ME557F19-A5-Khan_Lourie_Luchini

Assignment 4	
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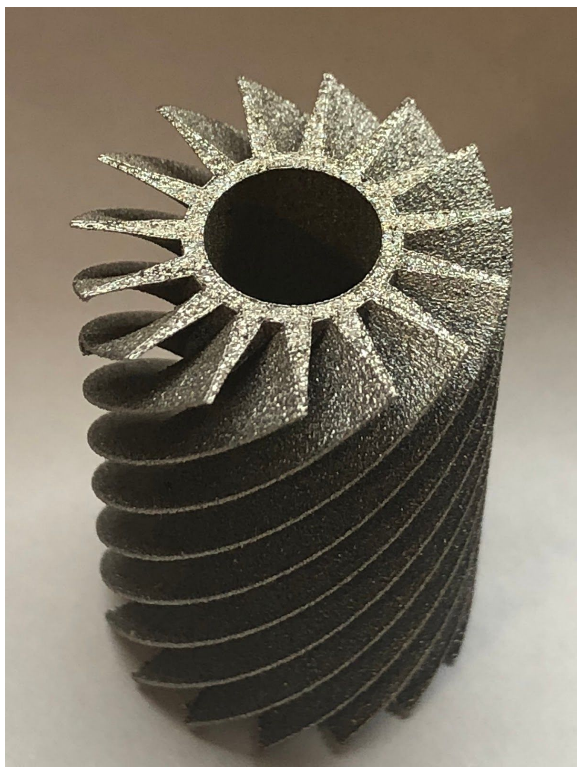
Short Description of Design



The team chose to design a cylindrical heat sink with helical fins. The part is small, with many thin fins that wind around the exterior of the heat sink. The helical orientation of the fins increases the surface area of the part, without increasing the overall volume as compared to a similarly designed part with straight fins. This would likely increase the heat transfer without taking up more space in an assembly.

Producing this part using traditional manufacturing methods, such as turning, would prove difficult or impossible due to the thin geometry of the fins. The part is thus well suited to additive manufacturing techniques which allow the production of this geometry.

What did you redesign to make it printable in metal?

Initially, the team explored creating a latticed heat sink, though this proved to be difficult to do with metal additive. The main concern was not the printability of the different geometries conceived, but rather the removal of loose powder during post processing to make the part safe to handle. Small, fine lattices are likely to trap powder inside, which will not reliably migrate out of the part during the post processing steps. Ultimately, the team moved away from a lattice due to these concerns, and tried to design a printable geometry that would demonstrate the capabilities of additive while allowing the part to be reliably cleaned in post processing.

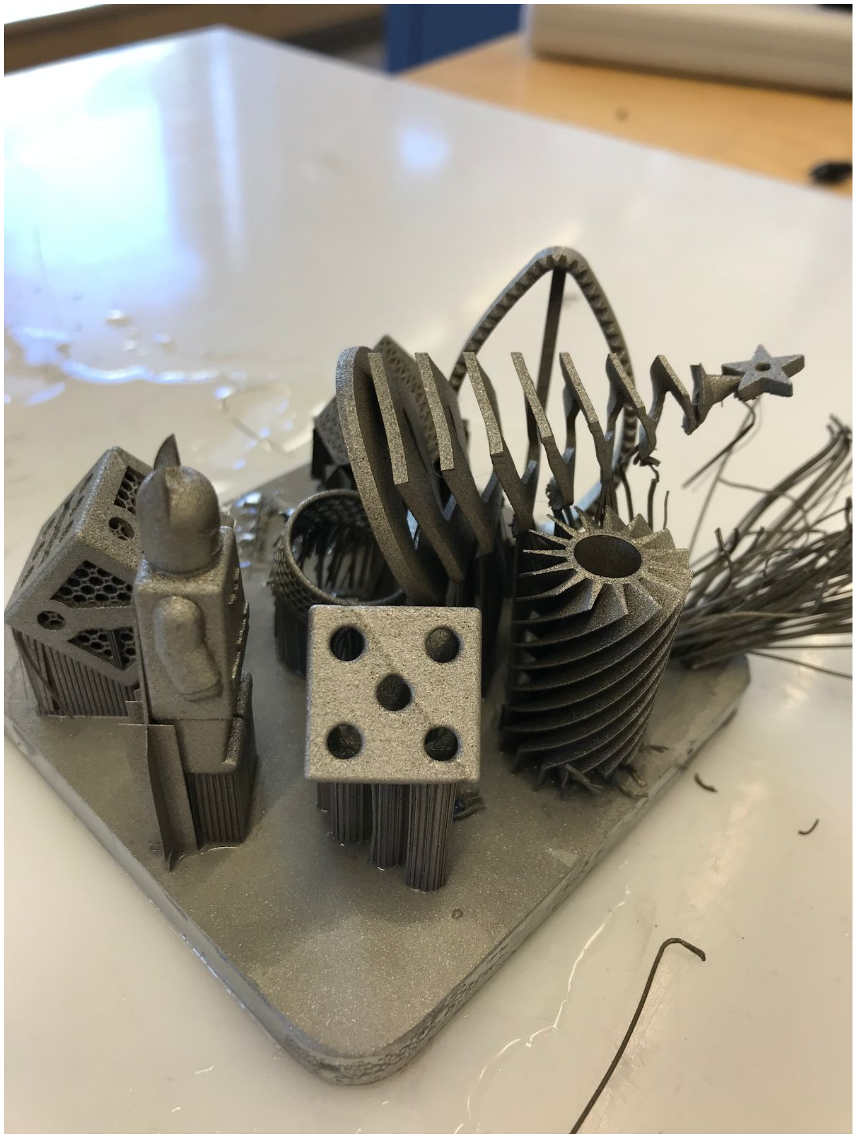
Care was taken to ensure the minimum thickness of the fins was greater than the minimum feature size of the printer, and that the overhangs created by the fins were less than 45 degrees.

How did you reduce the weight as much as possible?

Weight was taken into consideration while designing the part, by making the part relatively small. The team dimensioned the part to be only 3 cm tall, and making sure that the thickness of the internal cylinder was thin enough for metal printing capabilities. A lot of weight is reduced by the space between the fins, which is a result of thin walls and spacing. This benefited the printing process since minimal supports had to be added because the part was light weight and small.

Why did you put supports where you did?

The part geometry is self supporting. Each of the fins forms a continuous overhang as it winds around the core of the heat sink. The overhang angle is less than 45 degrees, so no supports are needed on the fins. Otherwise, supports were used to connect the bottom of the part to the baseplate, providing a solid connection for printing, and a way to draw heat out of the part during the printing process.

Describe how the part was located on the build plate and why.
 The part was oriented with the axis of the heat sink rising vertically from the build plate. This was the most natural part orientation, as it allows the continuous overhangs created by the fins to be within the limits of the machine. This orientation also allows the removal of the supports to be easier, with less likelihood of damaging the thin fins.

Describe the outcomes
The print was successful, with a couple small defects on the fins. Overall, the surface finish was acceptable, with no visible “staircasing” on the spiral fins. The top face of the part came out clean, and the bottom face has a rougher finish due to the support removal. The part does not appear to have warped overall, or shifted during

the print.

Shown above: The top face of the spiral heat sink (left), and the bottom face (right) where supports were removed.

There are a couple small defects present in the part. One fin has a small wrinkle near the top end of the part (shown below). This may be a result of localised warping during the print, or it could have resulted from a failure in one of the adjacent parts coming into contact during the print. It is also a possibility that the defect occurred during handling of the part during post processing, such as the part being dropped or dented. The defect is not visible in the image of the parts on the build plate, so it is difficult to determine the cause.

Above: A small wrinkle is present on one fin near the top of the part.

The second defect is a small bend on the bottom end of one of the fins. This fin would have been connected to the base plate by supports, so perhaps it pulled up slightly from the base during the printing process. This defect could also have been a result of rough handling such as the part being dropped. However the fins feel quite rigid despite their minimal thickness, so this may be unlikely.

Above: A slight bend is visible on the bottom edge of one of the fins.

What would you do differently?
If we were to design the heat sink differently, we would optimize the current design to have maximum surface area, taking care to stay within the capabilities of the printer. To do this we might increase the amount of twist in the spiral as well as the number of fins. We could simulate the efficiency of the design using a software such as Matlab, or Ansys.

Team: what did you learn
The printed part was up to the design standards, with the exception of the small defects stated above. The defects themselves might be prevented by having less parts on a single build plate, or altering the spacing. The surface finish of the bottom face of the part, which was negatively impacted by the removal of supports, could be fixed by a post processing operation such as sanding, or machining of the face. Ultimately, the final design printed well. Most problems were encountered during the design portion of the assignment. The group wanted to produce a latticed heat sink

on the metal printer, but struggled to generate a latticed part small and practical enough to print, that would also perform well as a heat sink, even after multiple design iterations. The main difficulty was producing a design where the lattice would not trap powder during cleaning. Instead, the group decided to do a spiral heat sink to utilize the capability of the printer to produce non-manufacturable geometry. To demonstrate a lattice in metal, the group might have switched to a part which would require less density of the latticed features, such as a pendent, or a game piece.

The group learned exactly how metal printing is done on a Concept Laser 2 printer as well as the design process for smaller metal printers. The market for the Concept Laser printer is very small, since the build plates are so small themselves, it was hard to think of designing a part that fit the criteria. The final part ended up being printed very nicely and with more post processing, can be used as an actual heat sink.