Objective:

The objective of this project is to develop a manufacturable and structurally efficient front hood panel for an automotive application, starting from the provided Class-A surface. The design encompasses the integration of critical subcomponents such as the hinge and latch mechanisms to ensure optimal fitment, functionality, and durability. Utilizing CATIA V5 R30, the project aims to achieve a robust CAD model that aligns with industry standards for styling, packaging constraints, safety regulations, and ease of manufacturing.

Project Scope:

This project involves the end-to-end design and development of an automotive front hood panel using a Class-A surface as the starting point. The key activities under the project scope include:

- **Surface refinement and packaging study** based on the given Class-A data to derive a Class-B and Class-C surface suitable for manufacturing.
- **Design and integration of hinge and latch mechanisms** ensuring proper assembly alignment, hood kinematics, and load path management.
- **3D modeling using CATIA V5 R30**, adhering to automotive design standards and OEM specifications.
- **Consideration of manufacturability aspects** such as panel thickness, hemming allowances, and tooling clearances.
- **Provision for structural reinforcements and mounting points**, accounting for durability and pedestrian safety requirements.

Design Methodology:

The front hood panel design was developed using a systematic approach to ensure functional performance, aesthetic alignment, and manufacturability. The methodology followed in this project is outlined below:

Analysis of Class-A Surface

- Studied the provided Class-A surface for curvature flow, styling intent, and boundary conditions.
- Identified critical areas for design constraints such as outer edge blending, hinge zone, and latch location.

Reference Data Study

- Reviewed vehicle package layouts, hood opening angles, striker and hinge locations, and surrounding components.
- Benchmarked similar hood assemblies from existing vehicle models for layout validation.

Class-B and Class-C Surface Generation

Developed tooling-friendly surfaces with appropriate draft angles and fillets using CATIA V5 R30.
Ensured continuity (G1/G2) and smooth transitions to maintain styling fidelity and manufacturability.

Hinge and Latch Mechanism Design

- Modelled hinge and latch assemblies to facilitate hood articulation, alignment accuracy, and secure locking.
- Defined mounting locations considering packaging and structural stiffness.

Structural Reinforcement and Inner Panel Design

- Created inner panel geometry to support outer skin, absorb operational loads, and meet pedestrian safety norms.
- Included bead patterns and emboss features for stiffness enhancement.

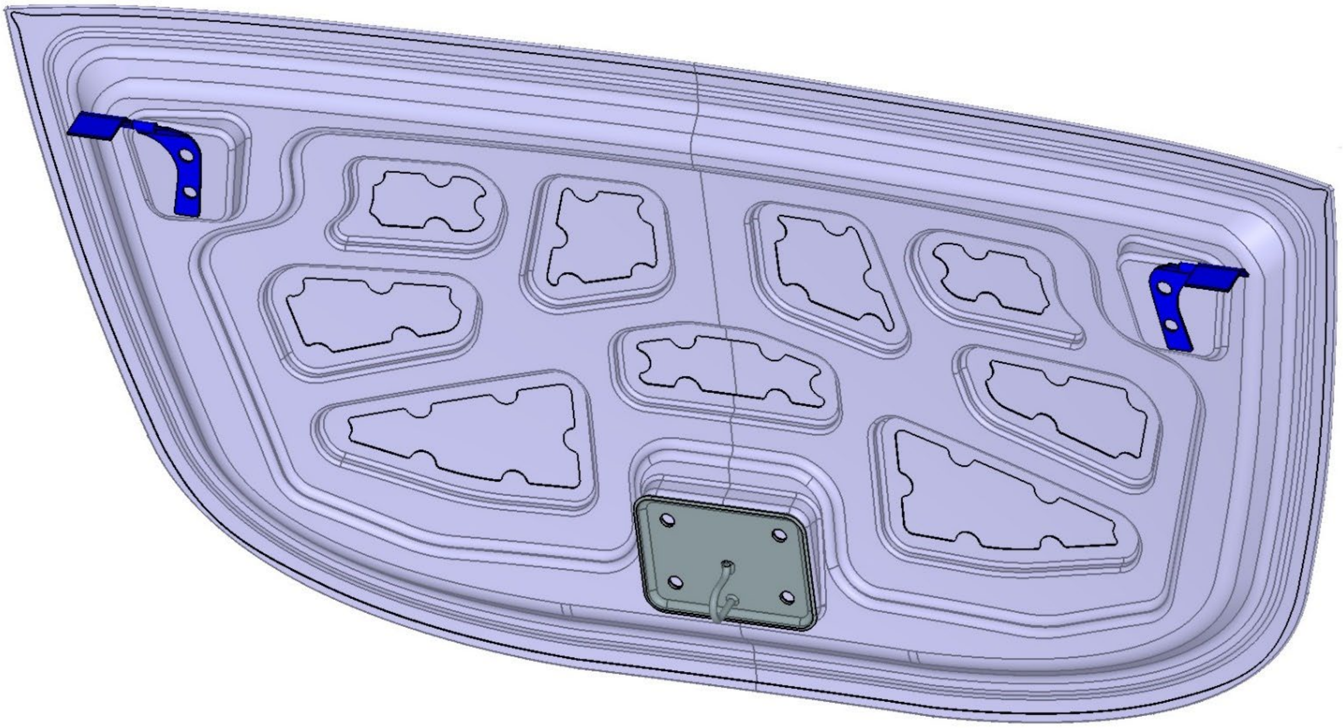
Introduction to BIW (Body-in-White)

Body-in-White (BIW) refers to the stage in automotive manufacturing where a vehicle's sheet metal components have been welded together to form the final body structure, but before painting, surface treatments, or the installation of moving parts (like doors, hoods, and trunk lids), trim, and powertrain components. BIW serves as the structural backbone of the vehicle and plays a critical role in ensuring crash safety, rigidity, and dimensional accuracy.

Key Characteristics of BIW:

1. **Material Composition:**
    - Traditionally made from **mild steel**, **high-strength steel (HSS)**, or **advanced high-strength steel (AHSS)** to provide a balance between weight reduction and structural integrity.
    - In premium or performance vehicles, materials like **aluminum** or **carbon fiber-reinforced plastics (CFRP)** may be used for further weight reduction.
2. **Manufacturing Processes:**
    - BIW construction involves **stamping**, **laser cutting**, and various **joining techniques** including **spot welding**, **MIG/MAG welding**, **laser welding**, **adhesive bonding**, and **riveting**.
    - Advanced automation with robotic arms is employed to ensure consistency and high production rates.
3. **Functionality:**
    - The BIW provides **torsional and bending rigidity,** which contributes to vehicle handling, noise, vibration, and harshness (NVH) control, and crash performance.
    - It offers mounting points for all vehicle subsystems like powertrain, suspension, electrical harnesses, interior trims, and exterior closures.
4. **Design Considerations:**
    - Design of BIW emphasizes **crashworthiness** (front/rear/side impacts, rollover), **weight optimization**, **manufacturability**, **cost**, and **durability**.
    - Components such as **A-pillar, B-pillar, roof rails, rocker panels, cross members**, and **crash boxes** are critical to BIW's load-bearing function.
5. **BIW Components Classification:**
    - **Upper Body:** Roof, A/B/C pillars, window frames
    - **Underbody:** Floor panels, cross members, tunnel reinforcement
    - **Front-End Structure:** Engine compartment rails, strut towers
    - **Closures and Openings:** Hood, doors, trunk/liftgate – although not always included in the "bare" BIW definition, their attachment points are integrated into the BIW.
6. **Relevance to Hood Panel Design:**
    - The front hood is one of the **major closure panels** in the vehicle and is mounted directly onto the BIW via **hinges and latch points**.
    - The BIW layout dictates the **hinge bracket mounting locations, latch striker placement**, and **opening angle constraints**, all of which must be considered during hood panel design.

FRONT HOOD PANEL:



Class A surface (Input):

Class A surface in automotive design refers to the outermost, visible surface of a vehicle part, typically requiring a high-quality finish. For the front hood panel, Class A surfaces are critical because they determine the overall aesthetic appearance and smoothness of the vehicle, influencing both the visual appeal and aerodynamics. The significance of Class A surfaces in the front hood panel includes:

- **Aesthetic Appeal**: As the most visible part of the vehicle, the Class A surface must be flawless, free of defects like scratches or irregularities, ensuring the hood maintains a premium, attractive look.
- **Aerodynamics**: The smoothness of the Class A surface plays a key role in reducing air resistance, contributing to the vehicle's overall fuel efficiency and performance.
- **Fit and Alignment**: Precision in the Class A surface is crucial for ensuring proper fit and alignment with other vehicle parts, such as the fenders and grille, which directly impacts the vehicle's structural integrity and quality.
- **Manufacturing**: Class A surfaces demand high-level precision in manufacturing, often requiring advanced techniques like stamping or injection molding, and necessitate strict control of the production environment.
- **Cost and Time Efficiency**: A well-designed Class A surface can streamline the production process, reducing the need for extensive finishing or rework. This makes it an important consideration in optimizing costs and time in automotive manufacturing.

In summary, Class A surfaces on the front hood panel are essential for vehicle design, influencing appearance, performance, and manufacturing processes.

In the sheet metal forming process for automotive front hood panels, the tooling axis and draft angle are critical elements that influence manufacturability, part quality, and ease of production. Here's a summary of their significance:

Tooling Axis:

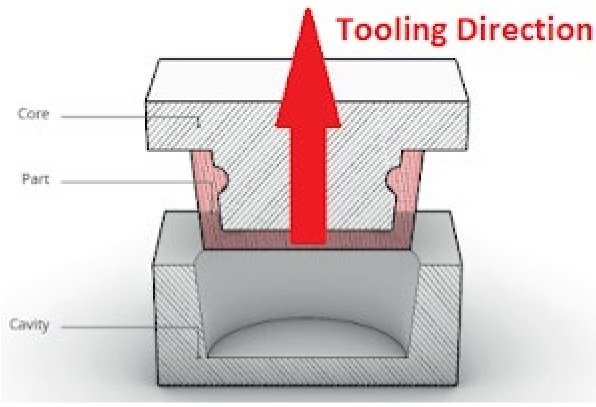
The tooling axis refers to the direction along which the tool moves during the manufacturing process, particularly in operations like stamping or die-casting. Its orientation is crucial for:

- **Ease of Part Ejection:** The tooling axis determines the direction in which the formed part will be ejected from the die. An appropriately aligned tooling axis ensures that the hood panel can be easily removed from the die without deformation or damage.
- **Minimizing Part Distortion:** A well-chosen tooling axis helps in controlling material flow during forming, minimizing the risk of unwanted warping or distortion, especially for large, complex panels like the front hood.
- **Tool Design:** Proper selection of tooling axis affects the design of the forming tools, die inserts, and related components, ensuring optimal manufacturing efficiency and accuracy.

Draft Angle:

Draft angle refers to the slight taper given to vertical walls of the part to facilitate easier removal from the die. It plays a significant role in:

- **Ease of Part Removal:** Draft angles allow the part to be removed smoothly from the die without sticking, reducing friction and preventing damage to the panel surface.
- **Tooling Life:** Proper draft angles help in reducing wear and tear on the tooling, as the die parts experience less force during ejection, extending the life of the tools.
- **Surface Quality:** The draft angle can help in achieving a smooth, even surface on the part, ensuring that the Class A surface of the hood panel remains free of defects.
- **Manufacturability:** Without the right draft angle, the stamping or casting process can lead to significant issues such as surface scratches, excessive wear on the dies, and difficulty in extracting the part from the mold, all of which can increase production costs.



Significance of Draft Analysis:

Draft analysis is a crucial process that ensures a smooth and efficient manufacturing experience, particularly for parts created using injection molding. Here's a breakdown of its importance:

- A draft analysis is a virtual inspection technique used in CAD software to assess the angle of a part's walls relative to the tooling axis (the imaginary direction the mold splits open).
- During injection molding, molten plastic is injected into a closed mold. Once cooled, the mold needs to open to release the finished part. However, if the part has walls that are completely perpendicular (90 degrees) to the tooling axis, it can get stuck in the mold. This is because the plastic has no angle to "slide" out as the mold opens.

- A draft analysis helps identify areas on the part where the draft angle might be insufficient. The software typically displays the draft angle in a color gradient, with areas closest to perpendicular highlighted in red or another warning color.

Significance of Class B Surface:

In automotive design, a Class B surface refers to a hidden surface that lies beneath the visually appealing Class A surface. It plays a crucial role in the car's structure and functionality but is typically not seen by the end user. Some of the characteristics of Class B surface are:

- **Supporting Structure:** Class B surfaces provide structural support and mounting points for the Class A surface and other vehicle components. They help ensure the overall rigidity and functionality of the car's interior or exterior panels.
- **Less Stringent Tolerances:** Compared to Class A surfaces, Class B surfaces have slightly looser tolerances. While smoothness is still important, minor imperfections are less noticeable and acceptable here.
- **Focus on Functionality:** The primary concern for Class B surfaces is their ability to fulfill their structural and attachment purposes. They may incorporate features like bosses, ribs, or channels that wouldn't be present on a purely aesthetic Class A surface.
- **Manufacturing Considerations:** While Class B surfaces require good quality, their manufacturing process is typically less demanding compared to Class A surfaces. This can allow for the use of different tooling or materials to optimize production costs.

Significance of Class C surface:

Unlike Class A and B surfaces, it's not directly concerned with aesthetics or providing core structural support. Class C surfaces often deal with internal features or hidden functionalities. They can be used to create:

- **Attachment points:** These surfaces might provide designated areas for clips, brackets, or other components that secure various parts within the car's assembly.
- **Support structures:** In some cases, Class C surfaces might offer additional internal reinforcements or ribs that enhance the rigidity of specific areas without impacting the outer aesthetics.
- **Clearance pockets:** They might be designed to create space for internal mechanisms or wiring harnesses to navigate within the car's structure.
- **Relaxed Tolerances:** Compared to Class A and B surfaces, Class C surfaces have the most relaxed tolerances. Minor imperfections or variations in their form are less critical, as they're not directly visible and don't significantly impact the car's overall function.
- **Focus on Efficiency:** The primary concern for Class C surfaces is achieving their designated purpose in the most efficient way possible. This can involve using simpler geometries or less precise manufacturing techniques compared to the higher-class surfaces.

Design Considerations in Hood for Better Pedestrian Safety Ratings

- **Adequate Head Impact Zone Clearance:**
  - Ensure a minimum deformation space (typically ~60–100 mm) between the hood inner panel and hard engine components (like battery, engine block, etc.).
  - This allows the hood to deform and absorb energy during a pedestrian head impact.
- **Energy-Absorbing Hood Inner Structure:**
  - Design the inner panel with crush zones, emboss patterns, and controlled collapse features to absorb kinetic energy.
  - Avoid rigid reinforcements directly under the head impact zone unless covered with energy-absorbing foam.
- **Material Selection:**
  - Use materials with high energy absorption and ductility—mild steel or aluminum with tailored thicknesses are common.
  - Advanced materials like composite sandwich panels may also help improve energy dissipation.
- **Use of Active Hood Systems (for Premium Vehicles):**
  - Integrate active hoods that pop up during impact using sensors and actuators to create space between the hood and engine hardpoints.
  - Helps significantly in meeting stricter pedestrian safety norms.
- **Avoidance of Sharp Edges and Stiff Spots:**
  - Smooth out any ribs, brackets, and mounting points within the impact area.
  - Keep latch and hinge reinforcements outside the primary impact zones or cover them with energy-absorbing pads.
- **Compliance with Global Standards:**

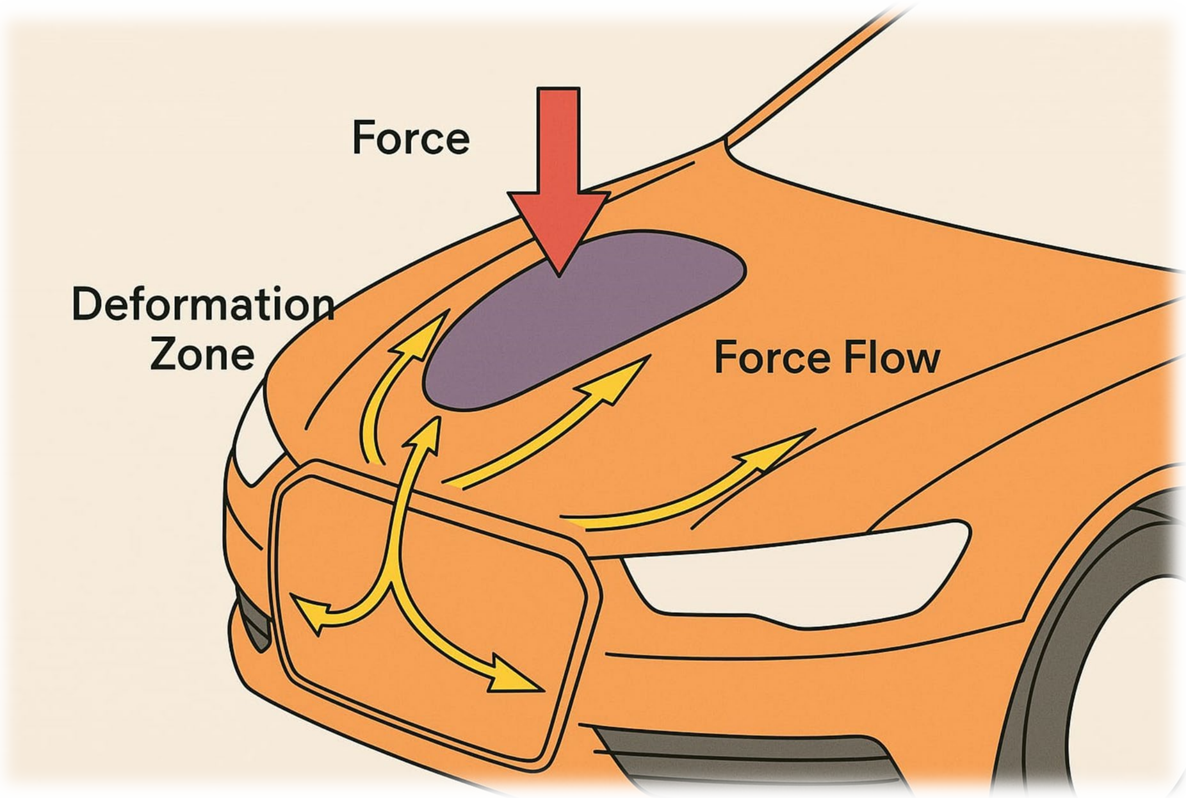
  Design according to regulations like:
    - EU Directive 2003/102/EC
    - UN-R127 GTR9 (Global Technical Regulation on pedestrian protection)
    - NCAP rating requirements (Euro NCAP, Bharat NCAP, etc.)
- **Simulation and Validation:**
  - Perform pedestrian headform impact simulations (FEA) using tools like LS-DYNA or PAM-CRASH.
  - Validate critical zones such as adult and child head impact zones, leg and pelvis zones, and optimize hood design based on results.
- **Hinge and Latch Placement Strategy:**
  - Keep hinges and latches outside the primary head impact zones whenever possible.
  - If within the zone, they must be collapsible or designed to deform safely on impact.

Force Dissipation and Safety in Front Hood Panel Design

The automotive front hood panel is a critical structural and safety component designed not only to cover the engine bay but also to manage and dissipate forces during pedestrian impacts and vehicle crashes.

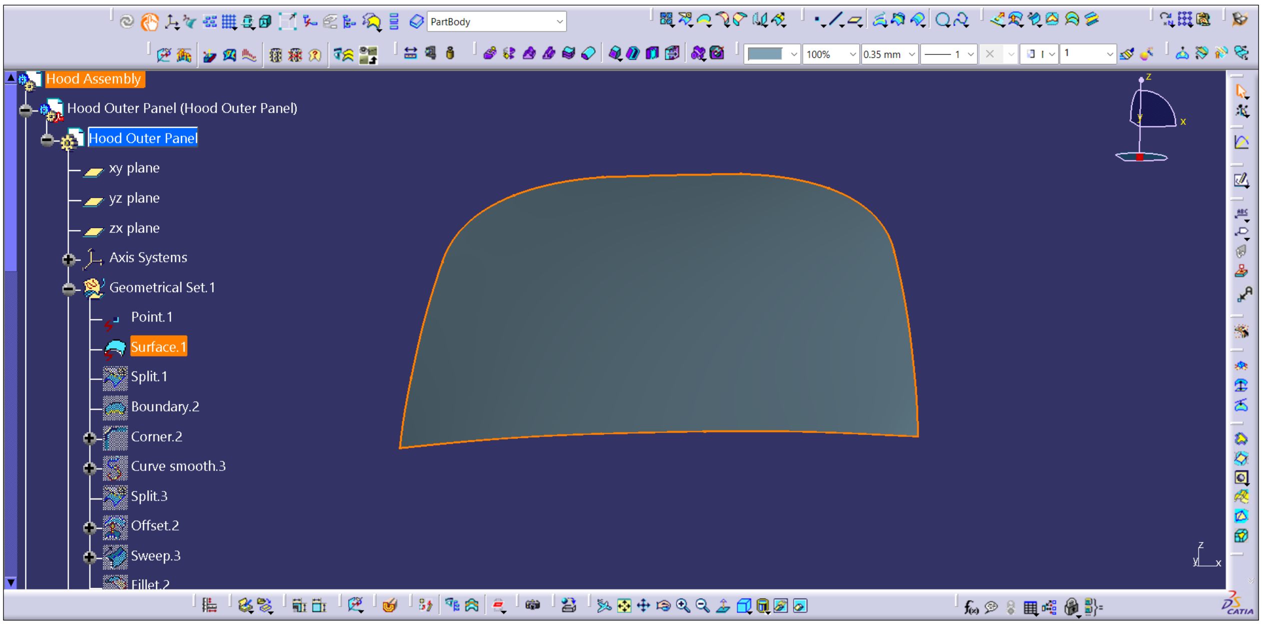
- **Force Dissipation Mechanism:**
  - During a pedestrian impact, especially head or legform impacts, the hood must deform in a controlled manner to absorb energy.
  - This is achieved by:
    - Emboss features and collapsible ribs in the inner panel to act as crush zones.
    - Material thinning or dimpling in impact-prone areas to reduce stiffness locally.
  - The gap between the hood and engine components ensures there's enough deformation space to avoid secondary injuries from hard components underneath.
- **Safety Aspects in Hood Design:**
  - Crash Energy Management:

    While not the primary load path in a frontal crash, the hood should not contribute to secondary injuries. It may crumple and direct forces away from the cabin.
- **Material Optimization:**
  - Selecting materials with good impact energy absorption characteristics (e.g., aluminum alloys or dual-phase steels) enhances both weight reduction and safety.

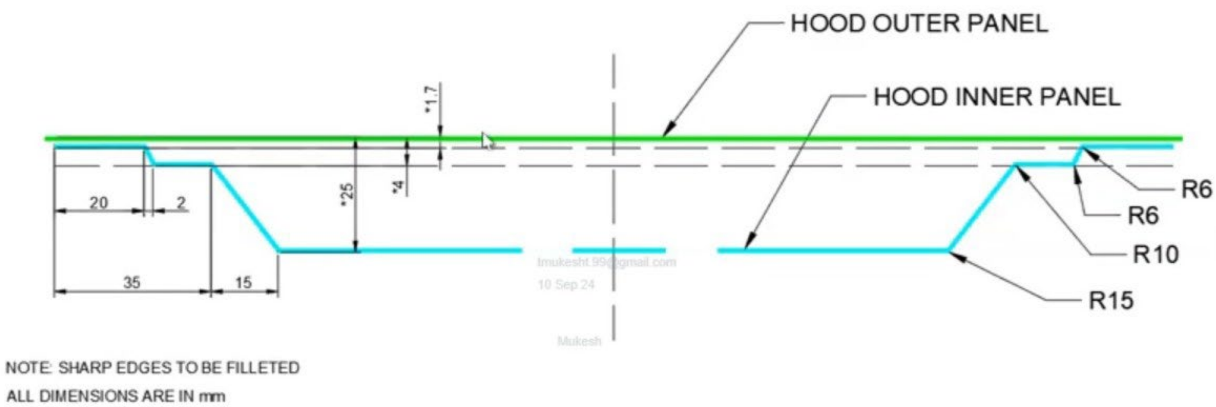


DEVELOPMENT OF AUTOMOTIVE FRONT HOOD PANEL:

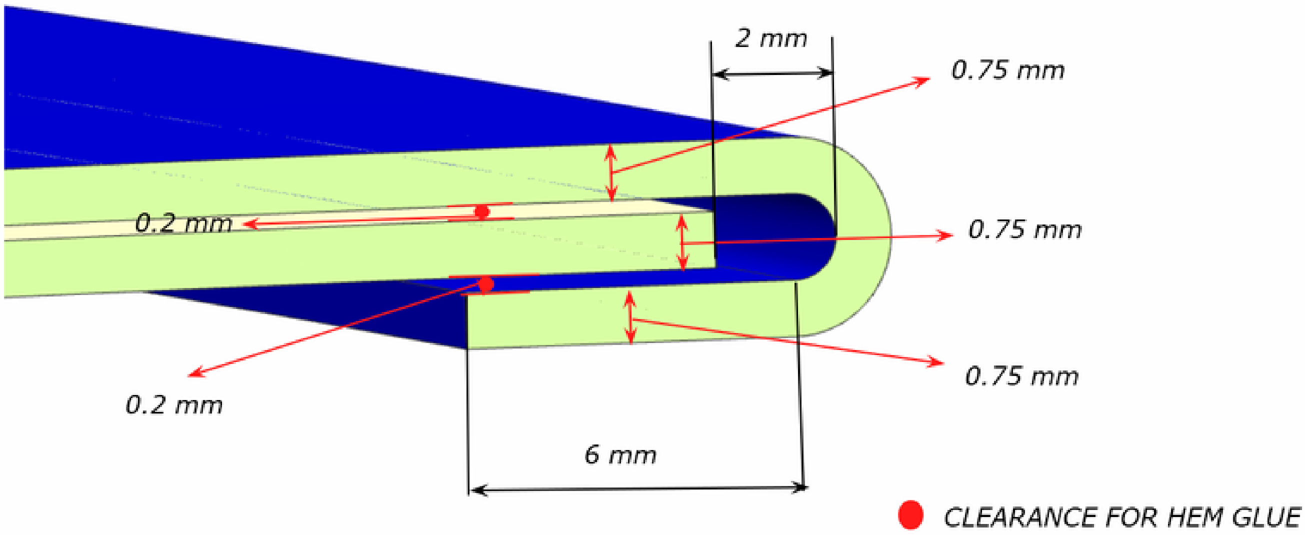
Inputs: Class-A Surface:



Hood Master Section:



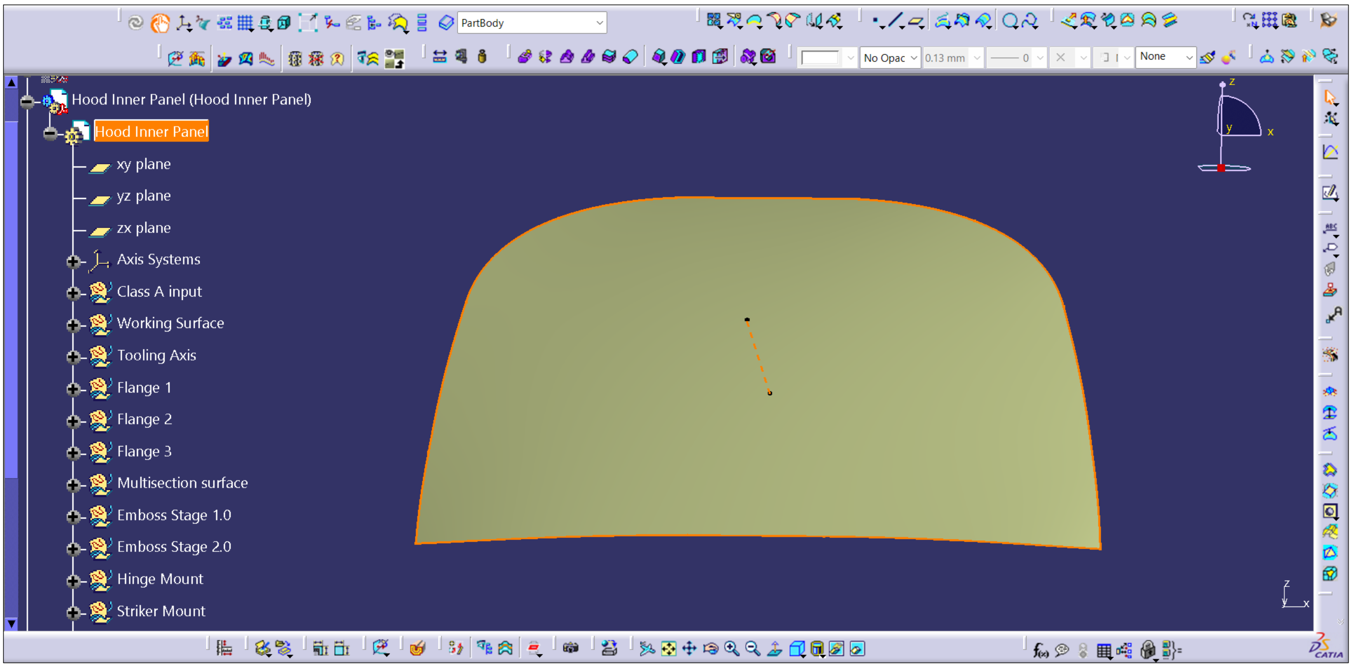
HEM Data:



Part 1: Hood Inner Panel:

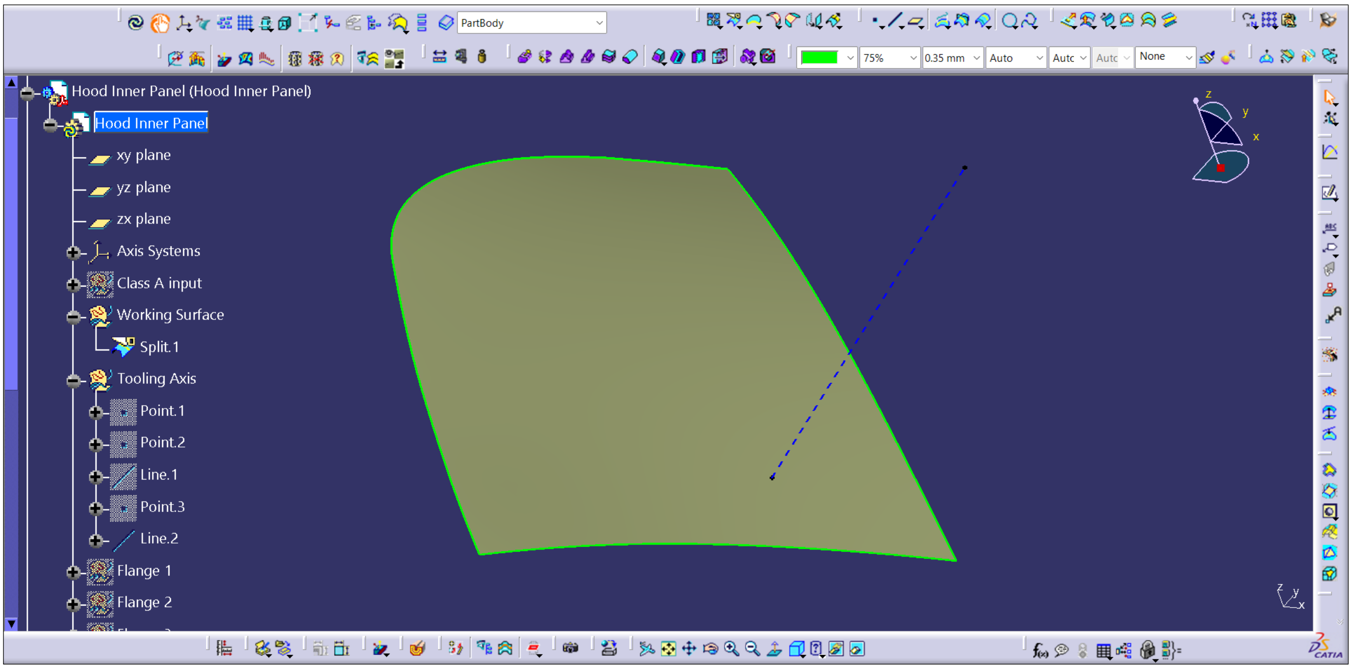
Creating Essential Geometrical Sets:

The first step involves in creating all the essential Geometrical sets itself under a geometrical set named Construction for the given model which includes:



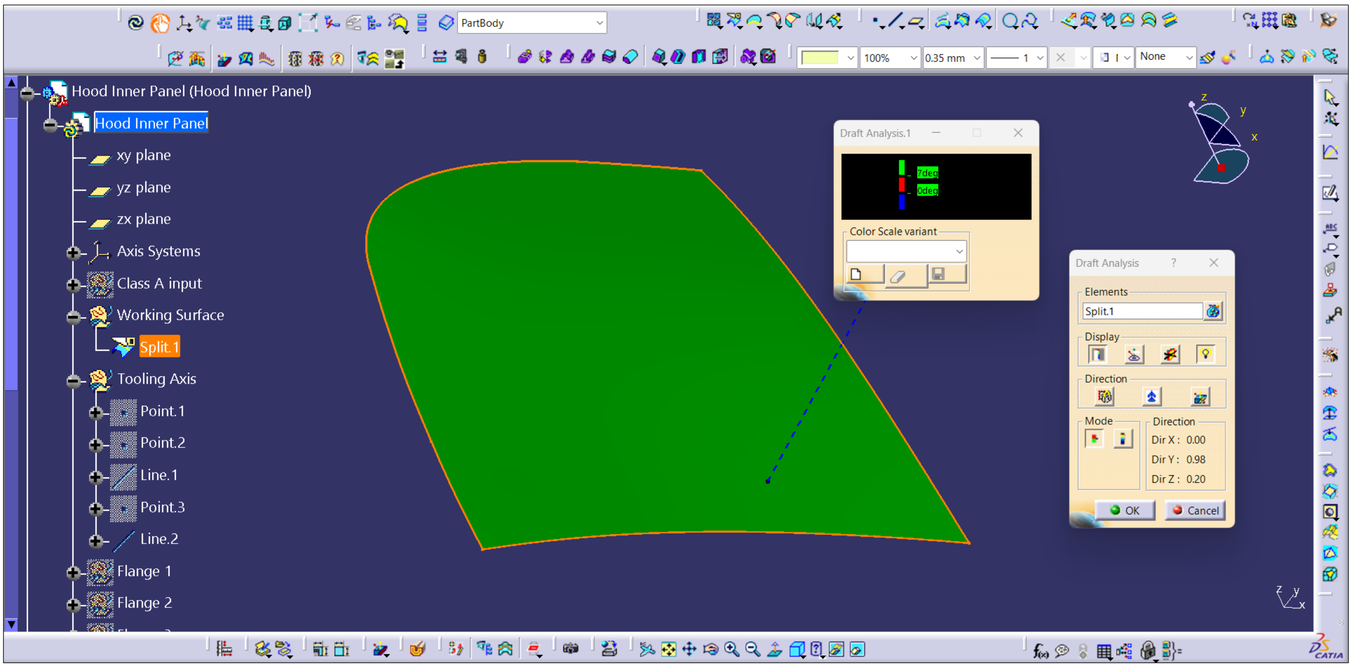
Creating Tooling Axis:

- Extract the flat surface from the Class A Surface using extract command.
- Create two points on the surface and create a line on Z axis with the mid-point as reference.



Draft Analysis:

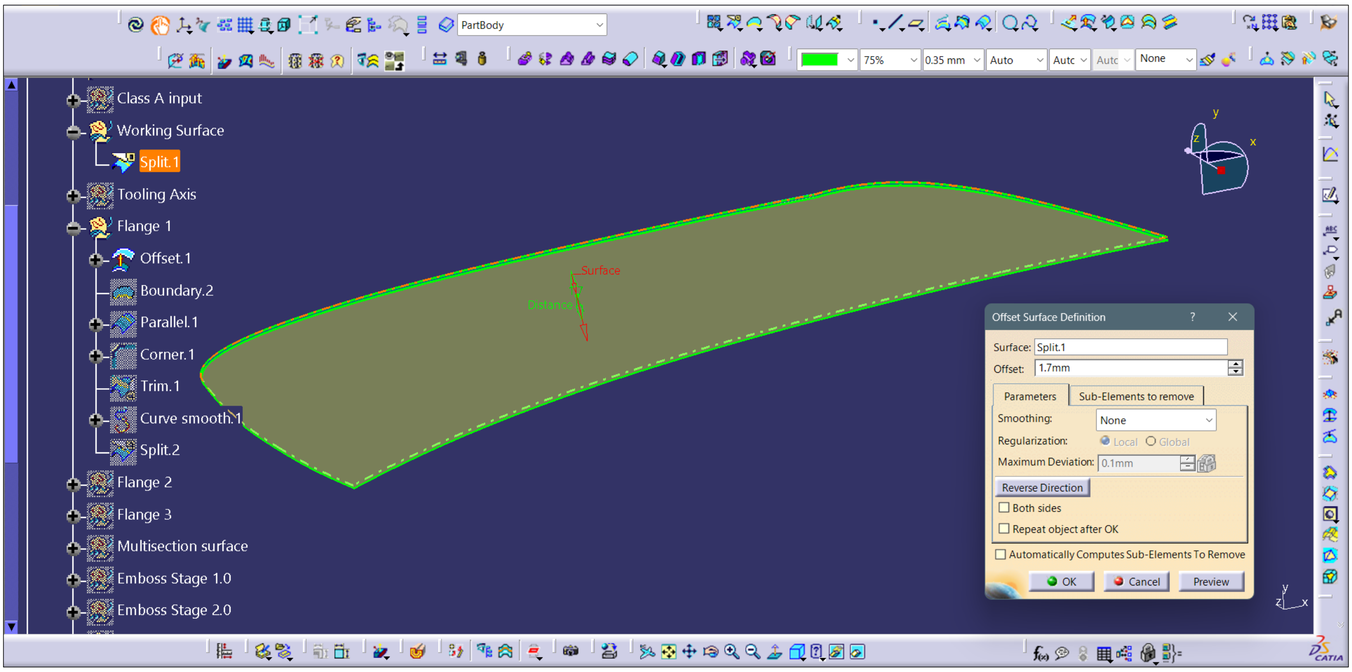
- Check draft analysis from Feature draft analysis tool to check whether the given working is clearing the draft angle of 7°.



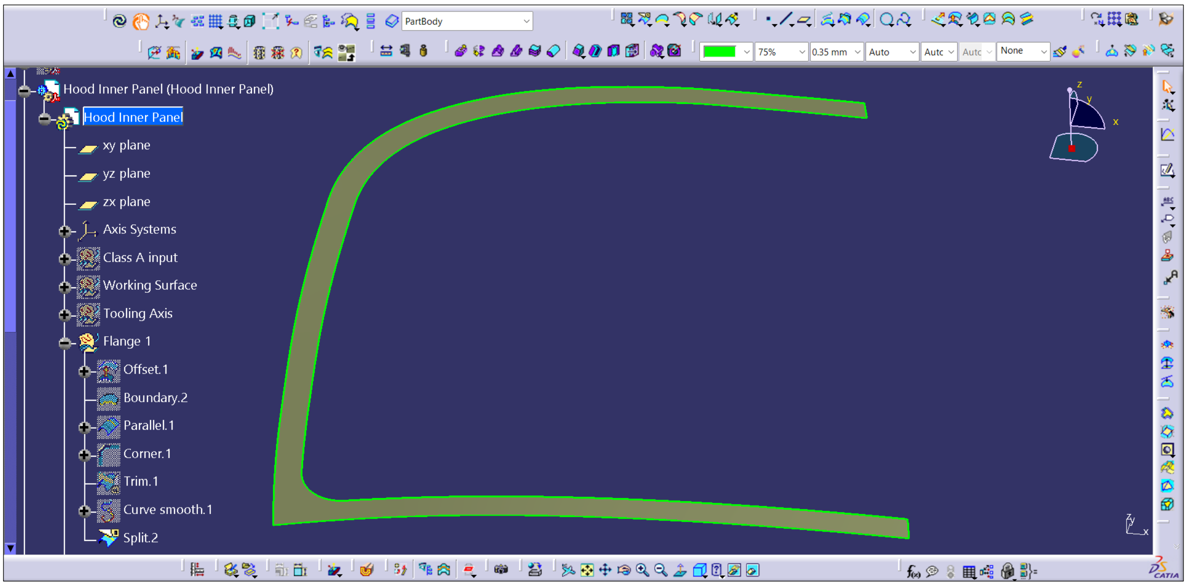
- Now the class A surface is clearing the draft analysis on the side core tooling axis.

Creating Inner panel:

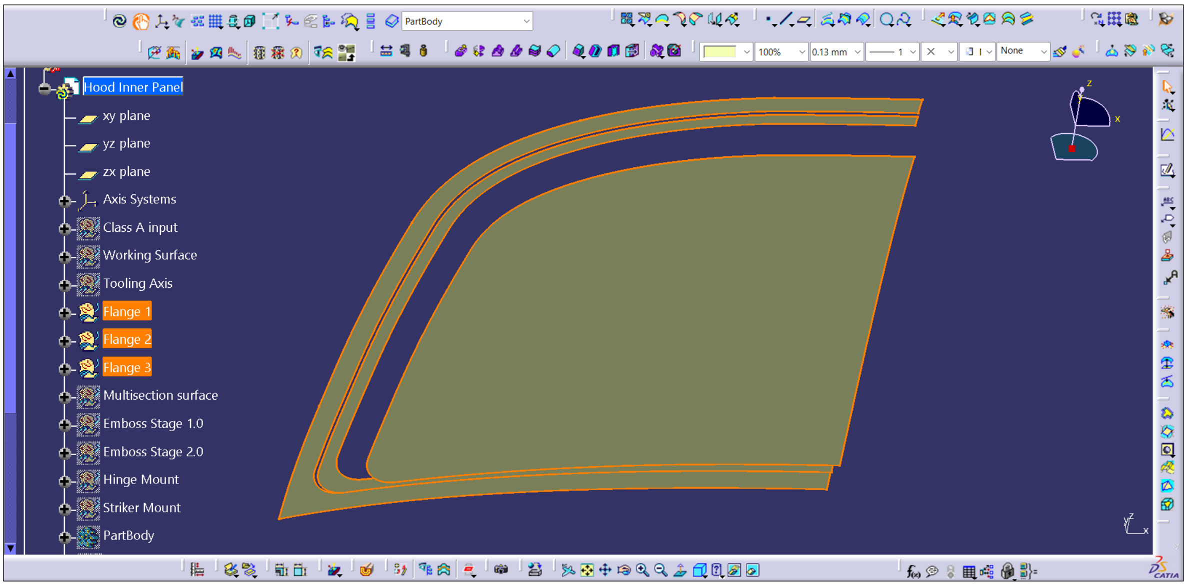
- Create a separate geometric set named flange and with the reference of master section data, the working surface is made offset of 1.7mm.



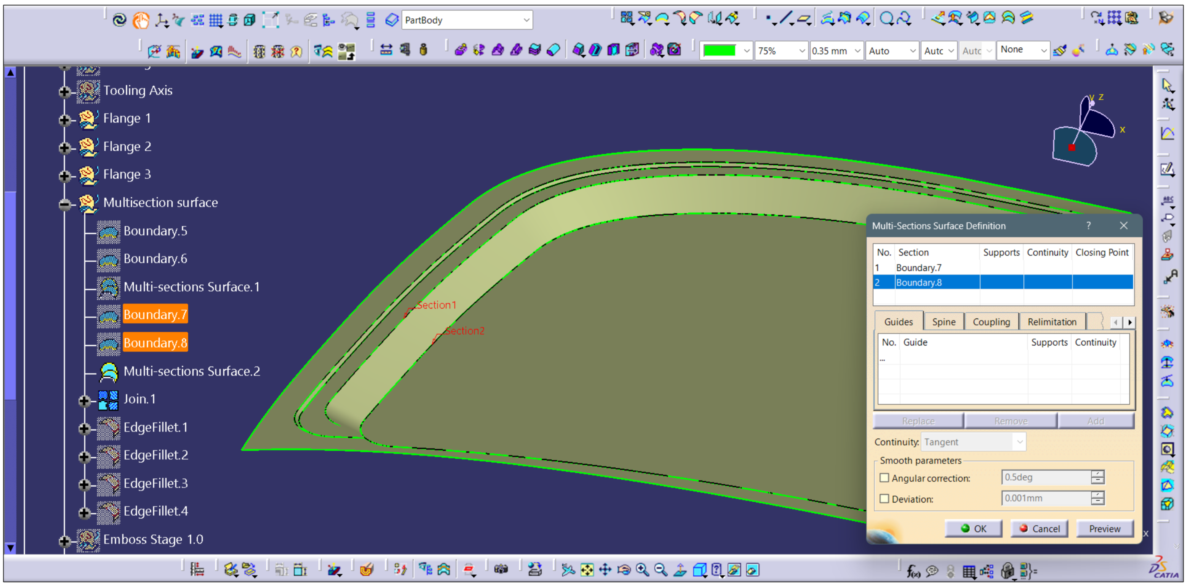
- Create the boundaries using boundary command and create a parallel curve as per the master section data and split the offset surface with the parallel curve.



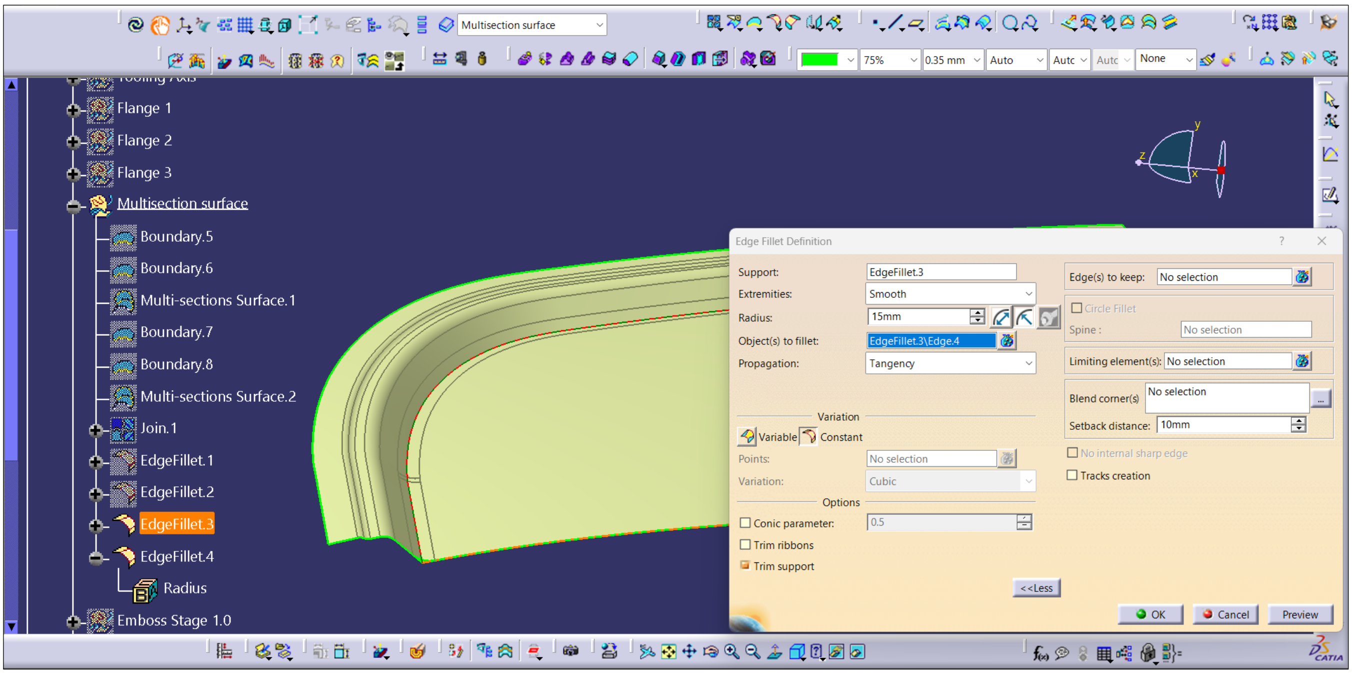
- The same process is repeated and the flanges as per the master section data.



- The drafted surfaced are created using multi section surface command by extracting boundaries of the flanges.

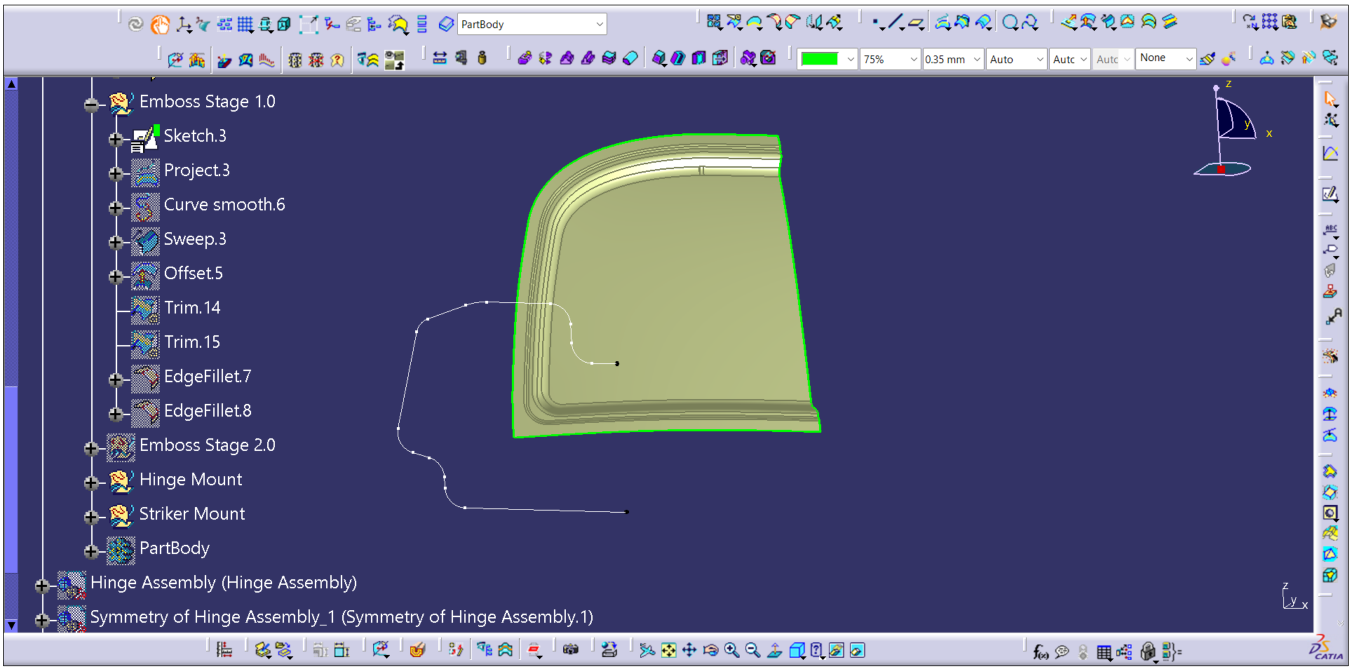


- The drafted surfaced are created using multi section surface command by extracting boundaries of the flanges. The fillets are created using edge fillet command with reference of master section data.

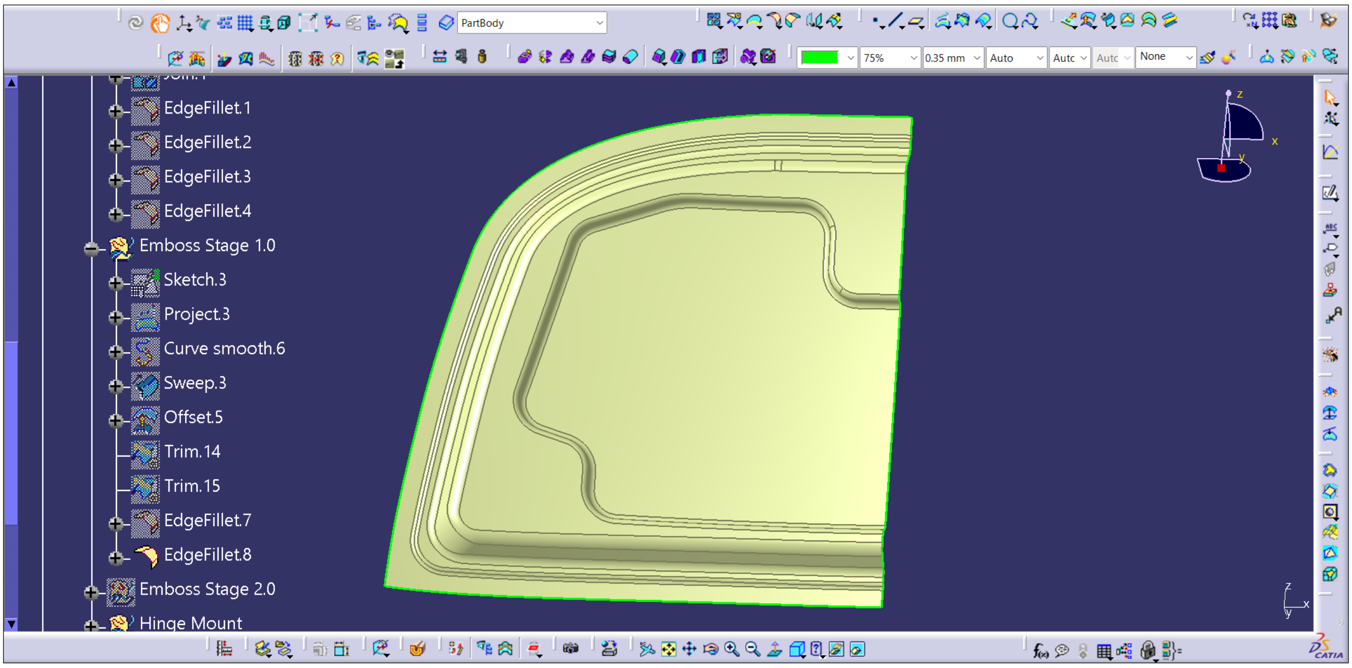


Creating Emboss Surface 1.0:

- A separate geometric has been created and named as emboss stage 1.0. A sketch is drawn on the parallel plane to the flange surface and projected on the flanged surface.

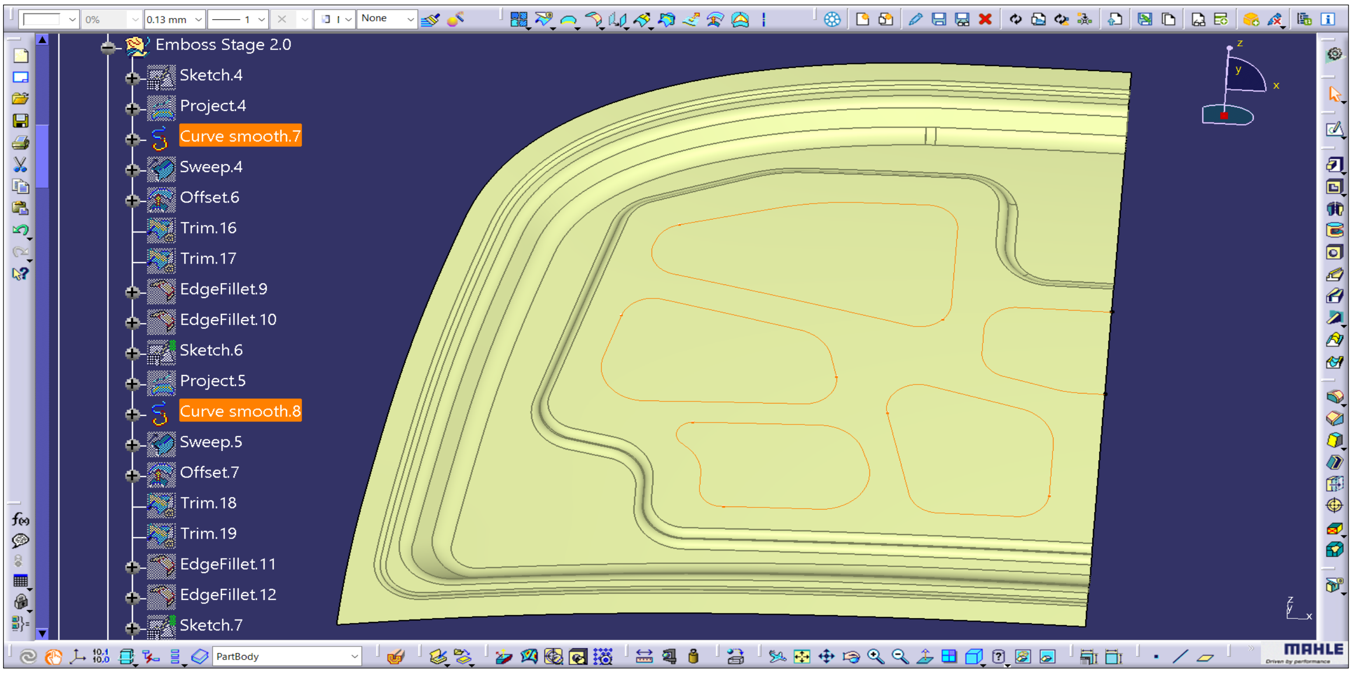


- Then the working surface is offset for 15mm and using sweep command the surface is created at a draft angle of 10° and the drafted surface is blended with the flanged surface using trim command and fillets are created using edge fillet command as the master section as reference.

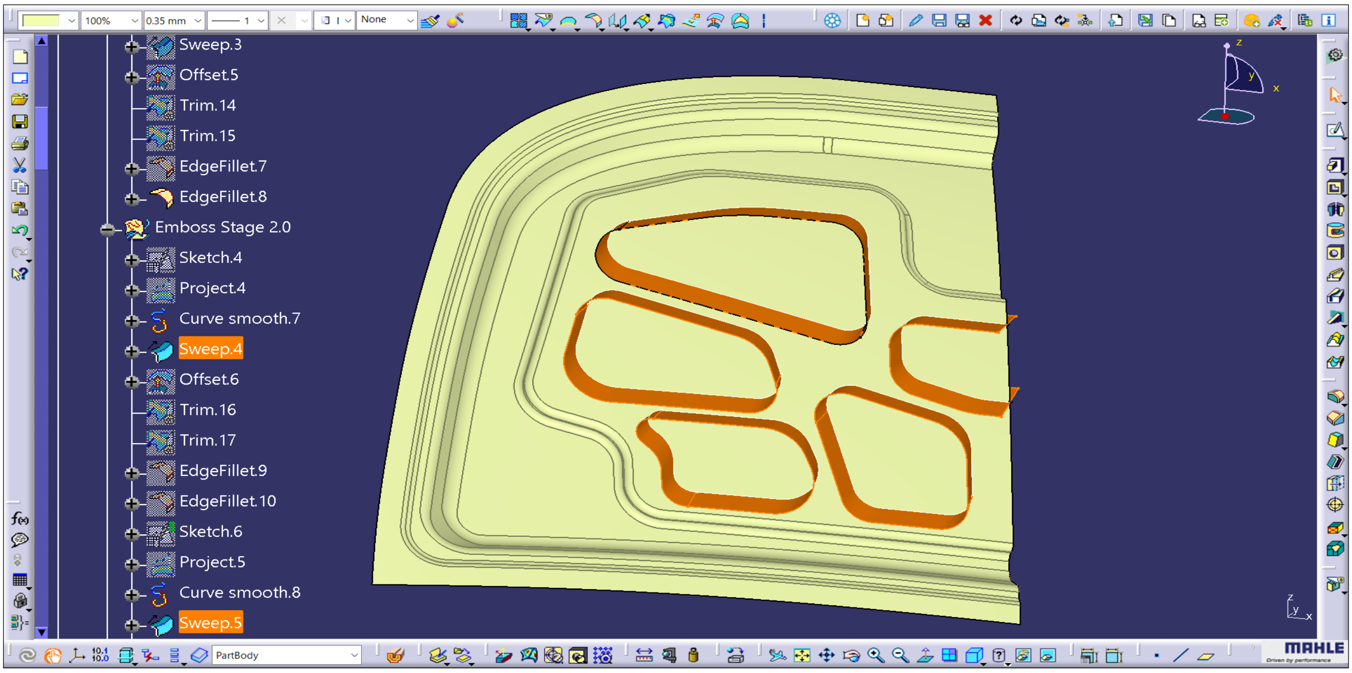


Creating Emboss Surface 2.0:

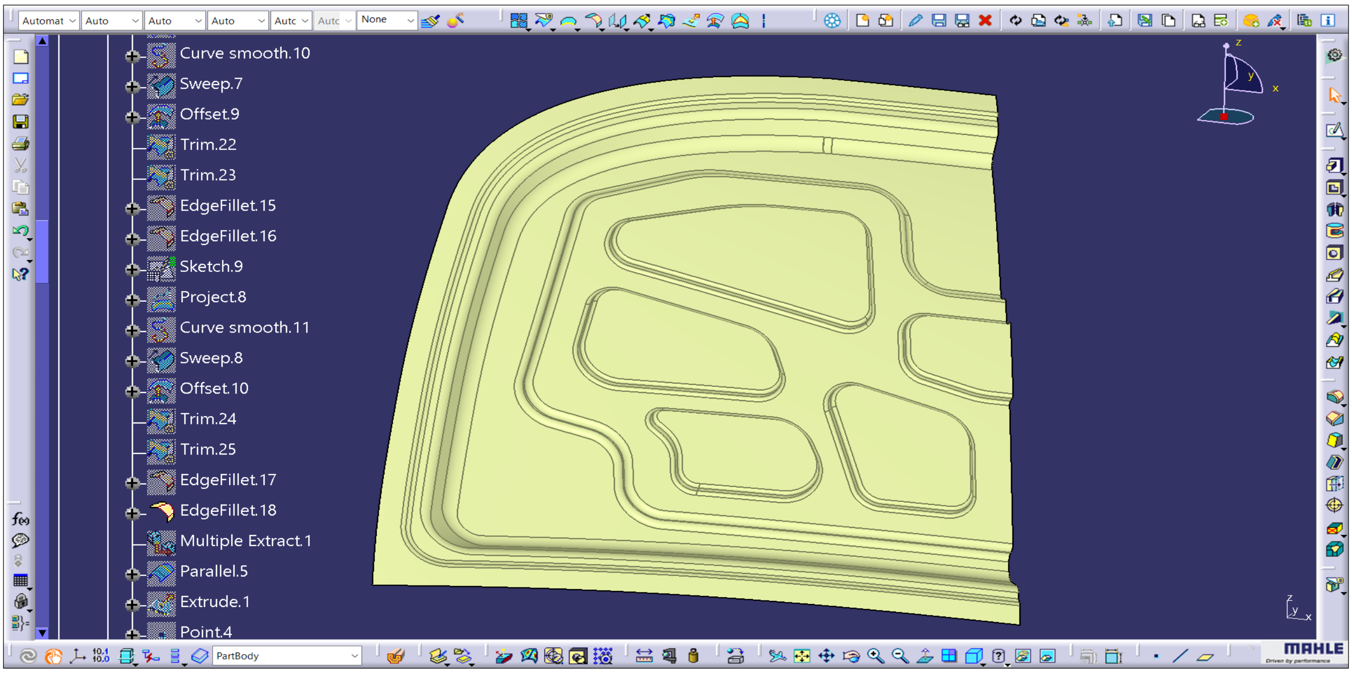
- Sketches with different cutout are created on the embossed surface for the stage 2 emboss as shown below.



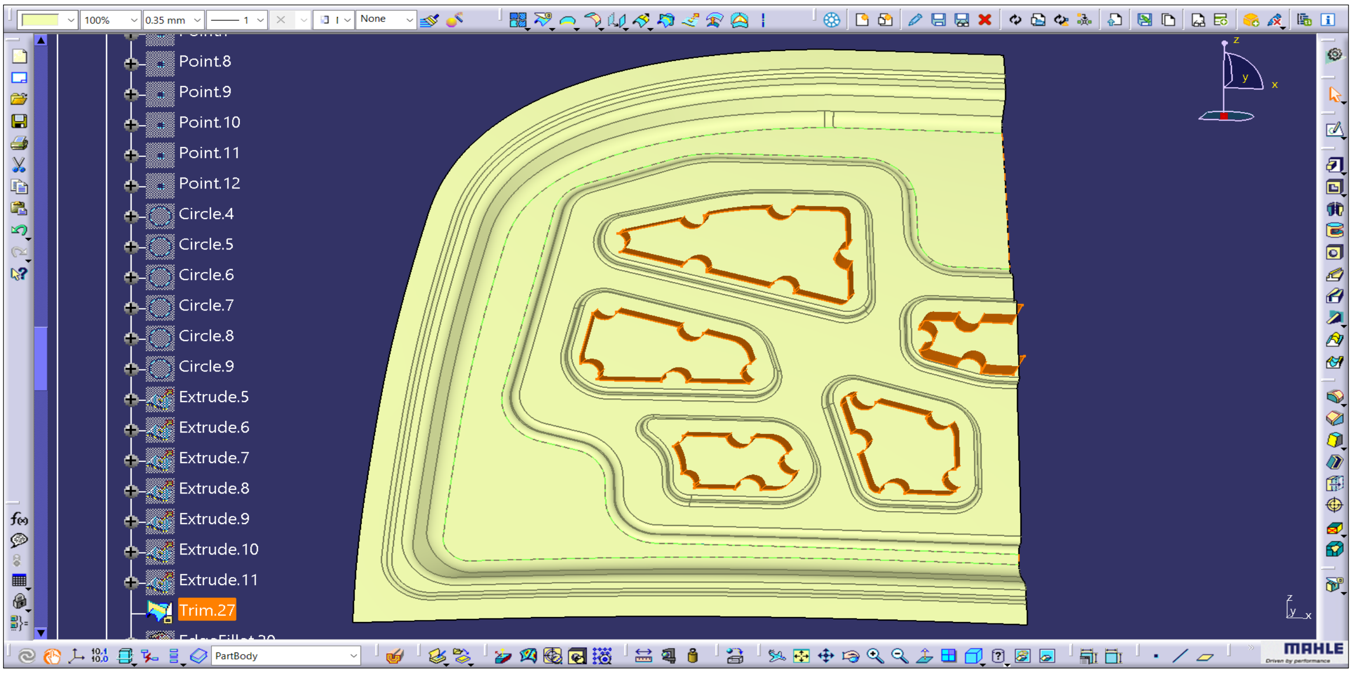
- Using sweep command, draft surfaces are created on the sketches created earlier.



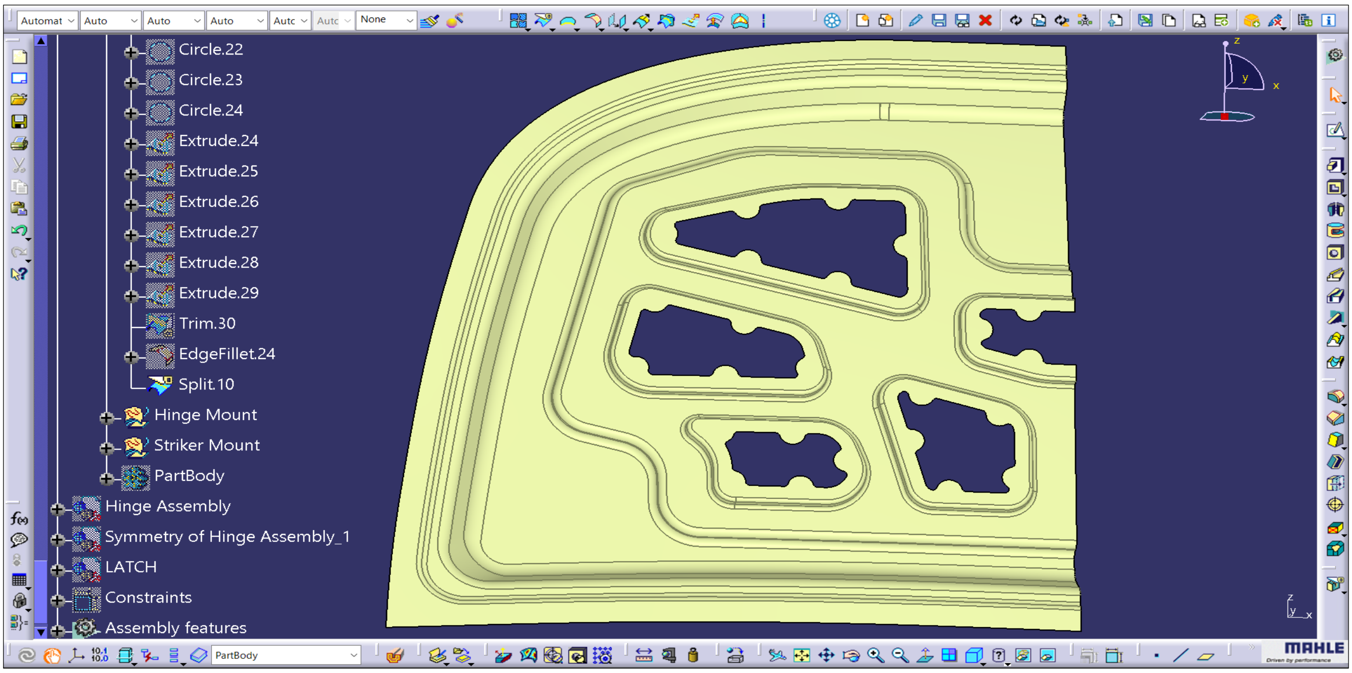
- Using trim command, the swept surfaces are blended with the embossed surface and the fillets are created on the egdes using edge fillet command.



- The inner edges of the secondary emboss cutouts are extracted using multiple extract and using parallel curve command the extracted boundaries are offset to create the cutouts and areas for mastic sealants.

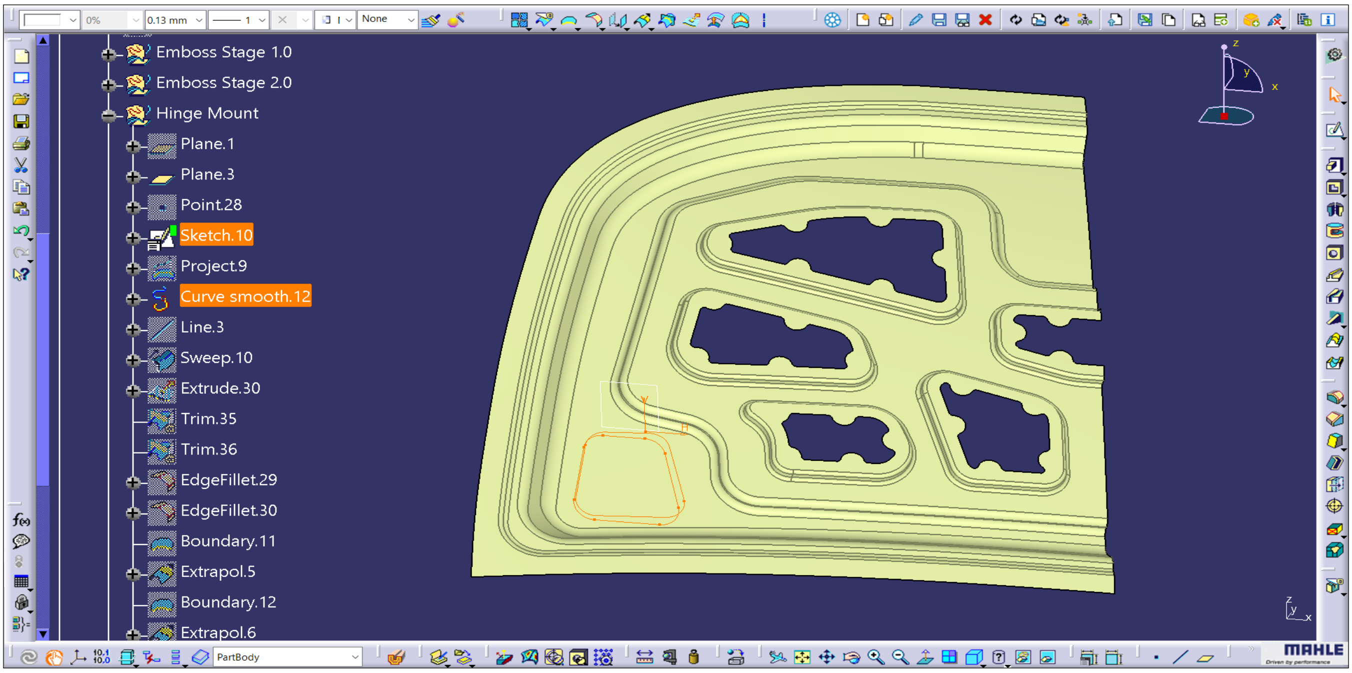


- Then the boundaries are extruded and using trim command the extruded surfaces are removed from the embossed surfaces as shown below.

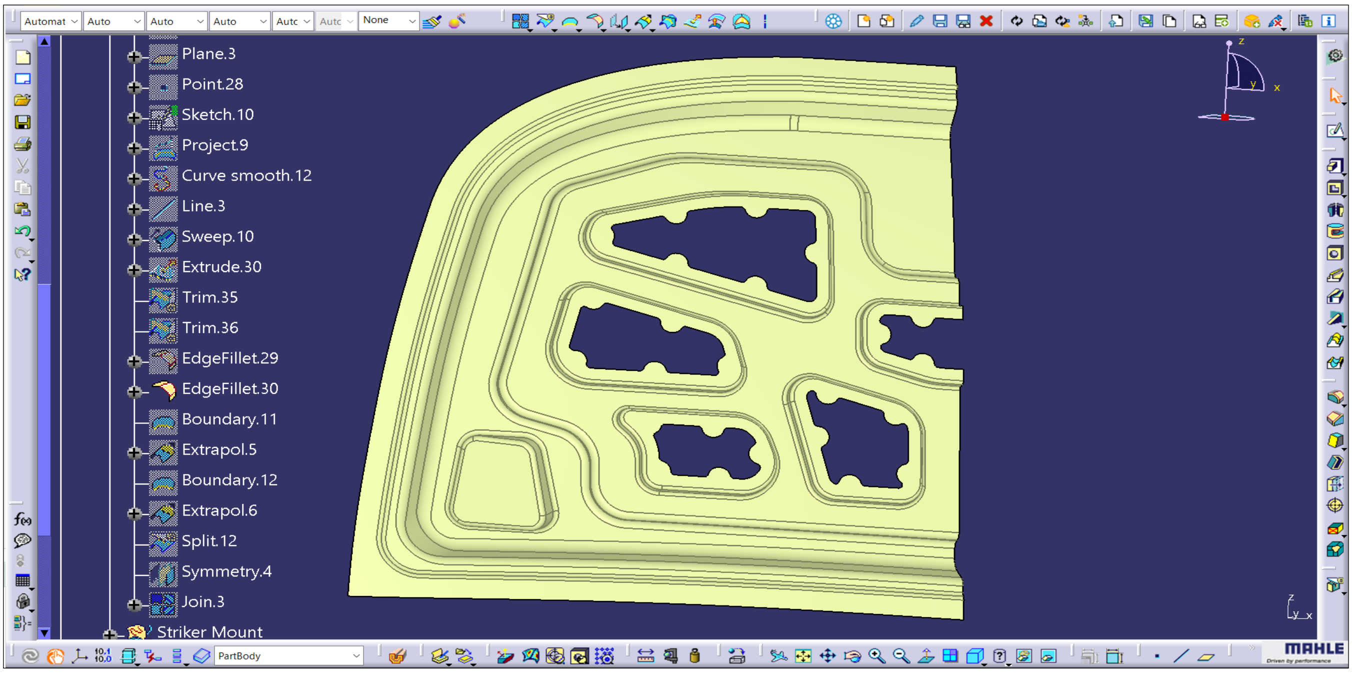


Creating Hinge mount:

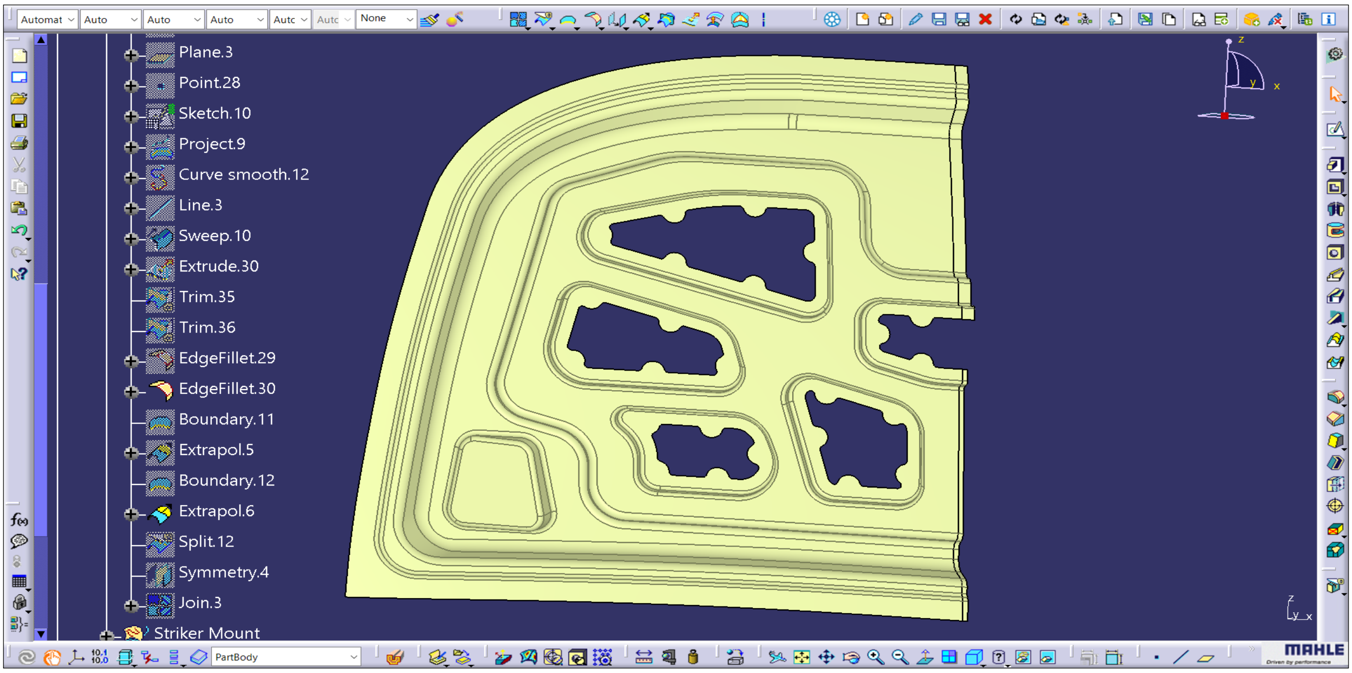
- The length and breadth of the given hinge is measured and with those dimensions and a plane is created parallel to xz plane and an outline sketch is created on that plane straight at right bottom corner of the inner panel.



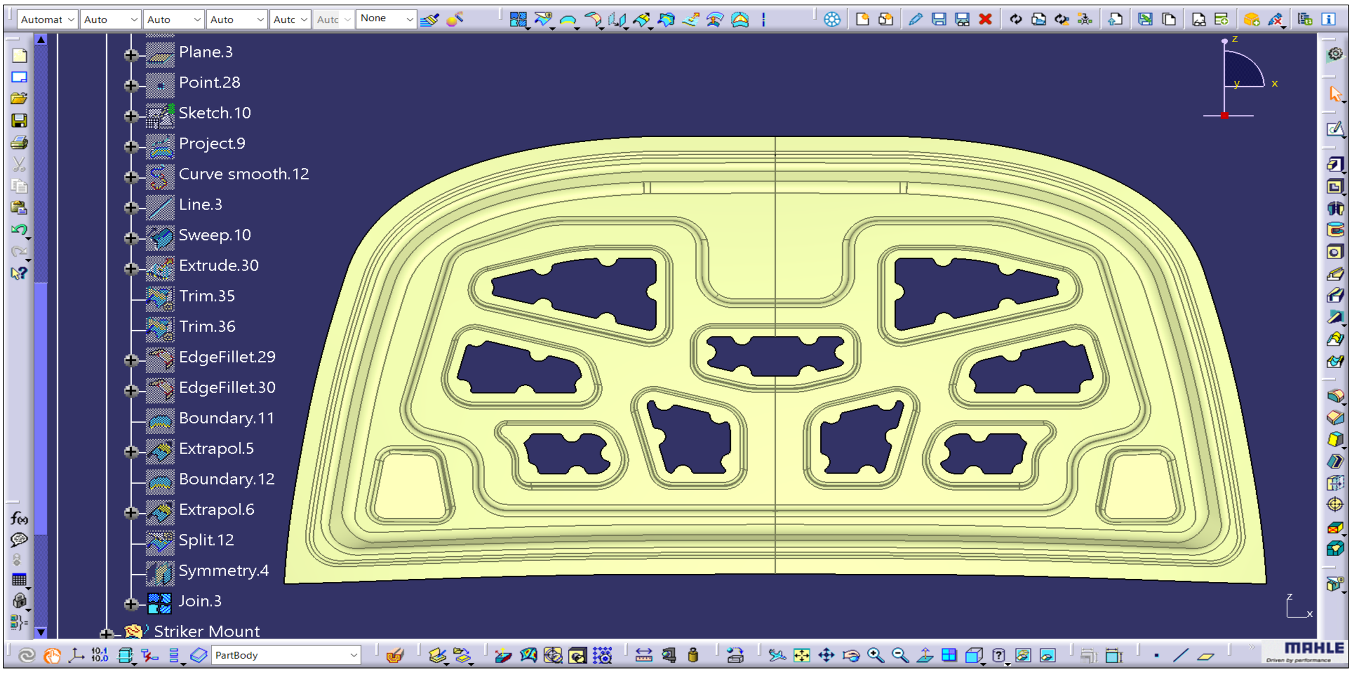
- The sketch is swept at a sweep angle of 8° and a parallel surface is created on the plane and the swept surface and the parallel surface is blend together with the emboss surface using trim command.
- Then the sharp edges are filleted using edge fillet command as shown below.



- Then the sharp edges are filleted using edge fillet command as shown below. Since the edges on the centre axis of the hood are uneven, the edges are extracted using the boundary command and the edges are extrapolated using extrapolate command.

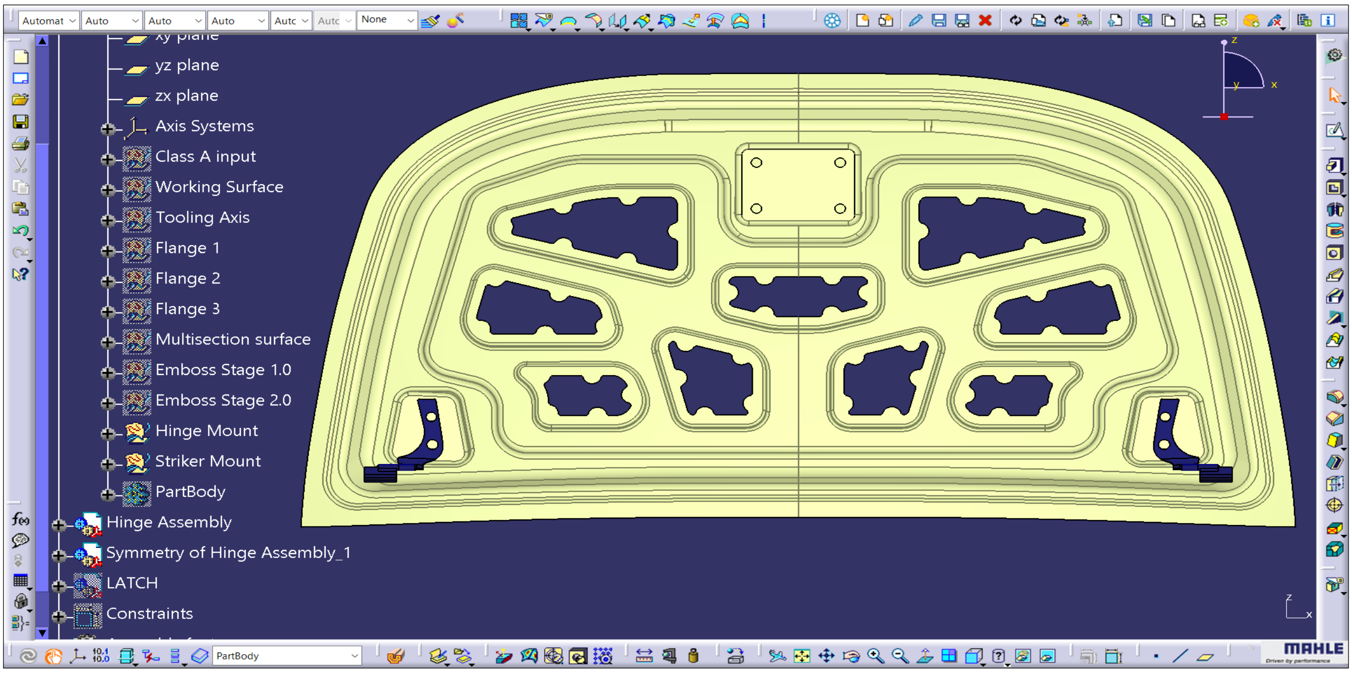


- Then using split command, the extrapolated are split using split command with yz plane as the cutting element.
- Using the symmetry command, the created surface is mirrored, and the complete inner panel of the inner hood is created.

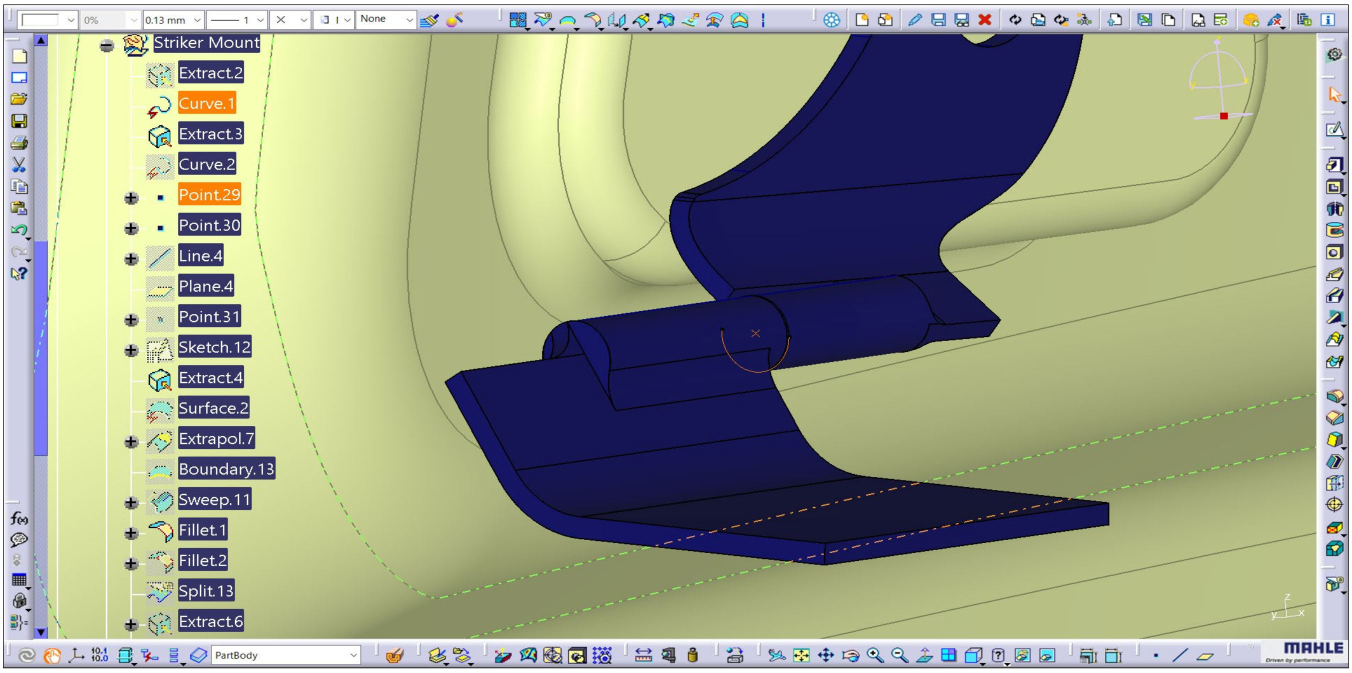


<u>Creating Trajectory Path:</u>

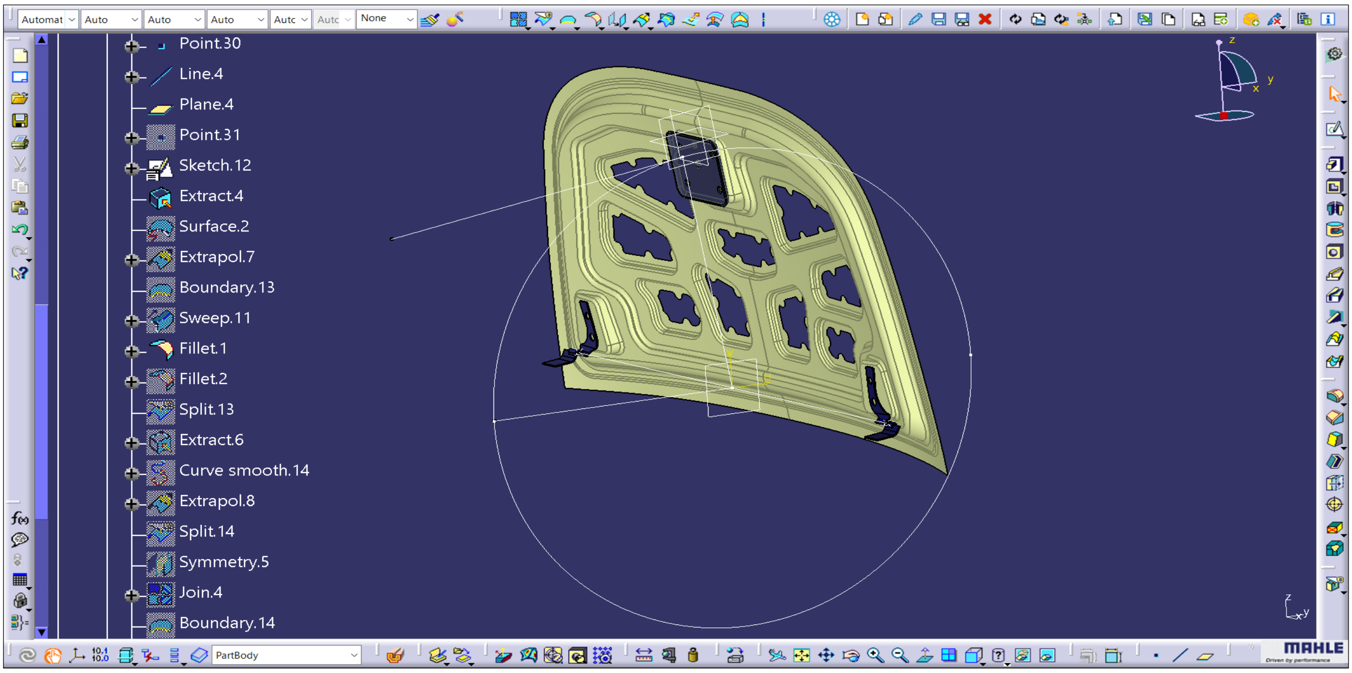
- Before creating the mount for the latch, the trajectory path for the hood must be created.
- To create the trajectory path, both the hinges had to be assembled on the inner panel upon the hinge mount area created earlier.



- The edges are extracted as shown below from both the hinges and isolated as separate curves and midpoint is created in-between both the open ends of the isolated curves.

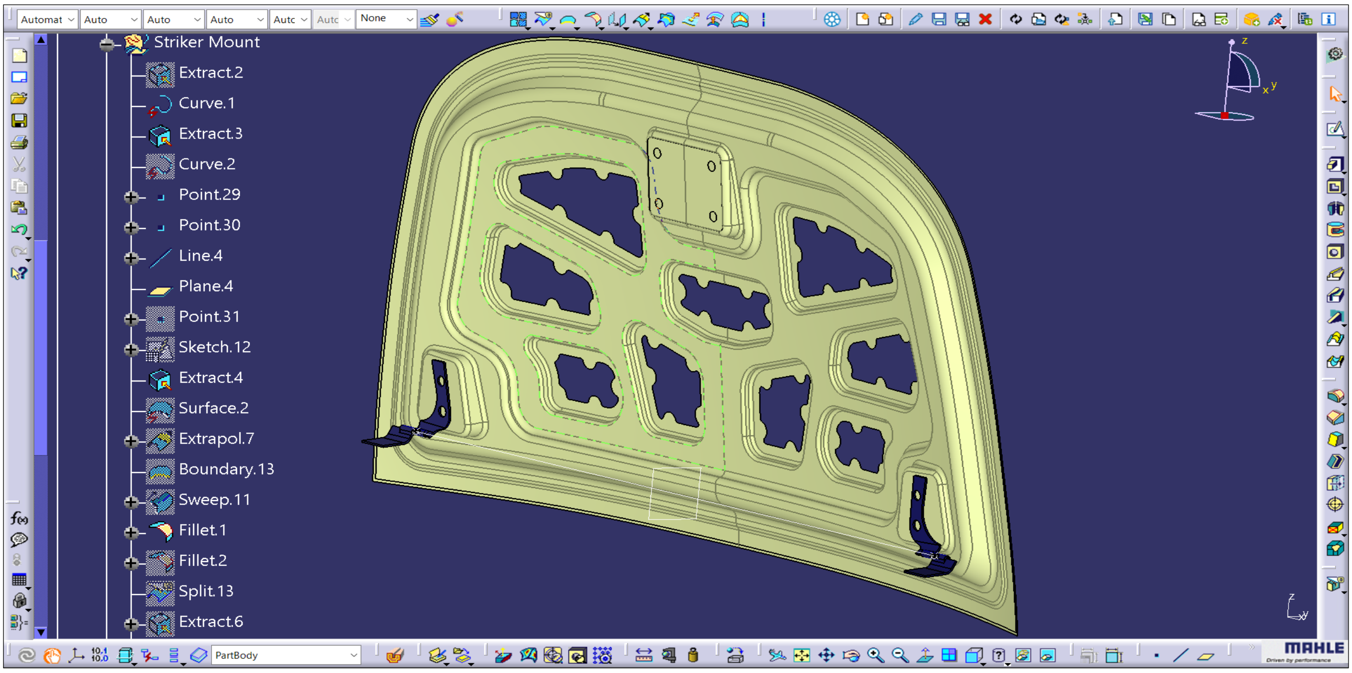


- Using the two-point line command, a line is created between the two mid-points. And a plane is created in between the line as shown below.
- Now a circle is created as the line as the centre point and the latch is assembled and made sure the latch is placed inline to the trajectory circle.

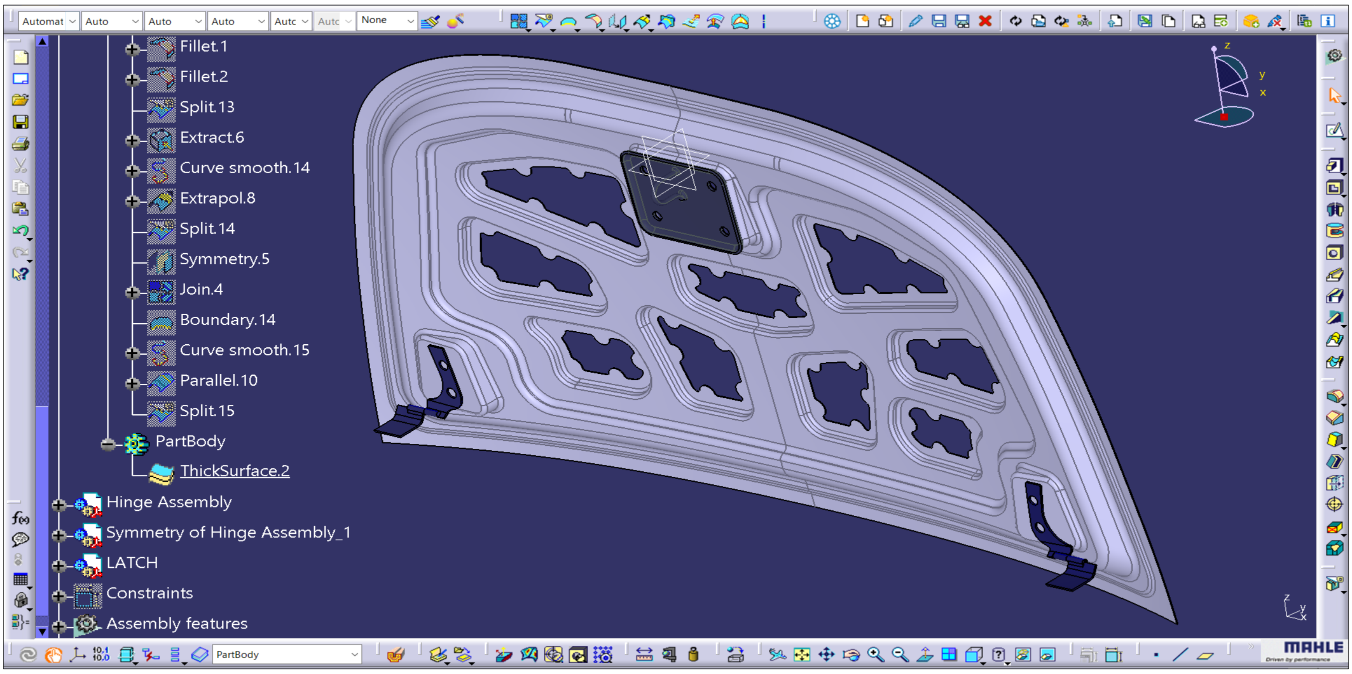


Creating Latch mount:

- The bottom surface of the latch is extracted, and the outer boundary is projected on the inner panel and a swept surface is created at an draft angle of 12° and the sharp edges are filleted using edge fillet command.

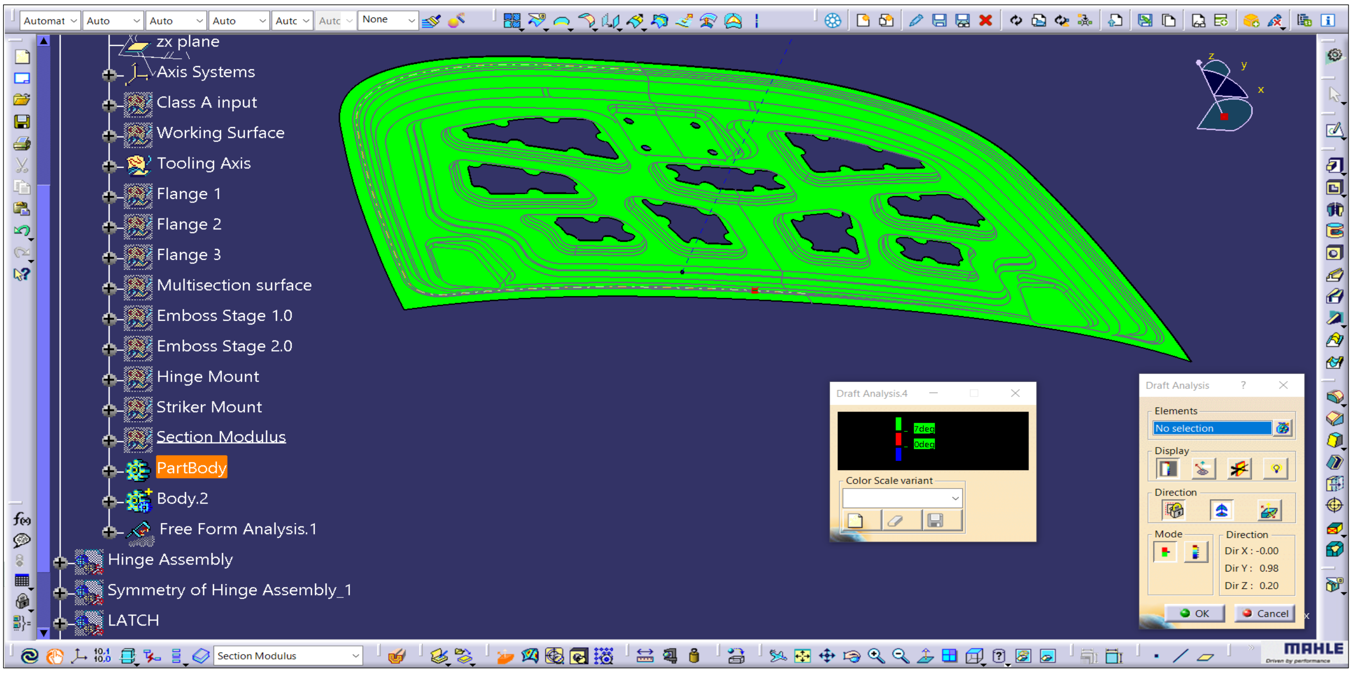


- The final inner hood panel is thicken using thick surface with the thickness of 0.75mm in reference to the master section.



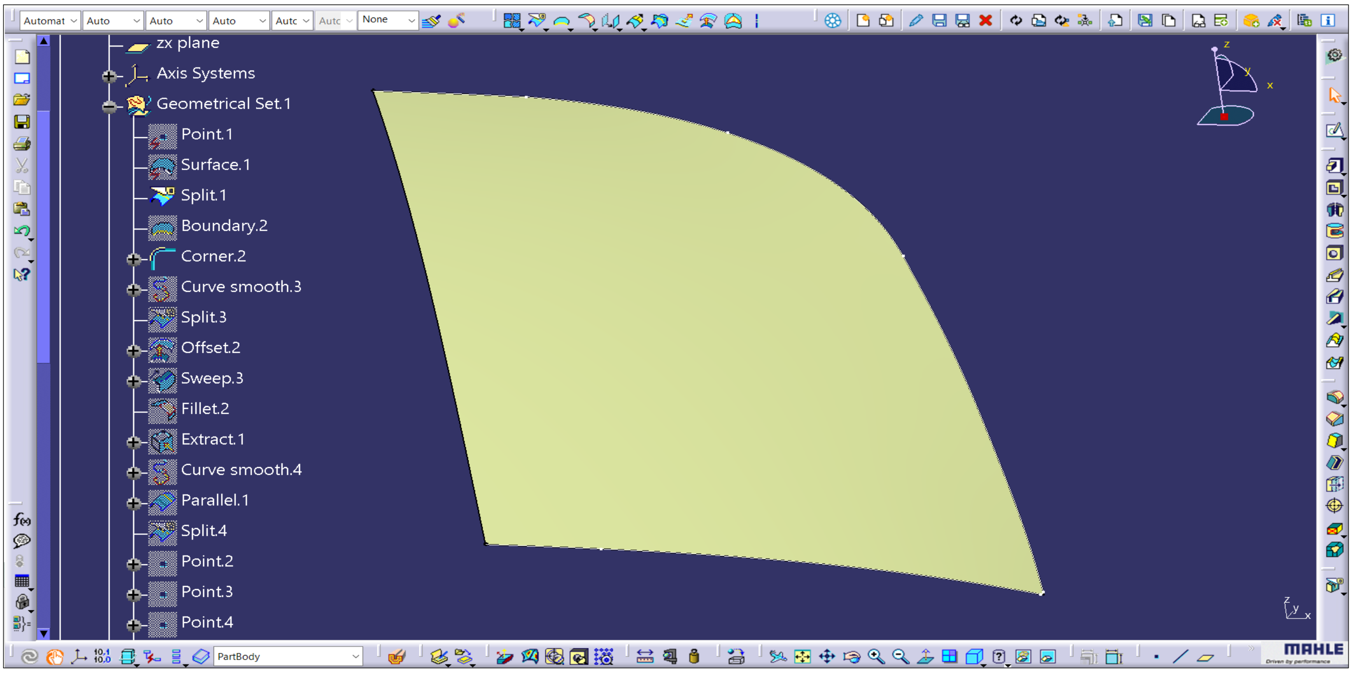
Performing Draft Analysis for Inner panel:

- Once the design of inner hood panel is completed the draft analysis is performed and checked whether the panel passes the draft analysis of draft angle 7°.

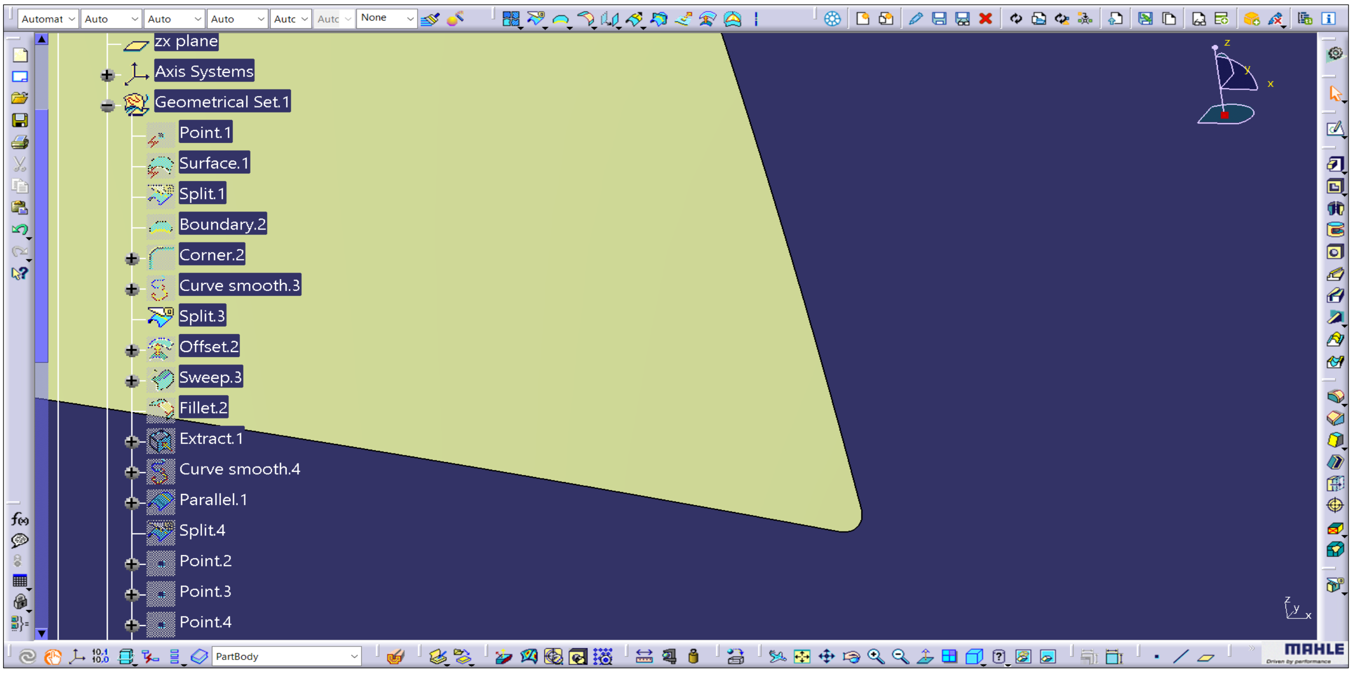


Part 2: Hood Outer Panel:

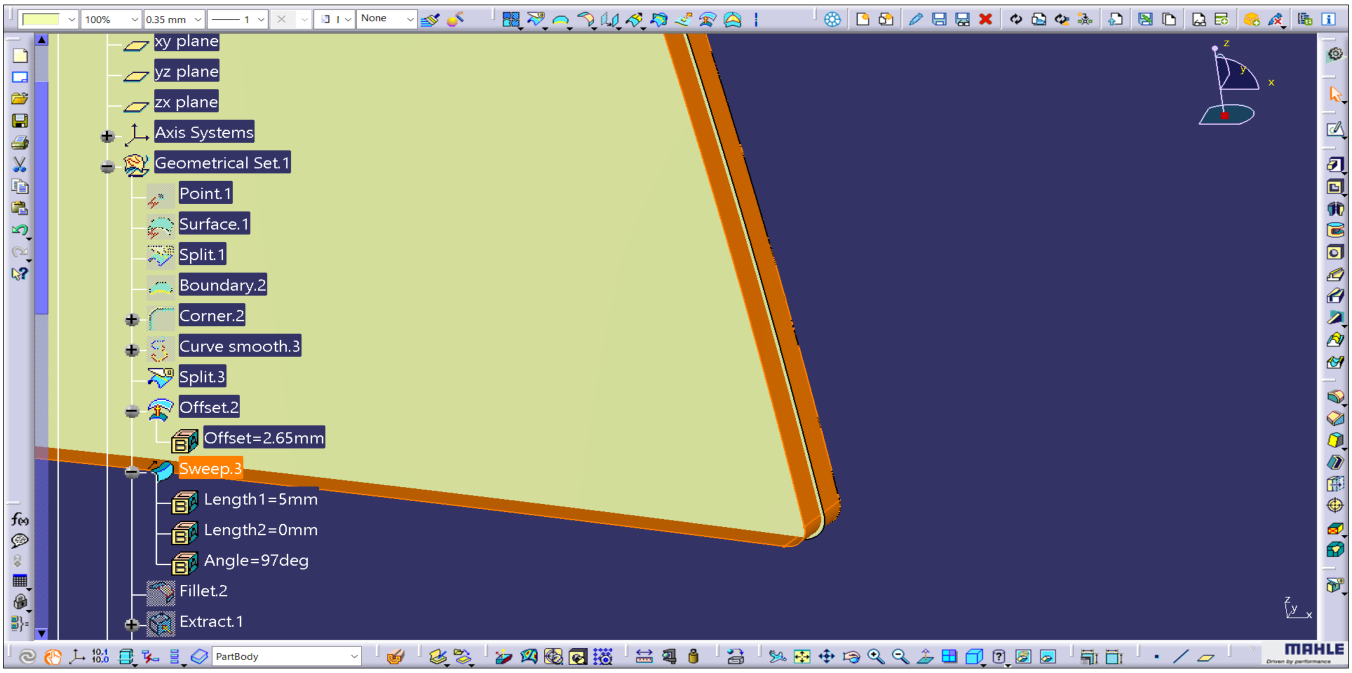
- With the given Class A surface as reference, the outer panel of the hood is created.
- The input class A surface is split yz axis and the boundary is extracted excluding the centre edge and the corners are smoothened with corner fillets.



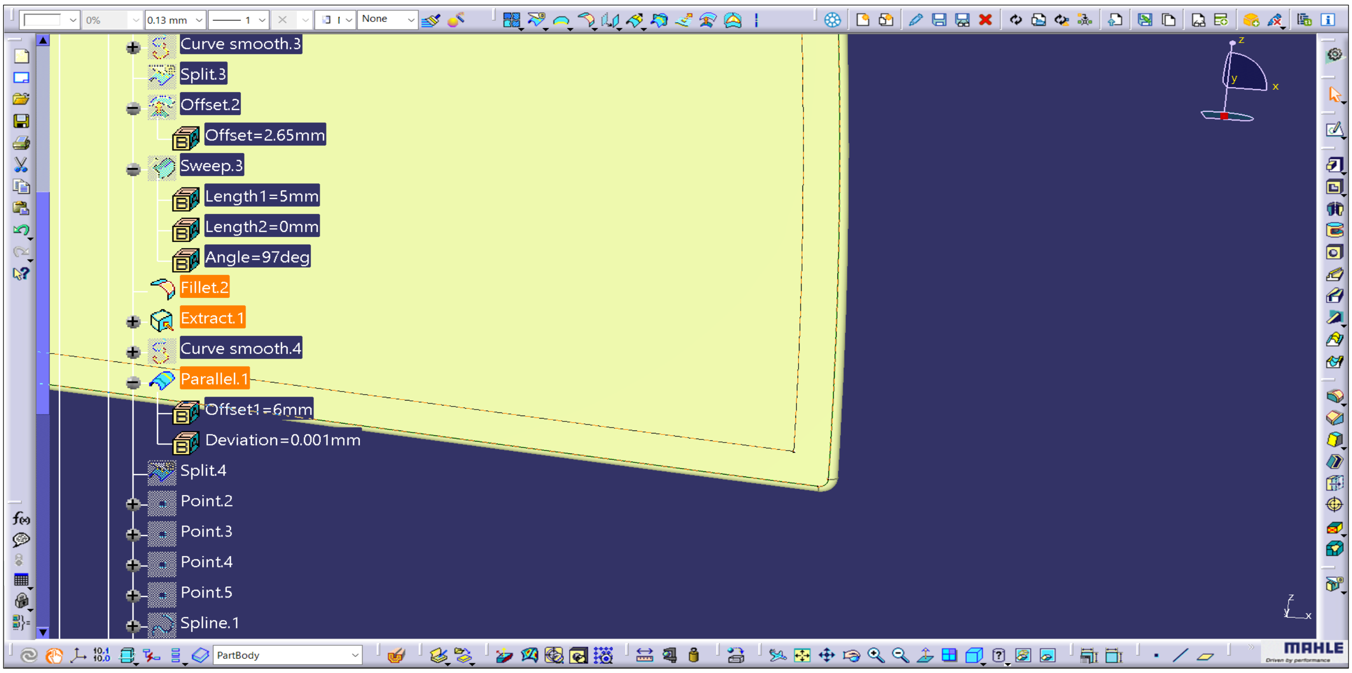
- With the given Class A surface as reference, the outer panel of the hood is created.
- The input class A surface is split yz axis and the boundary is extracted excluding the centre edge and the corners are smoothened with corner fillets and the surface is split using the split command with the extracted boundary as the cutting element.

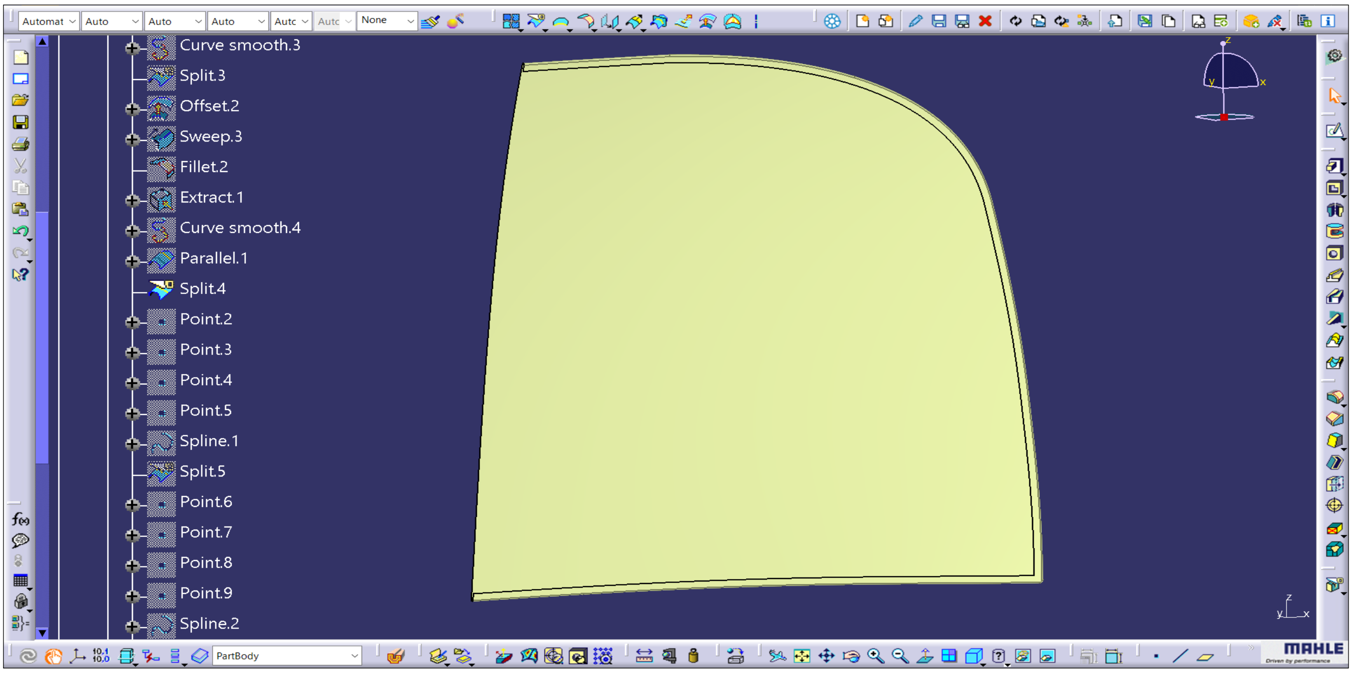


- With the master section as reference, the surface is offset of 2.65mm. And a sweep surface is created with an tilt angle of 97° and the swept surface is made sure that it cuts through the offset surface as shown below.



- Using shape fillet command, all three surfaces are blended as shown below. Then the inner edge is extracted and using parallel curve command, the boundary is offset of 6mm.
- Then using split command, the filleted surface is split with the parallel curve as the cutting element.





- Then using split command, the filleted surface is split with the parallel curve as the cutting element.

Hemming Process in Hood Manufacturing:

- Hemming is a sheet metal forming process in which the edge of one panel (usually the outer panel) is folded over the edge of another panel (typically the inner panel) to join them together.
- In hood design, hemming is used to assemble the outer and inner panels into a single unit, ensuring both structural integrity and a clean aesthetic finish.

Stages in Hemming Process:

- **Flanging:** A 90° bend is created on the outer panel edge using a flanging tool.
- **Pre-hemming (Intermediate Steps):** The edge is gradually bent in stages (usually at 45°, then 90°, then 135°).
- **Final Hemming:** The flange is fully folded (~180°) over the inner panel, creating a strong, seamless edge joint.

Types of Hemming:

- **Conventional Die Hemming:** Used for high-volume production using dies and presses.
- **Roller Hemming:** Flexible and suitable for low-volume production or complex shapes.
- **Tabletop Hemming:** Mostly used for large panels like hoods and roofs.

Importance of Hemming in Hood Manufacturing:

- **Structural Joining:** Securely joins the inner and outer panels.
- **Improved Aesthetics:** Creates clean edge lines, giving the hood a premium finish.
- **Corrosion Resistance:** Seals off edges to protect from environmental elements.
- **Edge Stiffening:** Increases the stiffness and vibration resistance of the hood.
- **Safety:** Ensures panel integrity during crash or pedestrian impact scenarios.

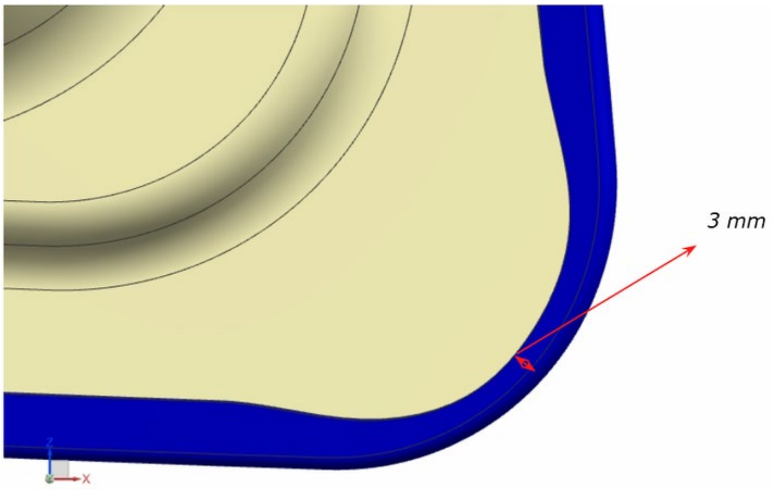
Hem Reliefs – Their Role and Importance:

Hem reliefs are cut-outs or notches made on the edges of the outer panel before the hemming process to relieve stress, prevent material buildup, and avoid wrinkling during folding.

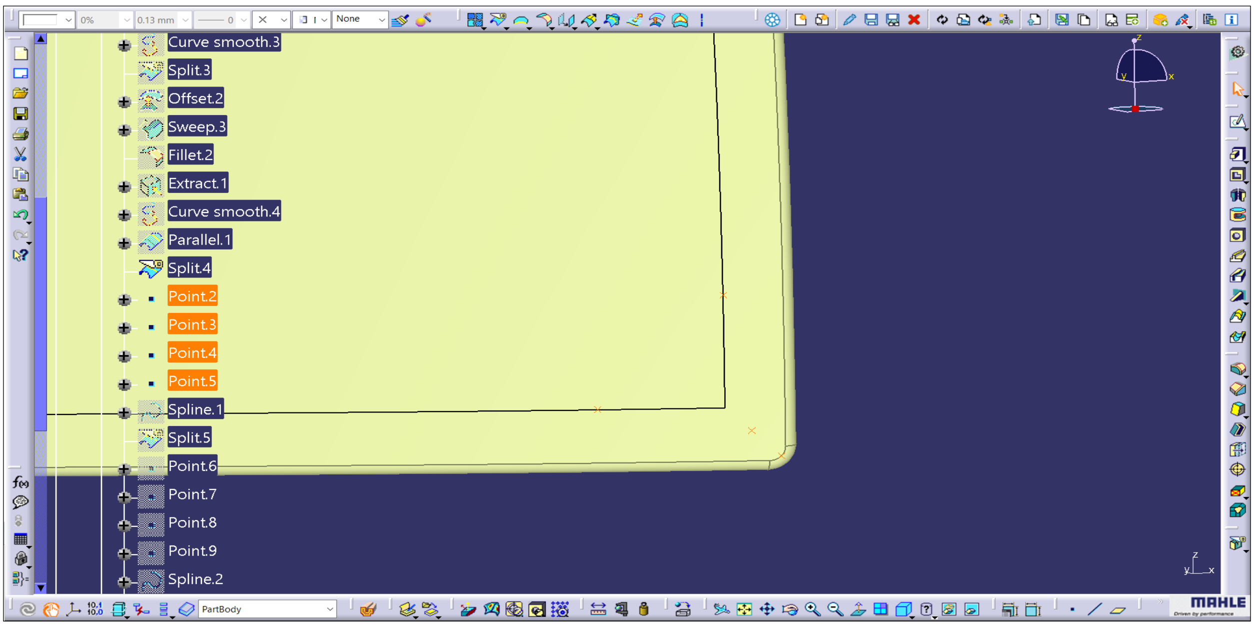
Importance of Hem Reliefs:

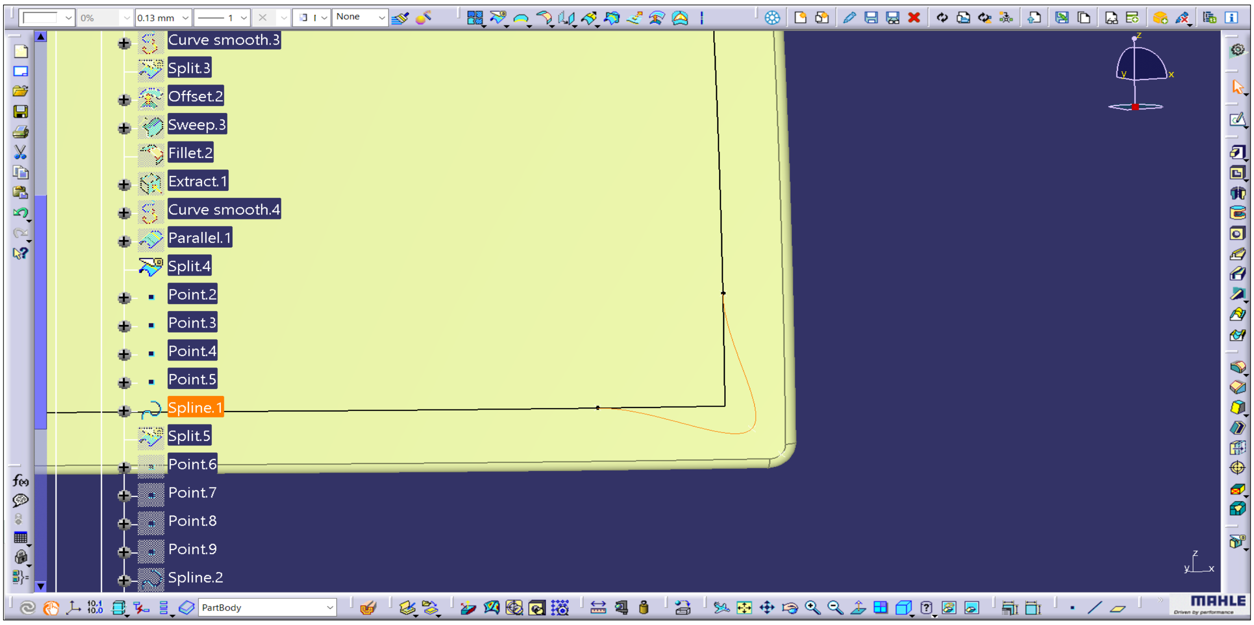
- **Prevent Wrinkling and Cracks:** At corners and tight radii, hemming without reliefs can cause wrinkles, thinning, or cracks. Reliefs reduce stress concentration in these areas.
- **Facilitate Smooth Hemming:** They allow the material to flow and fold easily during the hemming process.
- **Improve Dimensional Accuracy:** Proper reliefs ensure tight tolerances and panel fitment during final assembly.
- **Aesthetic Finish:** Eliminate bulging or unevenness on visible surfaces, especially at corners.
- **Avoid Panel Deformation:** Reliefs reduce spring back and distortion of the panel after hemming.

<u>Creation of Rear relief and Front relief section :</u>

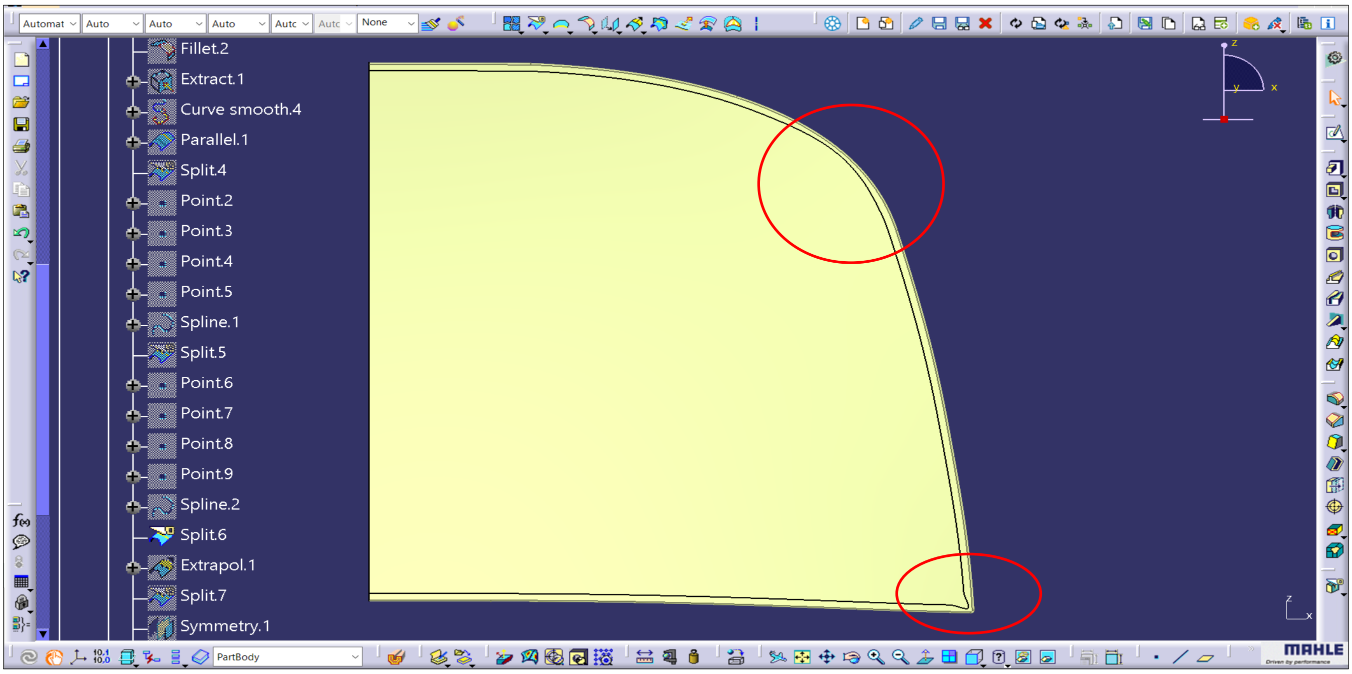


- With the given data as reference for rear side relief, 4 points are created at the corner points of the inner edge surface to create the spline using these points as shown below.

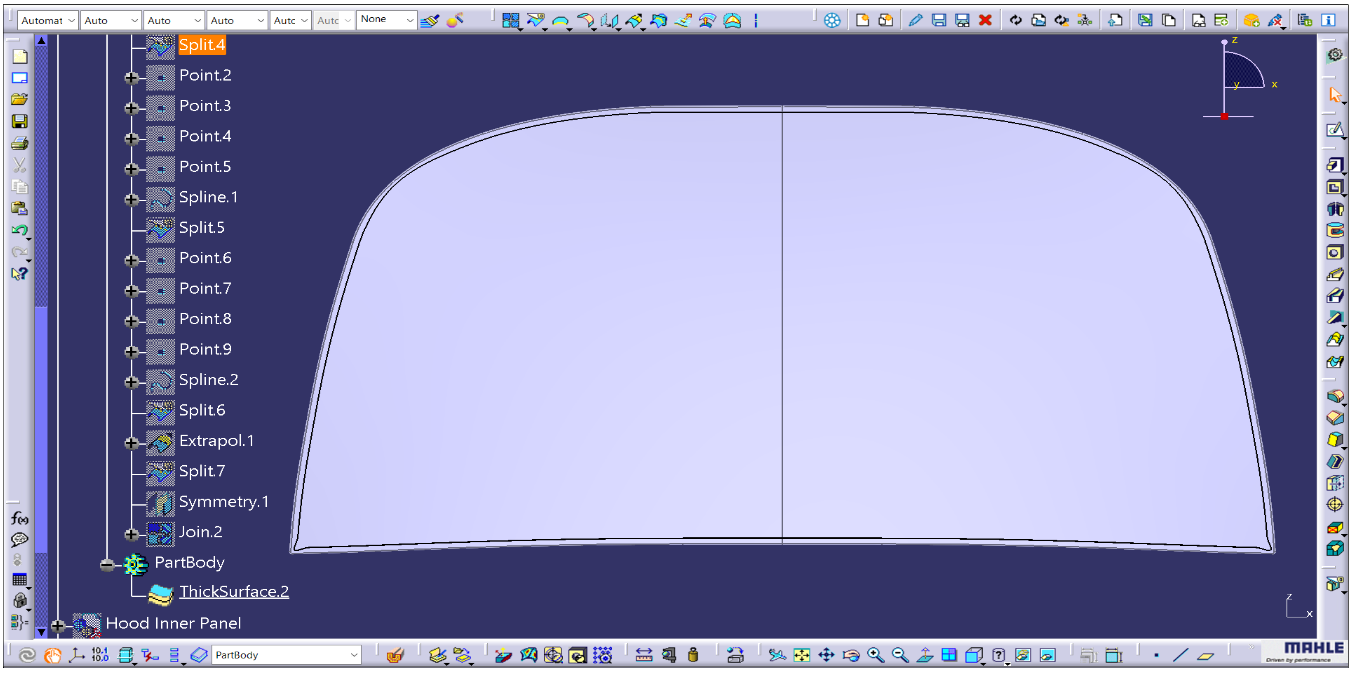




- Then the surface is split using split command, as the spline as the cutting element. Same is repeated for the front relief section too.



- The centre edge is then extrapolated and split using the split command as the yz plane as the cutting element. And the split surface is mirrored w.r.t yz plane and joined together using the join command.
- At last the joined surface is thickened inwards using Thick surface command with the thickness of 0.75mm.


Split.4
Point.2
Point.3
Point.4
Point.5
Spline.1
Split.5
Point.6
Point.7
Point.8
Point.9
Spline.2
Split.6
Extrapol.1
Split.7
Symmetry.1
Join.2
PartBody
ThickSurface.2
Hood Inner Panel

Calculation of Section Modulus for the hood panel:

- **What is Section Modulus?**

  Section modulus is a direct measure of strength of any sectional area of an object about an reference axis(neutral axis).

  Strength is nothing but, capable of supporting greater loads, so higher the strength it has a high capable of supporting greater loads.

- **Formula of Section Modulus:** It may be defined as the ratio of total moment resisted by the section to the stress in the extreme fibre which is equal to yield stress.

  Section modulus S = I/Y

  where:

  I = moment of inertia (Min)

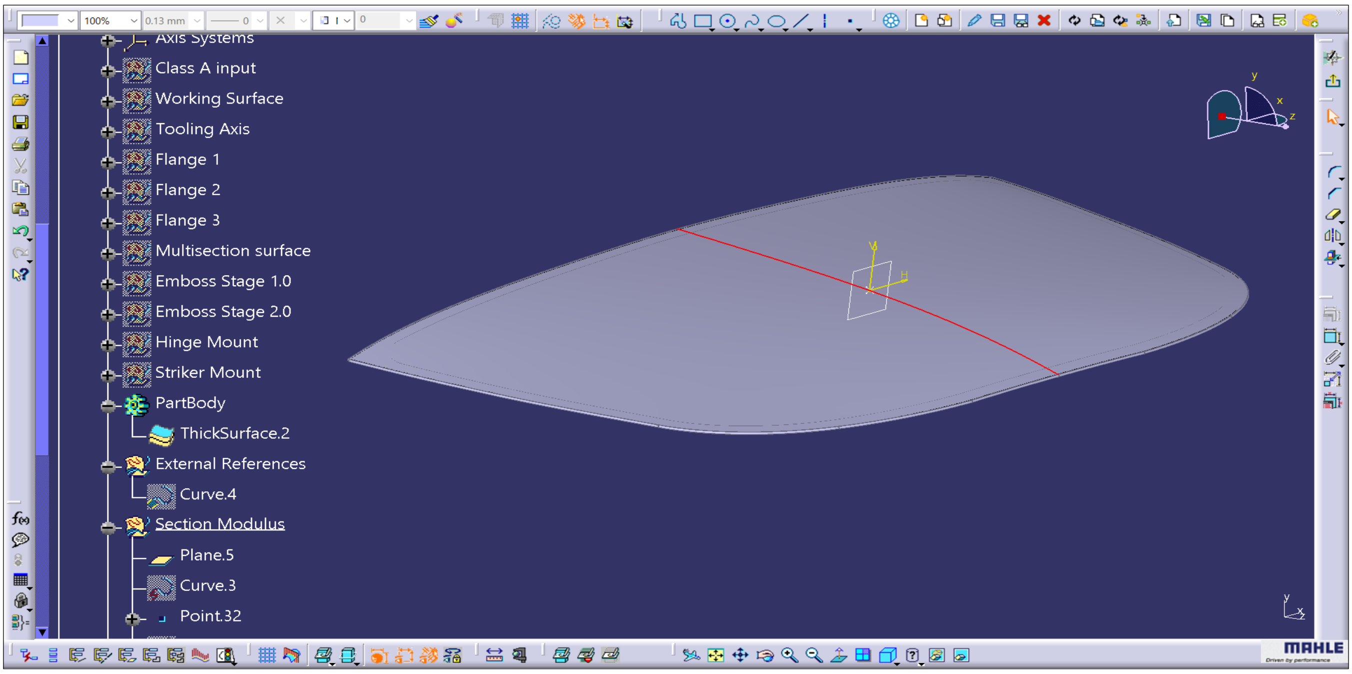
  Y = is the distance from the reference line (neutral axis) to one of the extreme end of an object.

- **What is Moment of inertia?**

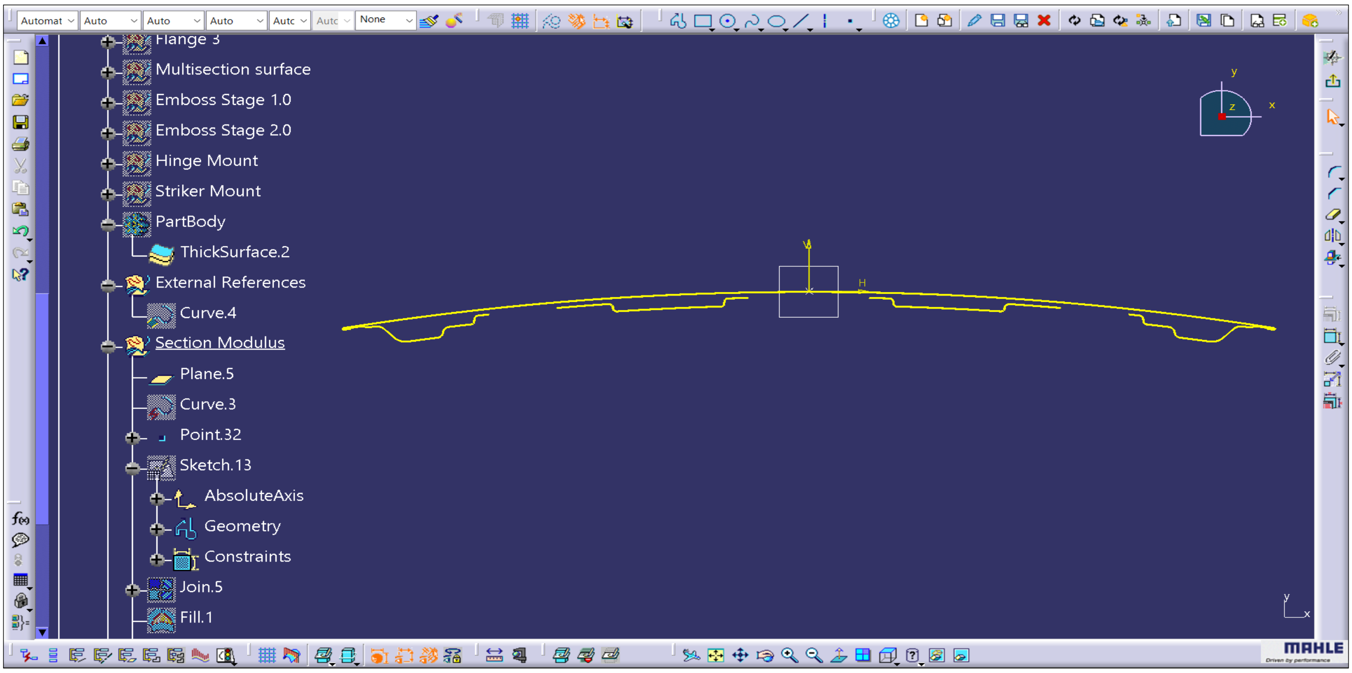
  Moment of inertia is nothing but offering resistance against of moment, bending or twisting, i.e., if we applied any external load on the body, how much resistance its offering to tend to deform.

Calculation of Moment of Inertia:

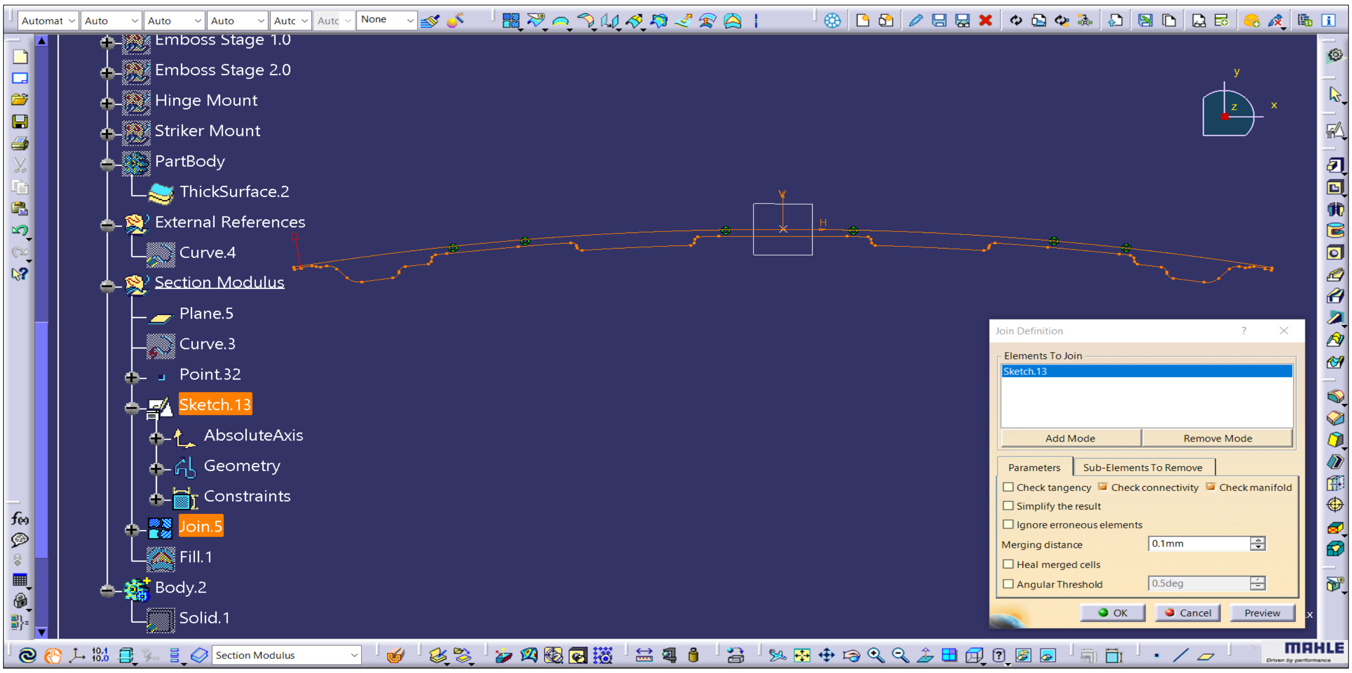
- A separate geometrical set is created under the inner hood panel part and named it as section modulus and a plane is created at the centre of the curve as shown below.



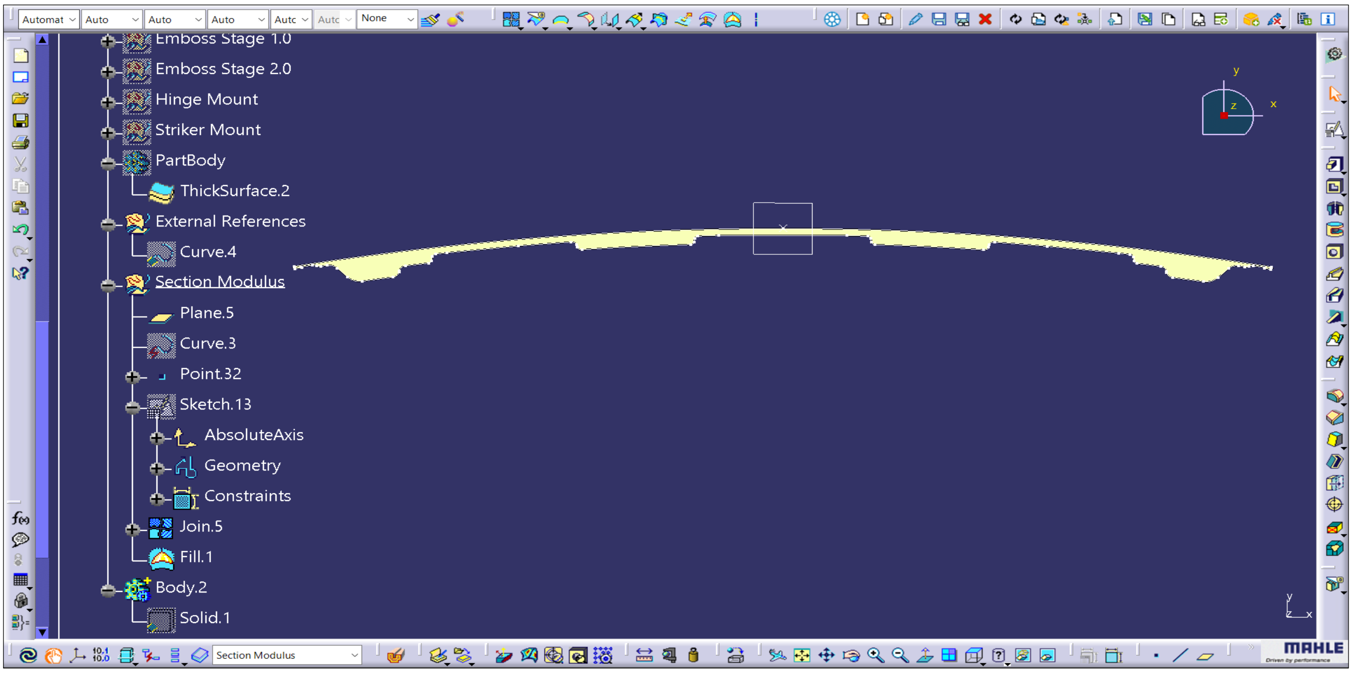
- Using the intersection command, the intersecting sketches for the thickened surfaced of both the outer panel and the inner panel is created on this plane.



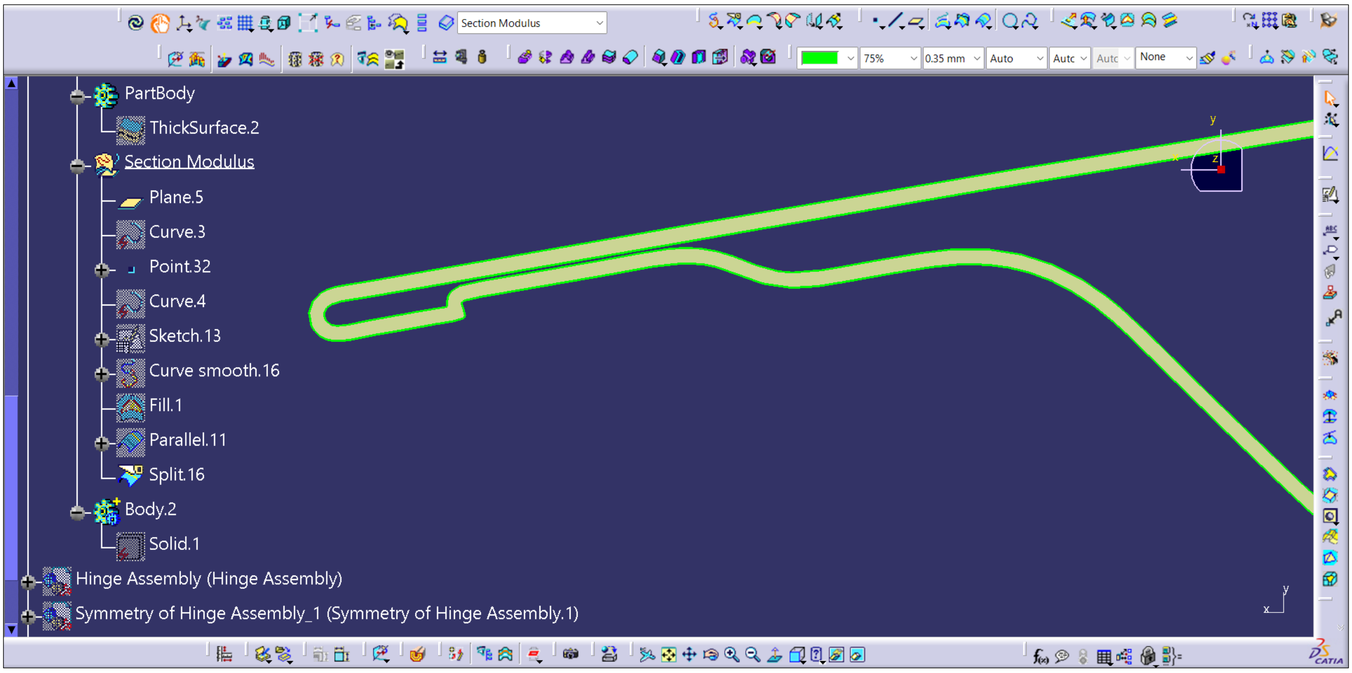
- Now both the intersected sketches are isolated, and all the inner lines are removed, and the open ends are joined together to form a closed profile.
- Using join command, the profile is made sure there are no open ends in it.



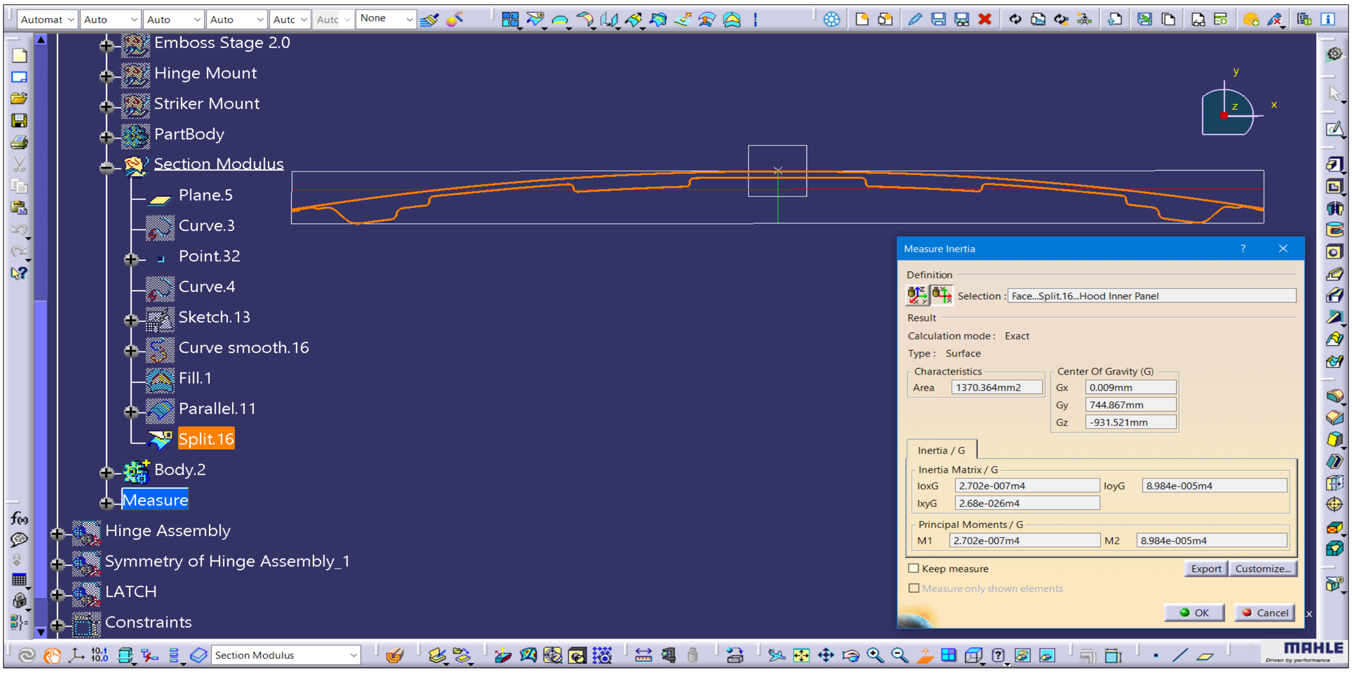
- And using fill command, a surface is created within the closed profile as shown below.



- Using parallel curve command, another close profile is created in the filled surface with a offset of 0.75mm since the thickness of the hood is 0.75mm.



- Now the 2D surface's inertia value is calculated using the measure feature.



- The calculated Principal moment from the measured 2d surface is

  I (M1) = $2702e^{-007}$ m^4 → $270200mm^4$ (moment of inertia (Min))

  Y = 435.91mm (distance from the reference line (neutral axis) to one of the extreme end of an object.)

  Section Modulus S = I/Y = 270200/435.91

  Section Modulus **S = 619.85 mm^3**

Conclusion:

The successful design and development of the automotive front hood panel in this project reflect a structured and industry-oriented approach to BIW (Body-in-White) component design. Starting from a provided Class-A surface, the project involved creating a manufacturable and functionally compliant hood assembly by integrating hinge and latch mechanisms, while adhering to packaging, pedestrian safety, and NVH considerations.

Utilizing CATIA V5 R30 as the primary design platform, the hood panel was modeled to ensure compatibility with adjacent components and meet OEM specifications. Special focus was given to design aspects such as material selection, force dissipation zones, hem geometry, and relief strategies to facilitate ease of manufacturing and enhanced crashworthiness. The inclusion of a comprehensive design methodology, safety guidelines, and hemming process insight demonstrates an in-depth understanding of closure system requirements.

This project not only solidified core CAD modeling skills but also deepened the understanding of how aesthetic styling surfaces are transformed into feasible engineering designs. It exemplifies how design considerations for strength, durability, pedestrian impact performance, and manufacturability must seamlessly blend to deliver an optimized hood panel ready for production.