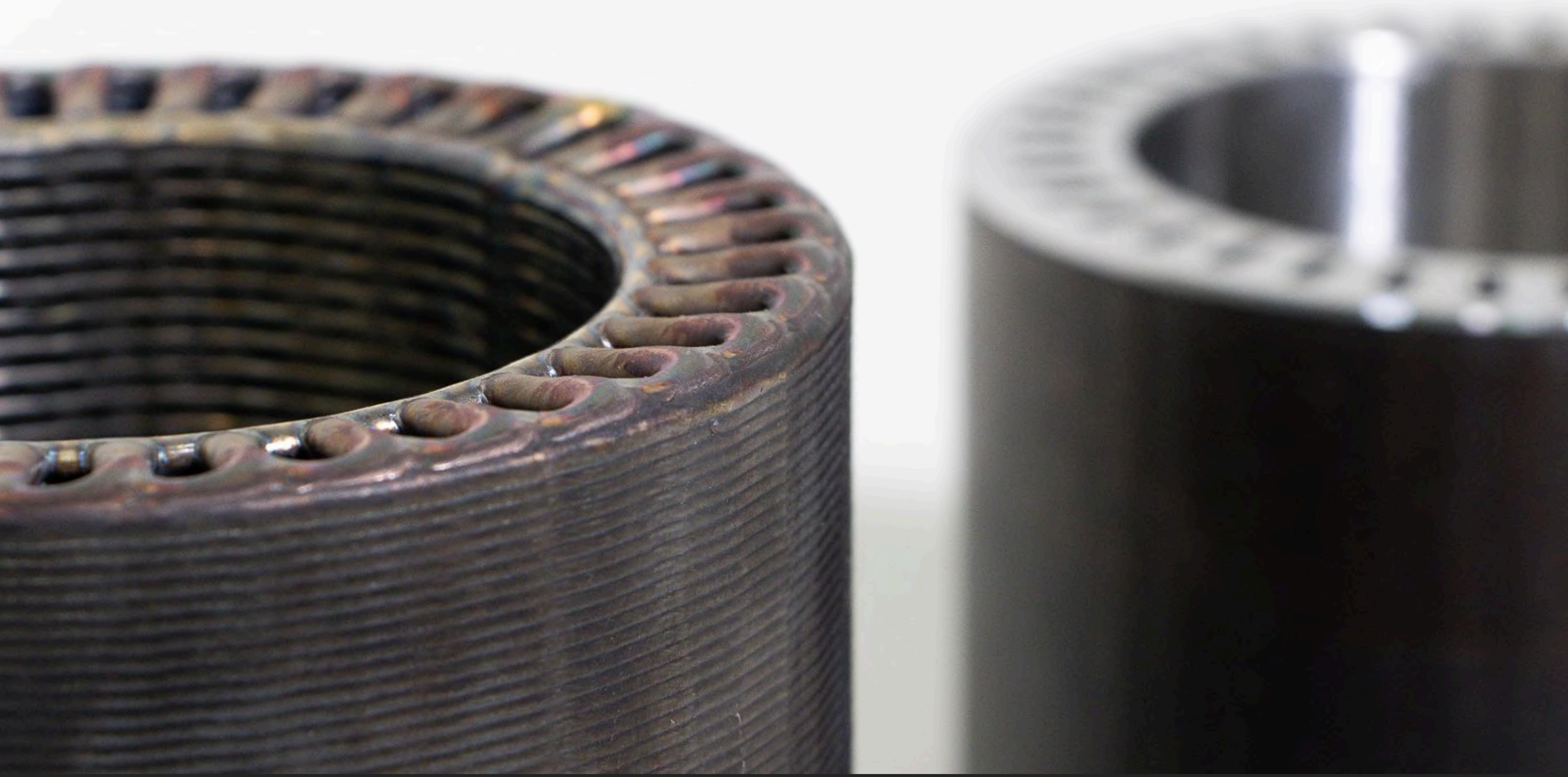
MELTIO

Q2 2023



Meltio Design Guidelines

Guidelines for materials and geometry to be printed with Meltio technology

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1. Material Overview

Meltio materials stands out as a recommendation for its additive manufacturing's systems due to its verified quality and optimized profiles developed that can guarantee part properties. Meltio has developed a line of materials that have undergone rigorous research, development, and testing processes to ensure superior performance and reliable results.

Meltio materials covers a wide range of applications and industries, catering to diverse needs and requirements. From stainless steels and tool steels to titanium alloys and nickel-based superalloys, Meltio offers a comprehensive portfolio that enables users to tackle various manufacturing challenges, whether it is in aerospace, automotive, medical, or other sectors.

Meltio materials with print profiles*	Supported materials without print profiles
Stainless Steel 316L	Other Stainless Steels
Stainless Steel 308L	
Stainless Steel 17-4PH	
Mild Steel ER70S	Carbon Steels
Tool Steel H11	
Titanium 64	Other Titanium Alloys
Nickel 718	Nickel Based Alloys
Nickel 625	
Invar 36	

** Check the material datasheet in Meltio website.*

Nonetheless, Meltio's technology is an open platform, offering unlimited third-party material choice. By embracing that, Meltio enables users to explore a wide range of materials that best suit their specific needs and applications. This flexibility allows for greater customization and adaptability, as different materials possess unique properties such as strength, durability, conductivity, or heat resistance. Users can leverage this diverse selection of materials to create parts that meet the most demanding requirements across multiple industries.

Meltio's open platform approach facilitates collaboration and knowledge-sharing within the additive manufacturing community. Allowing users to experiment with different materials and suppliers, valuable insights and discoveries can be shared, fostering an environment of continuous improvement and advancement in the field.

1.1 Dual Material Compatibility

The chart below offers valuable insights into the compatibility of the different Meltio materials with each other in the context of dual wire printing. The compatibility of materials refers to their ability to effectively bond or adhere to one another during the printing process. By examining the table, users can assess the compatibility of different material combinations and make informed decisions regarding material selection for their specific applications.

Compatible		Main Part Material (Wire 1)								
Incompatible		SS316L	SS308L	17-4PH	Invar 36	Nickel 625	Nickel 718	Tool Steel H11	Mild Steel	Titanium 64
Substrate Material (Wire 2)	SS316L									
	SS308L									
	17-4PH									
	Invar 36									
	Nickel 625									
	Nickel 718									
	Tool Steel H11									
	Mild Steel									
	Titanium 64									

Dual material compatibility chart.

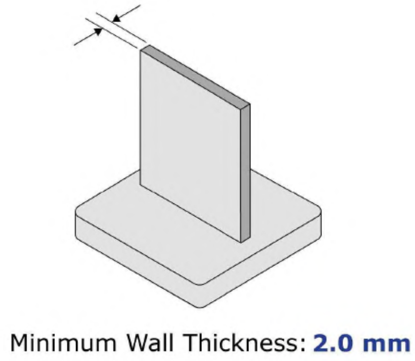
2. Geometry Analysis: Design Rules

The following design rules are applied for all Meltio systems.

2.1 Thin Walls

The minimum wall thickness is related to the wire diameter:

Wire diameter	0.8 mm	1.0 mm	1.2 mm
Minimum wall thickness	1.5 mm	2.0 mm	2.5 mm



Solution: If the model has thinner walls, modify CAD Model to add material to reach the required minimum wall thickness. This added material will be removed during post processing**.**

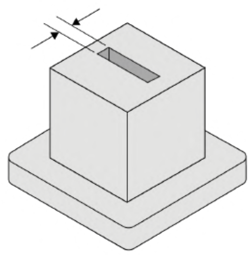
2.2 Minimum Slot Width

Represents the minimum separation between two vertical surfaces that remain without contact when printed.

The minimum slot width is 1,2 mm.

Printing slots at non-vertical angles requires additional separation between the two surfaces.

Parts printed with larger layer heights require larger separation between the surfaces to avoid contact due to their increased surface roughness.



Minimum Slot Width: **1.2 mm**

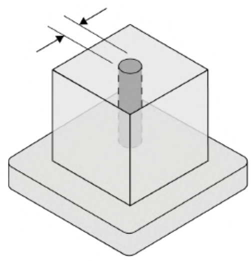
If the application permits, slots should always be printed at the maximum size possible to improve separation.

2.3 Minimum Vertical Hole Diameter

The minimum vertical hole diameter free of obstructions is 2,0 mm.

Same as slots, printing holes at non-vertical angles requires additional separation between the two surfaces.

Parts printed with larger layer heights require larger separation between the surfaces to avoid contact due to their increased surface roughness.



Minimum Vertical
Hole Diameter: **2.0 mm**

3. Systems utilizing 3-axis configuration

3.1 Fundamental geometry limitations

- **Meltio M450 print envelope:** 145,0 x 168,0 x 390,0 mm.
- **Largest Build plate:** 150,0 x 200,0 mm.

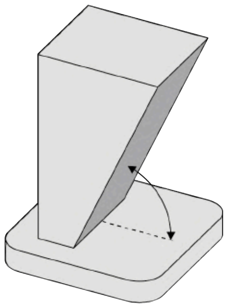
3.2 Weight criteria to determine if the part is a good fit for the technology

- **Dimensions** > 20,0 mm in all axes.
- **Weight** < 30,0 kg

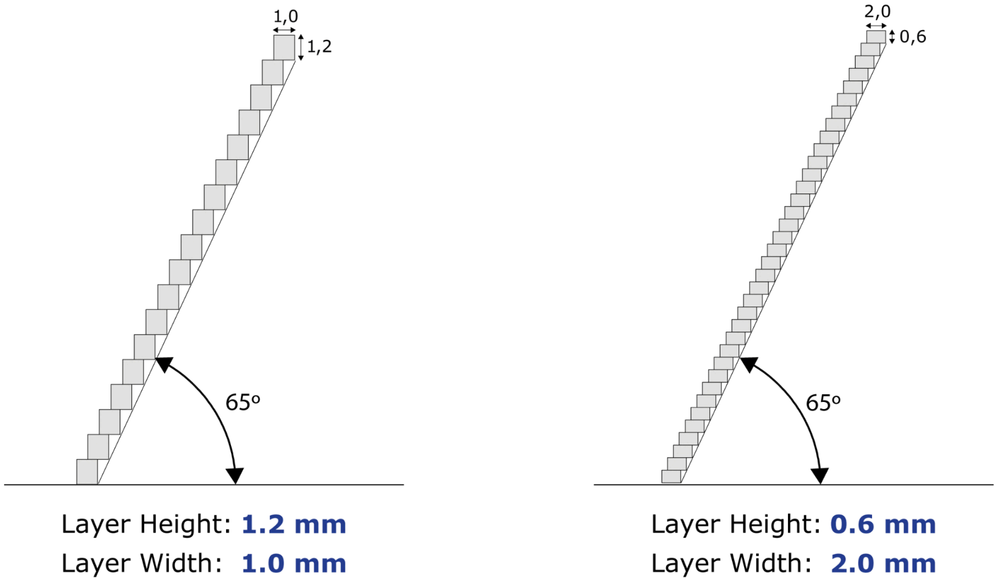
3.3 Maximum admissible overhang

- Represents the maximum overhang that can be done without the need of printing support.
- **From the horizontal axis =** 65º.

If the overhang gets steeper than that, support material will be required for 3D printing. Meltio's LMD Process achieves the largest overhangs at low layer heights because the bead width is constant, therefore the percentage of "overhanging material" on a layer per layer basis is reduced.



Maximum Admisible Overhang Angle: **65º**



Example of a single bead overhang print showing how individual layers overlap each other.

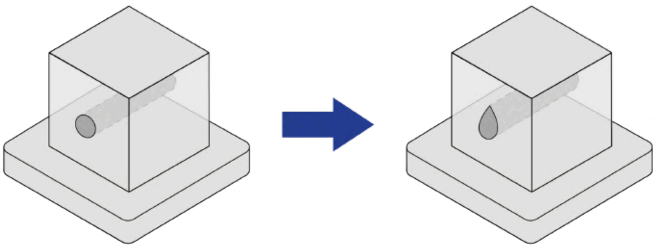
Printing at larger layer height is more economically interesting, because it reduces the print time. As Meltio Wire LMD is a near-net shape process and most of the parts require machining, it is usually faster and cheaper to produce the part in larger layer heights and machine a minimal amount of additional material once the component has been printed.

3.4 Horizontal cooling channels / Horizontal holes

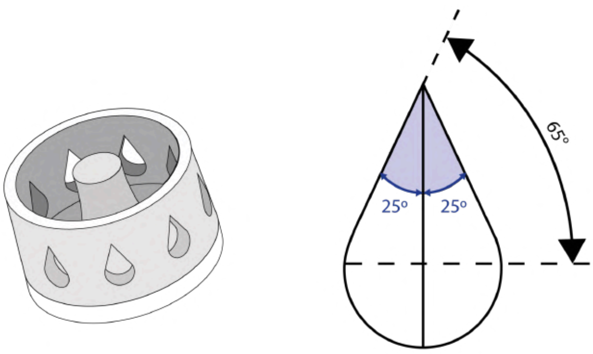
Horizontal holes cannot be printed with a round profile as they form a very steep overhang and bridge at the top.
Therefore two options are available.

3.4.1 Teardrop Profile

Changing the cross section to a teardrop shape reduces the maximum overhang angle to a manageable degree. This option is suggested if horizontal holes or cooling channels are unavoidable and can not be accessed for machining in post processing.



Cross section changed to a teardrop shape



Detail of the proper angle for the teardrop shape

3.4.2 Elimination and fabrication during post processing

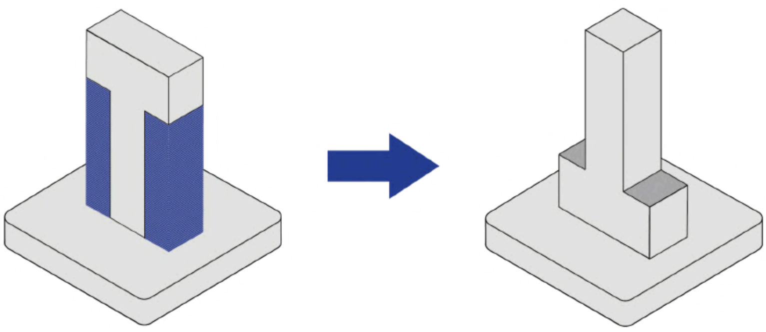
In most cases the easiest option is to remove the horizontal hole entirely in the CAD program and to machine it during post processing.

To facilitate machining, it is recommended to fill the hole and show the perimeter of the circle.

3.5 Overhang Solutions

3.5.1 Printing orientation

To print a part, its orientation should be selected in order to reduce the use of support. Also it should be considered using the build plate as part of the model if allowed by the geometry.

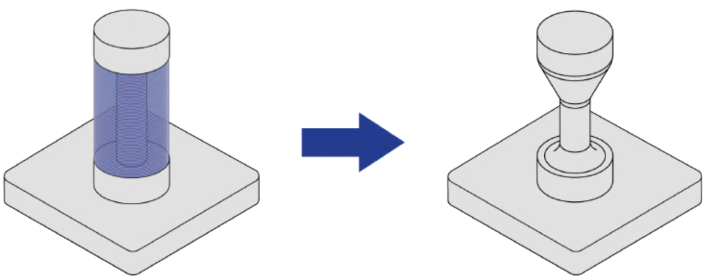


Need of support   No need of support

3.5.2 Modify part in CAD

If the area affected by the overhang does not belong to a functional area of the part and therefore can be modified, it is strongly recommended to do a redesign that complies with the design rules. (Overhang <65º from the horizontal axis).

In case the zone of the part is functional, there is always the option of subsequent machining.



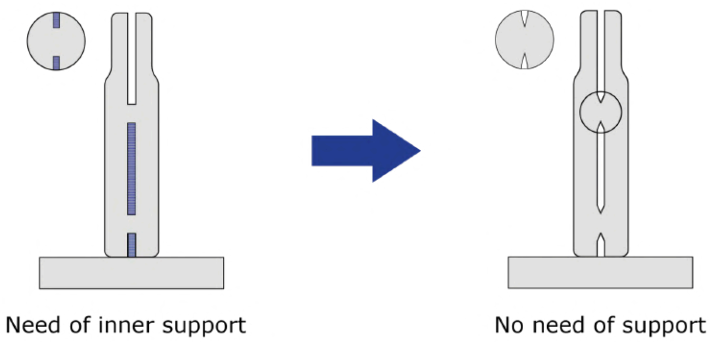
Need of support   No need of support

Desired net shape on left, modified part that meets design rules on right: Only a small amount of material is added compared to using supports from the slicer.

3.5.3. Smooth transition at bridges

LMD printing processes are not able to bridge gaps, due to the low viscosity of the molten material. As such, similar to the previous modification we need to support the bridged section with wedge supports.

Example below: same part with two bridged sections. First one printed with slicer generated support, sealing the entire gap and second one with support wedges which do not impact the parts functionality.



3.5.4. Add support material

Printing supports could be machined away after printing.

When working with more expensive materials it can be recommended to print the supports from a different material that can be lower cost and easier to cut. Typically, we recommend the use of Mild Steel for this application, when possible. (Check the dual-wire combination chart).

- CAD generated support

Using a CAD software to generate the support, instead of generating automatically in the slicer software, results in a more specific configuration for the support and gives the possibility to control its parameters.

- Automatically made by slicer

Automatically generate printing support in the slicing process to sustain surfaces that exceed the maximum overhang angle.
Easy process but not the most efficient, as supports are always placed vertically.

3.5.5. Print a part in 5 axis if possible

If none of the proposed solutions are acceptable, then printing in 5 axes should be considered.

3.5.6. Near Net Shape (NNS) and Over thickness

Near net shape (NNS) is an industrial term that refers to manufacturing processes that produce a raw part that is very close to its final desired shape or dimensions. The final shape is also known as the net shape. The term implies that further machining or finishing might still be required to achieve the final specifications or tolerances necessary for the part.

Meltio is a near-net shape technology because it has the capability for printing a model that is close in size and shape to its final version. Considering this, it is necessary to apply over thickness as a means to achieve the part with a near net shape. By incorporating over thickness, extra material is provided, ensuring that subsequent processes can be carried out without compromising the final dimensions of the part.

The process of applying over thickness to a part that will be printed with Meltio's technology typically involves modifying the original 3D design of the part to include additional material in critical areas and it should be done using CAD software or other design tools.**The recommendation is an addition of minimum 1.50 mm wherever the final surface must achieve low roughness and high accuracy by machining.**

4. 5-axis and 6-axis systems: Robot Engine Integration and CNC Engine Integration

For 5-axis and 6-axis systems, Meltio Deposition head can be oriented at any angle, being able to avoid the use of support material as the Meltio Engine Tool head can be oriented perpendicular to the previous layer.

Collisions between the deposition head and the part/build plate/movement system need to be carefully monitored as not all geometries are accessible with any building strategy. As well as with the Robot, CNC components that are being used have to be taken into account (such as the table, head or tool) to avoid collisions.

Every component presents its unique geometry, so the collision analysis is an individual task for each component. Therefore, it is necessary to study carefully every point, approach movements or travel trajectories. It is unfeasible to describe a certain rule to avoid all the possible collisions, nonetheless, there are some general features regarding the Meltio Engine Tool head dimension that would help to avoid some of them.

4.1 Overhang Angles

For Engine CNC and Robot Integrations, the maximum overhang angle printable in three axes is the same as for the M450.

- **From the horizontal axis =** 65º.

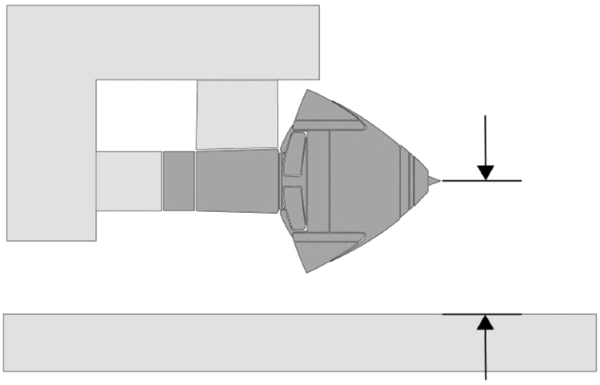
4.2 Limitations of Robot Integrations in Bridge Printing

Currently, robot integrations face limitations when it comes to printing bridges or enclosed spheres, primarily due to potential collisions between the deposition head and previously printed sections of the object. The recommended solution is to redesign the part to incorporate printable overhangs, by following the guidelines offered in this document.

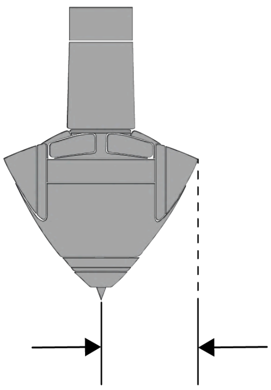
4.3 Head's Clearance

4.3.1. Minimum Distance

The safety distance that is normally applied when it is necessary to print using a 90 degrees orientation is 150 mm, to be sure that the tool is not going to collide with anything along its path. Occasionally it is necessary to create a workholding solution to elevate the part beyond the minimum clearance distance. It is also necessary to consider the axial distance between the tip of the nozzle and the most external edge of the head.



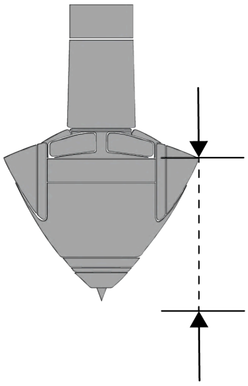
Minimum Distance for Head Clearance: **150.0 mm**



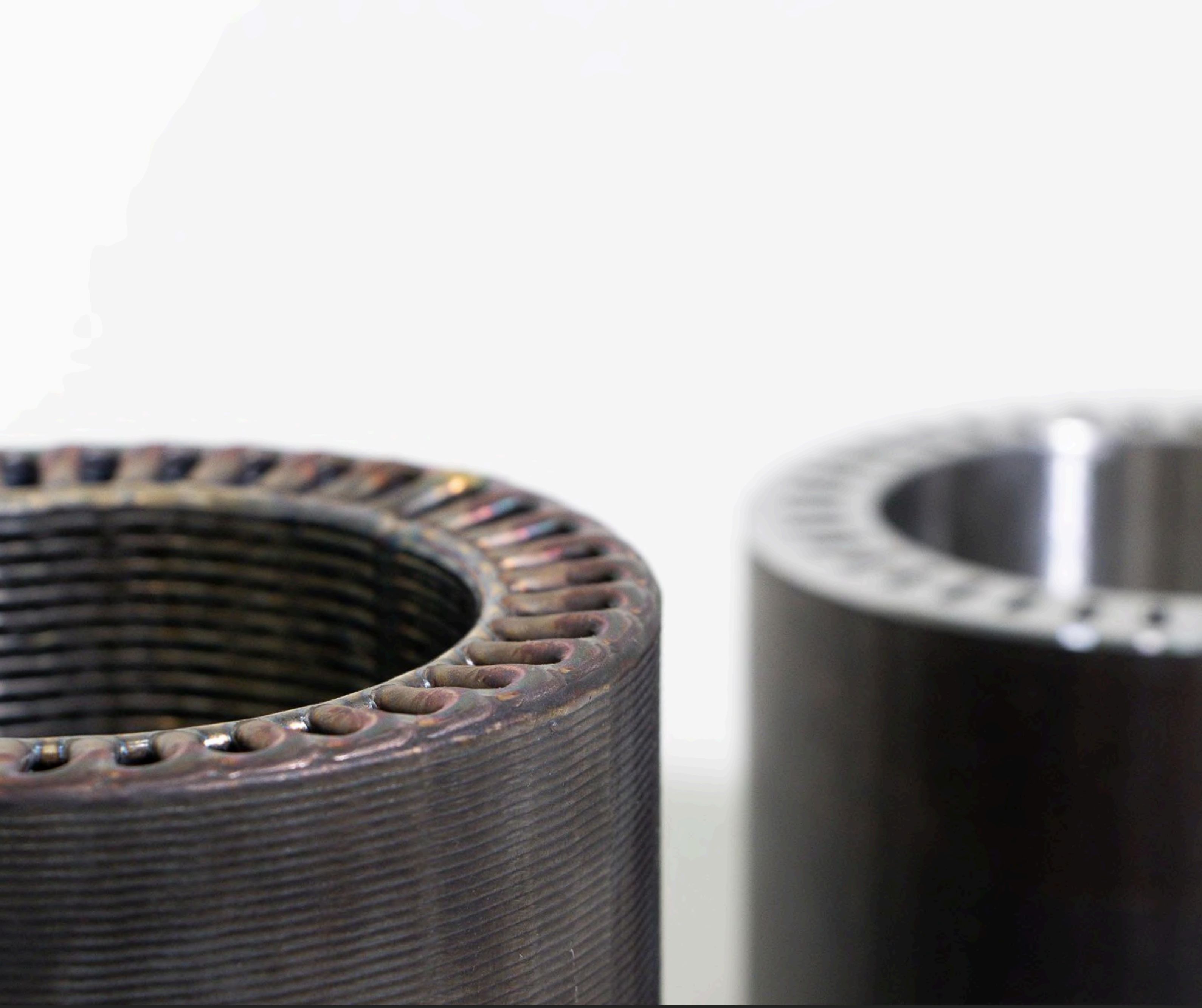
Minimum Horizontal Distance for Head Clearance: **100.8 mm**

4.3.1. Minimum Angle

Moreover, another important factor to take in account is the external angle of our Meltio Engine tool head.



Minimum Axial Distance for Head Clearance: **133.2 mm**



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