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Design Of Body In White

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Abstract

This article will trace the design of Body in White (BIW). Body in White (BIW) refers to the car's components that have been joined together by various techniques like welding (Spot, MIG, Taylor Welding Blank), riveting, clinching, laser brazing etc. These components are termed before the assembly of motors, sub-assembly and painting. BIW parts consist of Cover, Body, Floor and Encon. Cover is a closure which mainly consists of side/back door, hood and roof. Body consists of other components like A-pillar and outer body frame. Floor consists of driver/passenger cabin and Encon consists of engine components. Designing involved design of Hood, Fender, Roof and Tail gate with given input surface and also section modulus calculation and optimization is performed to enhance design strength and wheel arc verification is done using European standards. Designed with considering necessary design and safety criteria and optimized to get the better result.

Keywords: *Body in White, Hood, Fender, Roof, Tail Gate, Sectional Modulus Optimization, Wheel Arc*

1. Introduction

The classification of car bodies with respective to the construction involves Body-on-frame and Unibody. Body-on-frame refers to the separate body mounted on a rigid chassis that carries engine and drive train. Unibody is a construction in which the chassis is integrated with the metal body and provides support to all the components and protection to the vehicle occupants. For having cheaper repairs and better off-road capabilities Body-on-frame is preferred whereas for better handling and to get good fuel economy Unibody is preferred. According to the requirement the car body structure is preferred. Basic ideology of design to come out with the batter and safer product. To get the final product it involves various process like-

a. Pre-design and development
b. Design Engineering
c. Development Engineering
d. Sales

Pre-design and development involves Benchmarking, concept preparation and carryover study, were the product to be designed is pre checked with the previously existing design and how better it can be made. Concept preparation involves target segment decision, target volume and target market. Benchmarking involves price specification, component wise comparison from competitors product and features on segment. Carryover study involves creating the list of parts which falls under the scope of carryover to new car and this is carried until the design engineering phase. In design engineering development of the product takes place through CAD modeling with appropriate design consideration and safety criteria's. Designed model tot sent to CAE team and analysis report is given back to the design team which is reviewed by them and necessary changes are made. Finalizing of suppliers and tools begins. In development engineering co-ordination with suppliers and tooling takes with confirmation of GD&T. Major components are manufactured by company itself and minor components are given to the suppliers. Production problems are solved in this process. In sales customer feedback is taken with the help of JDP test to improve the quality of the product according to the customers need.

BIW design involved the design of Hood, Fender, Roof rails, Tail gate. Hood is the outer covering for the engine compartment for front wheel drive vehicles. Hood designed involved design of inner panel with input surface given by using cad tools like offset, trim and face blend etc. Design criteria's are considered like hinge axes, latch and striker reinforcement. Proper embosses are given with force during crash moving away from the vehicle occupants, finally outer surface is joined with inner panel with mastic sealant and at the outer periphery joined with hemming Fender is the closing component of engine and is to avoid the chipping inside the engine component. Mounting points of the fender are designed with considering design criteria and pedestrian safety. Roof design involves roof rails design which consists of front, rear, centre and bow roof rails and heat distortion criteria is checked. Front and rear ditch area part are provided with optimum angle for ensuring front and rear visibility criteria respectively and production criteria(positive draft angle). Centre roof rail

has two layers (with reinforcement), this is to strengthen the roof for roll over crash. Minimum of 5mm of gap between the inner panel and trim panel is maintained to have proper head impact zone. Top surface and roof rails are joined with spot welding and mastic sealant. Tail Gate/Back door is the closure part, inner panel is designed with outer upper and bottom surface with hinge, latch and striker reinforcement. Sectional modulus is calculated for hood and optimized for better results. Wheel Arc is verified according to the European standards.

2. Design of BIW Components

2.1 Design of Hood

It is the covering for engine in front engine vehicles, which protects the engine from sunlight and dust. It functions are-

- ✓ Helps in aerodynamical flow.
- ✓ Protects the passenger and pedestrian.
- ✓ Reduces the air resistance.

Below figure is the master sketch provided for design of inner panel of Hood.

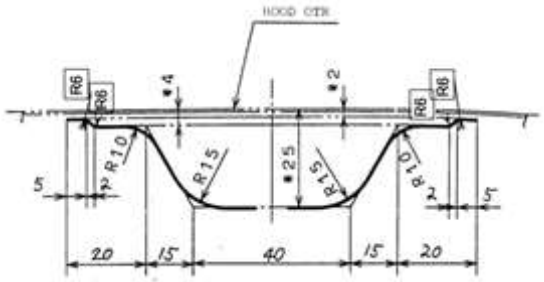

Fig 1 Master Sketch of Hood.

2.1.1 Design of Inner Panel

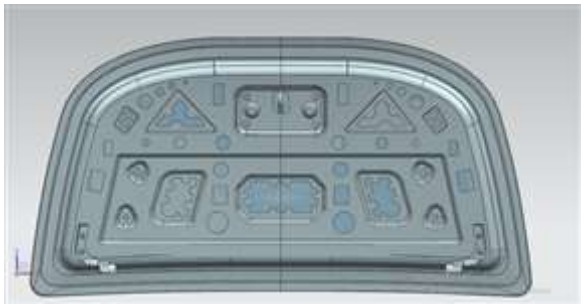

Fig 2 Inner Panel

Figure 2 presents the inner panel, designed according to the given dimensions of master sketch and thickness of 0.75 is given.

2.1.2 Positioning of Hinge and Striker

Taking centre of axis of hinge as centre of the circle drawn through the striker distance as the radius. It is positioned tangent, so that perpendicularity is obtained.

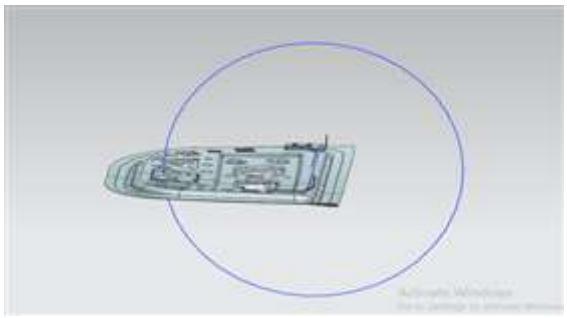

Fig 3 Hinge and Striker Positioning

2.1.3 Mastic, Emboss Definition and Hemming

Mastic is used to join the inner and outer panel with 5mm gap. Emboss is given so that during the crash the energy is dissipated outside / away from the vehicle occupants and along with the other cut outs to reduce the weight. Along with reduction in weight it even doesn't cost as it is a cut out. After embossing the required amount of material is trimmed accordingly with NX CAD tools and are given with a fillet radius by maintaining the minimum value of 3 + 0.75, so that no emboss is left out with sharp edges.

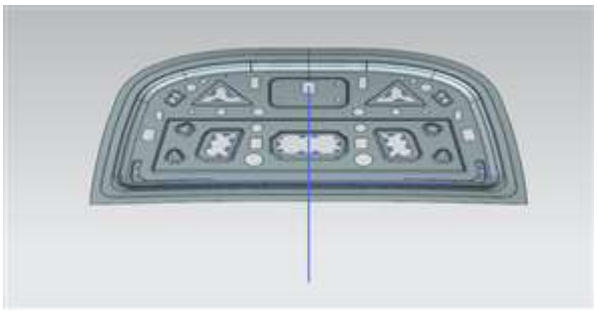

Fig 4 Mastic Region

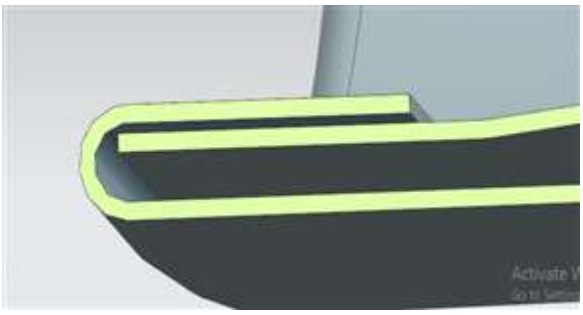

Fig 5 Hemming

Figure 5 represents the Hemming between the inner and outer panel, it is used joining the inner and outer panel and used instead of spot welding as surfaces cannot be joined with welding process. Hemming is a metal working process in which a sheet metal is folded over onto itself. Normally hemming operations are used to connect parts together, to improve the appearance of a part and to reinforce part edges. Hem flanges are protected by a sealant to prevent crevice corrosion of the sandwiched metal. In principle, the hemming technique produces sufficiently strong mechanical joints around the periphery of closure panels

When force is applied during hemming process there may be a change of shape which is examined and relaxation is given in those areas to decrease the stress concentration.

2.2 Design of Fender

Fender is the car body part that frames the wheel. Its purpose is to prevent sand, dirt, rocks and other road spray from being thrown into air by the rotating tire and close the engine component.

Mounting points are –

- ✓ Drip Area
- ✓ Bumper Mounting Region
- ✓ Sill mounting Region

- ✓ A-Pillar Mounting Region
- ✓ Wheel Arc Mounting

Below figure is used to as a master section to create drip area and rest of the mounting points are creates as per the design requirements.

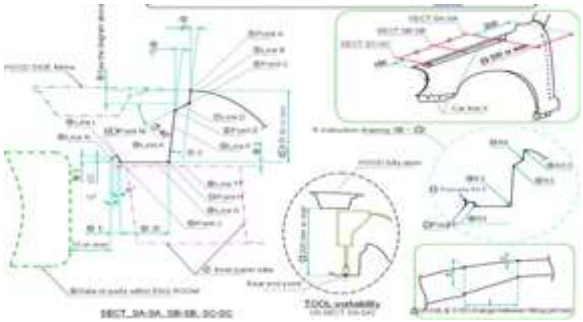

Fig 6 Master Section of Drip Area

2.2.1 Drip Area

It is the critical mounting area located inside the engine component. Designed according to the master section provided and optimal opening angle is maintained to make it look well assembled from outside.

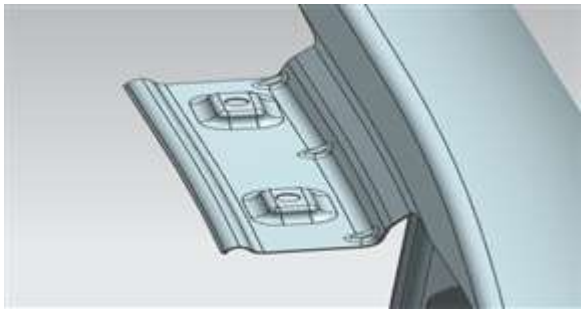

Fig 7 Drip Area Mounting

Minimum clearance from head lamp and cowl part is maintained. Vertical distance of the drip mounting is maintained less than 60mm to avoid the spring back effect.

Drip area is mounted to engine compartment by weld nuts.

2.2.2 Other Mounting Regions

Below are rest of the mounting areas, designed by maintaining emboss distance of 7mm and draft angle of 10 degrees. At the wheel arc baffle is added absorb noise from engine compartment.

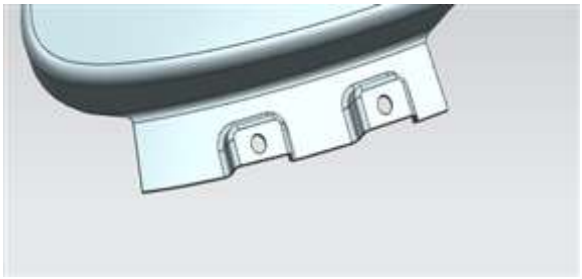

Fig 8 Bumper Mounting Region

Fig 9 Sill Mounting Region

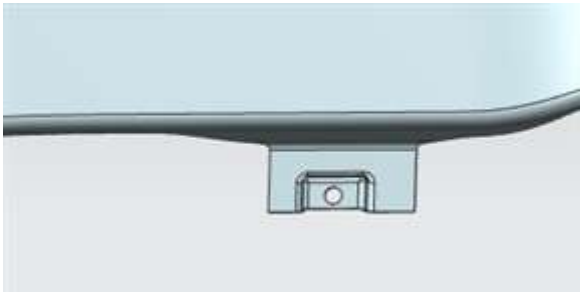

Fig 10 A-Pillar Mounting Region

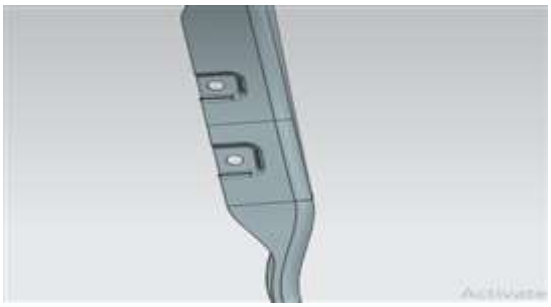

Fig 11 Wheel Arc Mounting Region

2.3 Design of Roof

Roof is the top most covering provided for the vehicle and for safety side it's important for roll over kind of accidents, which the basic test performed for safety purpose. In order to give strength, it is provided with embosses on top of the roof.

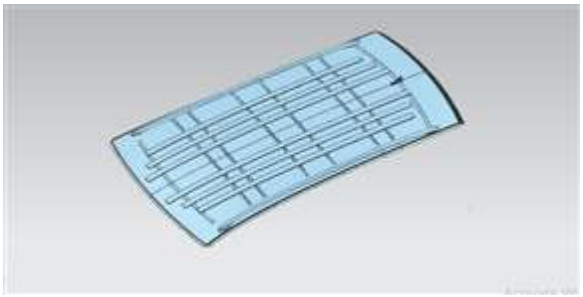

Fig 12 Roof

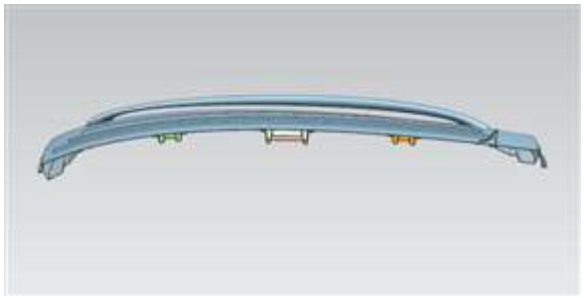

Fig 13 Sectional View of Roof

2.3.1 Bow Roof Rails

It consists of Front, Rear, Centre, Bow Roof I & II roof rails. Bow roof rails are provided for the support of the roof surface. The bow roofs are provided with mastic sealant as they are assembled with the surface as welding is not possible, whereas the ditch area, front and rear area is welded with the roof.

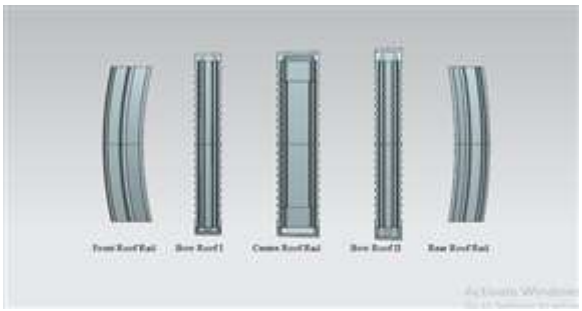

Fig 14 Bow Roof Rails

Front and rear roof rails are cut a part as there will be mounting of A and C pillars. Centre roof rail has two layers(reinforcement) as to protect it from roll over crash. Bow roof 1 and bow roof 2 are provided for better protection of roof from crash. Front and rear bow roofs are provided with optimal angle of inclination to meet the production criteria (positive draft angle) and visibility criteria. Mounting of windshield and rear glass becomes easier.

2.3.2 Checking of heat Distortion Criteria

It is the temperature at which the material starts softening when exposed to a fixed load at elevated temperature. Above this temperature the material can't be used. In order to know whether the material is in safer zone according the positioning of bow roofs, the test is performed by considering the below given formula -

$W = 1.73 \times 10^{-3} \times L + 1.85 \times 10^{-8} \times ((R^2) \div t) + 1.10x10^{-3} \times l - 2.68$

$R = 2(R_x \times R_y) \div (Rx+R_y)$

L = Roof Length in X-Direction [mm] (Roof dimension in 0-Y)

R = Roof curvature

R_x = X curvature

R_y = Y curvature

t = Roof plate thickness [mm]

l = Bow Roof Span [mm]

Judgment Condition: OK<2.7mm<NG

Results obtained –

Table 1: Heat Distortion Calculation

Sr. No	**BOW**	**RX**	**Ry**	**R**	**t**	**L**	**L**	**W**	**W < 2.7**	**OK /NG**
1	FRR&1st	6125	2674.3	3723.04	0.75	300	1197	0.06271	< 2.7	OK
2	1st&CRR	5730	10889.2	7508.79	0.75	340	1197	1.15556	< 2.7	OK
3	CRR&3rd	3905	11067.3	5773.03	0.75	340	1197	0.58689	< 2.7	OK
4	3rd&RRR	2065	12343.4	3538.09	0.75	400	1197	0.13959	< 2.7	OK

So as per the results obtained the roof is safer zone as the W values are below 2.7 as per the standard condition.

Thus the design passes the Heat Distortion Test.

2.4 Design of Back Door

Backdoor or Tailgate is the hinged door at the rear part of a vehicle and can be moved up or down. It lets us access the boot space or trunk.

Parts of Back door assemble –

- ✓ Inner Panel
- ✓ Outer Panel
- ✓ Hinge Mounting Bracket
- ✓ Hinge Inner Reinforcement
- ✓ Latch Inner Reinforcement
- ✓ Wiper Motor Mounting Bracket
- ✓ Gas Stay mountings and reinforcement(Heaver back doors)

2.4.1 Design of Inner Panel

Designed with consideration of given outer panel and followed with creating of embosses, mounting brackets and necessary reinforcement.

Embosses are given to make the inner panel stiffer and good endurance while crash. It is created in Y shape to allow the force to flow and get dissipated outside and hence to protect the vehicle occupants.

Fig 15 Inner Panel

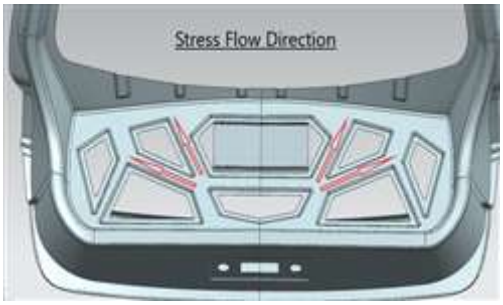

Fig 16 Stress Flow Direction

Inner panel is designed to dissipate the stress in outward direction.

2.4.2 Latch placement, Hemming and Relief

Hinge axis is taken as centre to draw a circle at the middle of the backdoor and latch is placed perpendicular to that circle.

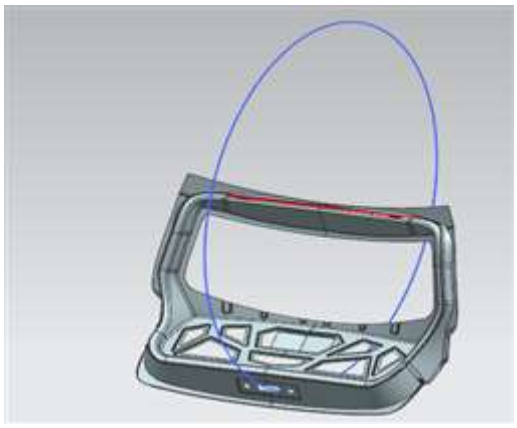

Fig 17 Latch and striker placement

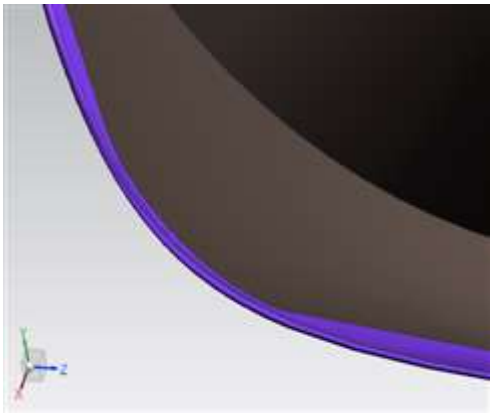

Fig 18 Hemming and Relief

Hemming is the process of joining of two surfaces using set of rollers and to bend the parent part over the sub part.

Relief is given on the outer panel to decrease the stress concentration.

2.4.3 Draft analysis and reinforcement

Draft analysis is done to see whether the metal drawn with particular design without any tear in the metal of disfiguration.

It is done with 5 degree of allowance. Green is good to go.

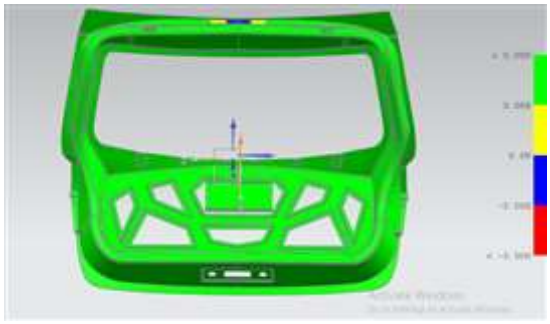

Fig 19 Draft Analysis

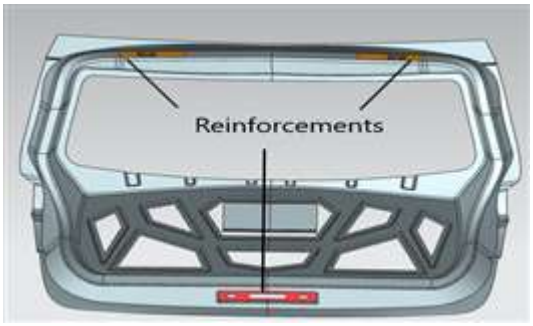

Fig 20 Reinforcements

Reinforcements are given at Hinge and Latch.

3. Sectional Modulus Optimization and Wheel Arc Verification

3.1 Sectional modulus optimization of hood

Sectional Modulus is the ratio of moment of inertia and distance between the neutral axis and extreme end.

It gives the idea of how much the material is resistant to bend/ deformation. As the moment of inertia increases the sectional modulus increases and hence more is the resistant to the bend.

Change is made in the design to improve the sectional modulus by varying the Y. For this emboss were given to reduce the distance between the inner and outer panel, as the distance decreases the sectional modulus increases.

Below are the images of initial and final moment of inertia.

Fig 21 Initial Section

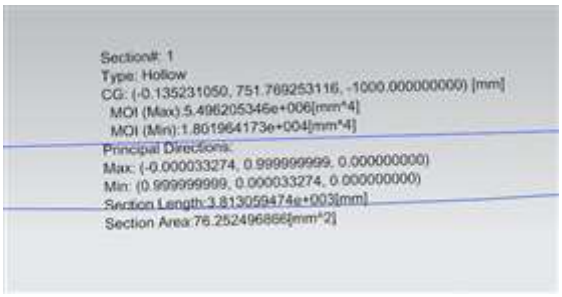

Fig 22 Improved Section

The inertia is increased, which increases the sectional modulus of the hood panel. This makes the hood more resistive towards the bend.

Main purpose of this analysis was to get the inertia of the hood and study of sectional modulus and improve it to withstand more loads.

3.2 Wheel Arc Verification Using European Standards

Wheel Arc is the part of fender and semicircular part positioned above the wheel. It protects the wheel from unwanted particles and entering of those particles into the engine compartment and even provides safety for pedestrian.

Requirements have been proposed by vehicle and road safety community to the minimum requirement of wheel arc distance from the wheel for safety.

Rules –

- ✓ Measure of CL L is done on sections SA, SB , SC, SD, SE.
- ✓ At all sections the value of CL L should be greater that 10mm.
- ✓ Wheel guard requirement -: The value of a shall be more that 5mm at 30^0 forward and 50^0 rearward from the central axis of wheel.

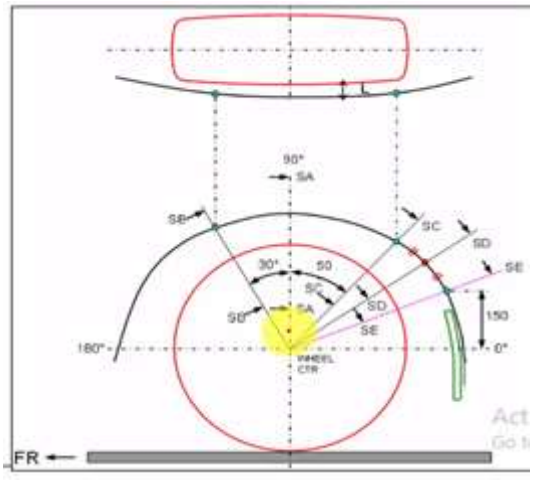

Fig 23 European Standards

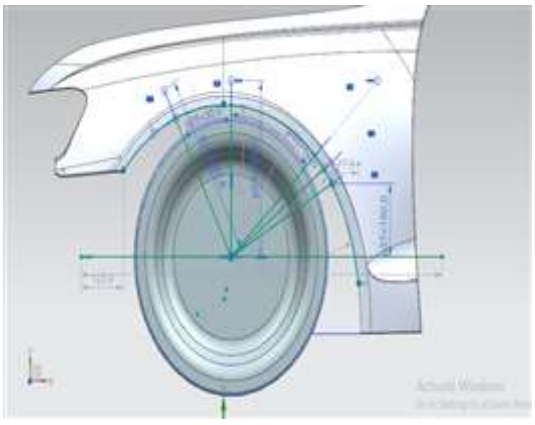

Fig 24 Wheel Arc

All the necessary distances are measured and tabulated below for analysis.

Table 2 Tabular Analysis

Section	Clearance Measured(mm)	Comments
SA	10	Pass
SB	10	Pass
SC	1.73	Fail
SD	-1.9	Fail
SE	-4.75	Fail

Conclusion

- ✓ Negative sign indicates that the wheel arc is behind the wheel
- ✓ All the section don\'t have the CL L value at least 10mm, only SA and SB is seen to have value 10mm.

Therefore the wheel arch does not satisfy the requirements as per the European standards. So the styling team needs to work at the section of SC, SD, and SE. For safety purpose the wheel arc should be outside the wheel and the value greater that 10mm and the SD, SE part should come outside the wheel.

3. Conclusions

In this work, the major BIW components were designed using necessary design standards and consideration with NX CAD software. Design of Hood involved design of inner panel with necessary reinforcements and embosses and hemmed with outer panel. Hemming involves joining of two surfaces and hemming adhesives are widely used to give improved strength, part stiffness, crash performance and corrosion protection. Mounting points of fender were designed. Roof design involved design of bow roofs and embosses on outer roof panel, heat distortion test was performed to check the design optimization. Tail gate design involved design of inner panel and hemming with outer panel. Optimization is carried out to get a safe design and to produce the part with optimal cost. It provides a unique design solution and requires less space with with compact dimension. To further reduce the cost of production and to get optimal design there is a scope for further study in optimization of design.

Acknowledgment

The author would like to thank Skill Lync for providing knowledge regarding BIW components and design.

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