



First part design and optimisation test at CERN



Design by Bruno Favrat

CAD USER FORUM - DESIGNING AM PARTS

For the Additive manufacturing method we have to think different, not only the design process, but also the manufacturing process compared to the traditional "subtractive" method.

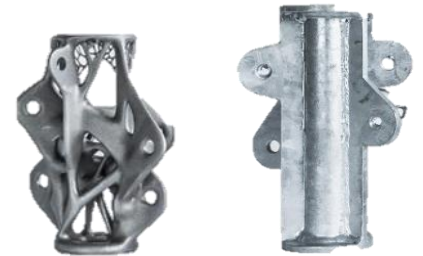
“Designers” must adapt their projects in advance to avoid difficulties during the manufacturing process.

The manufactured parts must respect (similar to plastic injection moulding parts) some essential rules in order to be able to produce them quickly and without error.

Some golden rules:



Change the mind-set of you and the people involved in the AM process and the production, from subtractive to additive thinking.



Each part is in different and need a specific analyse



Consult with each process expert before finalising the design for manufacture (machine operator, metrology, material specialist, engineers, client.....)

CAD USER FORUM - DESIGNING AM PARTS

We have every day new ideas at CERN and the 3D printing can open the door to these Ideas but we have to learn to think different:

“Adding material where it’s necessary”

and not

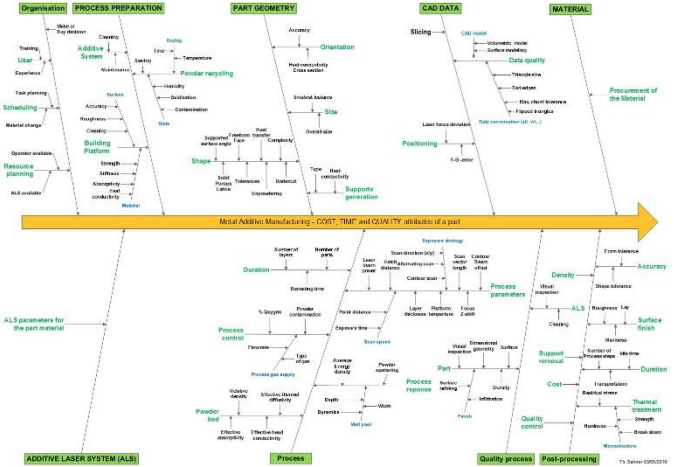
“subtracting material where it’s not necessary”



CAD USER FORUM - DESIGNING AM PARTS

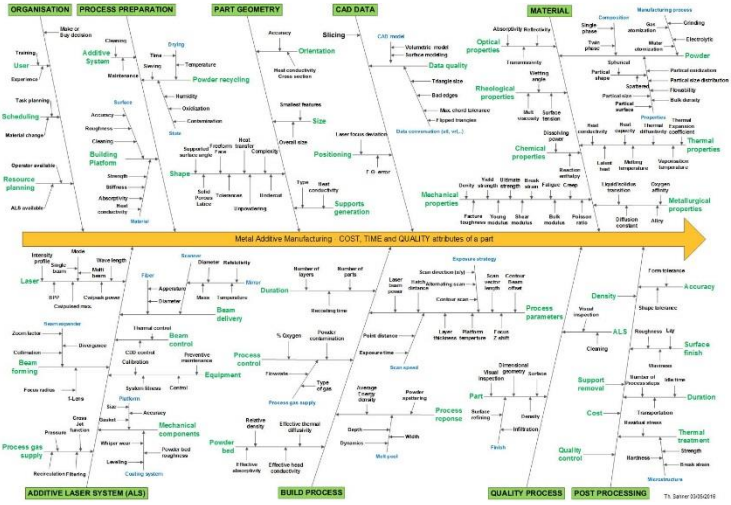
General requirements of AM parts

- Materials availability for AM
- Mechanical properties
- Geometry of the part
- Precision
- Production speed
- Surface quality
- Safety
- Price
-

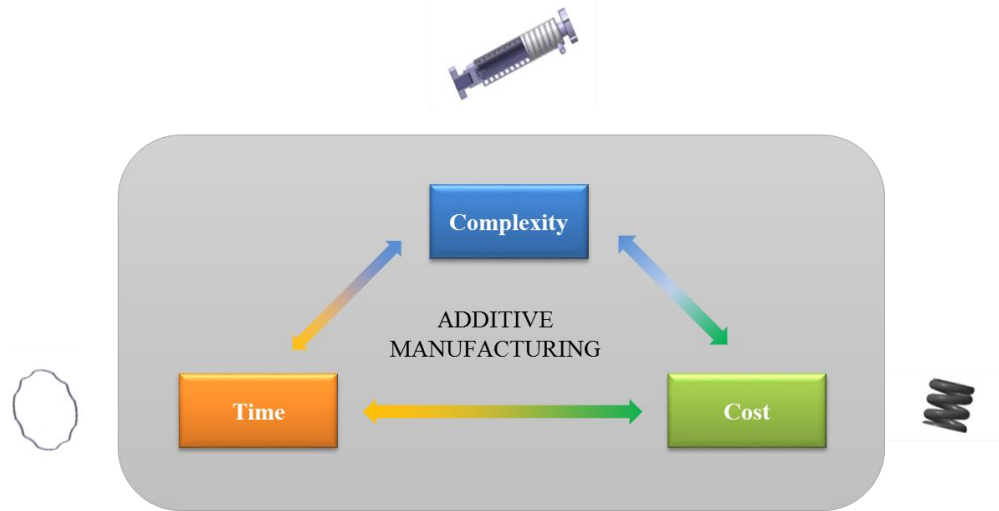


Additional specific requirements of AM parts for CERN applications

- Specific materials (e.g. pure Cu)
- Ultra high vacuum environment (10^{-13} atm)
- Outgazing behaviour
- Oxygen content ($>0,01\%$)
- Purity (up to 99.9%)
- Contamination (10-50ppm)
- RF behaviour
- Cryogenic ambience (working temp. $\sim 1,9K/ -271^{\circ}C$) with superfluid Helium
- High electrical conductivity at cold temperature



CAD USER FORUM - DESIGNING AM PARTS



Basic requirements and considerations:

Number of parts: ≤ 10 (depending on the size and form of the part)

Max. build size: $280 \times 280 \times 360 \text{mm}^3$ (x,y,z)

Material availability (Al,Ti, SSt)

Precision: better $\pm 0.1 \text{mm}$

Surface roughness: better $\geq \text{Ra}8.3$

Part un-powdering

Post treatment

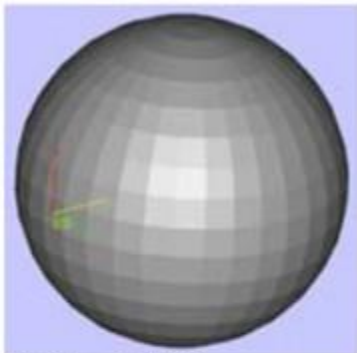
Support structure

.....

To reach better results consider additional costs or design modifications

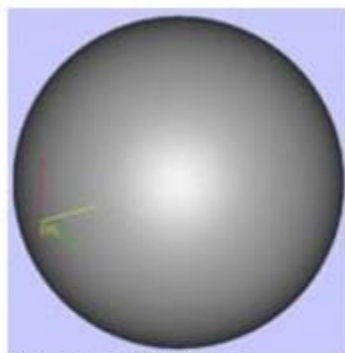
CAD USER FORUM - DESIGNING AM PARTS

Design resolution



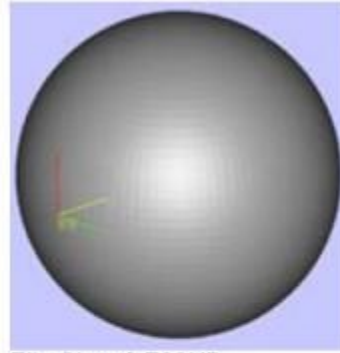
File Size: 705KB

Coarse Faceting (Poor)



File Size: 17,350KB

Excessively Fine Faceting (Fair)

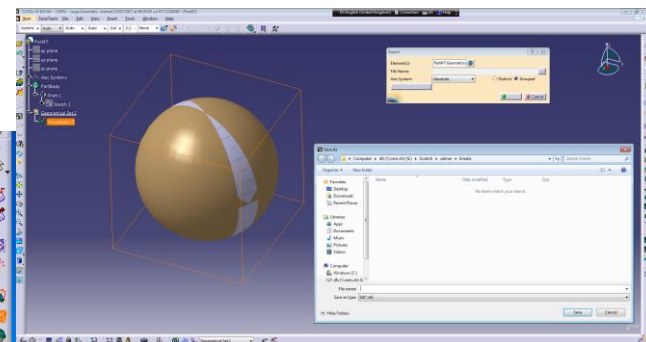
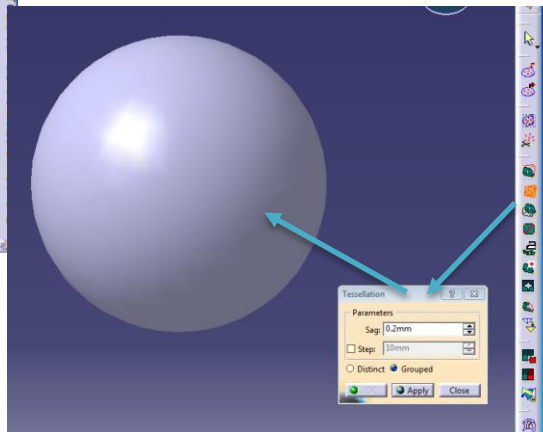
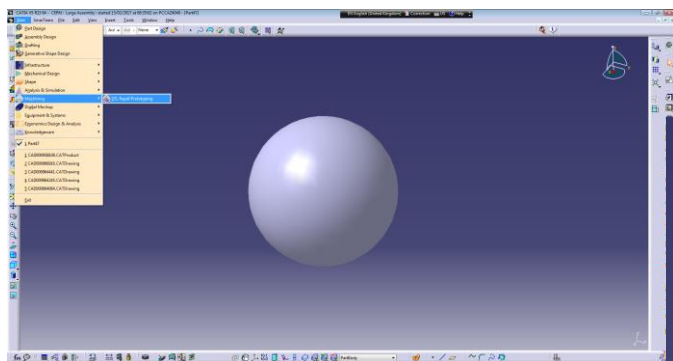


File Size: 2,760KB

Good Quality Faceting (Good)



If possible give a step file


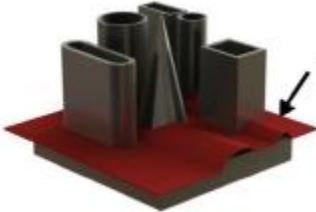



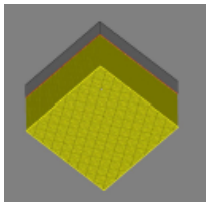
How to generate optimized STL files

How to generate optimized STL files?


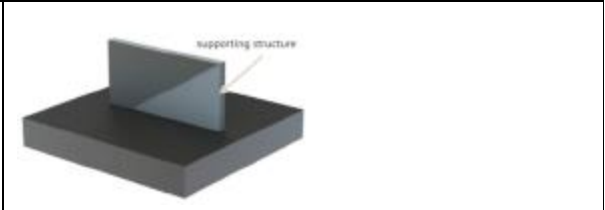

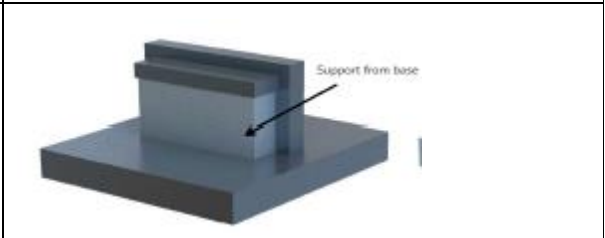
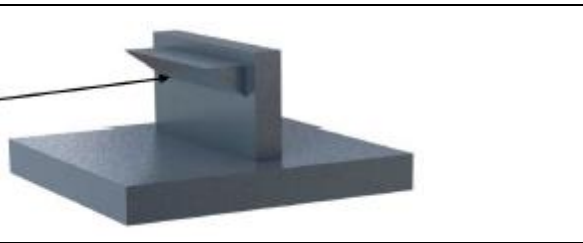
CAD USER FORUM - DESIGNING AM PARTS

Some general rules in the design of parts for laser sintering or electron beam



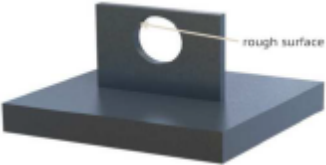


Position de la pièce	
	Comment positionner les pièces sur la plaque de la base
Réfléchir sur le trajet de coup	

Penser à l'orientation de la pièce sur la plaque de base, pour éviter un déplacement de la pièce pendant le mouvement du racleur.	
	Choisir la bonne structure du support

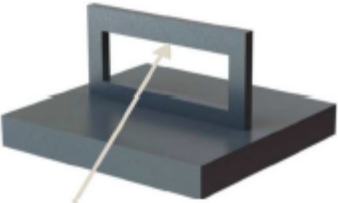


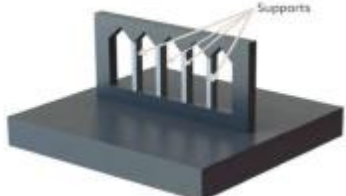

CAD USER FORUM - DESIGNING AM PARTS

Angles, Porte-à-faux Et ponts	
	Respecter des angles dans la conception des pièces. Il faut vérifier les angles pour chaque matériel
Inséré des supports si nécessaire	
	Eviter des porte-à-faux
Support pour les porte-à-faux	
	Insérer le support dans le design de la pièce

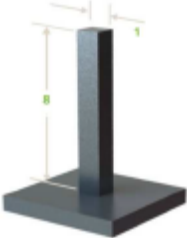


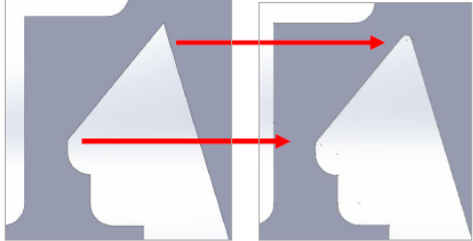
CAD USER FORUM - DESIGNING AM PARTS

<p>Eviter des ponts</p>	
	<p>Des ponts avec une largeur plus que 3mm, il faut prévoir un support</p>
<p>Trous</p>	
	<p>Pour les trous plus grands que 6 mm risque de surface dégradé</p>
<p>Insertion des structures de support</p>	
	<p>Eventuellement modifier la forme du trou pour une forme plus favorable a l'AM</p>

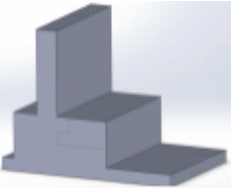
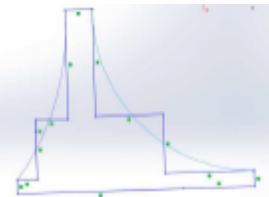
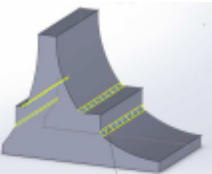

CAD USER FORUM - DESIGNING AM PARTS

<p>Eviter des faces sans support</p>	
	<p>Optimisez le support</p>
<p>Optimisez l'orientation de fabrication de la pièce pour éviter des dégradés</p>	
	<p>Changer le design vers des supports plus favorables</p>
<p>Optimiser la pièce</p>	

CAD USER FORUM - DESIGNING AM PARTS

	<p>Respecter le ratio de la fabrication ~1:8</p>
<p>Liée des structures</p>	
<p>Angles vif</p>	
	<p>Eviter des angles vifs</p>
<p>Ajouter des rajons</p>	

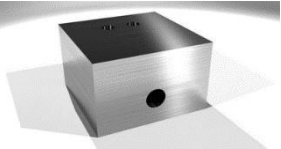
CAD USER FORUM - DESIGNING AM PARTS

	<p>Eviter des changements des sections</p>
<p>Modifier le design de la pièce</p>	
	<p>Arrondir les angles vifs</p>
<p>Générales</p>	
	<p>Respecter l'épaisseur des parois</p> <ul style="list-style-type: none"> Acier inox 1mm Aluminium 1mm Inconel 1mm Titanium 0,6mm Cobalt-Chrome 1mm

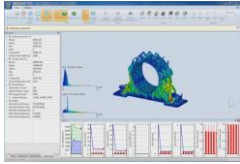
VDI 3405 Part 3: Additive manufacturing processes, rapid manufacturing. Design rules for part production using laser sintering and laser beam melting
 ISO/ASTM DIS 52910.2 Guidelines for additive manufacturing design

CAD USER FORUM - DESIGNING AM PARTS

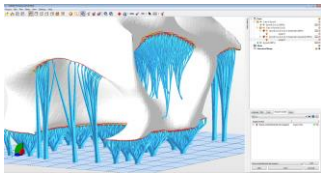
Part geometry optimisation or topology optimisation



Original engine block



Topology optimization



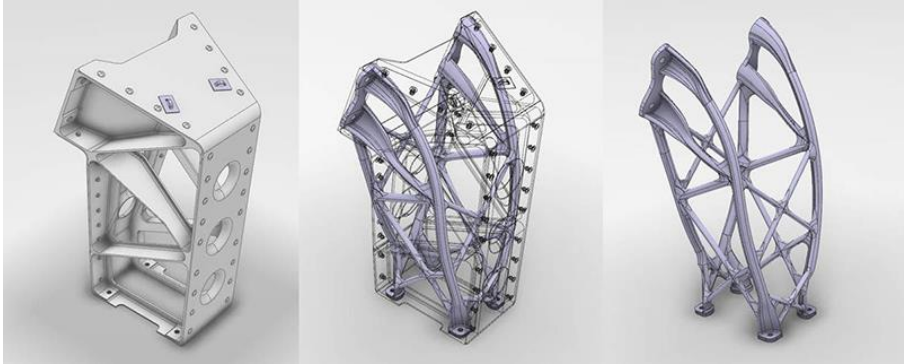
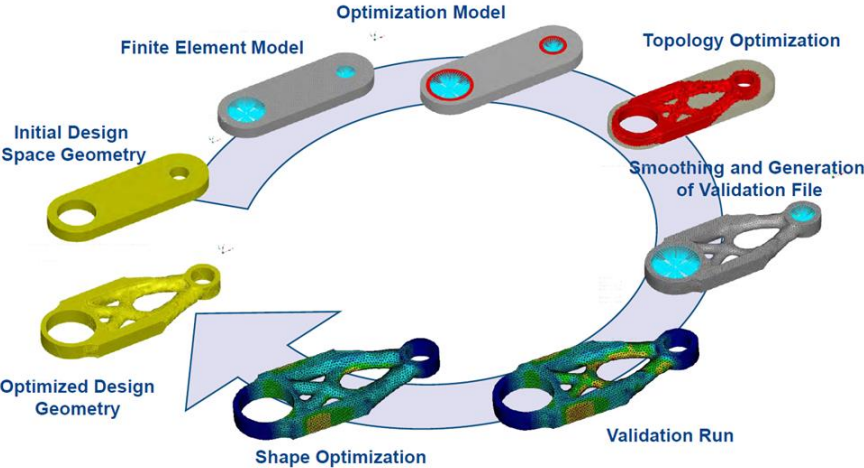
Support design



Manufactured design



Final design



Possible reasons:

Volume reduction respectively weight reduction for cost saving, manufacturing optimisation or mechanical limit optimisation.

Conclusion:

However, to further the adoption of these emerging AM technologies, there is a need for “Design for Additive Manufacturing” methodologies, tools, and guidelines that empower designers to realize products that fully capitalize on the novel processes’ capabilities.

We are at the beginning to discover the AM technology and the traditional manufacturing methods have hundreds of year advance in the understanding an mastering of the process parameters.

Do not afraid the new method but try to respect the rules and exchange with the experts in the different fields of manufacturing.

Next Steps:

- Understand more and get a feeling for AM;
- Find the “Design for Additive Manufacturing” methodologies;
- Training in AM design;
- See and reinforce software for part optimisation.

Thank you for your attention
and
Let's do things together