MANUFACTURING AN OPTIMIZED DOUBLE-SIDED SWING ARM USING SAND BINDER JETTING

ADDITIVE MANUFACTURING-ME-5390-011

DR. ROBERT TAYLOR

FALL 2019

Prepared By

David A. London

& Samarth Ramachandra 1001769785

Introduction

A double-sided swing arm is the main component of the rear suspension of most modern motorcycles and ATVs. It firmly holds the rear axle, while allowing vertical movement, to allow the suspension to absorb impact from the unevenness of the road.Conventionally, these swing arms are manufactured using processes such as cast molding, CNC machining, etc.

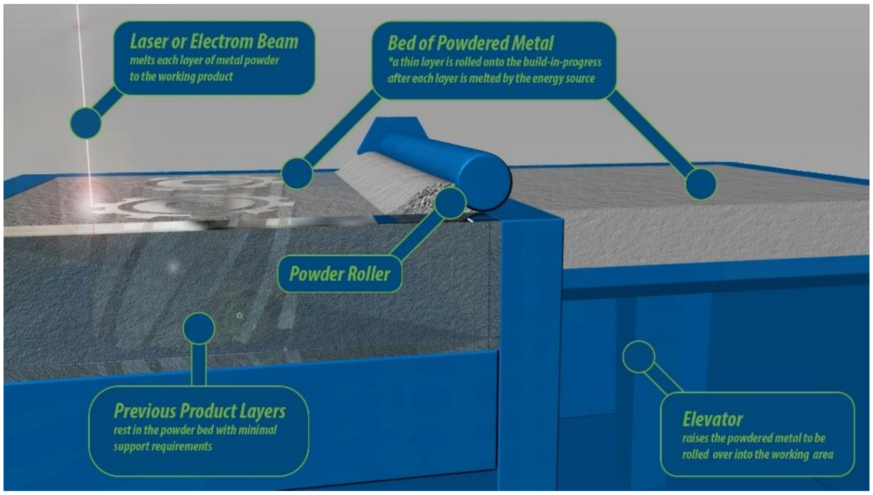
This project is an attempt to fabricate a double-sided swing arm using AM technology. The choice of method incorporated for this fabrication is **Sand Binder Jetting,** a type of binder jetting process**.** While we fabricate the part using the above-mentioned method, the part has also been topologically optimized resulting in a more efficient version of the part viz. an increased strength to weight ratio without compromising the functionality of the component.

Purpose of using Additive Manufacturing

The double-sided swing arm is one of the heaviest parts in a motorcycle or an ATV. With topological optimization using Altair Inspire, the weight could be reduced up to 36% of its original weight retaining all its mechanical properties and functionality.

Along with reduced weight the production cost and time is significantly reduced and simultaneously eliminating thermal associated stresses. With full access to the print bed several units of the casting mold can be printed in batches.

Binder Jetting



Binder Jetting is a type of additive manufacturing process in which the binder is deposited selectively onto the powder bed, forming adhesion among particles layer by layer to form a solid part. Metals, sand, and granular ceramics are generally used in binder jetting process.

Sand Casting molds (Sand Binder Jetting)

One of the most common uses of binder jetting is the production of sand-casting molds. With the major reduction in production time coupled with the low cost associated with production, sand binder jetting is an excellent alternative in comparison with the traditional methods of fabrication. Moreover, complex designs and patterns that are very difficult or impossible to produce using traditional techniques can be achieved with ease.

Sand or silica is generally used as the printing material due to their high thermal conductivity and because they are excellent for casting. The molds are immediately ready for casting right after the print. The metal part casted is then removed from the cast by breaking the mold. Even though these molds are for one time use only, the time and cost compared to traditional manufacturing is significantly reduced. Also depending on the size of one cast, multiple number of casts can be printed simultaneously if the limitations of the print bed permits.

Characteristics of sand binder jetting

Materials	Sand/silica
Dimensional accuracy	± 0.3 mm
Typical build size	800 x 500 x 400 (up to 2200 x 1200 x 600 mm)
Common layer thickness	200 – 400 µm
Support	Not required

Key advantages and disadvantages

- The production cost and time is significantly low in comparison with the traditional methods.
- Very large and complex geometries can be manufactured without the limitation of undesired thermal effects such as warping.
- Excellent for low and medium batch production.
- There is no requirement of support structures in this type of AM process.
- The bonding of the sand particles occur at room temperature and external compacting forces are not necessary for casting mold fabrication.
- Post processing of the component once it has been removed from the mold is same as in that of traditional casting.

Fabrication Process

- The cast design for the optimized swing arm in. stl format is uploaded into the PBF Printer. A maximum number of casting molds are selected for print.
- The mixture of sand and binder is the material used and the first layer/cross-section of the model is laid out.
- A new layer of sand binder mixture is spread across the previous layer by a roller.
- Further layers or cross-sections are added and fused.
- The process repeats until the entire model is created. Loose, unfused powder remains in position but is removed during post-processing.
- The molten material that is poured into each mold is an alloy of aluminum called aluminum 7075.
- The sand mold is broken once the molten metal solidifies and the model is then subjected to surface finishing and other post processing procedures.

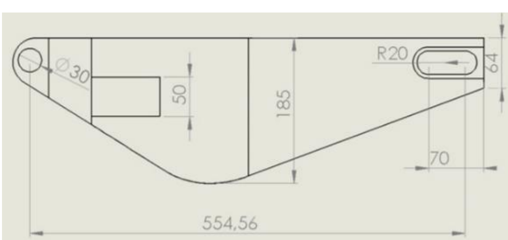
Post Processing

Post-processing includes removal of excess powder and further cleaning and CNC work. One advantage and common aim of post-processing are to increase the density and therefore the structural strength of a part.

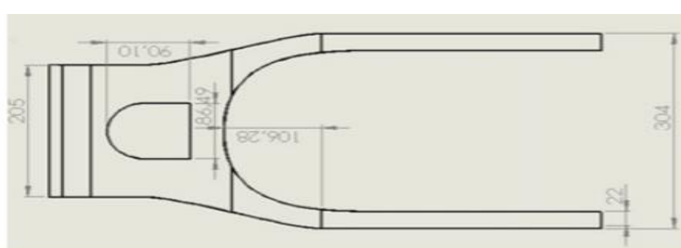
Actual Process Followed In The Project

- The model was created on Solidworks.
- Then the model in .igs format was imported on Altair Inspire and analyzed.
- Post analysis, the model was subjected to topological optimization with mass reduction of 35%.
- Once the model was created, a block was created around it and Boolean subtraction operation was used to subtract the shape of the model within the block.
- Further holes were created which are for the purpose of pouring the molten metal into the casting mold.
- The file was then converted to .stl format.
- The file was uploaded on a slicing software and parameters were set for PLA extrusion AM process. Once the parameters were set, the file was saved in .x3g format.
- Once saved in .x3g format the file is uploaded to flash forge creator pro for print.
- The support material used for the print is a soluble material (PVC) which is easy to remove once the print is done.

Component Design



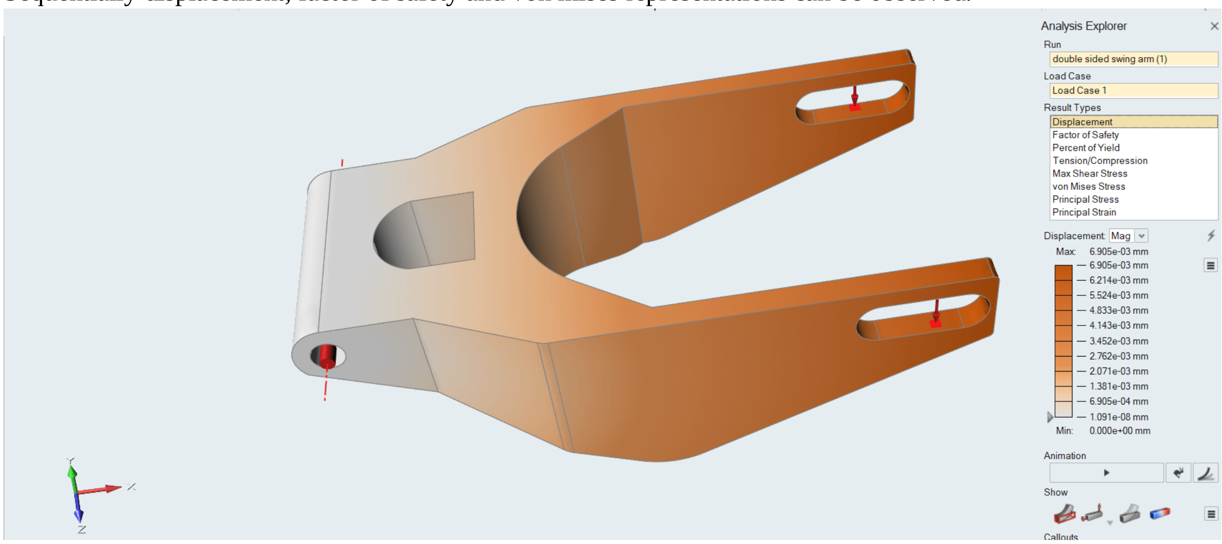
The following design dimensions depicted in the picture was considered for the design of the component. The designing process was carried out on **solidworks**.

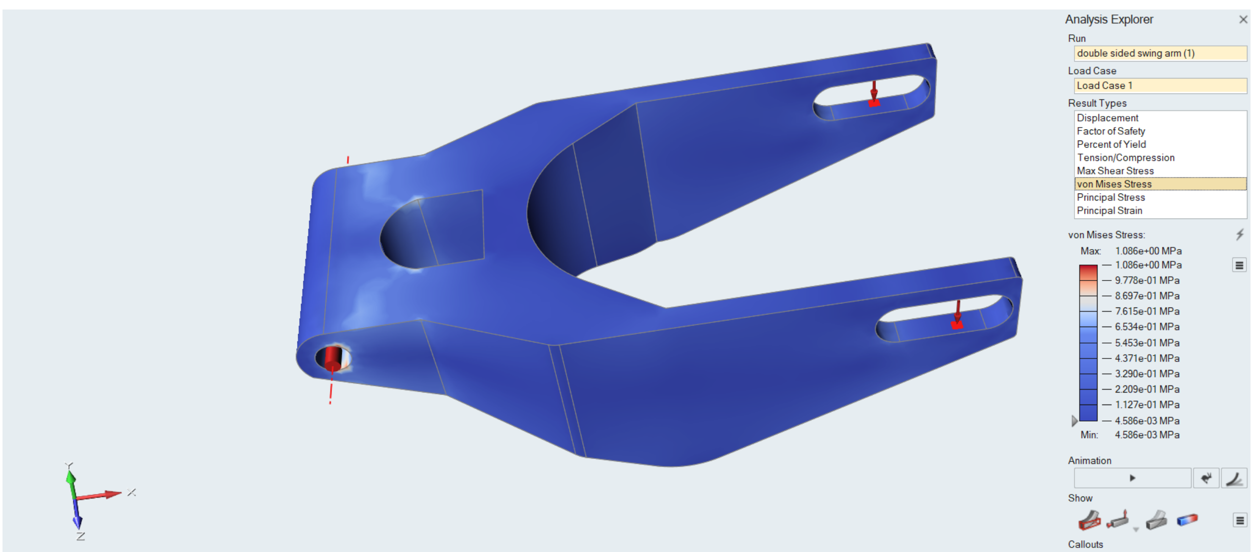


Analysis and Optimization

The analysis and optimization were carried out on Altair Inspire. Screenshots of the process can be seen below.

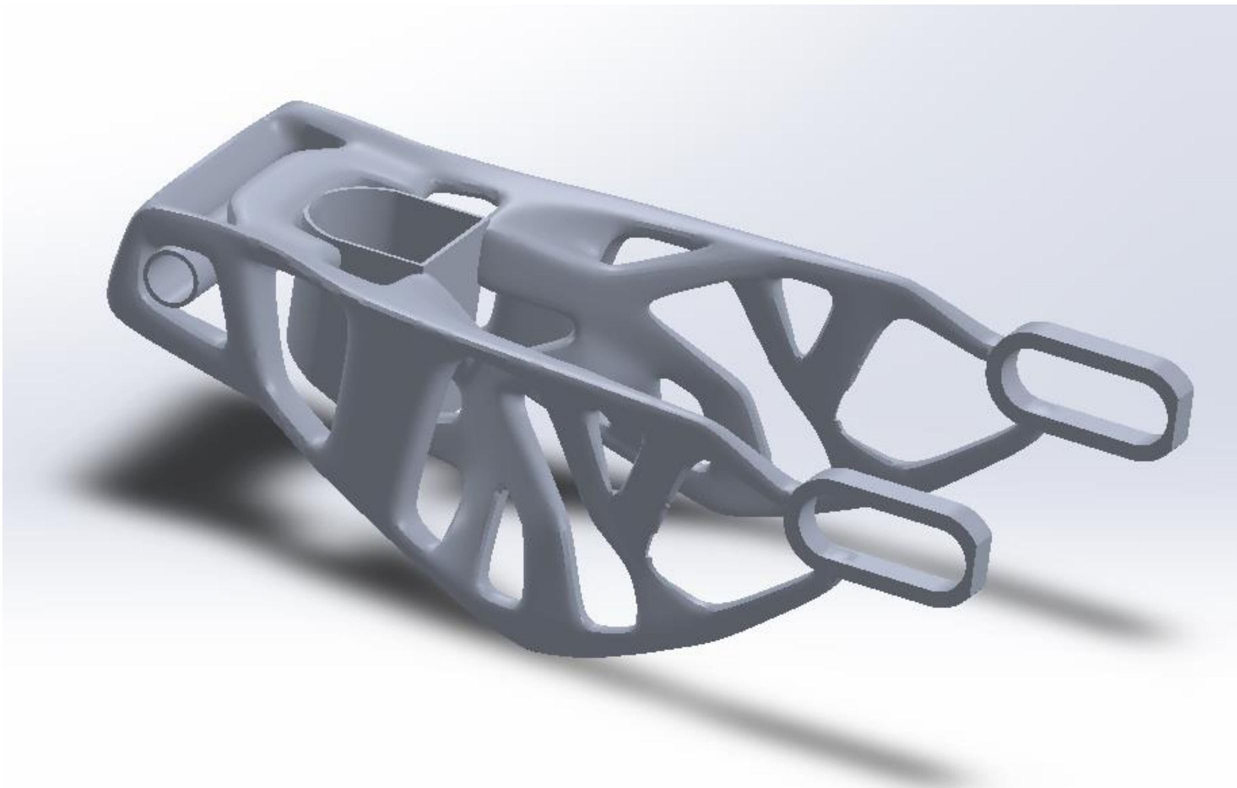
The images below depict analytical representation of the swing arm prior to topological optimization. Sequentially displacement, factor of safety and von mises representations can be observed.



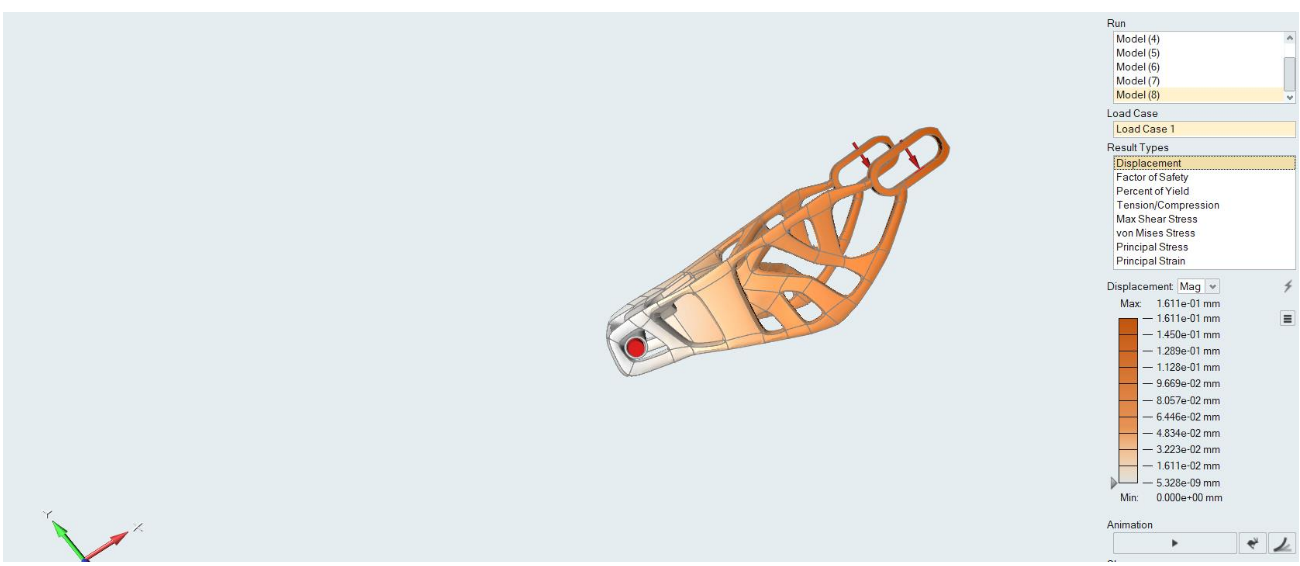


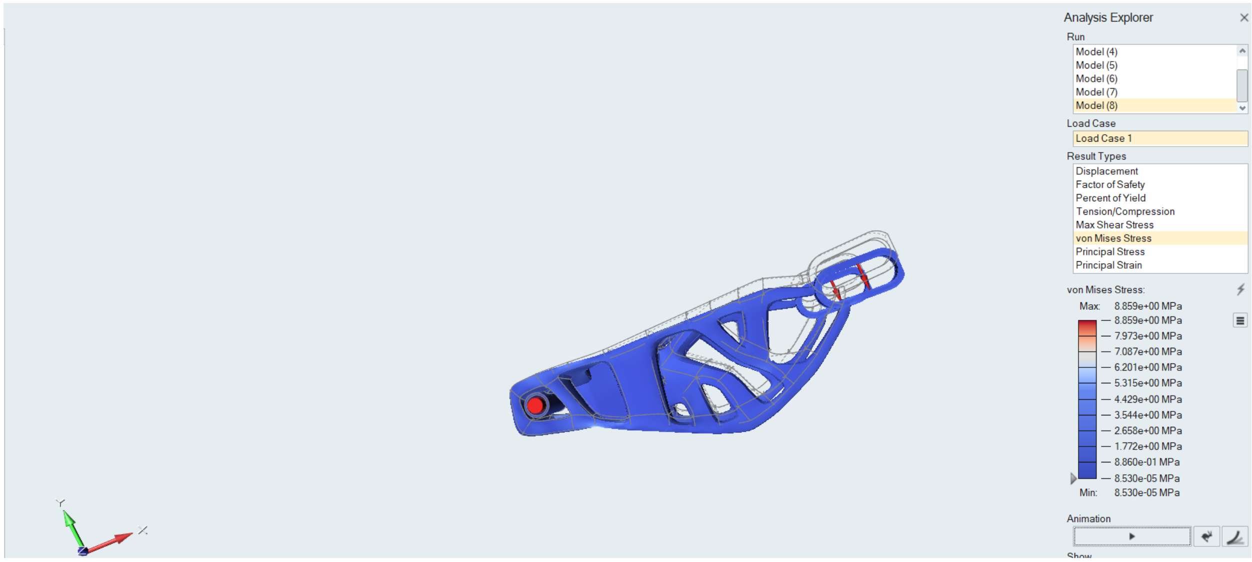
Optimization

the optimization was carried out with the primary objective of mass reduction of up to 35%. Once the optimization was complete polynurbs were fit into the design space to give the design aesthetic appearance.

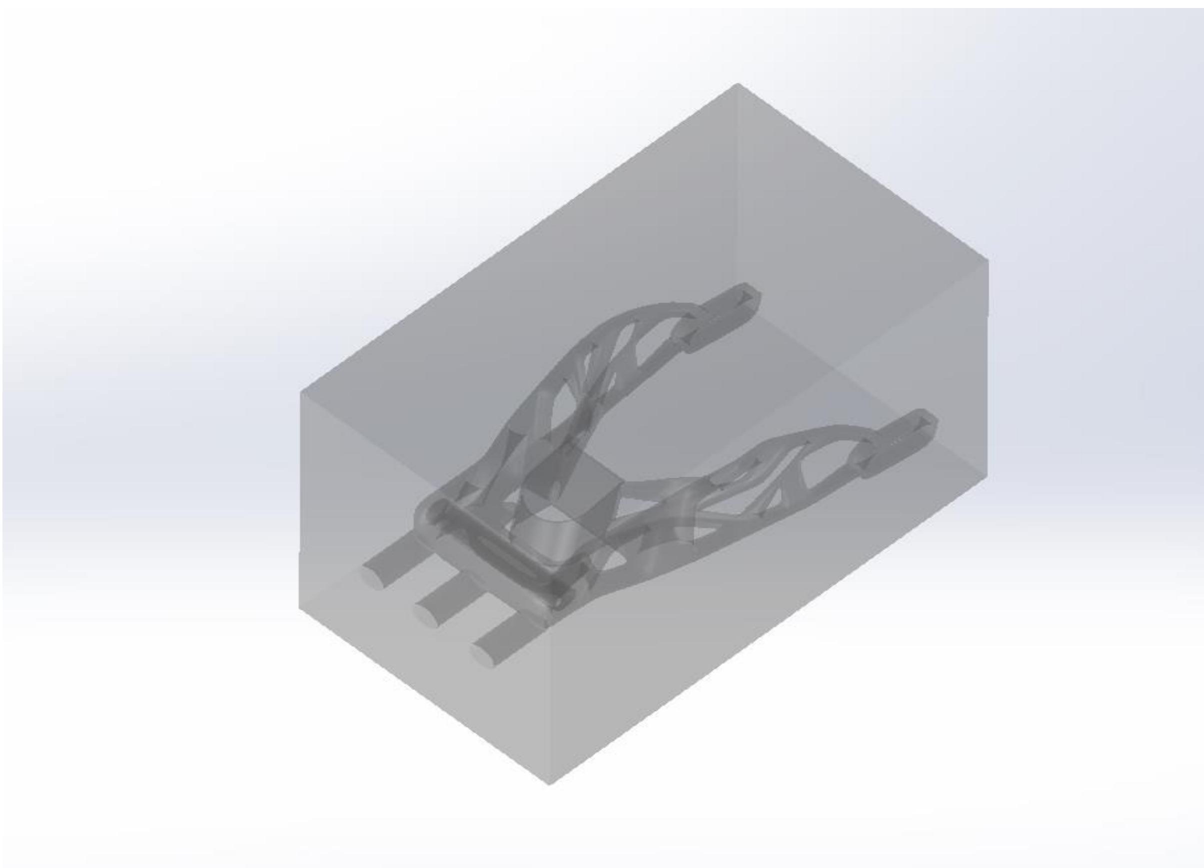


The finalized component was then analyzed for properties such as displacement, von mises stress and factor of safety and the screen shots of the same can be seen below.





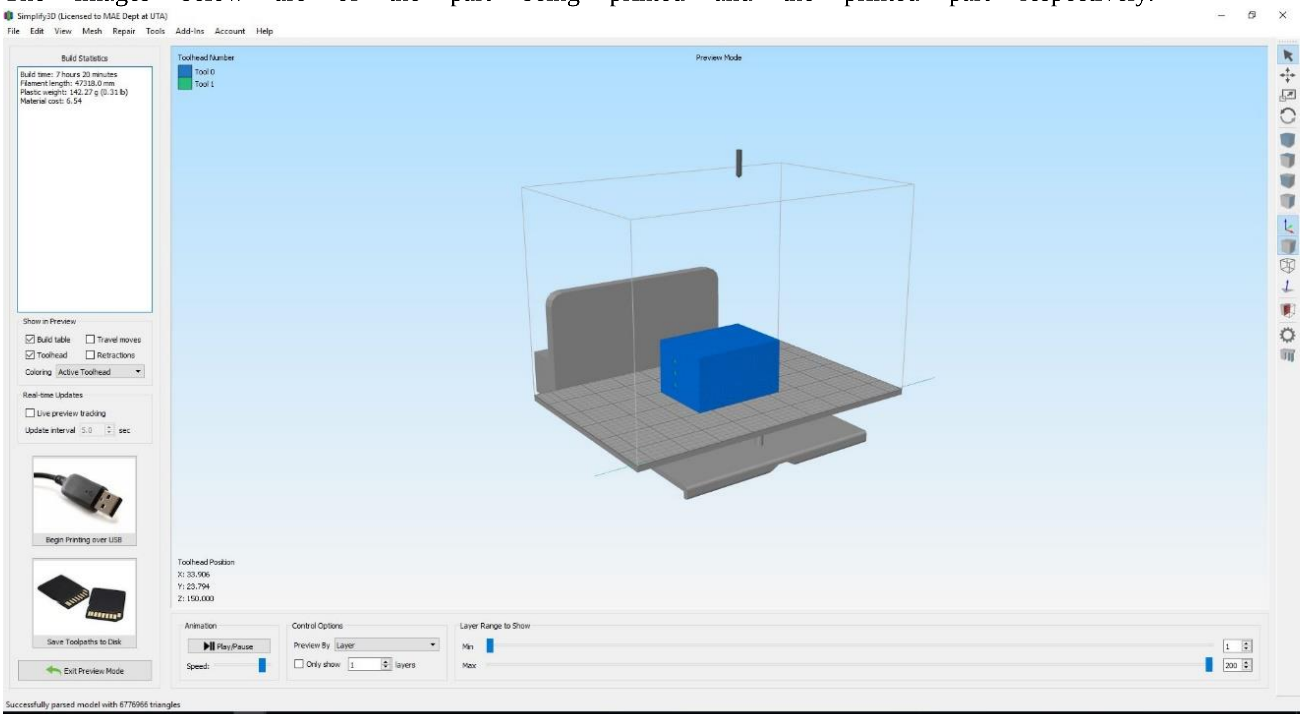
A block was designed and extruded around the component and the casting mold was created using the Boolean subtraction operation.

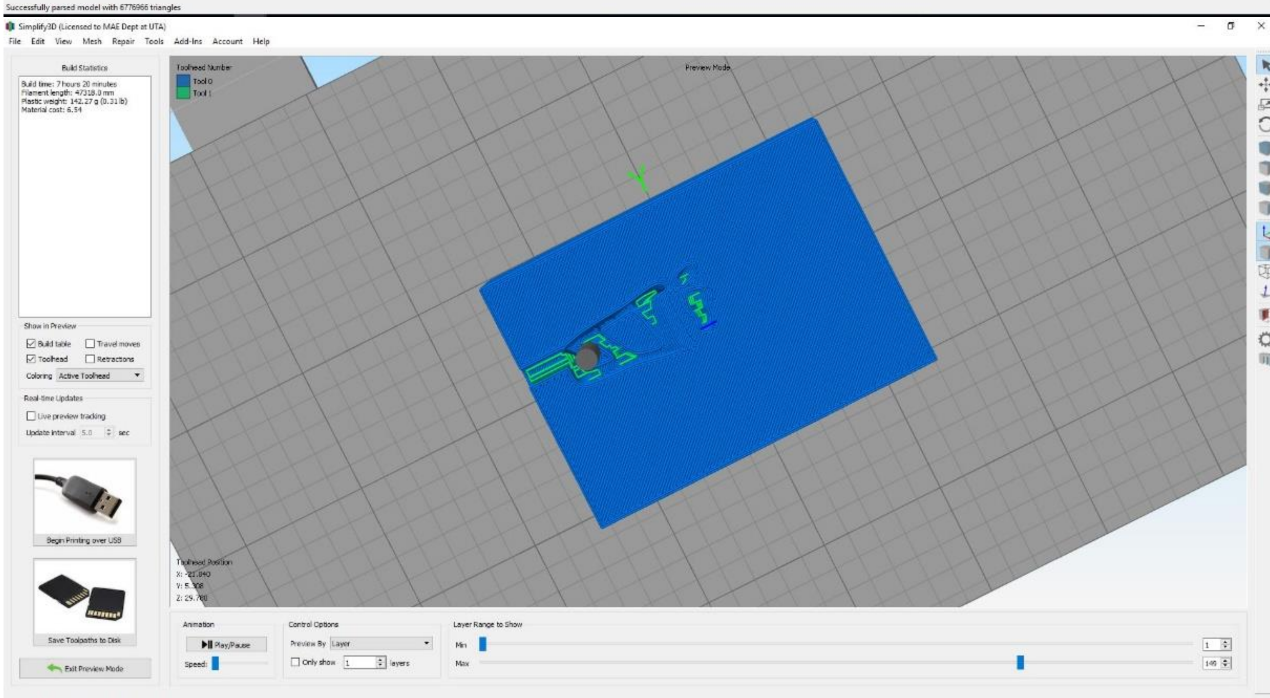


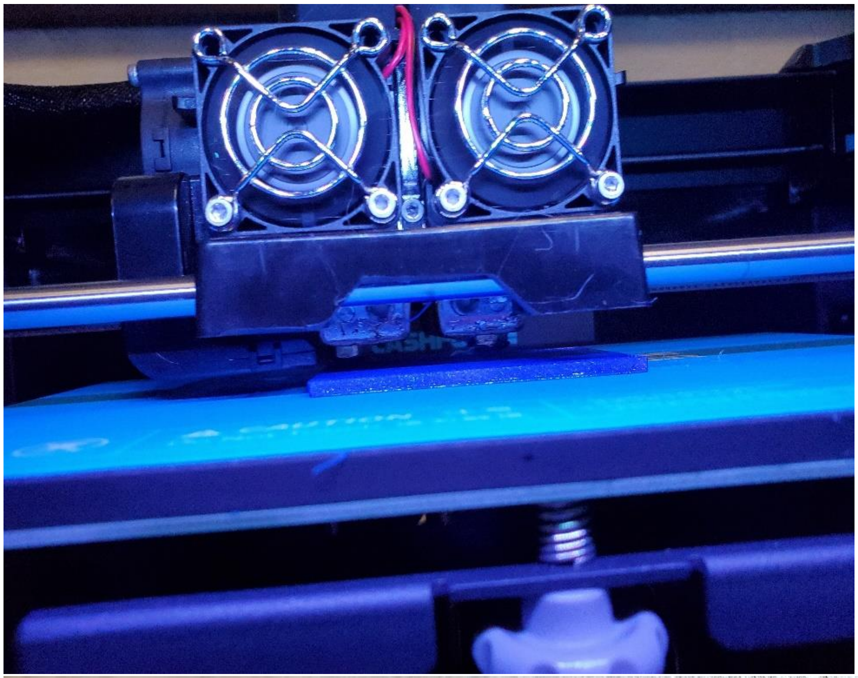
Build Preparation and Printing

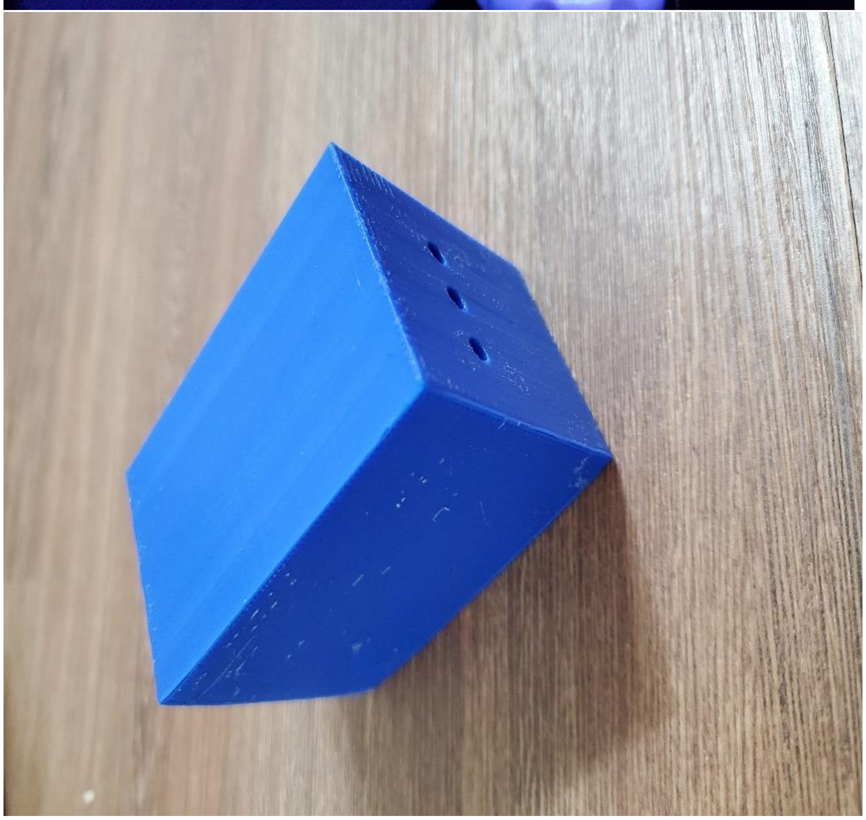
The .stl file of the casting mold was imported into Simplify3D and scaled down, temperatures were set for both the extruders, the left extruder for support material (PVC) and the right extruder for the print material (PLA). Support structures were generated by the software. Once the slicing was complete, the file was saved in .x3g format and loaded into the flash forge creator pro printer.

The images below are of the part being printed and the printed part respectively.









Conclusion

The outcome of the project was successful as the main objective of making a prototype of a sand-casting mold model was printed. This opens an opportunity for us to put the practice in use in the actual method of sand binder jetting. Many parameters were considered to optimize whole of the design and fabrication process, without compromising on the functional aspects. With reduction in the weight of the component, while also improving the mechanical properties and incorporating the suggested process for fabrication, the time, cost and wastage of material is significantly reduced. During this project, a plethora of new skills and techniques were explored imbibed which could not have been possible just by reading a book or knowing the techniques. Thus, exposing us to the practical aspects and limitations subjective to the actual 3D printing process and helped us develop very strong knowledge base about the subject.

References

https://www.3dhubs.com/knowledge-base/introduction-binder-jetting-3d-printing/

https://www.sculpteo.com/blog/2019/07/17/is-a-sand-3d-printer-the-future-of-additive-manufacturing/

https://www.3diligent.com/3d-printing-service/powder-bed-fusion/

https://www.3diligent.com/3d-printing-service/powder-bed-fusion/