3D Printed Shroud

Batch Number: 17
R Daya Karthic – 19BME1285 - 9790844743
Japhet Geonel K – 19BME1334 - 9150872600
Viswanath P Subramani- 19BME1321 - 8433826473
Course Name: **MEE2016 Rapid Manufacturing Technologies** Semester: FS 2021-22
Faculty Name: **Dr. Raghukiran N**
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School of Mechanical Engineering, Vellore Institute of Technology, Chennai – 600 027

***Abstract*— Tractors play an immense role in agriculture in India. The project aim is to make a shroud for Tractor using 3D printing technique. Some tractor export models will only be required in modest quantities, such as 40 or 50 units. It will be inefficient to make the shroud for these tractors using the traditional approach. Because the tool cost for the traditional technique of creating shrouds is so costly, we would never be able to recover our investment, even after many years, because each model requires a separate set of equipment. In order to make a limited number of tractor models, 3D printed shrouds will be a better option than the traditional way. It can save a lot of money while still maintaining the shroud's quality. As a result, we recommend 3D printing of the shroud. 3d printing of shroud will increase the material cost but the machining cost will be reduced. Shroud design is made using Solidworks. Polypropene Co Polymer is the best material available in the market with high strength and durability. Structural and thermal analysis is carried out in Ansys Workbench. The support structure is made using Ultimaker Cura. This shroud is done under the guidance of TAFE, Chennai.**

***Keywords*— Shroud, 3d printing, PPCP, Solidworks, Ansys, Ultimaker Cura**

Introduction

The Indian tractor industry is the world's largest, and tractors are an important aspect of mechanisation, which helps farmers increase production year after year. Tractors were first manufactured in India in 1961. And it has grown remarkably well in the previous six to seven decades, to the point that it could lead India to another green revolution. Tractors are the only way to do the best farming. Tractors are the most important farm machines not only in India, but all across the world. Tractors are crucial to the advancement of agriculture. Tractors are indispensable in modern agriculture.

Shroud is a component used in all automobiles including Tractors. It has a vital purpose in the engine cooling system. Engine cannot bear its own heating temperature and can even melt itself. To make the engine work properly without any flaws a coolant will be passed around the engine to cool the engine. The coolant after every cycle needed to be cooled down. The cooling of the coolant will be done in the radiator using a fan attached to the shroud. Shroud is a component attached with a fan which will absorb the heat from the coolant and restrict passing of hot air to the coolant in the radiator. Thus, the coolant can cool the engine properly.

In Tractor's components, we discovered the requirement for 3D printing shroud. A prototype 3D printable shroud was given. The material used to 3d print the shroud is polypropylene copolymer. Solidworks was used to design the shroud, while Ansys was used to simulate it. The shroud's support structure was created using Ultimaker Cura for 3D printing. All of these subjects are covered in depth in this report.

Hao, B., & Lin, G. (2020). 3D Printing Technology and Its Application in Industrial Manufacturing is referred to understand the need to 3d print automobile parts. To find the optimum material required to 3d print shroud Schirmeister, C. G., Hees, T., Licht, E. H., & Mülhaupt, R. (2019). 3D printing of high-density polyethylene by fused filament fabrication this paper used to analyze different type of materials available. We also finalized PPCP as our material to 3d print shroud.

Wu, W.-H., & Young, W.-B. (2011). Structural Analysis and Design of the Composite Wind Turbine Blade. Applied Composite Materials, 19(3-4), 247–257 discussed the use and importance for structural analysis. We ran structural analysis for our shroud in ansys and verified its potential to withstand sudden loads happening on it.

Dfam concepts is applied to our model in the designing process. Gebisa, A. W., & Lemu, H. G. (2017). Design for manufacturing to design for Additive Manufacturing: Analysis of implications for design optimality and product sustainability. Procedia Manufacturing and Li, S., Yuan, S., Zhu, J., Zhang, W., Zhang, H., & Li, J. (2021). Multidisciplinary topology optimization incorporating process-structure-property-performance relationship of additive manufacturing. Structural and Multidisciplinary Optimization discussed the importance of Dfam concepts and need to use it.

Objectives and Scope

The main objective of this shroud is to reduce machining cost. In industries some models require shroud in modest quantities. We went on with an industrial approach to give a betterment to society. 3D printing it brought all the costs to an affordable price. Currently the part costs around 1400 but the tool cost is 28 lakhs and it needs around 180 days to get the product. While using additive manufacturing the part cost will come up to 38500 and the tool cost will be nil and within 30 days the part can be delivered to the factory. If we see the tool life of the normal machine it has only 10 years, but in the AM if we maintain the 3D printer it's going to give a good output result at all times.

Methodology

Workflow

First initially the design was done with the help of Solidworks. The dimensions of the shroud is approximate to that of the original shroud. So next we need to assign a better material to the shroud so that it can maintain all the heat flow and load which acts on it. So, we came to a conclusion to select PPCP, where this plastic can be used and it has excellent properties to overcome all the major problems the shroud faces. Next this component is taken into Analysis, where analysis is done with the help of Ansys. Structural and Thermal Analysis was done to determine the strength and all the major issues it will face when placed in the tractor. Seeing all the factors the material will be fixed. Next after completing all the analysis the Cad file will be converted to 3D printed format and with the help of Cura support structures will be put up in the product and the product is ready to get 3D printed. After printing all the support structures are removed and the product is ready to use in the market.

Material

The material that is used to print the whole component shroud is nothing but PPCP (Polypropylene Copolymer). This material is available in colorless solid and it can be available in filament form. This plastic does not have any type of odor in it. This is completely non-reactive to the environment and makes sure that the environment is safe. This material is one of the high strengths and high durable material in the market. The PPCP is non-biodegradable. And this plastic has a very low toxicity rate. The equipment which is majorly used in this is nothing but a 3D printer. The major advantage of the 3D printed product is that the machining cost will come down compared to the actual manufacturing of the component. Since it is 3D printed the price of the product will rise for sure. The weight of the product will be majorly low since it is printed with PPCP.

There are a wide range of 3D printing techniques which are available in the current market. The method which will be used to print the component is Fused Deposition Modeling. So, this printing can be done both horizontally and vertically where the extrusion nozzle moves over a build platform. The process is done by melting the plastic and printing it layer by layer. As our product gets printed each layer can be distinguished by seeing the printing pattern. Once completely the product is printed all the support structures can be removed and we can get the finished product. FDM is majorly used in the manufacturing sector and since the product which we have designed is a major part of the Tractor which is Shroud. Since only limited tractors are sold in the market only a few numbers of the shroud will be in demand. So rather than buying a machine which costs 28 lakhs, we can 3D print it and use the product with the best material which is available in the market which show the same characteristics like aluminum alloy.

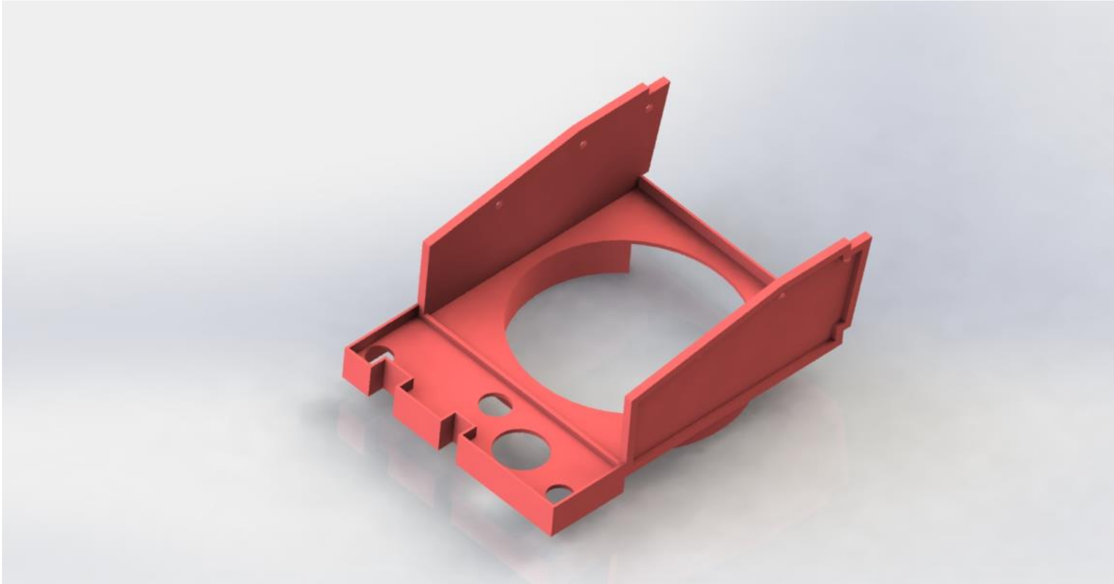
Design

The basic 3d model of the shroud is designed in Solidworks.

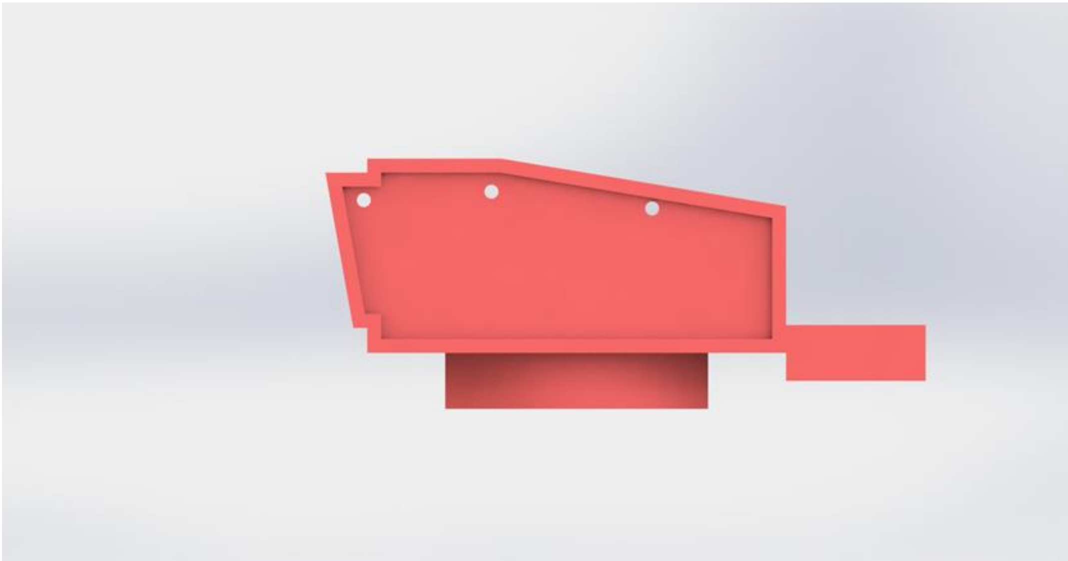
The dimension of the shroud is given below:

Length: 430mm
Breadth: 300mm
Height: 180mm

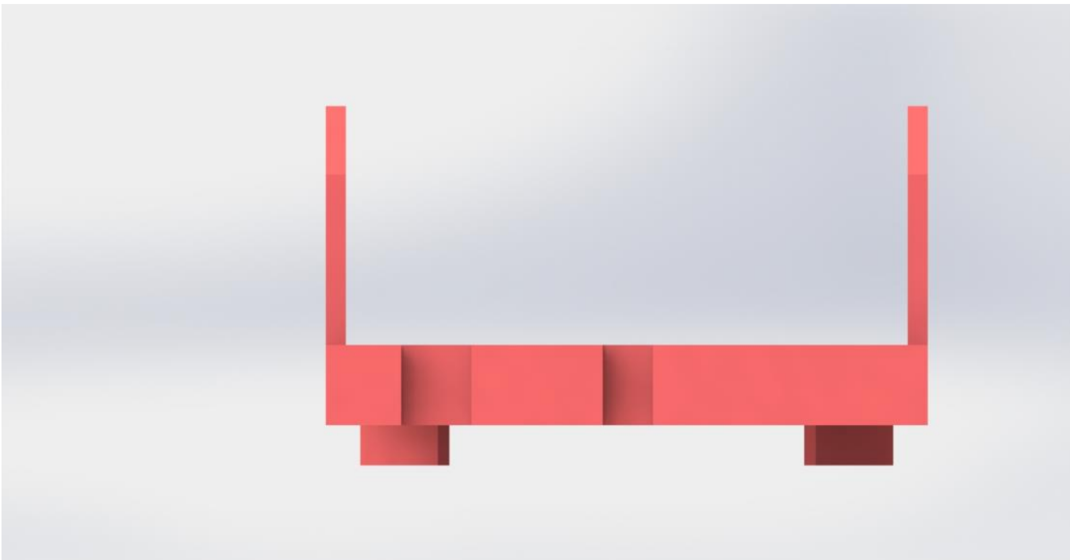
Isometric View:



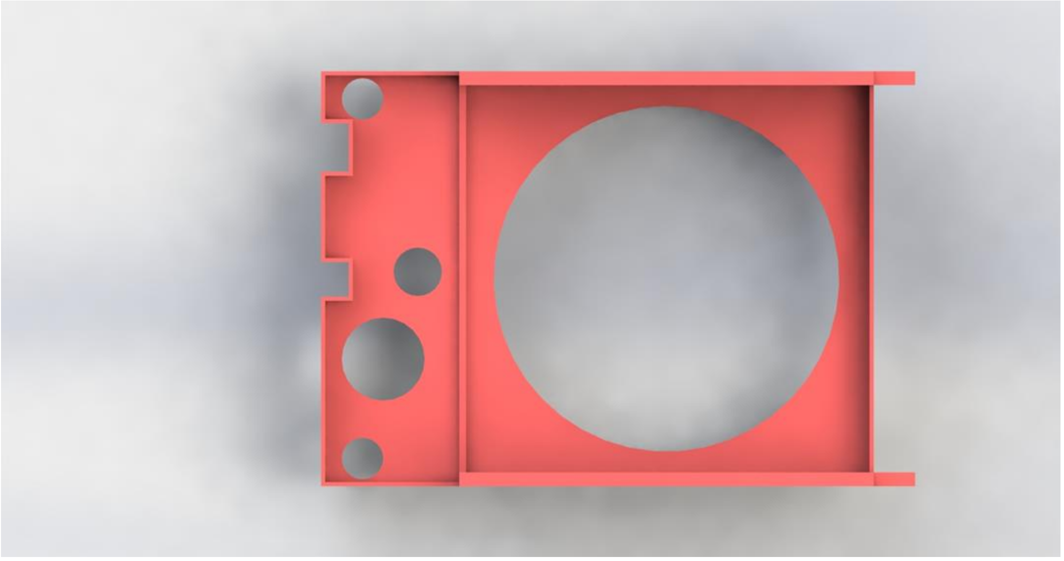
Front View:



Right View:



Top View:



Analysis

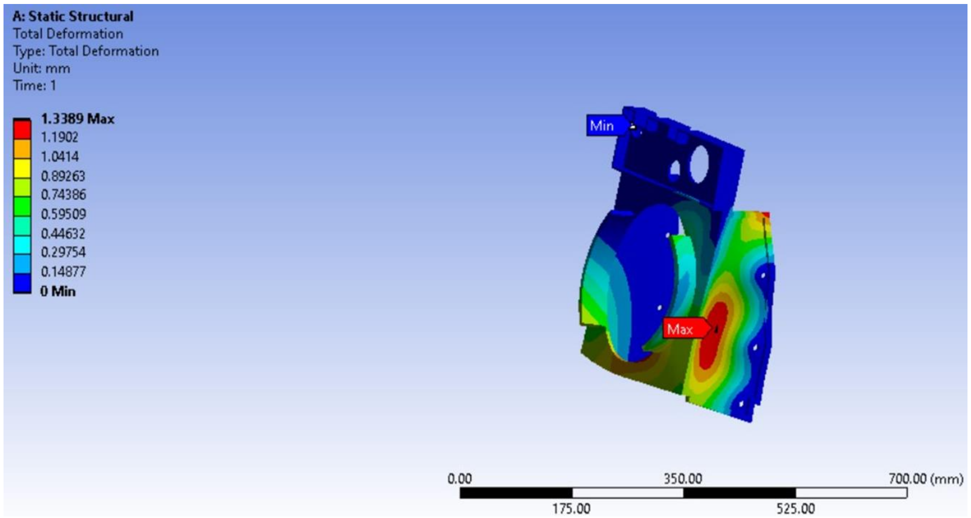
The first step involved is entering the Engineering data for the analysis. These include various parameters like young's modulus, Poisson ratio, Bulk modulus, Shear modulus. Some of the most important parameters entered for PPCP are Tensile Yield Strength, Compressive Yield Strength, Tensile Ultimate Strength and Isotropic Thermal Conductivity.

Structural Analysis

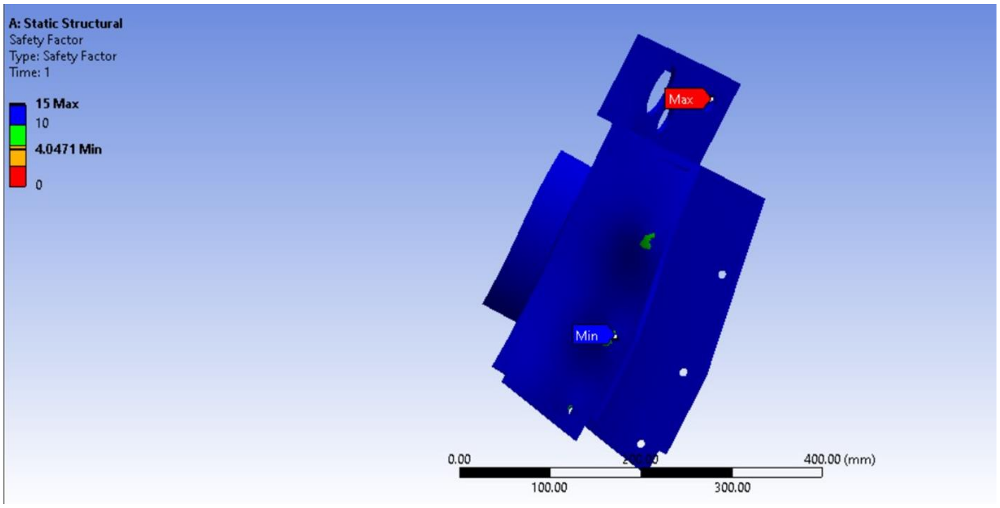
The structural analysis has the following Parameters:

Fixed Support
Force - 330 N
The analysis of force was in - Z direction. Total deformation and Factor of Safety were calculated by structural analysis

Total deformation:



Factor of Safety:



Thermal Analysis

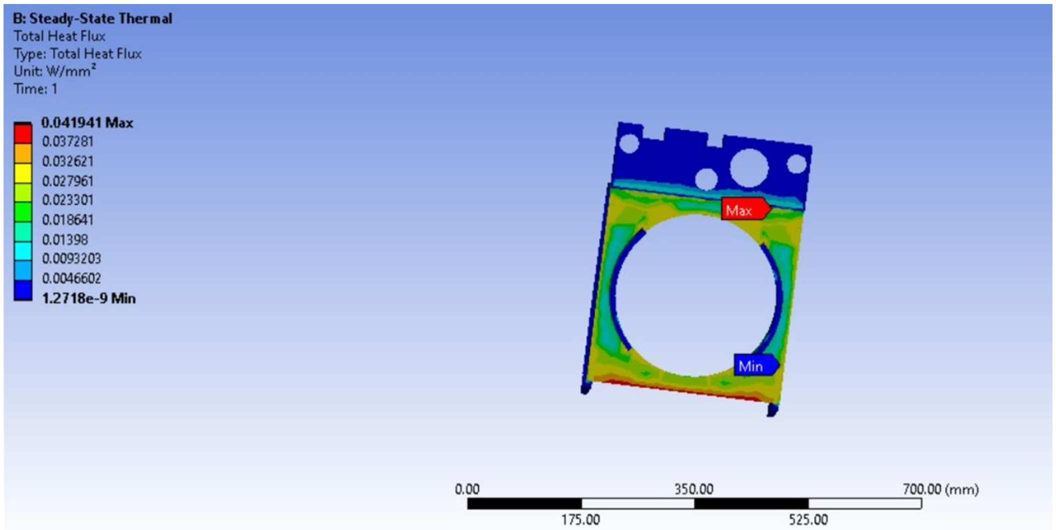
For thermal analysis, the parameters are:

- Convection
- Heat flow

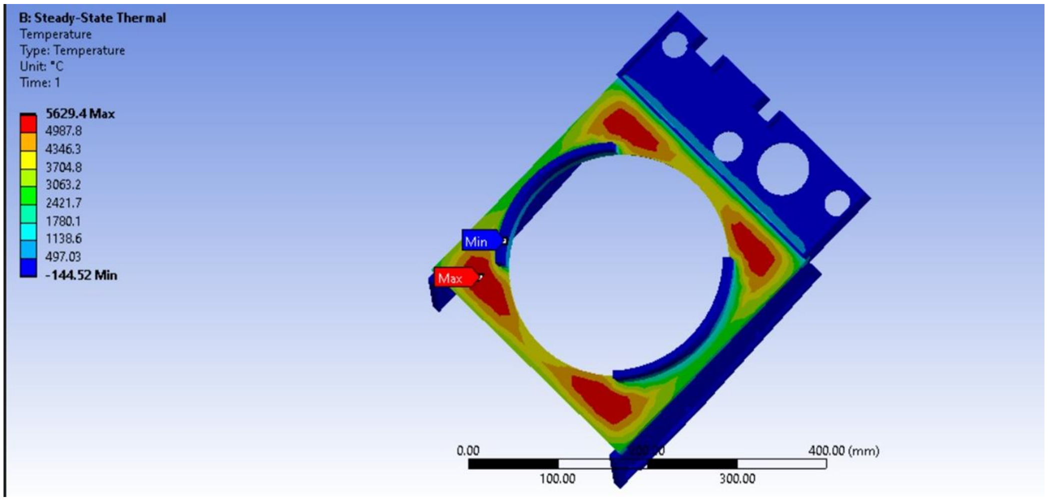
The convection has an ambient temperature 70 degrees. The film coefficient is 0.000005 (step applied). The Heat flow is 1000W.

The total heat flux and temperature were measured.

Total heat flux:



Temperature:

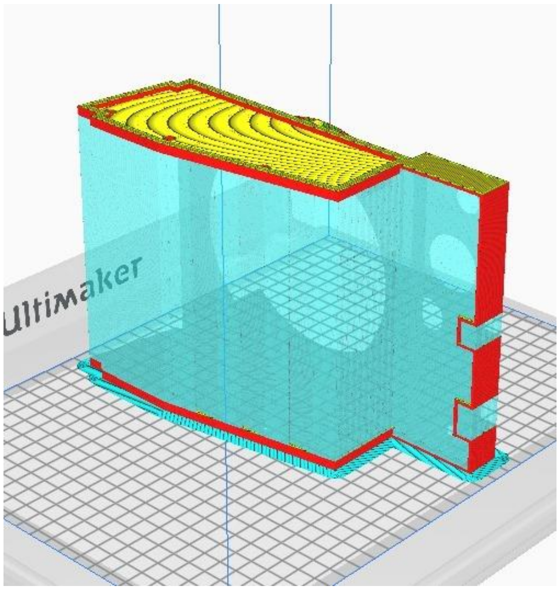


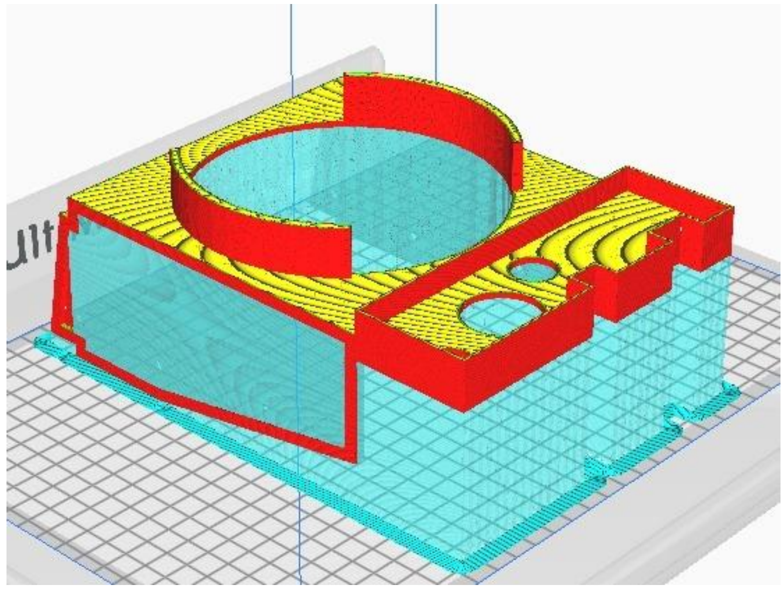
Pre-Processing Steps for 3D printing

Initially the product designed in solidworks imported as stl file to UltimakerCura. The shroud is placed center of the table. We generated support structures. We analyzed with different part orientation. The best orientation parameters are given in the table below:

Parameters	**Values**
Wall Thickness	1.0mm
Infill density	20%
Infill Pattern	Gyroid
Printing Temperature	240 c
Speed	70mm/sec
Print Profile	0.1mm
Build Plate temperature	60 c
Fan Speed	70 %
Support Overhang Angle	60 degrees
Weight	215 grams
Total Printing time	2 days 12 hours

In the comparative study, we are going to place the shroud in different orientation. Support structures will be generated for each of the orientation. After generating support structures, we ensured the material wastage and time for printing the shroud. We identified more the support structures more the time will be taken to print the material. The support structures for various orientation are given below:

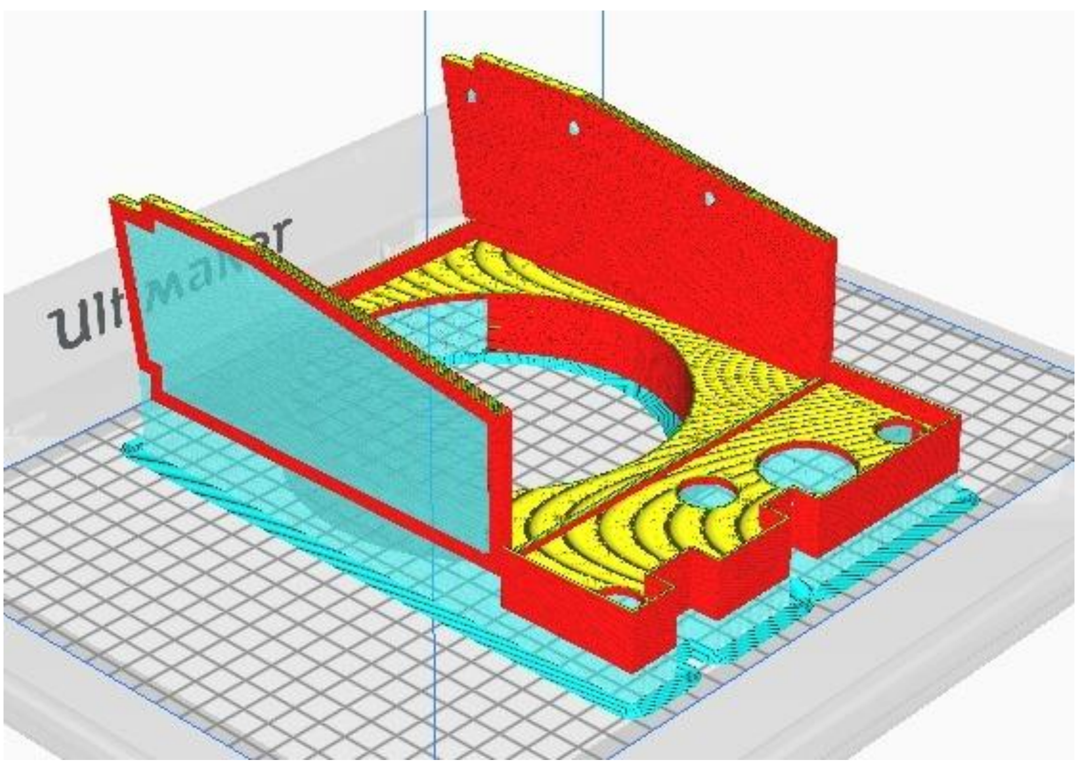




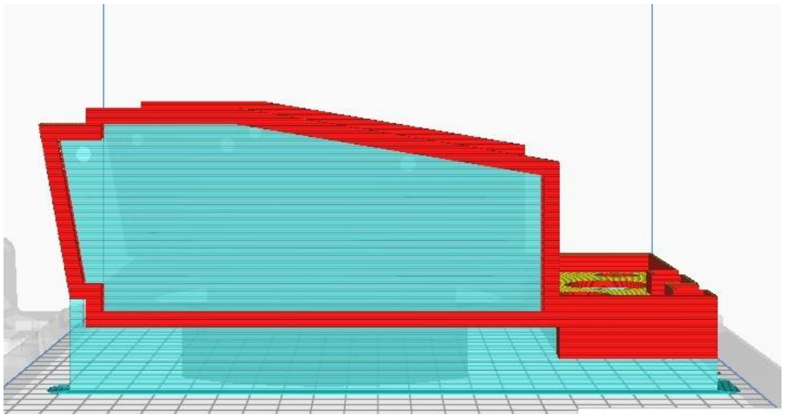
Optimal Structure:

Compared to the other two support structures the support structure given below is optimal. This way of 3D printing the part have two major benifts. The wastge material is very low. The time taken to print is only 2days 12 hours as shown in the table above.

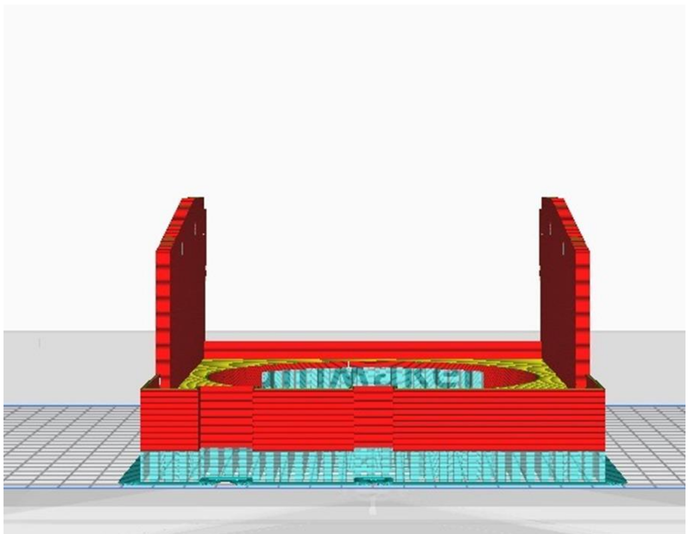
Isometric View:



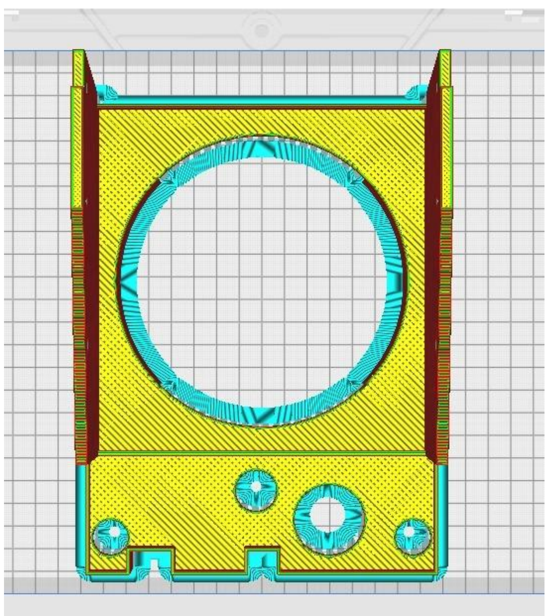
Front View:



Right View:



Top View:



Plan for 3D Printing

Fused deposition modeling is the prescribed method to 3d print our shroud. It has huge capability to replace traditional CNC machining process. FDM is used majorly to print most of the automotive parts. Since we are dealing with a high strength material like PPCP it is at ease to print it. FDM is done using professional grade printers and it will not only improve the workflow but also it deals with the functional testing of the parts. FDM parts are precise to 0.005 of an inch so it ensures to meet all the dimensions given by the user.

Conclusions

People are trying to reduce the machining cost and move to an alternative which is cheap. So, 3D printing comes in place. And now we have many materials which are available in market and we have the option to choose one of the best materials and print it and use it for our daily use. As for the shroud too only about 50 – 100 components will be required per year for the factory. So, 3D printing it with PPCP will be a better choice than the aluminum. So, let’s save all the machining cost and move to a world with 3D printing which can save huge loads of money.

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