VELO 3D

Additive Manufacturing Solutions

Stator Rings on Velo3D Sapphire

Velo3D Sapphire System & Flow Software Empower the Future of Additive Manufacturing

Stator rings, blisks, and similar low-angle parts are among the most difficult to create using metal AM (Additive Manufacturing) processes. Velo3D has changed the ground rules for printing this class of parts by combining an innovative printing system with ground-breaking process development work. This makes it possible to print low-angle parts with fewer or no supports, and to do so with tighter dimensional tolerances and less end-to-end production time due to the reduced need for post-processing printed parts.

The Velo3D Sapphire™ system, along with our Flow™ software, addresses these challenges. Velo3D believes it is the enabling technology that will usher metal AM into a new era.

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High-Value Geometries for Additive Manufacturing

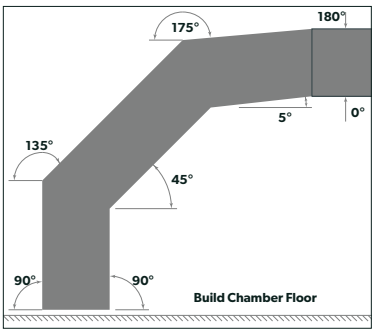
There are several canonical geometries that are frequently seen throughout the metal AM industry. These geometries include stator rings, impellers, turbine blades, and blisks. A representative stator ring is shown in Figure 2.

Specific Difficulties with Stator Ring Geometry

Stator rings are good candidates for metal AM because they are difficult to machine or cast in the types of high-nickel super-alloys often preferred for these applications. Stator designs have many of the features at which metal AM excels: surfaces with compound curves, internal fluid passages, and design considerations for weight reduction.

One of the big challenges in designing stators involves low-angle surfaces. (See Figure 1). Below a certain angle, such surfaces require supports in order to be printed correctly, and removing these supports later requires money and time. Current Design for Additive Manufacturing (DFAM) guidelines require that surfaces less than 45° be supported.

Figure 1.
Angle Definition for Metal AM Parts



Issues Associated with Supporting a Part

Supporting a part may seem like a straightforward proposition, but there are significant hidden costs and complexities in this process. The first is in the design of the supports.

Deciding where to put supports takes design time and effort during print preparation, because support shape and placement is not a simple process; it requires experience and judgement in order to get the best results.

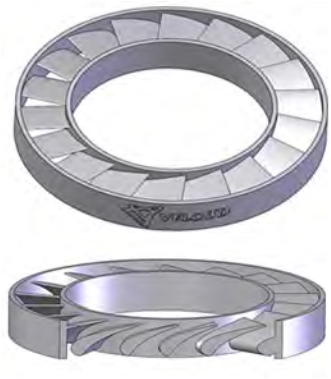
A frequent outcome is that designers err on the side of over-supporting low-angle surfaces, in order to avoid build failure. This results in many supports that later need to be removed, and depending on the complexity of the supports, this can be a difficult proposition, requiring multiple set-ups on a CNC mill, or wire EDM, or a turning step.

It takes time to print so many supports; this adds to the total build time, and build cost is primarily a function of build time.

Velo3D Advantage: Dramatically Reduced Support Structure

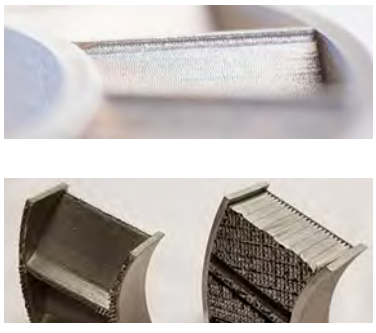
With our unique, patented technology, the Velo3D Sapphire system dramatically reduces the need for supports and the associated costs and complexities. An example of this difference can be seen in Figure 3, which shows a two-blade section of the stator printed on both a conventional system and on a Sapphire system.

Figure 2.
Isometric and sectional views of full stator ring geometry



The part was printed using an existing system at a service bureau. The resulting support structure is significant, representing about 19% of the total part mass. In contrast, the support structure of the part printed on the Sapphire system is roughly 2% of the total printed mass.

Figure 3.
Stator ring section printed on a Velo3D Sapphire (top), and another laser-fusion system (below right). Note the dramatic reduction in support requirements.



The Velo3D Post-Processing Advantage

When analyzing per-part cost, one must add post-processing time and cost to print time in order to get a true comparison. The Velo3D part in Figure 3 can be finished with a single setup on a 3-axis mill. This saves money and production time.

Meeting Dimension Specs Without Iterating

Velo3D Deformation Correction Software

Figure 4.
A structured-light scan of each part was compared to the CAD model. The upper part used Flow software to predict and correct for deformation. The lower part was printed without deformation correction.

Ensuring that a part meets all dimensional specifications can be difficult. Deformation occurs because of stresses caused by thermal expansion and contraction of the material during processing. In typical practice, this deformation is corrected through iterative changes to the geometry. These tweaks require reprinting the part, assessing the change, and trying again until the results are as intended.

Velo3D's Flow software includes deformation correction, which allows the user to produce parts that meet dimensional specifications without the need for iteration. It calculates deformation; this is then compensated for by pre-deforming the original geometry in such a way that the final part is dimensionally correct.

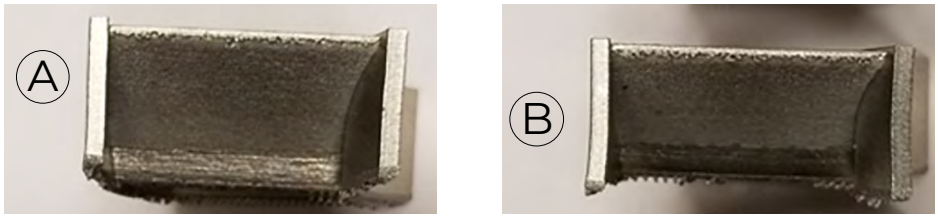
To test the effectiveness of Flow software, Velo3D calculated the predicted deformation of a part and then printed one part without pre-deforming it and a second part pre-deformed using the predicted deformation. Both parts were then structured-light-scanned and compared to the CAD model. The results are shown in Figure 4. As can be seen, the corrected part shows better agreement with the CAD model - proof of software accuracy.

The actual printed parts are shown in Figure 5. Velo3D's Flow software all but eliminates the iterations and trial-and-error currently employed to correct for in-process deformations.

Figure 5.
Stator ring sections

A. Printed after Flow software correction of geometry deformation. Note that the side walls are straight.

B. Printed without using deformation correction software. Here, the side walls are curved.



Conclusion: A Better Way to Make Parts

The combination of the Velo3D Sapphire metal additive manufacturing system and Flow print preparation software dramatically reduces the time and effort required, from design to final part. Velo3D will be happy to work with you to determine the ways additive manufacturing, done with Velo3D technology, can help you.