Project Report on

Design and Manufacturing of Seat-box and Center Tunnel

Documentation by:

Kamil Haris	: 981096
Utkarsh Bajpai	: 981138
Jaykumar Patil	: 980593
Yugandhar Vuyyuru	: 979860
Tharun Gogada	: 981113
Sudheer Nath Sannithi	: 981042

Processing period: October 10, 2023 – February 29, 2024

Supervised by: Prof. Dr.-Ing. H. Zoppke

Table of Content:

Part-1

Contents

Part-2

A. List of figure.

B. List of Tables.

PART-1

1. Introduction.

The proTRon Electric Project Car, which embodies cutting-edge technology and forward-thinking design, serves as a beacon of sustainable mobility in the ambitious landscape of electric vehicle innovation. For this project to be structurally sound and provide the best possible performance and user experience, critical components like the seat box and center tunnel must be manufactured and designed perfectly. This study explores the complex procedures and design techniques used to create these parts especially for the proTRon Electric Project Car. With a focus on manufacturing processes, material choices, and design details, this research seeks to provide a thorough understanding of the painstaking workmanship that goes into creating next-generation electric vehicles.

2. Current Analysis.

2.1 Dimension comparison of Seat-box.

The table presented below outlines a comparison between the existing seat-box and its upgraded counterpart. These parameters are crucial in the manufacturing and design process, providing essential insights into the dimensions and characteristics of the seat-box.

Parameters	Existing Seat-Box	Upgraded Seat-Box
Width of the Seat-Box	430 mm	440 mm
Base Inclination	90°	87°
Thickness (Upper Surface of C part)	7 mm	9 mm

Table 1: Dimension comparison

Width of the Seat-Box: The width of the existing seat-box is measured at 430 mm. In the upgraded version, the width has been increased to 440 mm, indicating a modification in the design to accommodate a slightly wider structure.

Base Inclination: Existing Seat-Box: The base inclination of the current seat-box is set at 90 degrees, representing a perpendicular orientation to the ground. With the upgraded version, the base inclination is adjusted to 87 degrees, implying a slight tilt towards the back, which could enhance ergonomics and comfort.

Thickness (Upper Surface of C part): The thickness of the upper surface of the 'C' part in the existing seat-box measures 7 mm. In the upgraded version, this thickness has been increased to 9 mm, suggesting a reinforcement or modification to improve durability or structural integrity.

These parameters play a pivotal role in determining the overall functionality, comfort, and structural stability of the seat-box. The modifications introduced in the upgraded version signify a concerted effort towards enhancing user experience and product performance, thereby reflecting advancements in design and manufacturing techniques.

2.2 Problems in Existing Seat-box.

The existing seat-box has space constraint for assembling electronics components along with rear occupant foot space which impacts during front or rear crash because of its complex geometry.

After analysis and brainstorming, new design was made simple and has more cross-sectional area which resolves the current issues and make the part more specious for components as well as the occupant seated behind with more safety.

3. Seat Box.

3.1 Existing Seat-box design.

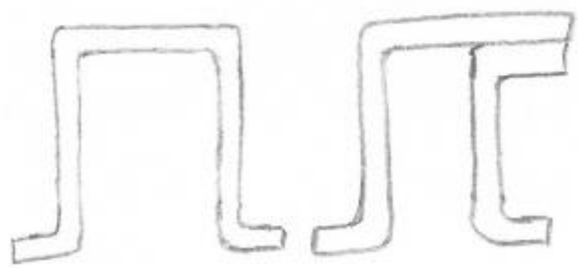


Figure 1 Doppeltes U-Profilmiteingerücktem U [1]

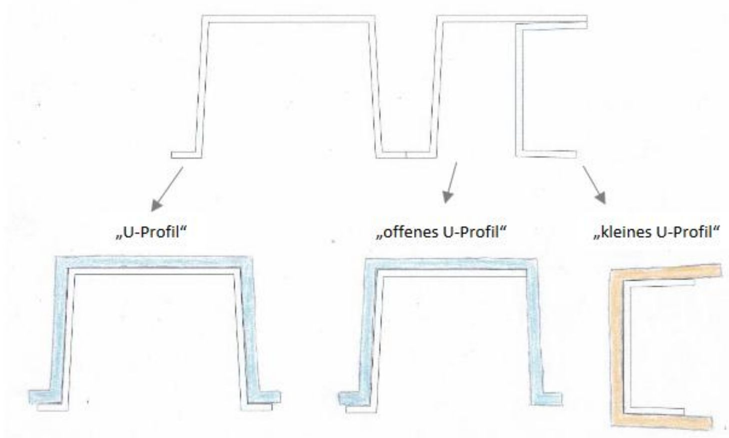


Figure 2 Sitzkasten und Form Konstruktion [1]

The winning concept, Concept 6, consists of two U-profiles. The rear U-profile is a modified form of concept 4. Modified form of concept 4. Instead of a slope, a U-profile with legs of different lengths is also used with legs of different lengths. This means that the U-profile can be indented deeper and create space for the occupant's feet. The front U-profile is a simple U-profile. Due to The fact that there is no longer a slope makes production and mold making very easy, very simple. [1]

3.2 Concepts.

<u>Concept 1:</u>

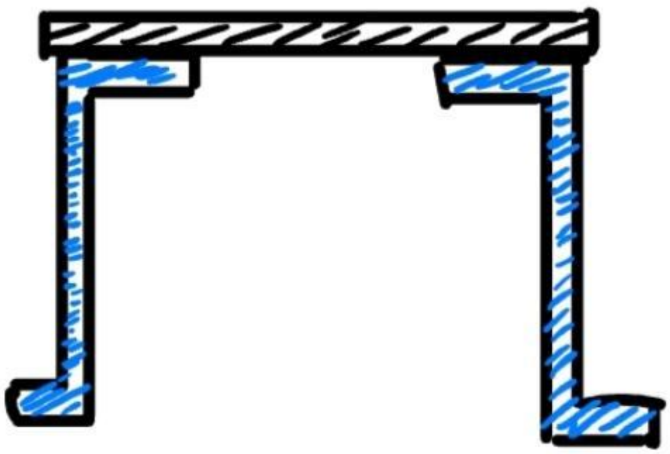


Figure 3 Concept-1

Concept 1 involves easy manufacturing and assembly of the design into a single part using glue. This results in a component with high strength due to seat force distribution. However, this method reduces the height of the part and requires several gluing areas.

Advantages	Disadvantages
Good transmission of seat forces	Needs more glue
Large surface area for the force balance	Less foot space
Simple Geometry for production	
Large surface area for the force balance	
Closed surface for easy entry and exit	
Easy installation of seat screws	

Table 2: Concept-1 Advantages & Disadvantages

Concept 2;

Figure 4 Concept-2

In concept 2 the seat box in a car is ingeniously crafted with a simple design for ease of manufacturing, serving as a single part component. Positioned strategically within the vehicle, it optimizes space and enhances structural integrity while accommodating various seat mechanisms. Moreover, its design incorporates an expanded area specifically allocated for electronics, facilitating seamless integration and enhancing the vehicle's technological capabilities. As a central element in the vehicle's architecture, the seat box exemplifies the harmonious blend of efficient manufacturing techniques, functional design, and technological innovation, embodying the essence of modern automotive engineering.

Advantages	Disadvantages
Storage space near center of gravity	No alterations can be made
Increase cross sectional area for side crash	Less Foot Space
Large surface area for the force balance	
Access for electronics	
Easy installation of seat screws	

Table 3: Concept-2 Advantages & Disadvantages

Concept 3:

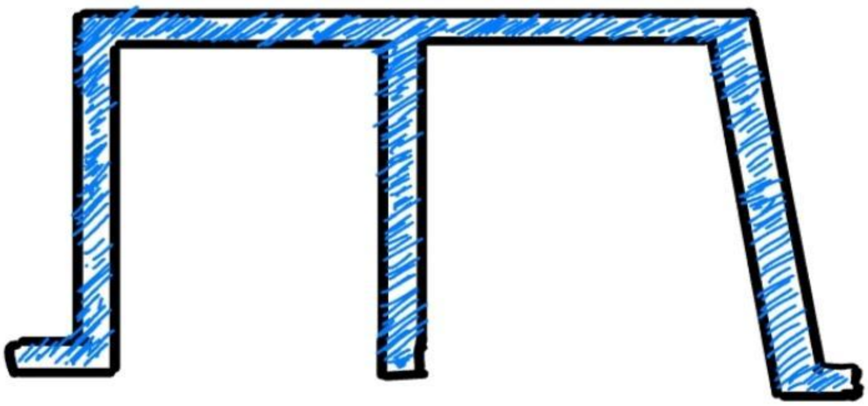


Figure 5 Concept-3

In concept 3 the seat box in a car serves as a pivotal single part, strategically positioned in the middle to efficiently support seat forces, ensuring stability and comfort for occupants. Its design incorporates an expanded area, providing ample space for electronics integration, enhancing the vehicle's technological capabilities. As a crucial component of the vehicle's structure, the seat box not only reinforces the chassis but also facilitates the seamless integration of various functionalities. By serving as a centralized hub for seat support and electronic components, it exemplifies the intersection of structural integrity and technological advancement within automotive engineering.

Advantages	Disadvantage
Storage space near center of gravity	Not a simple geometry for production
Increase cross sectional area for side crash	
Large surface area for the force balance	
Access for electronics	
Closed surface for easy entry and exit	

Table 4: Concept-3 Advantages & Disadvantages

Concept 4:

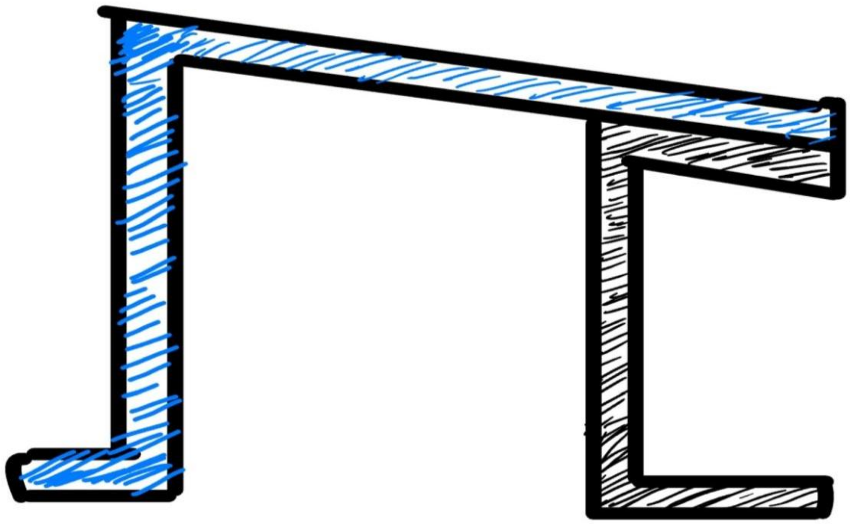


Figure 6 Concept-4

In concept 4 the seat box in a car embodies a streamlined design optimized for efficient manufacturing, ensuring simplicity without compromising quality. A key feature is its capacity to enhance foot space for rear passengers, addressing comfort concerns effectively. Moreover, advancements in its design contribute to heightened strength, bolstering overall structural integrity and safety standards. Additionally, certain iterations may incorporate an inclined profile, further enhancing passenger comfort during extended journeys. By seamlessly blending simplicity in manufacturing, improved foot space, heightened strength, and optional ergonomic inclinations, the seat box epitomizes the fusion of practicality and innovation in automotive design.

Advantages	Disadvantages
Increased legroom in the rear area	No direct access to the hard points
Sufficient cross-sectional area	
Storage space possible under the seat box	
2 parts - only two shapes	

Table 5: Concept-4 Advantages & Disadvantages

3.3 Decision.

The seat box concepts shows that concept 4 “Seat-box combination – two parts/one box” represents a compromise between all concepts and does not have any serious disadvantages.

The hard points through a service opening or similar in the seat box is of little relevance, as the connection to the battery does not normally have to be removed, except for repairs to the battery pack. This service opening can be made large enough to create storage space or installation space for other vehicle components under the seat box. Closing the opening with a plastic cap would protect the components from dust and would not negatively impact the appearance of the interior influence. In terms of weight and cross-section, the concept is in the middle range. It offers low weight and a sufficient cross-section while at the same time providing enough legroom for the rear area. Future concept in cases of any need to access the electronics, the seat box can be cut from the front side on front face if it is required and can be glued it.

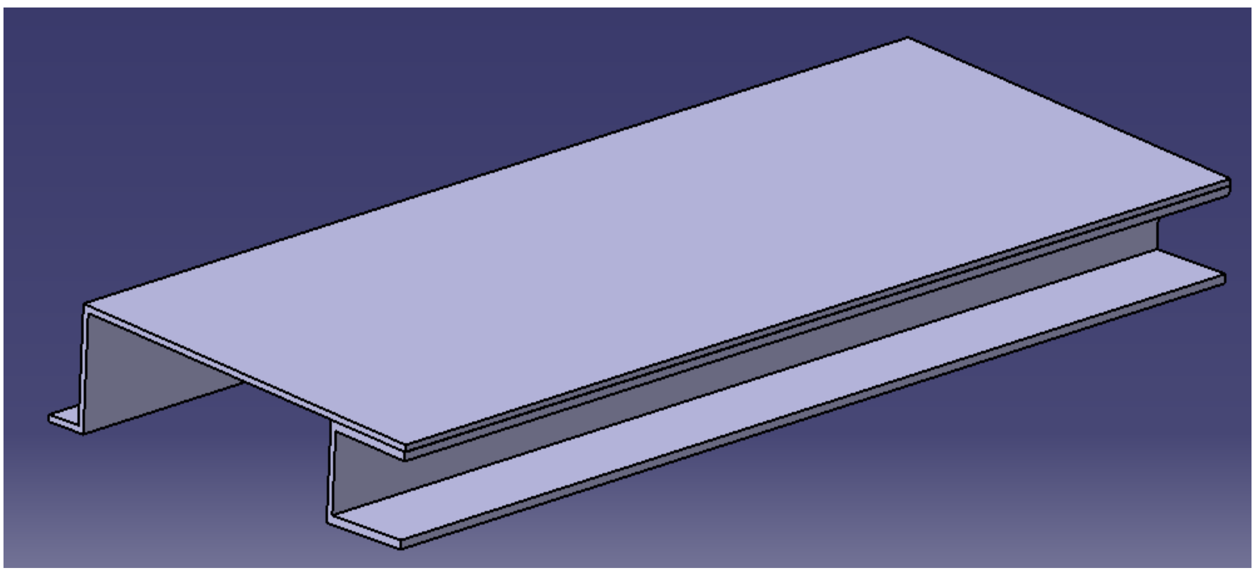


Figure 7 ISO View of seat-box

3.4 Drafted View.

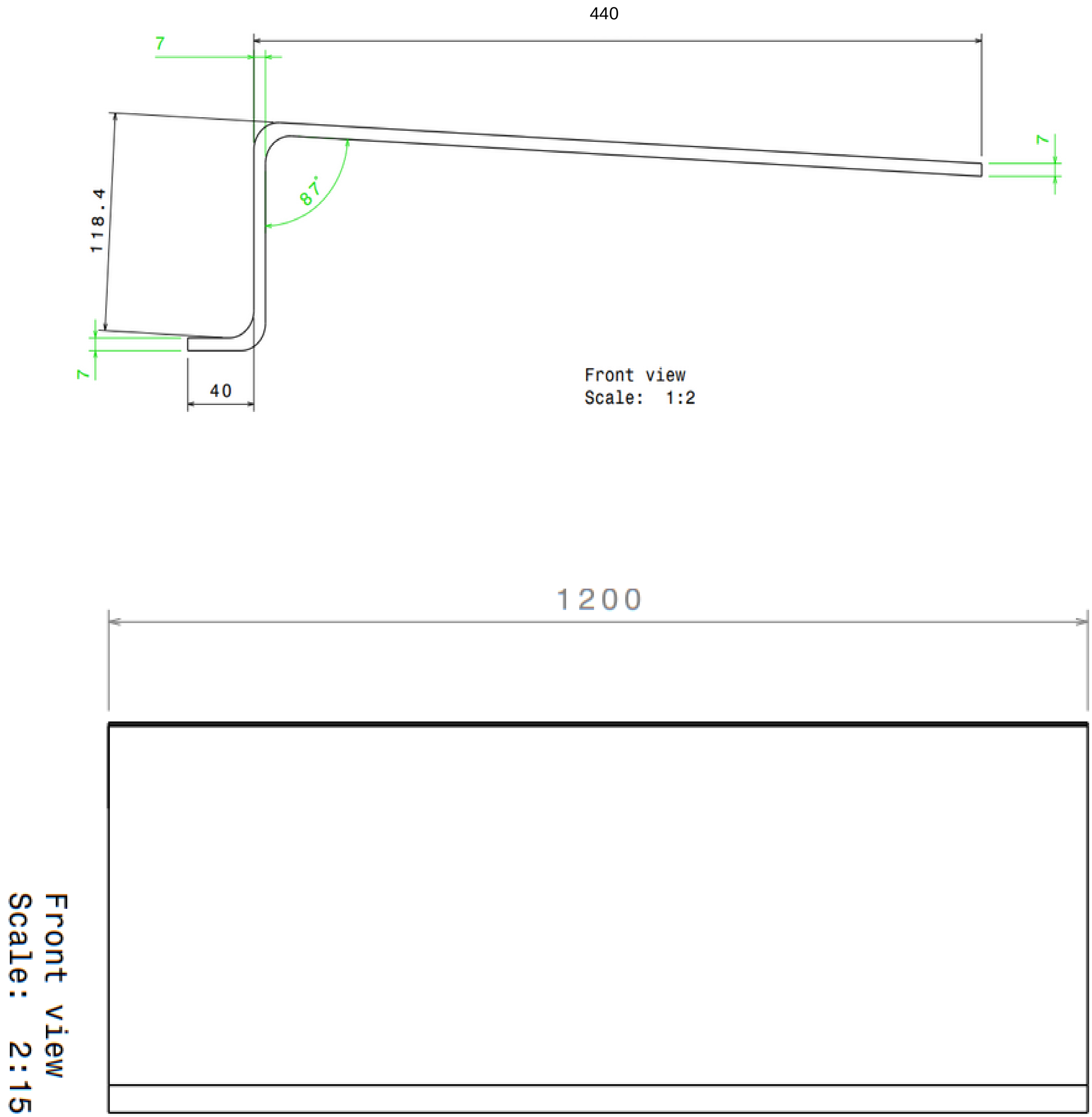


Figure 8 Drafted View

* All dimensions in mm

3.5 Calculations for fiber.

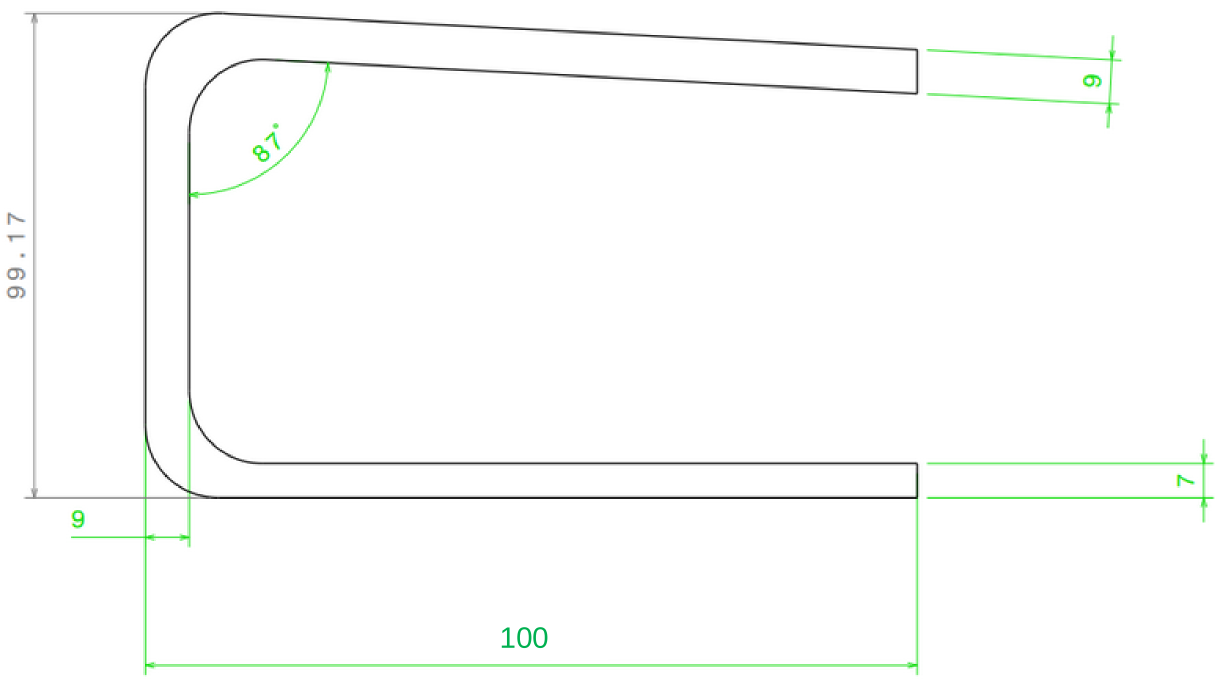


Figure 9 C-part

Exact dimensions of C profile:

Length (mm) = 1200 [50+50 (extra)]

Width (mm) = 100+100+101.2+ [50+50 (extra fiber)]

Total area in mm^2 for C surface = 1300 length * 400 width

Total Layers for C profile = 22.5

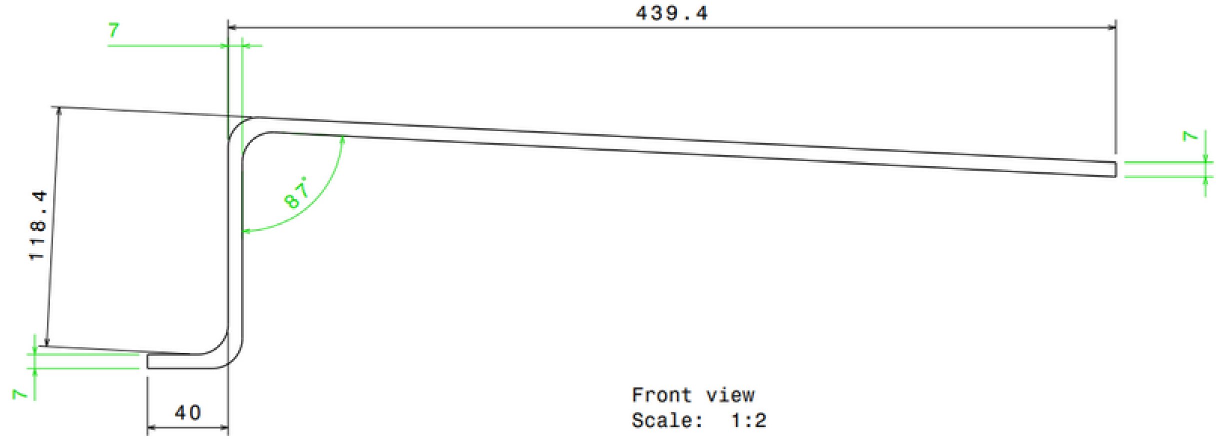


Figure 10 L-part

Exact dimension of L Profile:

Length (mm) = 1200 (50+50 extra)
Width (mm) = 40+118+440+ [50+50 (extra fiber)]
Total area in mm^2 for L surface = 1300 length * 700 width
Total Layers for L profile =17.5

Cross-Sectional area for Seat box:

Cross-Sectional area for L = 4183.9 mm^2
Cross-Sectional area for C = 1634 mm^2

Total Cross-Sectional area of the Seat Box= 5817.9 mm^2

4. Center Tunnel.

Figure 11 Current Center Tunnel [1]

This is the reference image of existing center tunnel according to which the seat box is designed and manufactured as this dimensions would fit the seat box with high load distribution and with higher strength for crash test.

5. Conclusion.

This project involved the complete design and manufacture of a final seat box with existing center tunnel concept and manufactured. Both components are designed to support the monocoque in the event of a frontal or side impact. In the event of a frontal or side impact and provide sufficient survival space for the occupants. Through an extensive series of tests with different layer structures, important basic knowledge about the material behavior under compressive loads. Based on the many tests, it was possible to create a computational model which the designer can use to make a rough calculation of the layer structure without having to carry out a FEM simulation. In addition, the independent production of the molds, extensive knowledge was gained about the practicality of previously designed components.

PART-2

1. Design of Mold.

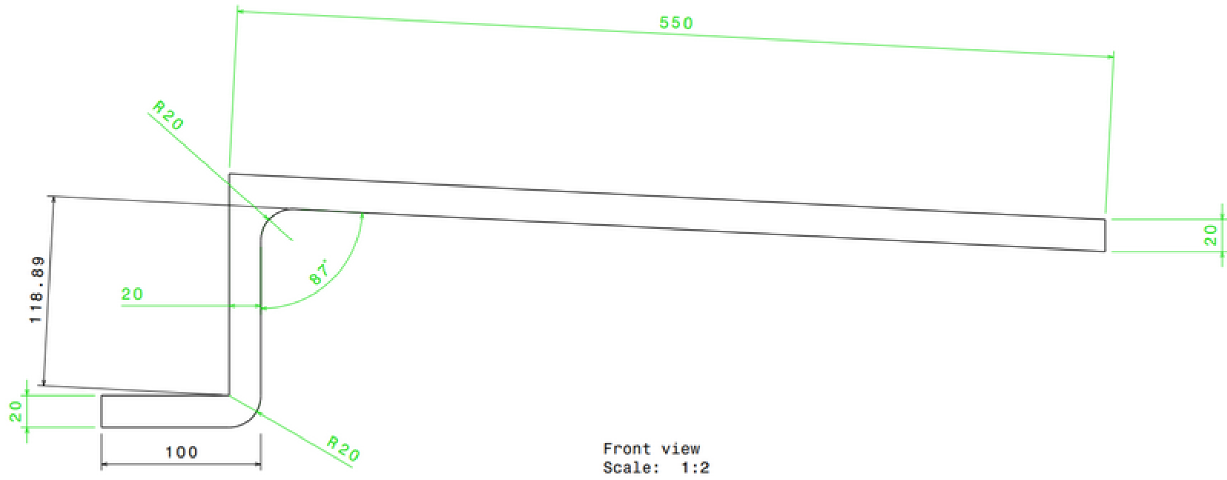


Figure 12 Mold Part-1

- Length of the Mold is 1400 mm

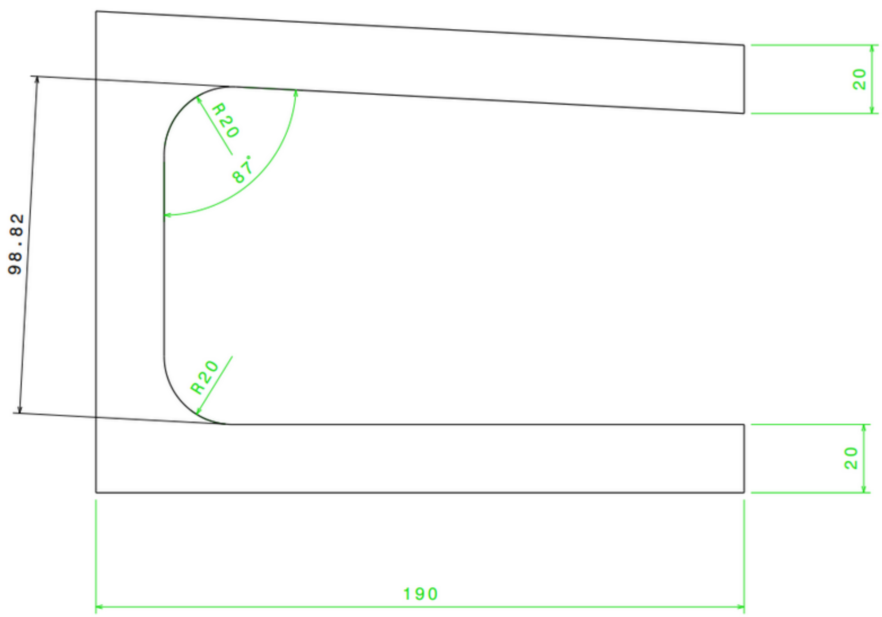


Figure 13 Mold Part-2

Detailed design specifications for the product that the mold will produce. These specifications include dimensions in mm. The appropriate material for the mold based on factors such as the type of product, production volume, expected tool life, and cost considerations. Common mold material is wood with fine surface. Molds must be high accuracy and precision to ensure that the final products meet dimensional and tolerance requirements.

2. Requirements of Materials.

Sl No	Materials
1	Ply Wood
2	Fiber
3	Foam
4	Resin
5	Screw
6	Vacuum Bag
7	Sticky Tape
8	Vacuum Pipe

Table 6: Material list

3. Estimated Seat Box Weight

L Part Calculation:

Weight of the fiber = 300gsm/layer

Number of fiber layers in L-Part = 18

Weight of one layer= 0.21528 kg/m^2

Total weight of L part without resin= 3.9kg/m^2

Total weight of L part with resin = 11.7 kg/m^2

C Part Calculation:

<u>Calculation 1:</u>

Weight of the fiber = 300gsm/layer

Number of fiber layers in C-Part = 13 full profile

Weight of one layer= 0.108 kg/m^2

Total weight of C part without resin=1.4 kg/m^2

Total weight of C part with resin= 4.2 kg/m^2

<u>Calculation 2:</u>

Number of 100 mm length layer = 5

Weight of one layer = 0.036 kg/m^2

Total weight of 100 mm length 5 layer without resin =0.18 kg/m^2

Total weight of 100 mm length 5 layer with resin = 0.54 kg/m^2

Total Weight of the C Component= 4.74 kg/m^2

Total Weight of the seat box: 11.7+4.74= 16.44 kg/m^2

Note: 4mm thickness foam is added in the vertical and top surface of C part and the weight is negligible.

4. Properties of Resin.

Selection aid/comparison data for epoxy resin systems

	Resin L + hardener S	Resin L + hardener L	Resin L + hardener CL	Resin L + hardener GL 1	Resin L + hardener GL 2	Resin HT 2 + hardener HT 2	Resin L 285 + hardener 285	Resin L 385 + hardener 386
Processing time 100 g batch at 20 °C	15 minutes	40min	60min	30 minutes	210min	45min	50min	120min
Mixing ratio in parts by weight	100:40	100 :40	100:30	100 :30	100 :30	100:48	100:40	100:35
Mixing ratio in parts by volume	100:45	100 :45	100 :35	100 :35	100 :35	100:55	100:50	100:43
Viscosity (mPa.s, 25 °C) resin	700±70	700±70	700±70	700±70	700±70	400	600-900	700-1050
Viscosity (mPa.s, 25 °C) Hardener	-	95-135	70-120	100±50	14±2	200	50-100	40-90
Mixed viscosity (mPa.s) resin + hardener	887 ± 100	580±100	500±100	820	248	201 ± 50	625±100	650±100

Figure 14 Resin chart [2]

Characteristics

Very low viscosity	High static and dynamic strength
Solvent-free and filler	Excellent fiber wetting
Curing temperatures from 15 °C	Increased heat resistance after hot curing
Curing Conditions	**24 h at 23 °C (73 °F)**

Table 7: Characteristics

5. Manufacturing of Seat Box

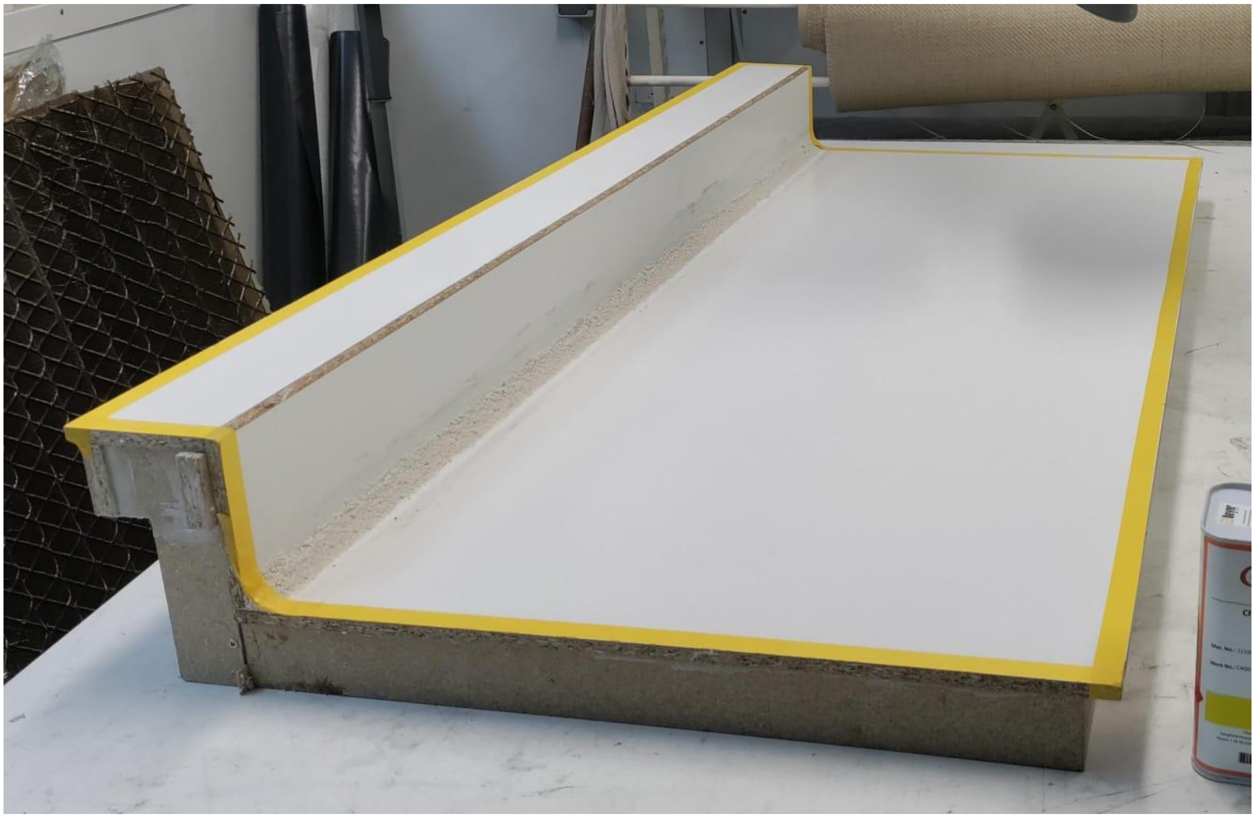


Figure 15 Mould for L Part

Dimension of L Profile Mould:

Length (mm) = 1300
Width (mm) = 750
Thickness of the ply in mm = 10

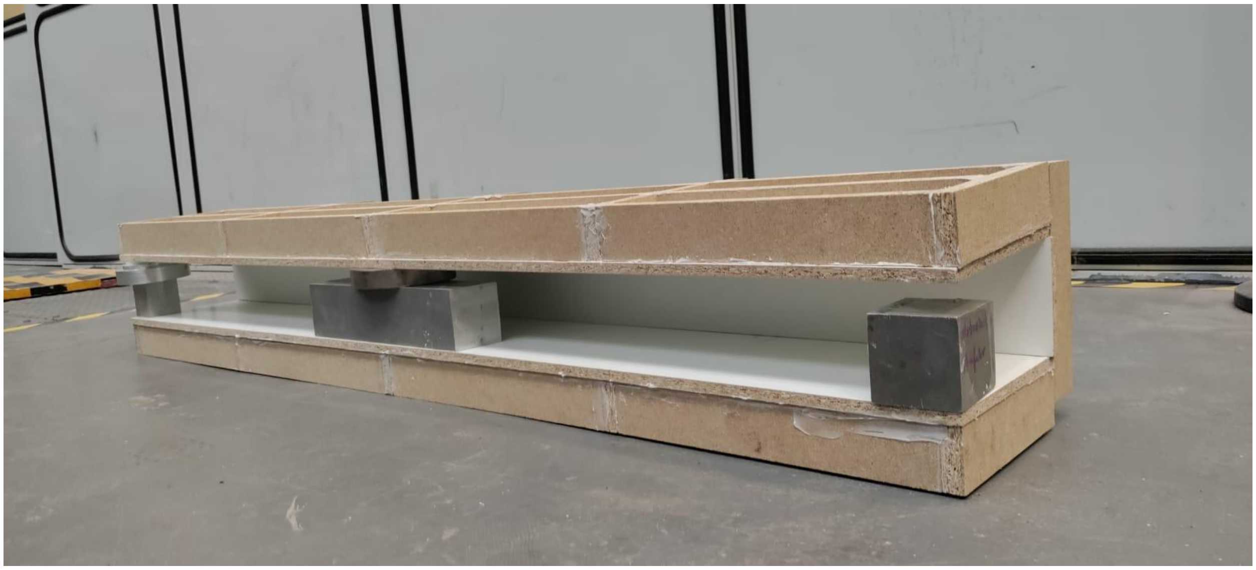


Figure 16 Mould for c part

Dimensions of C profile Mould:

Length (mm) = 1300
Width (mm) = 402
Thickness of the ply in mm = 10

6. Process followed for Manufacturing:

Prepare Vacuum bag according to dimension of mould and give clearance of 300mm for each part.

Clean the mould thoroughly. Use resin and hardener with ratio of 100 & 35 respectively, and glass bubbles and thixotropic with ratio of 80 & 20 respectively for radius of 20° with tolerance of 5°.

Fiber cutting for L Part:

Fiber Material	Direction	Layers
Uni-Directional	0°	6
Woven	+45°	3
Woven	-45°	3
Uni-Directional	90°	6

Table 8: Layers arrangement for L part.

Fibber Cutting for Part:

Fiber Material	Direction	Layers
Uni-Directional	0°	6
Uni-Directional	90°	6
Woven	+45°	3
Woven	-45°	3

Table 9: Layers arrangement for C part .

Clean the mould twice by applying EP thinner with twenty minutes time duration after applying first layer. After cleaning process use masking tape on the edges of the mould covering 20mm from the end edge. Apply Chemlease PMR EZ on the entire mould (5 layers) with 15 minutes of duration after apply each layers and up to 48hrs approximately.

Apply adhesive tesa spray glue permanent on the edges of the fiber and stick it on the mould, the first six layer is of 0° and then place the form of 1200 mm × 98 mm in the top and 1200 mm × 100 mm in the vertical surface overlap six layers of +45° and -45°on top each other then finally six 90° layers on top of previous fiber.

Check for air leakage by sticking Vacuum bag with sticky tape on the prepared mould. By using vacuum for 24 hours check for the air leakage, if there is leakage in the mould find the leakage source and clear it by pouring resin once it is cured apply resin on mould and then generate suction on the mould for 24 hours and after 24 hours remove the vacuum bag and cure it for 7 days. The same process will be followed for "C part".

7. Laminating Complete Steps:

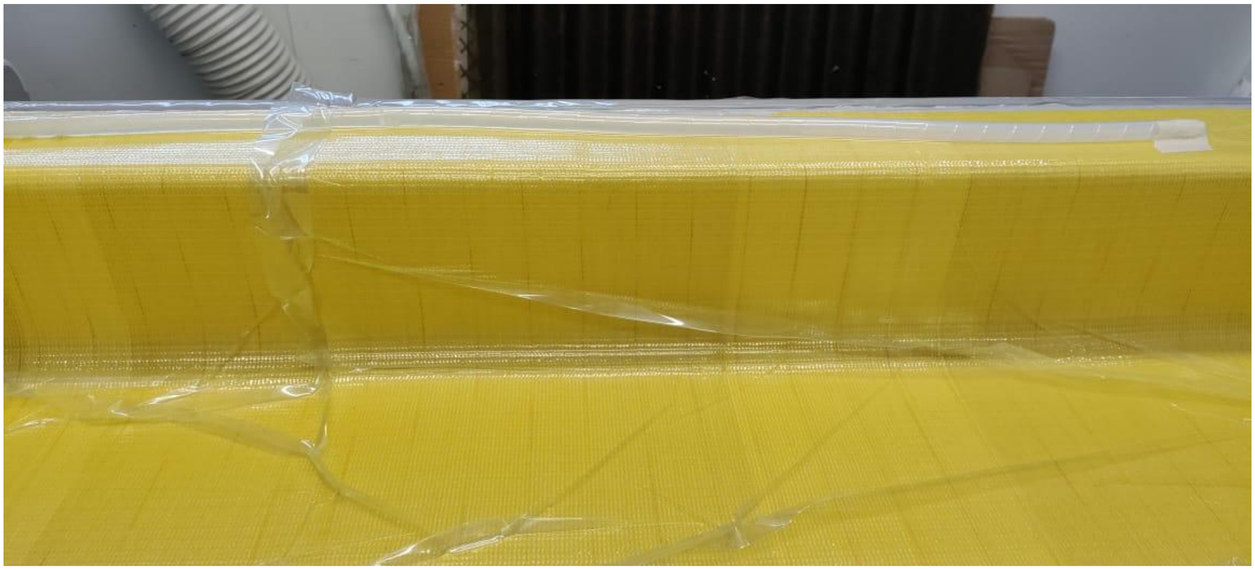


Figure 17 Vacuum Check

After the fibers are placed the on the top of fiber place peel-off fabric and then mesh then place tube on the top and bottom, with the help of sticky tape seal the vacuum bag, then check for leakage in the part by using vacuum bag this process is carried out before the lamination is done the size of the vacuum bag should be $\frac{1}{10}^{th}$ bigger than the area of the mould to have enough clearance. The average vacuum should range between 70 to 90 microns and once after the pump is turned off the mould should hold the vacuum if we notice change in vacuum gauge we need to find for leakage and seal the leak after that we can move to next process.

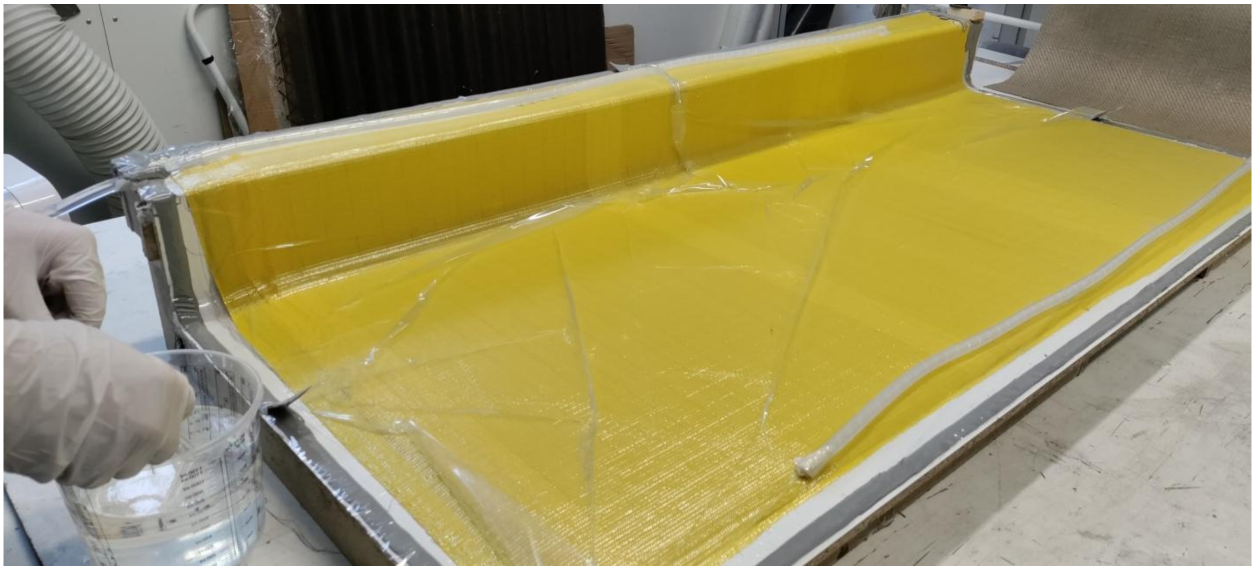
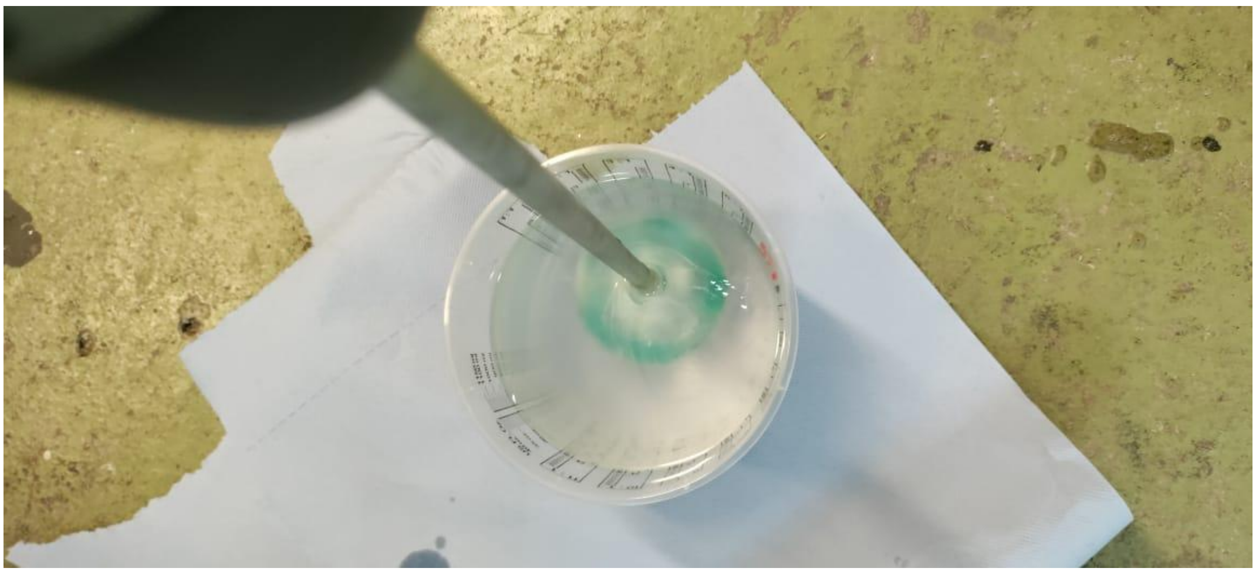


Figure 18 L Part before lamination

After the Fiber is placed in the required direction a tube is placed in the top and another in the opposite to it. From the top part we supply resin for the lamination and from the bottom side the



excess resin is pulled with the help of pump.

The resin is mixed according to the total weight of the fibers. The mixture of resin and hardener is 70% of resin and 30% of hardener; Mix it well until it is completely mixed with each other. After the resin mixture is ready then it is degassed and all the air is removed out of the resin

using pump. This process has to be done for minimum 15 minutes to remove the air completely from the resin.

Figure 20 Degasification of rein

After degasification the resin is pumped inside the mould and once the complete part is filled with resine the left end is blocked using line clamp and the laminated part is left to dry for 24 hours after that the part is seperated from the mould and the mesh is removed from the part, later it is cut to the actual dimension of the seat box 1200mm length and wait for 48 hours for the part to dry completely.

Figure 22 Measuring the weight of the part

Figure 21 Laminated Part

Finally the part is weighed and the weight of the part is 5584.8 grams which is close to expected weight.

In the “C part” we have placed foam as shown in the fig 24; it is placed for flexibility of the part, so as to withstand whole seat and human weight. After placing 6 layers of 0° fibers the foam is placed and after that 3 layer +45° and -45° fiber is placed then whole process is similar as explained above.

8. End Result of C Part

The part after lamination was removed from the mould and the top side where the foam was places was found raw without any resin on the side. It is because of the foam that restricted the resin flow on the top part.

8.1 Possible reasons for failure of laminate:

- The foam was not having any space for resin to flow through it so that it could reach the other side of the part.
- There was only one inlet tube placed for resin to enter the mould and the tube did not cover the other end of the part.
- The Pump was pulling out all the extra resin out of the mould even before the entire part was wet.

8.2 Preventive Methods:

- Make various small holes in the foam so that it will allow resin to flow throw it and reach

Figure 24 Failure of C part

  the other side of the part.
- Give inlet from both the end, it will supply resin to entire part without any gaps and the it will consume less time for resin to reach the corners easily and the process will run smoothly.

References

[1] J. Gries und J. Hahn, *Konstruktion und Fertigung des Sitzkastens und Mitteltunnels,* 07.07.2018.

[2] Faserverbundwerkstoffe, „https://www.r-g.de/art/100133," [Online]. Available: https://www.r-g.de/wiki/Vergleichsdaten_Epoxydharzsysteme.