DESIGN FOR ADDITIVE MANUFACTURING RULES

ERMAKSAN

INNOVATIVE TECHNOLOGIES

Process limitations

• Cost

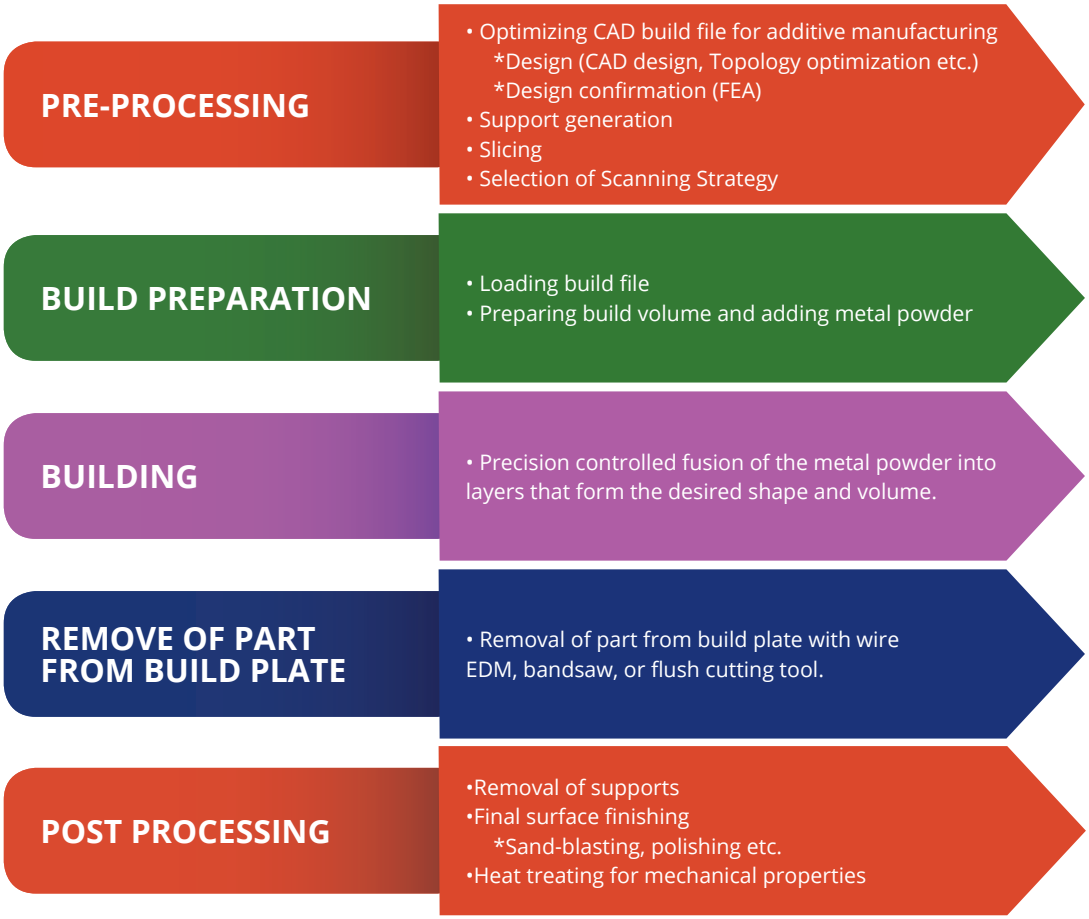
The cost of both metal AM machines and the materials they use are very high. Because of this, for some applications, traditional manufacturing techniques may be the most cost-effective solution (metal AM is unsuitable for the production of lots of generic washers/fasteners or large parts that are typically fabricated). Metal AM strength lies in complex, bespoke manufacturing where a high level of customization is required, or geometries are needed that traditional manufacturing techniques are unable to produce. To remain cost-effective, most metal AM machines need to be producing parts as often as possible with very little idle time.

• Design for additive manufacturing (DFAM)

One of the biggest misconceptions for metal AM is that all applications designed for conventional manufacturing can be converted to an AM solution. If a part was originally scoped and designed for conventional manufacturing, then it is more likely not a great candidate for 3D printing for a number of reasons. If a simple part has a large part size to part complexity ratio, then the manufacturing time to build is relatively high without the added value or improved function capable of a part designed for AM.

• Machine complexity

Metal additive manufacturing systems are not plug-and-play. Metal AM machines are industrial in size and require experienced operating, material handling, post-processing and maintenance procedures. Typical way to produce a part with metal printing defined with following steps:



* The given rules are not limited to these and there can be additional rules

• Support material

Due to the high temperatures involved in the metal printing process and the layer by layer nature of part construction, support structures are required to connect unsupported geometry to the build platform and act as a heat sink for thermal energy. Thermal energy can cause residual stress on the part during the building process. Residual stress resulting from the differential cooling means that each layer of a metal print wants to curl up and distort. Supports structures, helps to draw heat away from the recently printed sections and part to the base plate. As a second mission supports structures helps to produce the part properly against to the thermal stress.

Support therefore plays is an essential factor to consider when designing for metal printing.

Support adds extra cost to a build job and must be removed after printing job complete. Surfaces in contact with support always require post-processing (like grinding, polishing, sand blasting etc)

• Post processing

To be reach the final product some of the post process recommended. The most common post processing methods for metal printing are:

- Heat treatment
- Support removal
- Machining
- Surface treatment
- Polishing
- Mechanical polishing
- Electro polishing
- Sand-blasting

• Typical design rules

Explained design rules are typical rules and can be updated with the experimental usage. For different geometrical shape some rules should be modify accordingly.

Component orientation on build platform affects:

- Manufacturing cost (print time)
- Post-processing costs (support removal)
- Thermal build-up (large lasered region in single layer) = distortion, residual stresses
- Printability of certain features (e.g. internal channels)
- Surface quality

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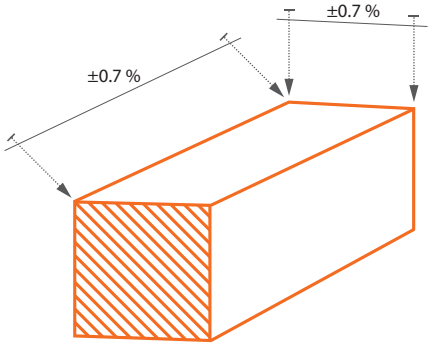
1. Support requirement

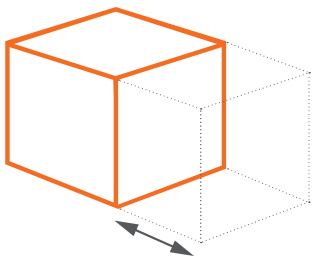
- The melt pool requires support during solidification
  - ➔ The complete process continues above the previous layer therefore previous layer supports the next layers
  - ➔ Insufficient supports can cause print failures like:
- Thermal distortions lead to geometric inaccuracy
- Accumulating distortions can lead to re-coating defects

Overhanging Surfaces - The minimum angle where support material is not required on an overhanging surface is 45° or above relative to the horizontal in most cases.

2. Tolerances

- Shrinkage processes during cooling influence the component dimensions depending on the component size and the material used.
- Manufacturing precision ± 0.7% of the linear dimension (minimum tolerance ± 0.1% mm , 100 -200 µm)





Tolerances - Part tolerance in the print direction is ± 1-layer thickness. In the XY plane, the achievable tolerance is ± 1 mm

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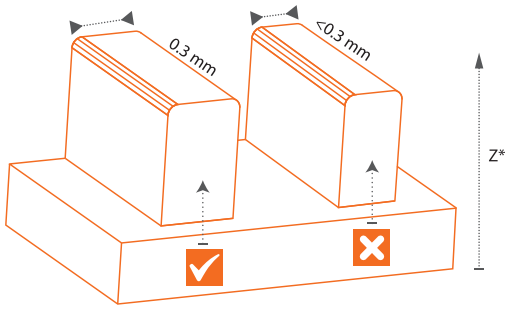
3. Wall thickness

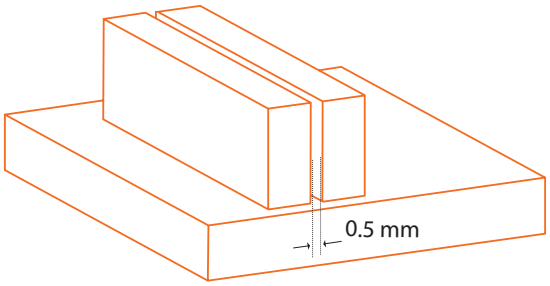
• Walls can be created with thicknesses > 0.3 mm. This value may vary to 1 mm according to powder types.

• The minimum wall thickness limited by the diameter of the laser and process parameter.



4. Minimum spacing

• If the spacing between contours is less than 0.5 mm, there is the risk that the cavities will be closed off with material or may even become fused.



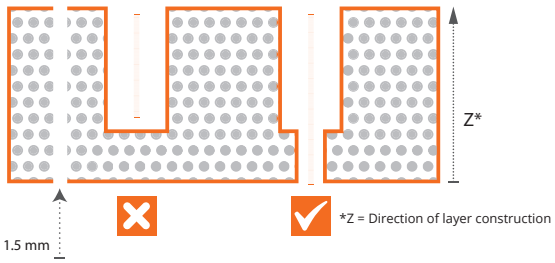
5. Drilled holes

• Components can be produced with blind holes, but through holes are more suitable.

• To minimize the stepped layer effect and maximize precision, cylindrical components and drilled holes should be oriented in the Z direction.

• The minimum dimension for drilled holes is 1,5 mm.

• Hole size - Holes diameters between 0.5mm and 6mm can be printed reliably without supports. Support free building of hole diameters between 6mm and 10mm is orientation dependent



Hole size - Holes diameters between 0.5mm and 6mm can be printed reliably without supports. Support free building of hole diameters between 6mm and 10mm is orientation dependent. Horizontal holes with a diameter greater than 10mm require support structures.

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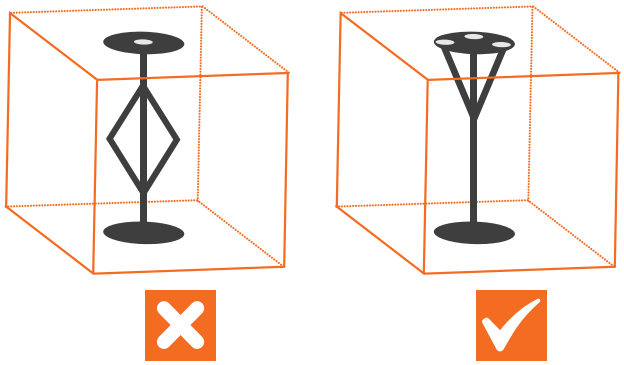
6. Channels

• Parallel systems should always come together again and be accessible from one side in order to avoid “dead corners”.

• Soft transitions can reduce the resistance and make powder removal easier.

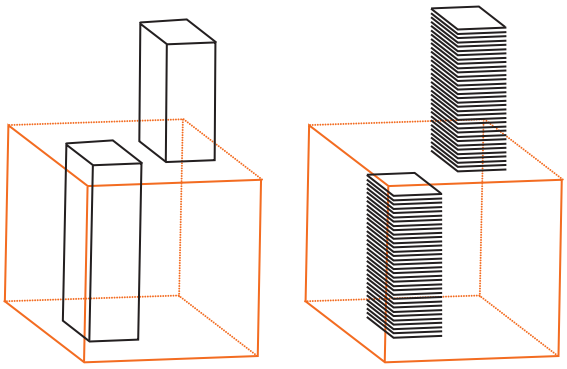
• For channels with cross-sectional dimensions measuring d > 8 mm, channels should be tear-shaped in order to avoid use of support structures.



7. Thread

• The smallest printable thread size is M6. Secondary machining is required for all diameter values.

• Threads as small as M2 can be created manually after production is completed. The appropriate core diameter must be created during the part design process.



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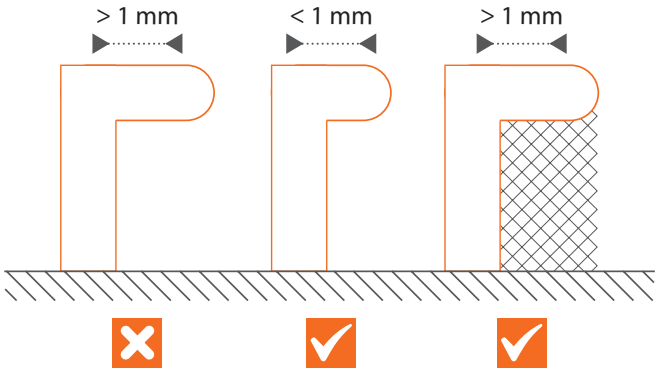
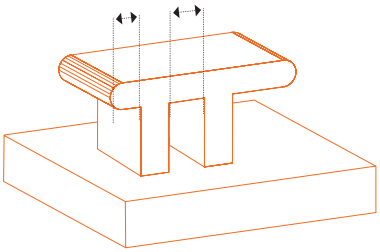
8. Wall thickness

• Free overhangs of up to 1 mm can be created without support. This value may vary according to geometry and powder types.

• Larger overhangs require a support structure or rounded corner in order to ensure the stability of the component during production.

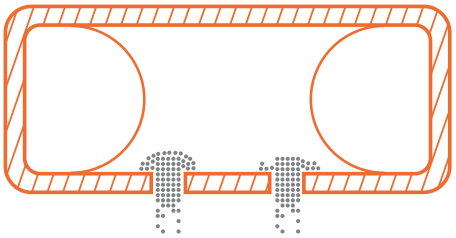


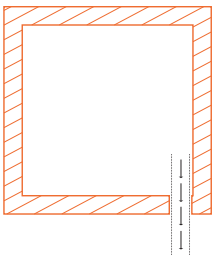


Unsupported Edges - The maximum length of a cantilever-style overhanging surface is 0.5 mm. An overhanging horizontal surface supported on both ends can be 1 mm long.

9. Powder escape

• Holes are required to allow powder to escape from enclosed printed structures. A minimum hole diameter of 3.0 mm (0.12 in) is recommended. Larger holes will increase the speed of powder removal.





Escape holes - Holes are required on hollowed metal parts to remove unmelted powder. A bore hole diameter of 2-5 mm is recommended. Using multiple escape holes will improve the ease of powder removal.

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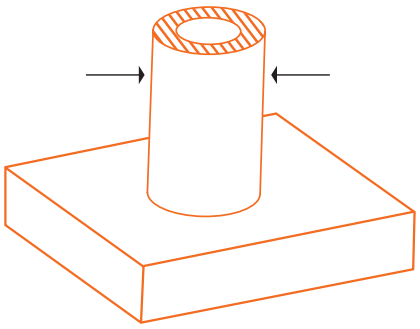
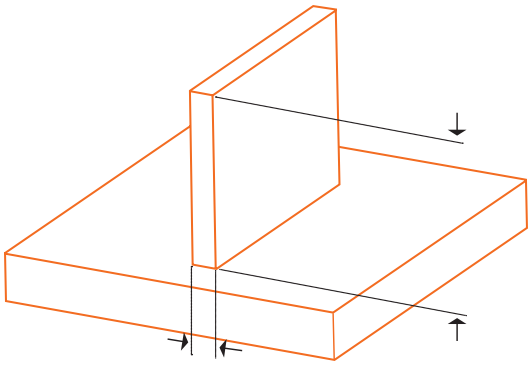
10. Pin diameter

Pin diameter - The minimum reliable pin diameter is 1mm. Smaller diameters are possible, but will have reduced contour sharpness.



11. Aspect ratio

Aspect Ratio - The Aspect ratio of wall thickness to height should be 1:6 to ensure stability of the printed part on the build plate.



These are basic information of D.F.A.M. For further information please contact us.

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