Optimization of Void Areas for Additive Manufacturing

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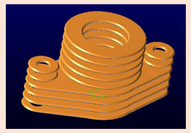
About CAMufacturing

CAMufacturing develops software for Additive manufacturing (AM). Their main product is APlus. The bulk of their software runs as a Mastercam CHook but they also have a Standalone product as well. Aplus is a software that is constantly being developed to meet the needs of this cutting edge field.

What is Additive Manufacturing?

Additive manufacturing (AM) is also known more commonly as 3D printing. AM is a layering process, where a part is built from the bottom up. There are many different AM processes:

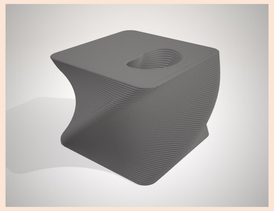
- Laser cladding
- Wire arc
- LSAM/BAAM
- And more!



A part is broken up into layers that will be deposited one at a time. Provided by Dr. Jill Urbanic.

Why Additive Manufacturing?

- AM can be used to repair broken or cracked parts.
- AM saves resources.
- Create parts that could not be created with traditional manufacturing.



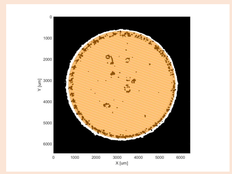
Provided by Shane Peelar

My Role at CAMufacturing

My research project at CAMufacturing was on the topic of void optimization for additive manufacturing, but during my work term I also worked on development and enhancement of GUI features, attended the CMTS tradeshow, updated and created helpfiles and designed a new toolpath strategy.

Voids: Small Things that Add Up to a Big Problem

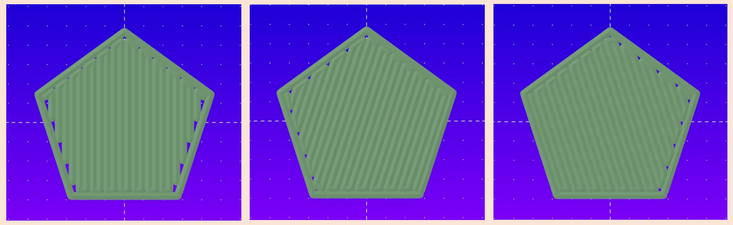
Void modelling is an emerging area of research in additive manufacturing. Voids are unwanted ”empty” regions that occur at boundaries, creating structural weaknesses.



Provided by Dr. Mihaela Vlasea

Minimizing Voids

When creating additive toolpaths, we have control over many parameters with the potential to minimize voids. The parameter I considered in my research was raster fill angle.

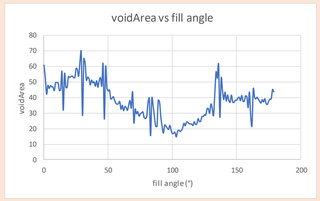


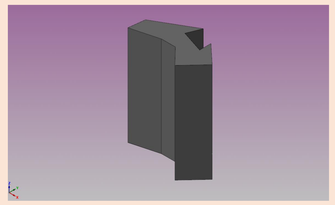
A pentagon with different fill angles. Left to right: 90 degrees, 72 degrees, 108 degrees.

There already exists code that can give us information about voids, but it has a long processing time. The goal of this research is to **quickly** find the fill angle that produces the smallest void area.

Method/Approach

Using the already existing software, I was able to gather data about void area for different kinds of geometry.



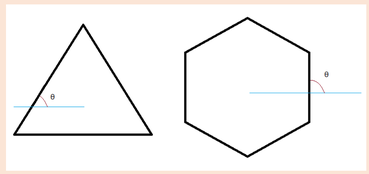


My belief is that the solution to this problem relies solely on the geometry of the part and useful information can be extracted from that geometry. Some geometrical features I studied included:

- Length of sides
- Interior angles
- Exterior angles
- Perpendicular angles

Side Angles as a Solution

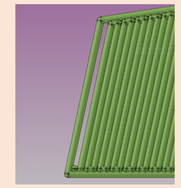
Side Angle: The angle that a side of the geometry makes with the positive x-axis <180°.



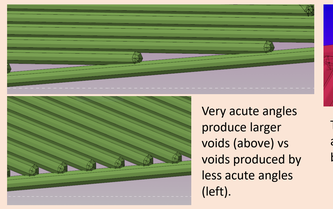
Side Angles as a Solution

I determined that the side angle along with the angle perpendicular to the side angle are good candidates for producing minimal void area provided that:

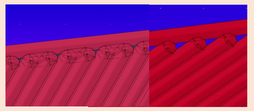
1. No side gap is produced
2. No voids as a result of very acute angles are produced
3. The number of bridges is maximized (for zigzag fill patterns)



Side gap.



Very acute angles produce larger voids (above) vs voids produced by less acute angles (left).



The presence of bridges reduces void area (above) vs fill beads which do not bridges.

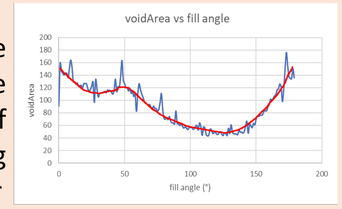
angle (°)	number of bridges	large void present
162	7	0
30	7	0
83	8	0
15	8	0
47	8	0
137	8	1
105	7	0
173	7	0
120	7	0
72	6	0
The Best Angle:		
83		

Output of side angles code for the part shown in “Method/Approach”.

I developed code that takes these factors into consideration and provides the user with the best angle.

Conclusions + Continuing Work

A solution was found for n sided polygons. This is a good starting point for a heuristic solution. However, an angle that is not equal to any of the side angles can sometimes provide an even better solution. This angle is represented as the minima of the void area vs fill angle curve. I have begun work to find the equation of the overall curve by approximating all voids to be right triangles. Other future steps in this research include manipulating part orientation to minimize voids and extending to the research to thermal mapping.



Acknowledgements

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