Cost Effective Manufacturing and Optimization of the Formula Student Nose Cone

Antim Gupta[1]

[1]*B.Tech. Student, Department of Mechanical Engineering, Vellore Institute of Technology, Chennai, Tamil Nadu, India*

Abstract – *This paper proposes a cost effective way and optimization of manufacturing of Nose cone for formula student car. Weight reduction plays an important role in manufacturing of bodyworks of* ***FSAE*** *cars, so this paper mainly focuses on cost effective way to manufacture the nose cone of about 1.5 kg approximately. It contains the detailed description about modeling of nosecone, manufacturing of nosecone mold by hand layup method(****CFRP****) and vacuum Bagging. The simplest way of making the mold without the use of* ***CNC*** *machining is described so that any FSAE team can manufacture the mold easily in less time. The Software used for modelling is Solidworks 2018. This paper will help the* ***FSAE*** *team to manufacture nosecone with in garage at a very low price in less time clearing all the rules for bodyworks that are mentioned in rulebook of Formula Bharat, Formula Student Germany, Supra India and many other Formula Student events. 3-Point bending test in Universal Testing Machine(****UTM****) has been done to get the result under compressive load.*

Key Words: Composites, Mold, Carbon Fibre, pre-pregs, Nose Cone, CFRP, Vacuum Bagging, UTM.

1. INTRODUCTION

The Formula Society of Automotive Engineer (**FSAE**) competition challenges engineering student to design and fabricate formula car in accordance with good engineering practices.
Every event has some guidelines to be followed to make a formula type car.

The rules of Nosecone are:

1. There must be no openings through the bodywork into the driver compartment other than that required for the cockpit opening.
2. Minimal openings around the front suspension and steering system components are allowed.
3. All edges of the bodywork that could come into contact with a pedestrian must have a minimum radius of 1 mm.
4. The bodywork in front of the front wheels must have a radius of at least 38 mm extending at least 45° relative to the forward direction, along the top, sides and bottom of all affected edges.

The Modelling of nosecone should be according to these rules. Model with 3-D splines and surfacing is used to get the exact intersecting curve details.

Mold creation is a crucial step in the manufacturing process of the parts. Converting the CAD to real mold is a difficult task. A complete idea of manufacturing is described in this paper. The idea is to completely manufacture the part without the use of CNC machining. This paper aims to cut down the cost of manufacturing of nose mold.

The composites play an important role in manufacturing of bodyworks of car. The use of fiber reinforced composites has become increasingly attractive due to their increased strength, durability, corrosion resistance, resistance to fatigue and damage tolerance characteristics. It is highly relevant in industries like aircraft and aerospace industry, automobile industry, defense sector, and infrastructure. Carbon Fiber pre-pregs are easy to use and plays an important role in manufacturing of nosecone as it provides higher strength to weight ratio, corrosion free surface, good texture. The carbon fiber used in manufacturing of nosecone of 3k, 200 gram per square meter(gsm) quality. The binder used was epoxy resin along with hardener to catalyze the reaction.

Vacuum bagging was done to achieve the weight reduction as much as possible. Open molding hand layup method using **CFRP** to make it sufficiently stiff.
To check the Stiffness of nosecone a detailed description of *3-Point bending test in Universal Testing Machine(****UTM****) has been done to get the result under compressive load.*

1.1 Nosecone Modelling

Modelling of nosecone can be done using any modelling software. In my case I have used Solidworks for modelling. First the chassis was imported then a 3D sketch using lines and splines were used to model the nose. The nosecone should clear the rules that are mentioned in rulebook. The main rules are **"The bodywork in front of the front wheels must have a radius of at least 38 mm extending at least 45° relative to the forward direction, along the top, sides and bottom of all affected edges.".**

The front part of nose should have at least 38mm radius with minimum 45 degree extending forward. Boundary surface feature was used to get the proper curve of nose cone.

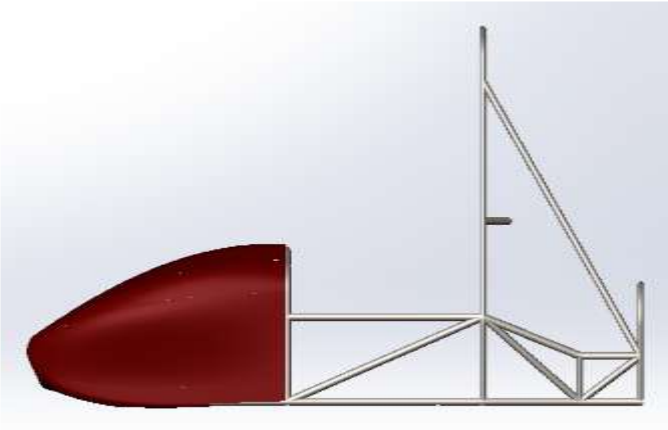


Fig 1.Side view of nose with chassis.

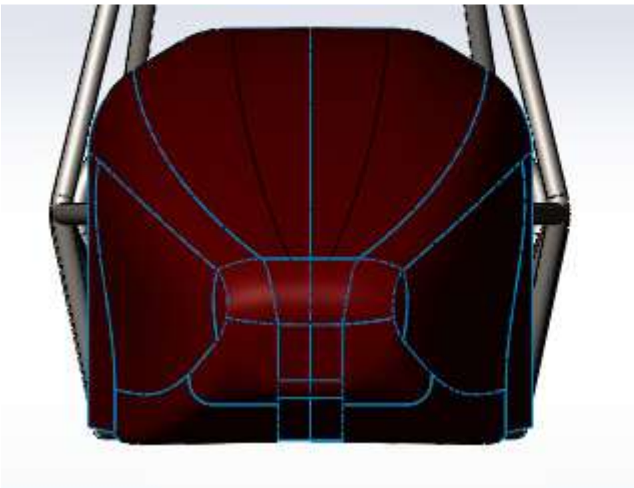


Fig 2.front view of nose with chassis.

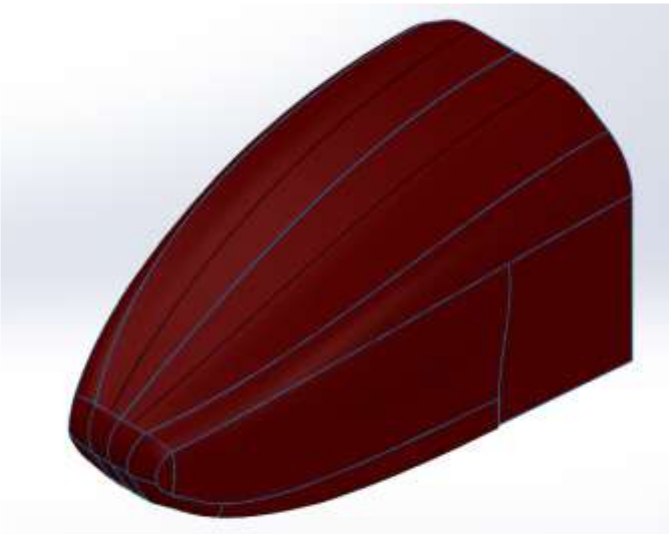


Fig 3.Isometric view of nose with chassis.

For intersecting curves, many planes were created with plane distance same as the thickness of polystyrene foam used for molding.

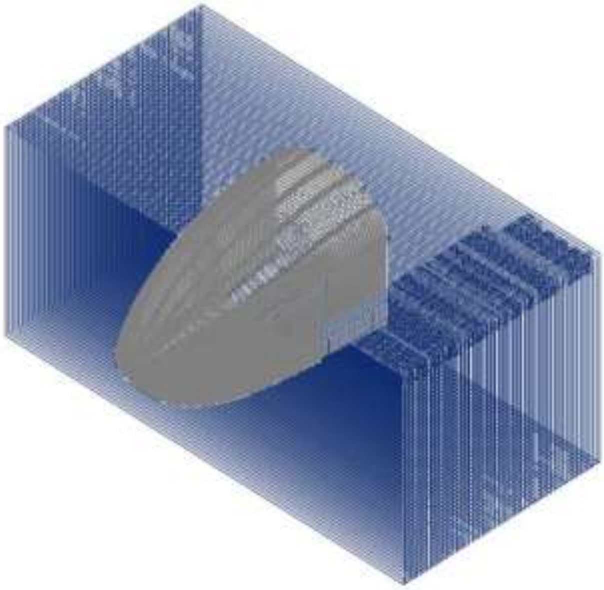


Fig 4.Isometric view of nose with insecting curve on different planes.

All the 2-D intersecting curves were printed on A0 sheet to manufacture the nosecone mold and a rod was extruded to get the proper alignments of profile.

1.2 Mold Manufacturing

Mold creation is a crucial step in the manufacturing process of the parts. Polystyrene sheets were used for manufacturing of nose mold.

The 2-D intersecting curve sketch were used to sketch the same profiles. Then profiles were aligned in a tube to get the proper curve plaster of paris (POP) was applied on it. Then for fine details emery paper was rubbed along the curved edges to get a smooth finish.

Fig 5.Nose cone mold without finish.

Fig 6.Finished mold of Nose cone.

2. MATERIAL SELECTION

The composites play an important role in manufacturing of bodyworks of car. The best material for fabrication of nose cone is carbon fiber pre-pregs. It has high strength to weight ratio, corrosion resistance, provide enough strength, light weight etc. The Carbon fiber used is of 3k 200 gsm quality. Sandwiching of carbon fiber along with glass fiber can also be used to reduce the cost of manufacturing.

3. CFRP-CARBON FIBER REINFORCED PLASTIC

Open molding hand layup method using CFRP along with vacuum bagging to achieve the minimum weight and also enough strength. Two layers of carbon fiber (3k 200 gsm) was used for fabrication of nose. The less the number of values of k more weight reduction can be achieved. The kit used for vacuum bagging was provided to us by CFW Enterprises, Delhi.

Fig 7.Fabrication kit vaccum bagging .

For manufacturing of nose mold, surface needs to be smooth enough so that the nose can easily be removed from the mold. Taping can be done to remove nosecone.

Fig 8.Mold with tapping.

Taping was done to prevent mold from getting damaged. Whenever we apply epoxy and hardener, a high exothermic reaction ocuurs which releases high amount of heat that can damage the mold.

A layer of mold wax was applied to make the surface smooth. Then a layer of Polyvinyl alcohol(PVA) was applied on it to make it extra smooth. The ratio of hardner and resin used was 1:10 . The resin used was epoxy resin along with hardener. Sealant was applied to the boundary of nosecone to create a vaccum using vaccum film.A layer with the same proportion was applied on mold then the pre-pregs were laid with the exact area of nose, then again a layer of resin was applied. The wight and strength depends on the number of layers of carbon fibre and amount of resin used. Then a porous film is laid on the carbon fibre, then, a peel ply along with breather. These layers help in absorbing extra resin, reduce the air bubble inside the layers, achieve the weight reduction and to make the suface smoother with enough strength.

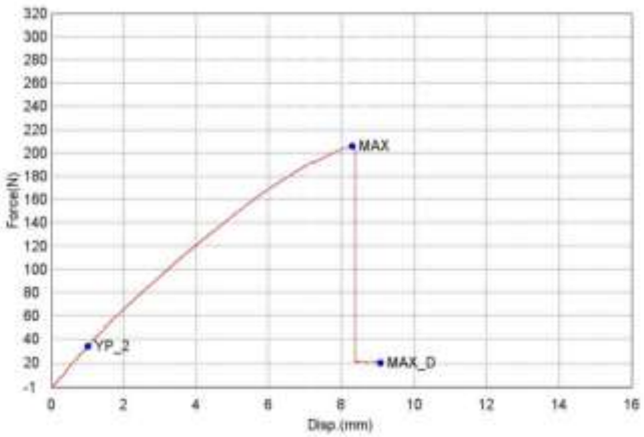
Finally, the mold was sealed with the help of vaccum film and sealant tape along the boundary of mold. A spreader was placed inside the mold to suck the air from inside and to create vaccum inside the mold. The spreader was connected to vacuum pump and it was turned on for about 30 minutes. Then, the pipe was cut and locked with a clamp to create the vacuum to last for a few more hours. The mold was left for one day in dark room for drying. Then, the nose cone was removed from the mold safely.

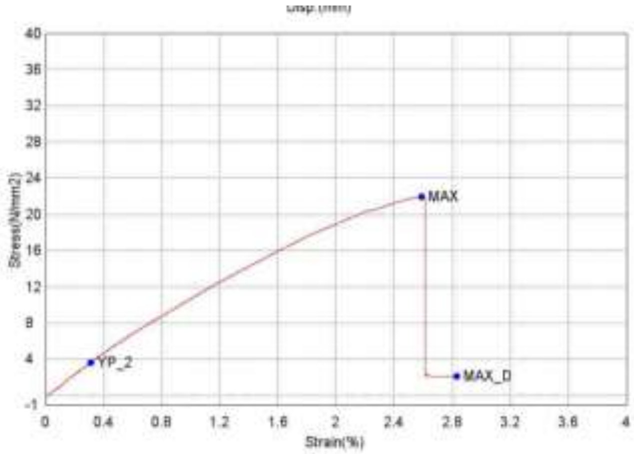
Fig 9. Layers used during vaccum bagging.

Fig 10. Different views of final product-Nosecone.
Final Weight was found to be 1.7 KG

4. STRENGTH TEST

Along with weight reduction enough stiffness also plays an important role in manufacturing of nosecone.
3-Point bending test was performed from the sample to get the stiffness of nosecone. The failure load was generated using Universal testing machine(UTM).





The maxmium force that the nose can withstand was found to be 205 N and the elastic region remains for some time then failure ocuurs as this is an anisotropic material i.e. it has different properties in different directions.

CONCLUSION

This paper successfully integrates designing, material selection, manufacturing process and quality assurance. The paper contributes to advancements in cost effective manufacturing of composite parts. It discusses the methodology of making molds. The proposed method provides an intermediate path that ensures cost reduction along with striking a balance on providing a good surface finish to the mold and weight reduction of final product.

REFERENCES

[1] Agarwal BD, Broutman LJ, Chandrasekhar K. "Analysis and performance of fiber composites." 3rd ed. Wiley; 2006.

[2] OPTIMIZING THE MANUFACTURING OF THE NOSE CONE OF A RACE CAR BY Karl N. Karbhari1, Yusuf M. Bhinderwala2

[3] Formula Bharat Rule Book 2019

[4] Supra Rule Book 2019

AUTHOR

Antim Gupta
The author is an undergraduate student of mechanical engineering at VIT-Chennai and Designer at Shaurya Racing, Chennai, India.