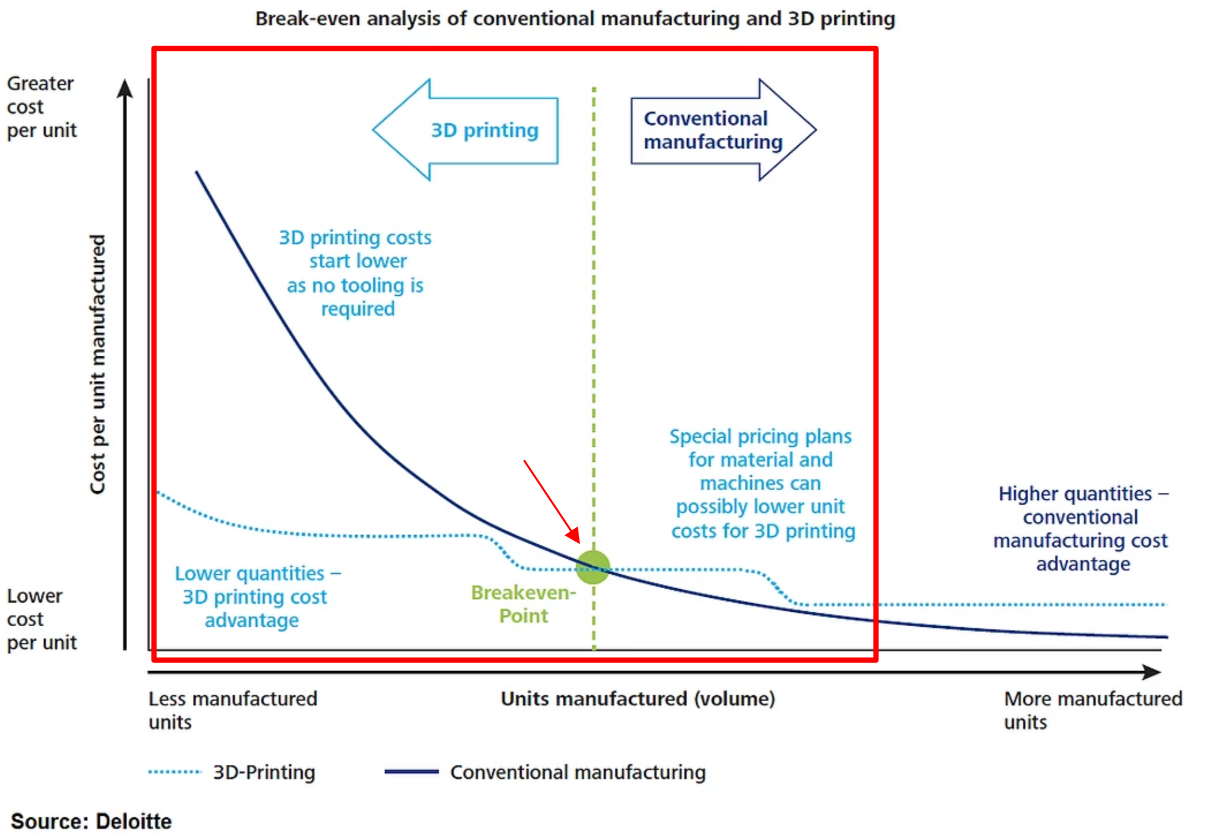



*Figure 6: Break-even analysis of conventional manufacturing and 3D printing (Source: Deloitte).*

## Examples for better understanding

We have prepared two practical examples that will help you to better understand this class. The two examples will guide us through the next topic blocks and provide you with a clearer understanding of the theoretical content.

### Example 1: Optical connector

Receptacle for a fiber connector that transmits a high power laser beam (Figure 7).

The connector is used in the MPRINT metal 3D printer to receive the optical connector that transmits the laser power to the welding optics.

**Original motivation for redesign**

- Long lead time
- high price

**Indicators for redesign**

- Parts with internal channels

    - assembly has an internal cooling channel
- Assembly with many parts
    - 8 parts used in assembly
- Low part volume
    - only a small amount of parts is needed
    - parts were needed very quickly

*FIGURE 7: OPTICAL CONNECTOR*

### Example 2: Tooling for feeding system

The tooling conveys and orients components in a vibratory feeding system (Figure 8).

The tooling is used in feeding systems of the Hoffmann and Stirner GmbH to feed and orient bearing housing components into an assembly machine.

**Indicators for redesign**

- High degree of machining
    - Typically machined on 5-axis machine out of a large tool steel block
- Assembly with many parts
    - 2 parts used in assembly
- Low part volume
    - only one part required per tooling set

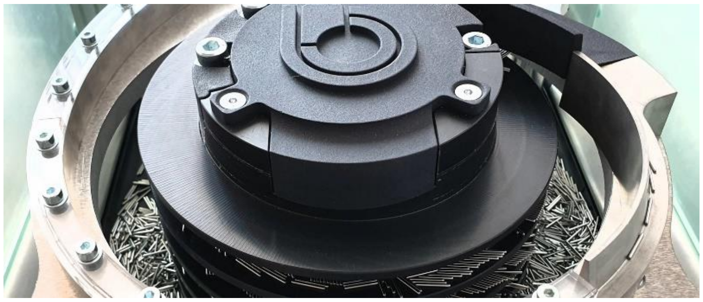


*FIGURE 8: TOOLING FOR FEEDING SYSTEM (SOURCE: HOFMANN & STIRNER GMBH WEBSITE).*

# Part III: Redesign Parts

First question that probably comes in mind is why redesign at all? Why not just the same CAD-model? Just like any other manufacturing process there are design guides also for LPBF which you should follow to achieve good results. You need to tailor your part for the manufacturing process.
A small overview of the design guides is summarized for you in Figure 9.

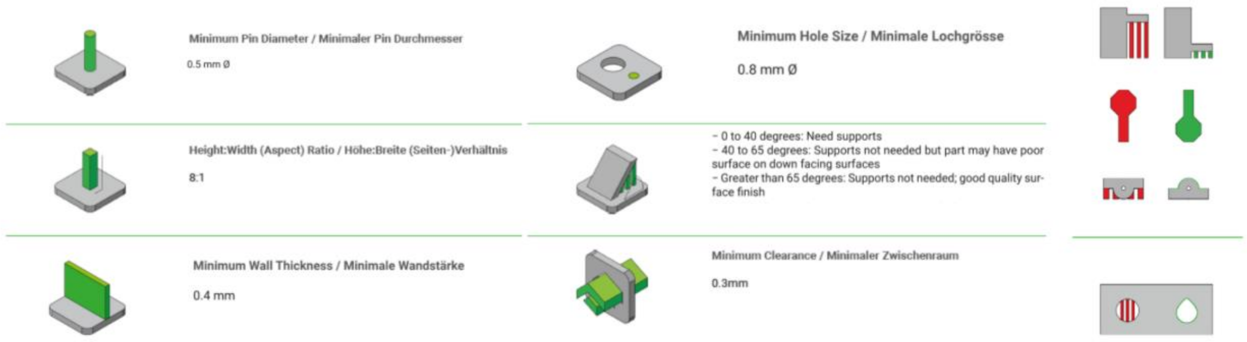



*FIGURE 9: DESIGN GUIDE RULES (SOURCE: ONE CLICK METAL).*

### Let’s come to our example 1 for redesign: Optical connector

During the welding process laser light is reflected from the melt pool into the optics. The water cooler around the optical connector prevents cooles away this excess energy (Figure 10).

**Assembly**

- casing
- inner core
- 2 O-rings large
- 2 angled connectors from SMC
- 2 hollow screws for angled connector
- optical connector
- 2 O-rings small
- nut to hold the cooler

➔ 12 components

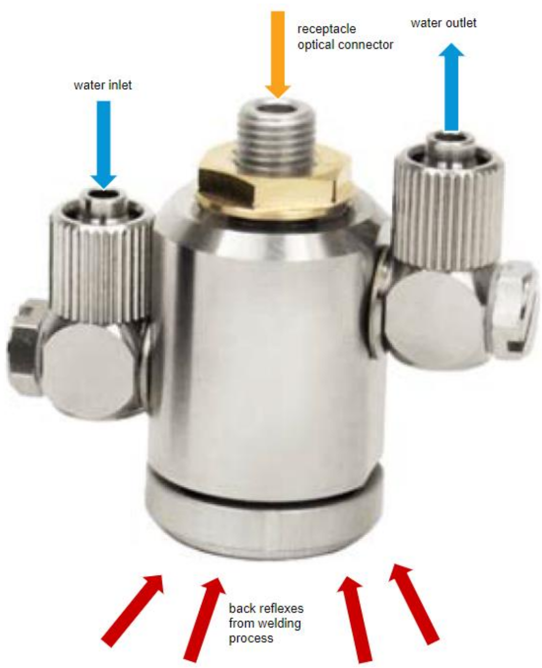



*FIGURE 10: OPTICAL CONNECTOR*

### The first redesign

The first redesign tries to mimic the original shape and is only optimized for the printing process however NOT for any post processing steps.

Issues with component that came up

- not tool runout for tapping
- only 4 components combined

Click here to watch video: https://youtu.be/tYQJ-yT9sAg

### Start from scratch: what are your functions?

To make the redesign as effective and easy as possible, you need to focus on the functions of your part. For additive manufacturing, it doesn't make much sense if you just try to reconstruct the part from conventional machining – that would offer no special added value. So in our case for the optical connector, you see the functions we needed down below.

- **Absorbing laser light**

The cooler should absorb laser light on its internal surface to dissipate the heat from the connector.

- **Receive and offer a liquid**

The liquid needs to be taken in at one point of the assembly and needs to leave it at a different point. These points should point upwards.

- **Fit into same assembly**

The focus laid on the cooler itself, so it needed to fit over the original laser receptacle.

- **Transmitting heat to liquid**

To get rid of the access energy the cooler needs to efficiently transmit the heat to a liquid.

- **Route liquid**

The assembly needs to route the liquid between the inlet and outlet

### The second redesign

The second redesign is focused on producing the whole cooler as one AM optimized component but it still has some issues.

**Fixed issues to previous component**

- tool runout for tapping
- 6 components combined
- added additional features to increase laser absorption
- roughly 30% cost saving

**Remaining issues with component**

- no clamping points for 3 jaw chuck
- not capable to machine on our machines
- only 6 components combined

Click here to watch video: https://youtu.be/J5m6Z4fPNBw

### The third redesign

The third redesign is going to incorporate also the optical receptical to

**Fixed issues to previous component**

- better cooling
- 12 components combined
- clamping points integrated

**Remaining issues with component**

- machining still required

## …now to our other example 2 for redesign: tooling for feeding system

The tooling is used in feeding systems of the Hoffmann and Stirner GmbH to feed and orient bearing housing components into an assembly machine.

**Indicators for redesign**

- High degree of machining
    - Typically machined on 5-axis machine out of a large tool steel block
- Assembly with many parts
    - 2 parts used in assembly
- Low part volume
    - only one part required per tooling set

Click here to watch video: https://youtu.be/VzF6o3QUnns

### Again: what are your functions and requirements?

To make the redesign as effective and easy as possible, you need to focus on the functions of your part. For additive manufacturing, it doesn't make much sense if you just try to reconstruct the part from conventional machining – that would offer no special added value. So, in our case for the tooling for feeding system, you see the functions we needed down below.

- **Provide conveying surface**

The 3d printed tooling must provide the same geometrical features to assure proper conveying and sorting of the components.

- **Faster lead time**

Lead time was 2-6 weeks. Especially for changes this was a long process.

- **Fit into same assembly**

The new tooling components needed to fit into the original assembly.

- **Quick redesign steps**

Redesign needed to be quick so all elements of the tooling can be redesigned quickly.

## Original parts

We will focus on the last segment in the tooling since it holds the most potential.

- complicated to machine
- two components
- easy to fit into build envelope

Click here to watch video: https://youtu.be/1S6a9_e1G3w

## Combining the parts

Using the combine feature the two parts were combined as the functional surface was only split to allow easy machining

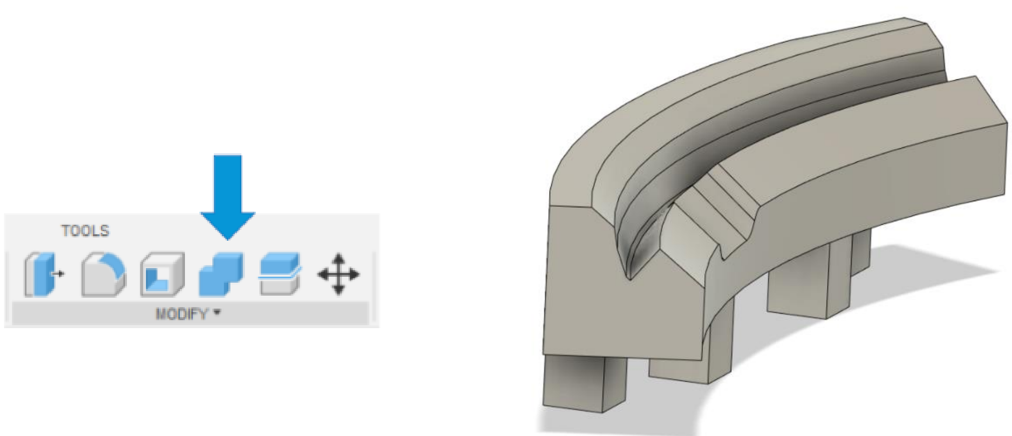



*FIGURE 11: COMBINING THE PARTS.*

### Removing excess geometry

We have to remove excess geometry until you are left with only your functional surfaces.

- removing fixturing studs
- mark connection points for later
- remove bulk geometry

➔ We are left with only our conveying surface

Click here to watch video: https://youtu.be/ZS4k5ZxIa94

### Adding mounting points

Now we have to add new mounting points to the part

- add two studs
- remove any excess geometry
- cleaning up the studs

➔ We could say we are done now but there is more

Click here to watch video: https://youtu.be/NNP18uu2MSQ

### Adding supports

Now we can add support structures that aid during the printing process and also stiffen up the part

- adding support to upper mounting point
- hollowing support
- rounding of connection point

➔ done

Click here to watch video: https://youtu.be/0lfz9l2EqcA

### Other techniques

Sometimes simple push and pull extrusions are not sophisticated enough or the part is too complex. In this case working with surfaces is a good choice

Click here to watch video: https://youtu.be/iKFi-yAULqs

### Using generative design

Using generative design can speed up the process for more complicated geometries.

Facts for this component:

- much stiffer part
- only about 7% heavier
- already optimized for printing direction

Click here to watch video: https://youtu.be/cRdl4OQwK3A

### Results of using additive manufacturing

Facts for this component

- drop in replacement for original part
- significantly shorter lead time (4 days)
- cost saving about 50% compared to machining
- more flexibility in surface design for future parts

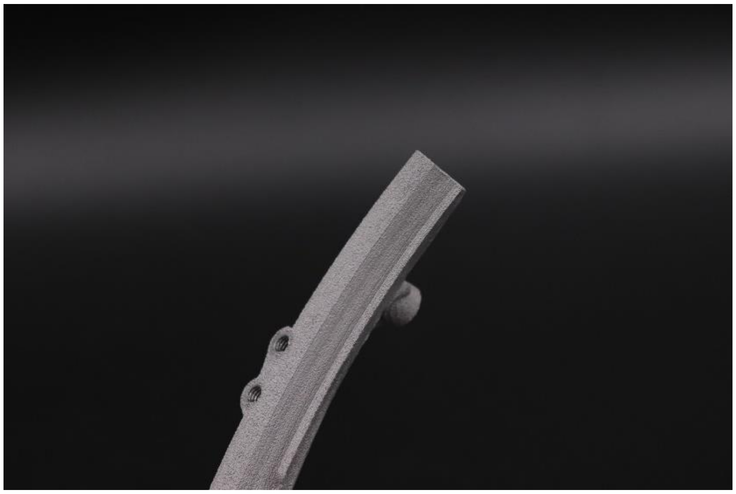


FIGURE 12: RESULT OF REDESIGN

## Part IV: Limits of LBPF

### Knowing the limits

**Part quantity**
L-PBF is good for single part to medium lot production. (~10k parts per year). However, it has not YET reached capabilities of mass production.

**Overhangs**
While it is said that you get “complexity for free” this only accounts for certain complexity. There are still limitations regarding overhangs which need supports.

**Part volume**
The larger you part the longer the build job and the more likely it is the build will fail. Also, the larger the part the larger the machine. The welding process is much harder to control in a larger machine.

**Process chain**

The printing of the part is only one step in the process chain and also only accounts for a part of the cost.

## Summary

### Cost of tooling part

In case of the tooling not even half of the cost is caused by the printing itself. This example was calculated ONLY printing one part on the build plate. The cost per part is lower when you fit more parts in to one build job.

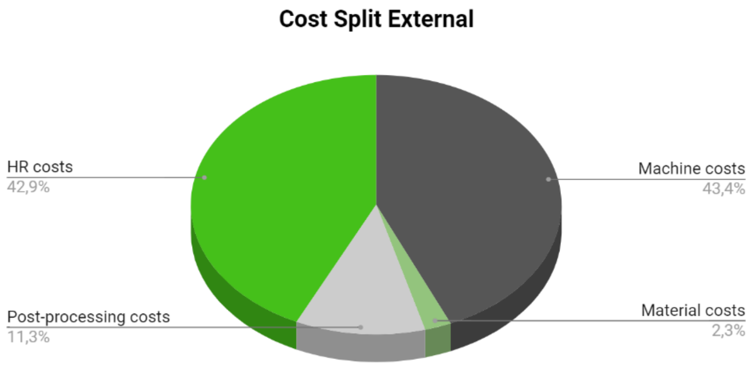
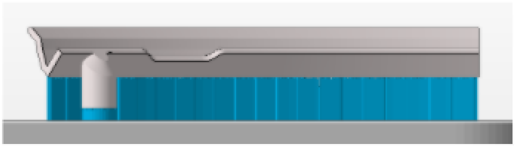



*Figure 13: Cost of tooling part*

### Part orientation

- printing your part flat saves  printing time
- printing it standing up saves time during post processing
- balance between cost of printing and cost of support removal



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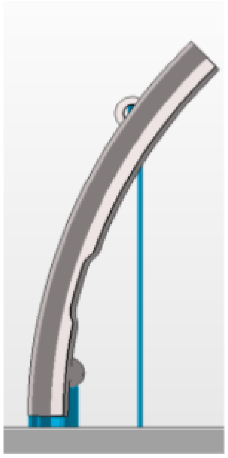

17h

*FIGURE 14: PART ORIENTATION*