# Additive Manufacturing Design Guide

3D printing using iglidur®

Design for quality
Design for manufacture
Design for function
Design for cost
Design for parts consolidation

plastics for longer life®

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# Your path to the ideal tribo component

In order to achieve an ideal 3D printing result, it is important to consider limits of the process. The objects must fit in the manufacturing space (220mm x 170mm x 300mm). For gears, the gear modules must not be smaller than 0.5mm, and the tooth head thickness not less than 0.4mm. The wall thickness of components must not fall below 0.7mm. Ensure that you work in CAD models with integer multiples of the 0.1mm layer thickness - an adaptation to 0.05mm is only possible in a few cases. If you want to mark components with information, you can use engraving (at least 0.5mm) or a constructive font (≥ 0.5mm).
To minimise rework, openings such as holes and slots should be straight - if necessary, conical for long holes. In addition, make sure that internal channels can be reached with the drill to remove the printing powder (alternative: multiple division of the component). Note that reworks such as chemical smoothing can result in deviations of up to 0.4%.

## Design for quality
Ensure sufficient data quality, which directly affects component quality and function

## Design for manufacture
Create a production-oriented CAD model, keeping an eye on the process limits

## Design for function
Ensure the desired component functionality

## Design for cost
Optimise your component from an economical point of view:
Costs, material consumption and production time

## Design for part consolidation
Benefit from the entire design freedom of additive manufacturing for functional integration, reduction of parts and assembly costs

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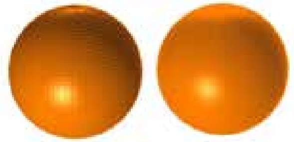
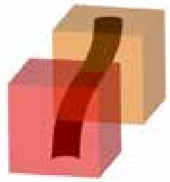
# Design for quality

## Export 3D model for printing

**Choose the highest possible resolution for your STL file**

You have created the CAD model of your component. Now it's time to export the file for printing as an STL file. Attention: select the highest resolution in the STL export setting to get the best possible print result. This is the only way to ensure that the 3D printer, for example for printing gears, works out the tooth profile correctly. For your CAD model, make sure you avoid open contours, join multiple solids, and hide surfaces and sketches. If you do not have your own CAD programme, you can use the igus® CAD configurators for plain bearings, rollers, gears and racks for your tribo parts at www.igus-cad.com.

| | |
|---|---|
| **Process:**<br>all<br>**Problem:**<br>CAD data quality poor/too low resolution<br>**Solution!**<br>Adjust STL export settings! |  |
| **Process:**<br>all<br>**Problem:**<br>CAD component defects, such as open contours and multiple shells, can lead to body separation in the laser sintering process<br>**Solution!**<br>Finally join components consisting of several solids; hide surfaces and sketches |  |
| **Process:**<br>SLS<br>**Problem:**<br>Shrinkage, curling of components due to different wall thicknesses and high length ratio (L/d)<br>**Solution!**<br>Provide even wall thicknesses, if necessary, execute ribbing or multiple parts |   |
| **Process:**<br>all (mainly laser sintering)<br>**Problem:**<br>The gear has a rough profile and/or does not run neatly<br>**Solution!**<br>Pay attention to the best possible export quality of the gear model in the CAD system. Make sure radii and the tooth profile are completely and neatly displayed. Alternative: use of the igus® gear configurator! |   |
| **Process:**<br>SLS<br>**Problem:**<br>The adjustment of the hole diameter in the data processing is made more difficult by rounding due to software<br>**Solution!**<br>Omit rounding or use chamfer. Rounding as far as possible only if functionally absolutely necessary |   |

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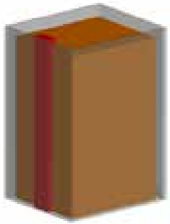
# Design for manufacture

## Make CAD model

**Pay attention to manufacturing space, wall thickness, layer thickness and reworking**

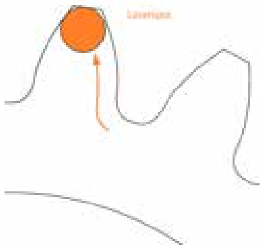
Would you like to produce your additive manufactured component as cost-effectively and time-efficiently as possible? Design for manufacture deals precisely with this topic - economical and design-oriented adjustments to your component, which are adapted to the igus® 3D printing process. The following illustrations demonstrate what you have to consider in terms of manufacturing space, wall thicknesses and layer thicknesses. Furthermore, we will point out which design guidelines you should internalise in terms of reworking.

**Process:**
SLS/FDM
**Problem:**
The part does not match the model: some features are wrong or not implemented at all
**Solution!**
The process limits must be observed: maximum manufacturing space 220x170x300mm / smallest features and wall thickness min. 0.7mm, manufacturing tolerance size-dependent for component dimensions up to 50mm: ± 0.1mm, moreover ± 0.2%, adaptation to 0.05mm possible in some cases, design in average tolerance

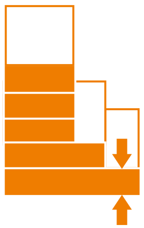


**Manufacturing space SLS printer 220 x 170 x 300mm**

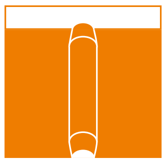
**Process:**
all (mainly laser sintering)
**Problem:**
Teeth of the gear are not properly developed or not functional
**Solution!**
Note the process limits for laser sintering of gears:
Minimal tooth module: 0.5mm
Minimum tooth head thickness: 0.4mm
Max. outer diameter: 172mm



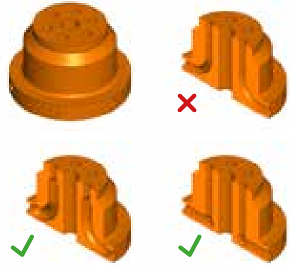
**Process:**
all
**Problem:**
Small structures/wall thicknesses below 0.7mm and general component dimensions that are built in Z-oriented
**Solution!**
Dimensional variations must, if possible, be constructed in whole layer thicknesses, that is as a rule, 0.1mm layer thickness. (No dimensions with 0.0x, especially when oriented in Z-direction).



**Process:**
SLS
**Problem:**
Small holes are closed or cause rework
**Solution!**
If possible, select the hole diameter depending on the depth in order to avoid reworking, if necessary widen the holes conically



**Process:**
SLS
**Problem:**
Inner channels cannot be freed from powder
**Solution!**
Drill a hole of at least 3mm, widen the channels on the inside so that it is easier to remove the powder/ make the component in several parts so that the channels are open.

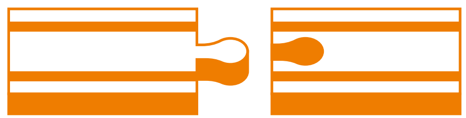


**Process:**
SLS
**Problem:**
Component variants are difficult to distinguish/logo or label should be attached
**Solution!**
Fonts engraved:
≥ 0.5 mm, font height > 5 mm
Constructive fonts:
≥ 0.5 mm, font height > 6 mm
independent of orientation (smaller fonts are feasible in the x/y-direction)


**Process:**
SLS
**Problem:**
The surface quality is not sufficient for the intended application
**Solution!**
If necessary, request the following reworking procedures to achieve the specified surface characteristics:
- colouring
- surface machining
    - Chemical polishing
    - Vibratory finishing

| | $R_z$ [µm] | $R_a$ [µm] | $R_{max}$ [µm] |
|---|---|---|---|
| Nature, glass bead blasting | 80 – 125 | 20 – 30 | 240 |
| Vibratory finishing* | n.b. | 15 | 120 |
| Chemically polished | n.b. | 10 | n.b. |

**Process:**
SLS
**Problem:**
Parts that are too big for the manufacturing space cannot be manufactured
**Solution!**
Divide component and provide joint geometry (form-fitting), which allows a precise assembly during bonding

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# Design for function

## Make CAD model

**Make sure that geometries work**

Make sure all functional elements are correctly designed. Example of threaded component: while some CAD programmes illustrate a threaded texture, they do not make it part of the 3D model. The printed part then has a non-functional hole. Pay attention to consciously design the geometry - or get that done by igus®. We implement printable thread sizes from M6 upwards. In addition, we recommend a thread clearance of +0.3mm at the diameter for lead screw nuts, and a clearance of +0.1mm at the thread flank in the Z direction. For the best possible function in interlocking structures, a gap of 0.2mm is recommended.

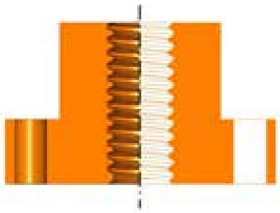
**Process:**
all
**Problem:**
The printed part should receive a functional thread
**Solution!**
Use one of the following options:
- Let threads be cut (M1.6 – M6)
- Provide threaded insert, see table (M3 – M8)
- Design printable threads (from M6)

| | M3 | M4 | M5 | M6 | M8 |
|---|---|---|---|---|---|
| Hole diameter | 4.7 | 6.1 | 7.5 | 9.2 | 11.2 |
| min. depth | 6 | 8 | 10 | 14 | 15 |

**Process:**
all
**Problem:**
Threads are inserted into CAD, but are not included in the printed part
**Solution!**
CAD illustrates thread texture to indicate threading in the drawing (left picture). However, the 3D model contains no matching geometry, so the part has only one hole in the result. The thread must be designed (right picture) - by the customer or by igus®. Printable nut size from M6

**Process:**
SLS
**Problem:**
Parts that interlock and are designed precisely to size do not match
**Solution!**
Interlocking structures provided with the appropriate gap size. A distinction is made between assemblies produced in one piece (here 0.4-0.5mm gap, right picture) and individually built components (here 0.2mm gap, left picture).

**Process:**
SLS
**Problem:**
Printed drive nuts run poorly or not at all on the lead screw
**Solution!**
Thread clearance at the diameter (D1 and D4): +0.3mm
Thread flank clearance in the Z direction: +0.1mm
Printing of drylin lead screw geometries can be requested



# Design for cost

## Think additive - save costs

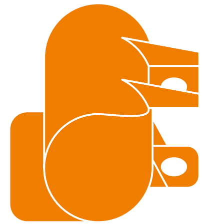
**Consider material recesses**

3D printing gives you the opportunity to save production costs. Unlike conventional manufacturing processes such as machining, complex geometries can be implemented in additive manufacturing without additional cost. The process does not require expensive special tools. So think additively and only add material where it fulfills a function - for example, in the gear, where you place sufficiently sized spokes instead of a solid disc.

**Process:**
SLS
**Problem:**
High component costs due to high volume, material unnecessary
**Solution!**
- Save material where reasonably possible
- Use braces instead of solid material for rigidity
- Prefer thin-walled construction (see injection moulding)

Volume: 100% Volume: 40.3%

**Process:**
SLS, FDM
**Problem:**
The part is not optimal (in terms of cost, function, etc.), since a production-oriented design was selected for conventional methods
**Solution!**
Production-oriented design for additive manufacturing: "Additive Thinking". Only add material where it is needed. Perform analysis based on the functional areas



# Design for parts consolidation

## Think additive - save costs

**Make your component multifunctional**

3D printing is a production technology that allows you to implement complex geometries at no extra cost. It is therefore advisable to equip the component with as many functions as possible, thereby reducing part costs and assembly costs. For example, optical instructions for operation, bearing points, sprockets for belt drives, snap hooks, logos or addresses can be integrated. Complexity plays (almost) no role - unlike traditional methods such as milling.

**Process:**
SLS
**Problem:**
Assembly costs and parts costs
**Solution!**
Functional integration: integrate as many functions as possible in one component - complexity plays (almost) no role





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/9001:2015

/16949:2016

igus® is certified in accordance with ISO 9001:2015 and IATF 16949:2016 in the field of energy supply systems, cables and harnessing, as well as plastic bearings.

## Do you have any questions about additive manufacturing?

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